Artec Metrology Kit

Version 1.0 Manual

Artec 3D

Artec Metrology Kit

Introduction

The Artec Metrology Kit (AMK) is a hand-held optical coordinate measuring system used for the mobile inspection of parts and components. The AMK system is typically used to measure objects up to and including vehicle size.

The integrated software of the measuring system enables fully automatic evaluation of digital images, regardless of the camera type employed. The AMK software is integrated in the Artec Studio software can be easily adapted to different measuring tasks and optimized to suit individual user requirements.

The software features a “one-button-click” solution for use in production environments. Experts are also able to perform their complex measuring tasks by means of parameterization.

By combining absolute precision with the mobility and flexibility of a photogrammetric measuring system, the Artec Metrology Kit is suitable for a wide range of applications in many different sectors:

- Inspection of objects, machine parts and components
- CAD comparisons
- Creation of references for 3D scanners and Artec Studio applications
- Deformation or distortion analyses

Differences between the two available kits

Entry Kit	Professional Kit
20 Megapixel camera	30.3 Megapixel camera
Reference cross and bar combined	Separate reference cross and scale bar
Point accuracy 4µm + 5µm/m	Point accuracy 2µm + 5µm/m
Volumetric accuracy 25µm + 25µm/m	Volumetric accuracy 15µm + 15µm/m
Basic range of measurement accessories	Additional measurement targets
Metrology Kit plugin for Artec Studio	Metrology Kit plugin for Artec Studio
Adjustable camera settings	Adjustable camera settings

Table 1. Difference between the Artec Metrology Entry & Professional Kits

About this manual

This user manual is an integral part of the product. Carefully read and follow the instructions given in this manual. Maintenance and repair work of the system must only be carried out by an authorized service technician or a staff member of Artec 3D.

 This manual has been carefully prepared. However, we cannot guarantee the correctness of the contents. Since mistakes cannot be completely avoided despite all efforts, we are grateful for any feedback in this respect.

Version 1.0, Subject to alterations.

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Starting the software

The software is integrated in Artec Studio. To launch the software, go to the File menu in Artec Studio, and click on the ‘Generate reference cloud...’ option.

The software is only available after you have activated your Artec Metrology Kit in the Artec Installation Center, using your MyArtec account.

Managing components

The component management window can be used to create measurement templates along with all the necessary components. It can also be used to make general settings for the Artec Metrology Kit.

The operating concept for this overview is the same for every component. The meaning of the icons and structure of the overview pages are therefore explained at this point in the manual:

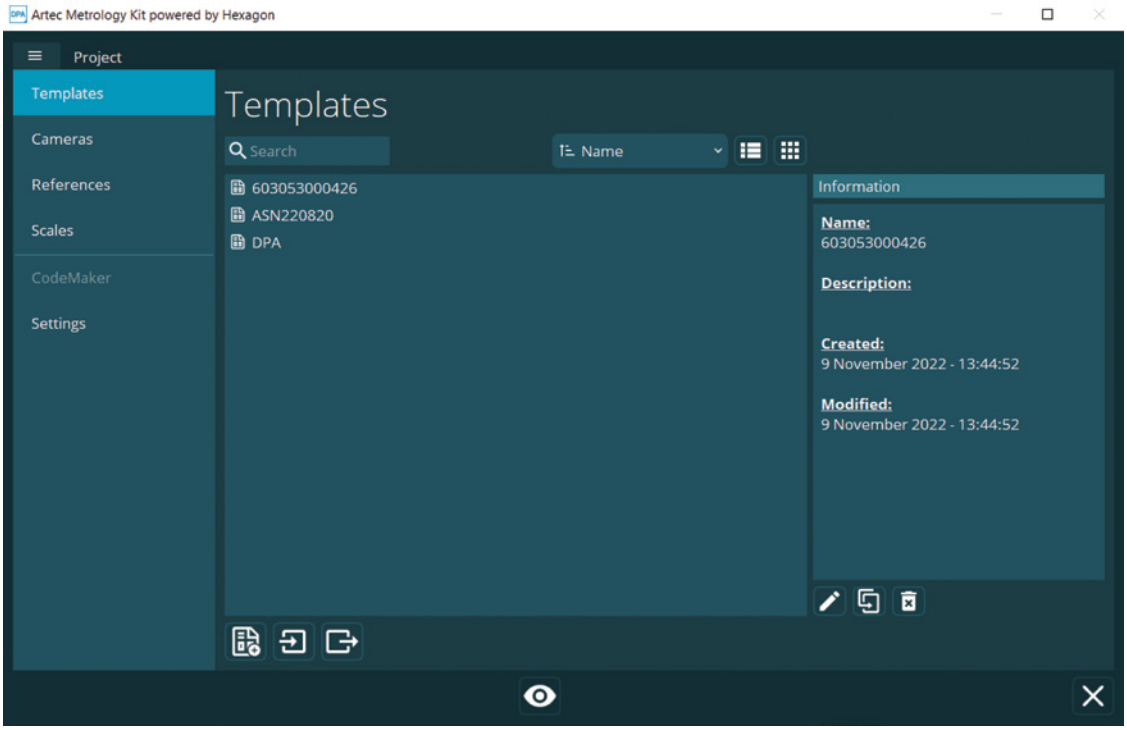


Figure 1.Component management window of the Artec Metrology Kit software

The operating elements specified in Table 2 can be used to alter the representation and layout of the components in the overview:

Icon	Function
	Tiled view whith large icons
	List view

Table 2. Icons for changing the component layout

Above the component overview is a search box, which can be used to enter text defining how the components are to be filtered. The components can also be sorted by name, creation or change date in ascending and descending order.

The right-hand window displays details for the selected component, such as the creation and change date along with an optional description of the component.

Describes the functions of the icons:

Icon	Function
	Create new template
	Import
	Export
	Edit
	Duplicate
	Delete

Table 3. Icons in the component management window

Templates

Templates can be used to compile all components required for a measurement and to make all necessary settings for the measurement.

Selecting Templates in the component menu bar opens the overview page for the templates. A list of all existing templates is displayed here.

When a template is newly created or opened for editing, the Template data window opens. This window is divided into three tabs:

- Details
- Components
- Settings

Use this optical measurement solution to analyze the deformation characteristics of materials under different environmental conditions and loads – processes where a short measuring time is crucial. The Metrology Kit is great for analyzing the geometrical changes of things like storage tanks, vehicle components, or design prototypes.

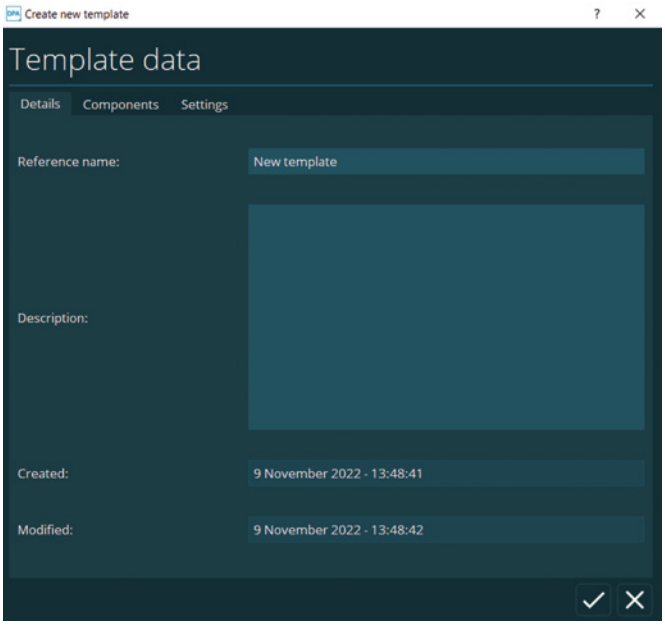


Figure 2. Templates

A template consists of a combination of components (scales, references, and cameras), which can be viewed and selected on the **Components tab**.

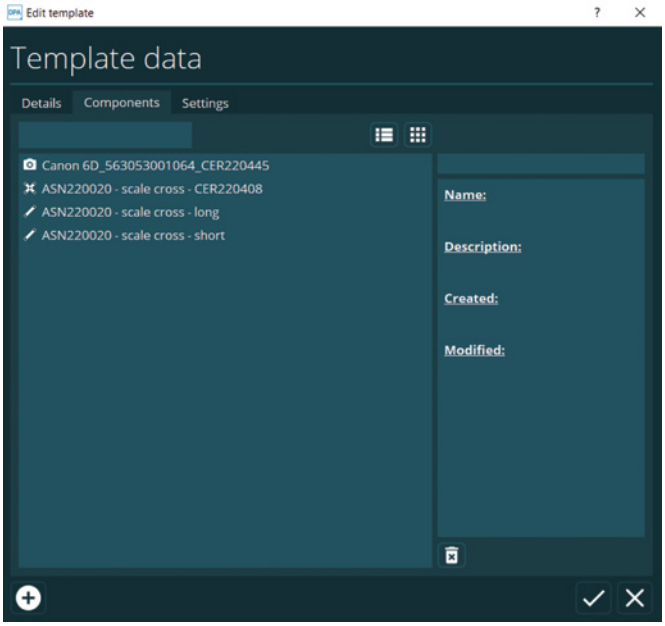


Figure 3. View of the selected components

Click ⊕ to change the component selection. A tree view of all available components appears. Entire groups of components or individual components can be selected or deselected here. Individual components can be removed from the overview by clicking 🗑.

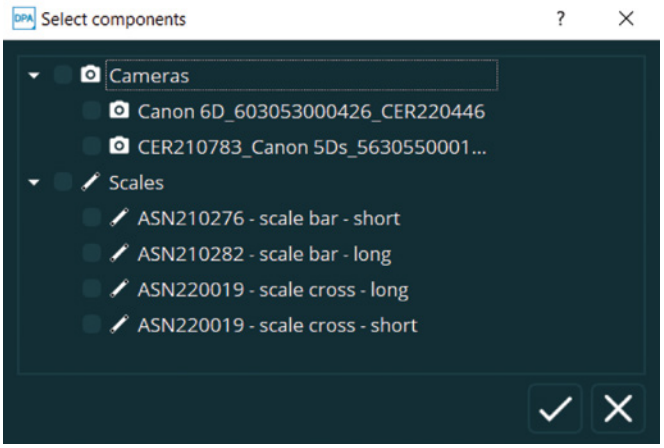


Figure 4. Component selection

The **Settings tab** can be used to adjust measurement parameters and define quality criteria for assessing the success of the measurement. A description of the settings and their effects is provided in the following chapters.

Settings: Image measurement

The **Settings tab** can be used to adjust measurement parameters and define quality criteria for assessing the success of the measurement.

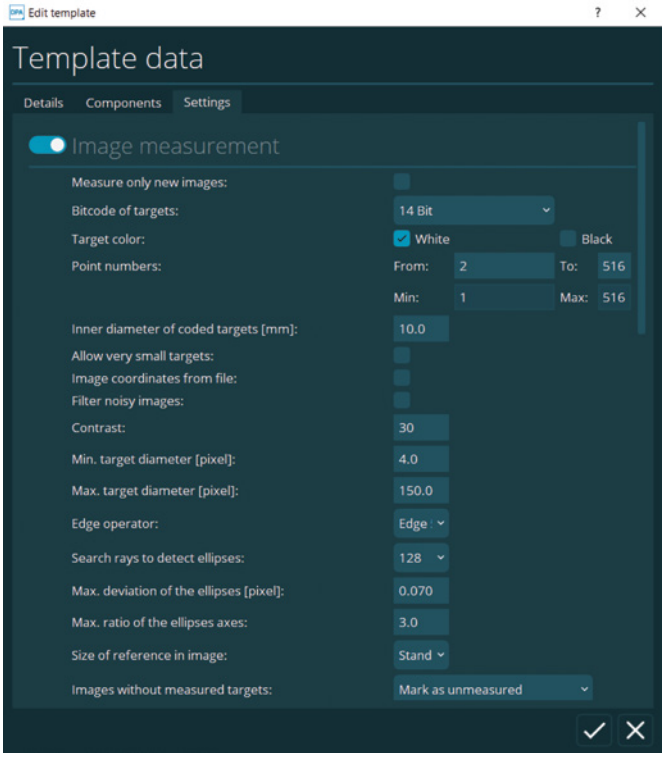


Figure 5. Image measurement settings Table

Lists the image measurement functions:

Function	Description
Measure only new images	The image measurement is only carried out for newly added images. Old images are skipped. If this option is not activated, the software carries out another image measurement for all existing images, but this is only useful if the measurement parameters have been modified. It is recommended to activate this option. **Example:** At the end of a measurement, a user realizes that some targets have been insufficiently captured. He takes 3 new images of this area. If this option is activated, the software carries out an image measurement only for these 3 images and keeps the results of the other images.
Bit code of targets	Target coding: Users can select between 12-bit, 14-bit, 20-bit and Anco code or a combination of Anco and 14-bit code. Depending on the selected code, a valid point number range is produced, which can be further restricted under Index values (see below). Generally, only 14-bit coding is used with the AMK software.
Target color	Users can select between black and white targets. Simultaneous measurement of black and white targets is also possible.
Point numbers	The range of the used point numbers can be restricted such that coded targets outside the specified range are ignored.
Inner diameter of coded targets [mm]	Entering the inner diameter of the coded targets prevents code segments being falsely detected as non-coded targets. We recommend that users always specify the inner target diameter of the smallest coded target to be used. If this function is to be deactivated, the value 0 must be entered as the target diameter.
Allow very small targets	If the images contain very small points (only ~3 pixels), this option should be activated. However, this raises the risk of incorrect measurements in the images, e.g. due to minimal reflections, which increases the time required for post-processing.
Image coordinates from file	Instead of measuring in new images, it is also possible to import the 2D image coordinates from a previous measurement (*.phc file).
Filter noisy images	Activates additional filters to perform measurements in very noisy images (e.g. underwater photogrammetry).
Contrast	In the case of images with poor contrast, i.e. with a low grey scale value difference between the target center and contrast ring, the value can be reduced to allow a target measurement to be performed.
Min. target diameter [pixel]	Minimum diameter that a target in the image must have to ensure that it is detected *Recommendation: Increase the value when many incorrect points are detected (reflection, texture of the component).*
Max. target diameter [pixel]	Maximum size required for the diameter of a target in the image to ensure that this target is detected.
Edge operator	Users can select between Edge3, Edge5, Edge7 and Edge9. With higher values, blurred edges are also detected.
Search rays to detect ellipses	To detect the exact edge of an ellipses, a specific number of search rays are used to examine the ellipses. The number of search rays can be 32, 64, 128 or 256. The greater the number of search rays employed, the more detailed the result, but the higher the computation effort.
Max. deviation of the ellipses [pixel]	Maximum permitted deviation of the measured ellipses from the shape of an ideal ellipse *Recommendation: Increase the value to perform measurements in very noisy images or when using targets with poor print quality.*

Function	Description
Max. quotient of the ellipses axes	Maximum permitted ratio between the long and short main axis. *Recommendation: Increase the value to be able to perform measurements in images that have been taken at a very flat angle.*
Size of reference in image	Ratio between the reference size and the area of interest of the image. Options: large, standard and small.
Images without measured targets	Marks images where no targets have been measured, as successfully measured and orientated. As a consequence, the software does not try to measure or orientate these images again when an existing measurement is continued. This option is mainly relevant for automated processes.

Table 4. Image measurement settings

Settings: Adjustment

The **Adjustment tab** can be used to set the parameters for the adjustment.

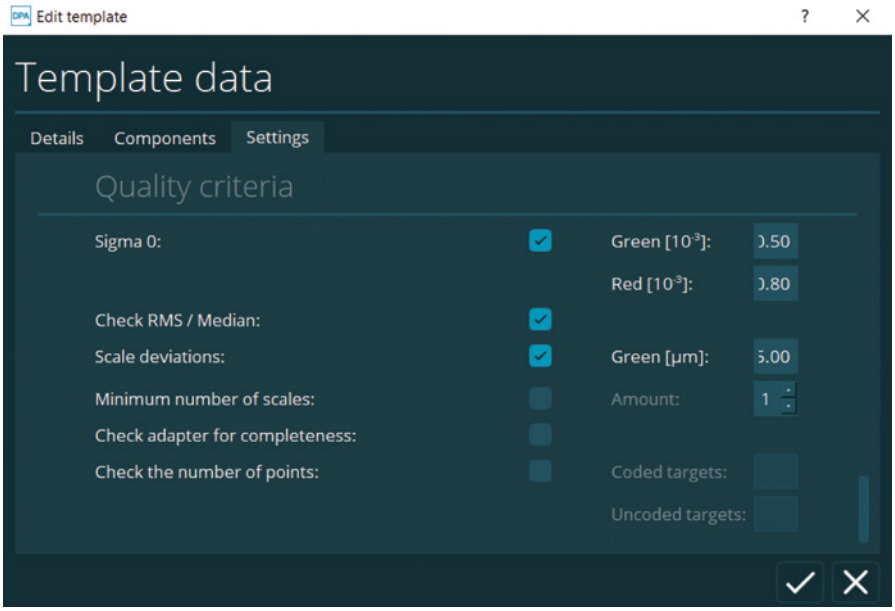


Figure 7. Settings for image orientation, point assignment and bundle adjustment

Lists the adjustment functions:

Function	Description
Orientate only new images	The pre-orientation is performed only for as yet non-coded images.
Delete old point assignment	When new images are added, the previous point assignment is deleted and a new point number is assigned to all measured, non-coded targets (including in new images). If this function is deactivated, only coded targets are calculated in new images.

Table 5. Adjustment settings

Settings: Point assignment

Lists the parameters for the point assignment:

Function	Description
First non-coded point number	Specifies the number from which the numbering of non-coded marks begins. Default value is 1000.
Point assignment	Specifies the accuracy of the point assignment. The more accurate the point assignment, the slower the assignment becomes.
Min. distance of points	Specifies the minimum three-dimensional distance of two measurement points. If the centers of two points are closer together than the specified value, one of the two points is ignored.
Limit for point number matching	Specifies the limit value for the search range of the point search im mm for each point of the reference data set in the current data set / the current capture. If a point is found in this range, the point number of the reference data set is assigned to it. If there is no point in this range, the point receives a new number.

Table 6. Point assignment settings

Settings: Bundle adjustment

Lists the parameters for the bundle adjustment:

Function	Description
Min. amount of rays per point before the adjustment	Points with fewer rays than the minimum quantity are excluded from the adjustment.
Max. distance for nearby scale points	Up to the specified distance, the system searches for the corresponding coded targets in the environment of the endpoints to determine non-coded scales.
Finish adjustment at a Sigma0 of	When the specified Sigma0 is reached, the adjustment is stopped prematurely. This option can be used to reduce the time taken for the adjustment.
Weight of coded targets	Factor used for the weighting of residual errors for coded targets. The weighting for coded targets is to be regarded as relative to the weighting or non-coded targets. The default value (neutral) is 1.
Weight of non-coded targets	Factor used for the weighting of residual errors for non-coded targets. The weighting for non-coded targets is to be regarded as relative to the weighting for coded targets. The default value (neutral) is 1.

Table 7. Bundle adjustment settings

Quality criteria

Upon completion of a measurement, the level of success of the measurement is indicated via a color code to enable rapid assessment of the results:

Green = successful **Yellow** = moderate success **Red** = failed

Some criteria for this assessment can be adjusted. These criteria serve as indicators for the quality of a measurement. Default values based on empirical values for standard use of the AMK software are preset.

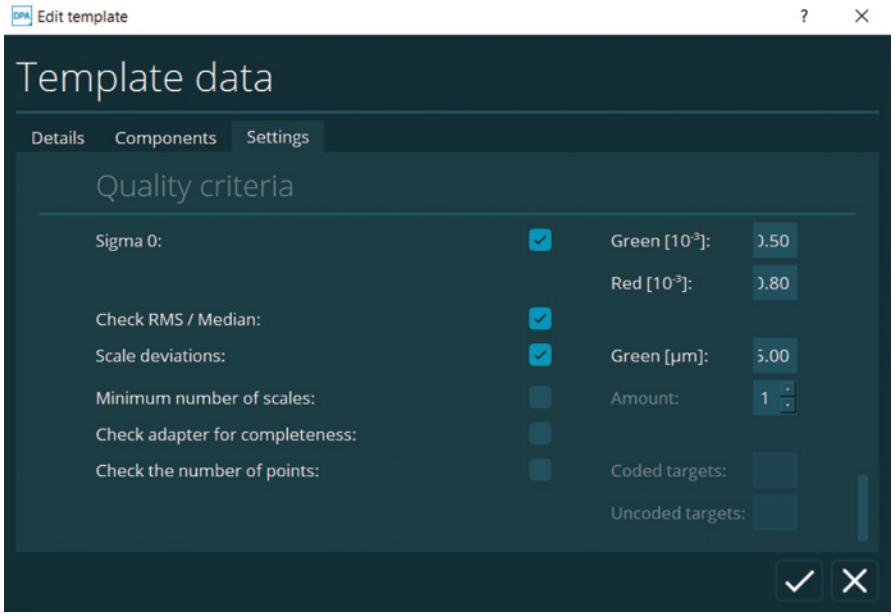


Figure 7. Quality criteria settings

Lists all criteria and their meanings:

Criterion	Description
Check Sigma 0	**Green colored measurement result:** The Sigma 0 is below this value. The result is classed as successful. Limit value as of which the result for Sigma 0 is classed as successful. If the Sigma0 is less than or equal to this value, the measured result for this criterion appears in green. **Red colored measurement result:** The Sigma 0 is above this value. Thexresult is classed as unsuccessful. **Yellow colored measurement result:** The measurement result is between the two limits.
Check RMS / Median	The RMS value denotes the root mean square of the established standard deviations. If this option is activated, the program checks whether the RMS for a component is greater than 3 times the median of the component. If this is the case, the status of the measurement appears in red otherwise the status appears in green. *The median and RMS for each component should ideally be identical. If not, this indicates individual points with significant deviations.*

Table 8. Quality criteria for the measurement

Criterion	Description
Scales deviations	Deviation of the measured distance of a scale from the distance specified for the scale. **Green colored result:** The entered limit value is met. **Yellow colored result:** The entered limit value is not met. **Red colored result:** The MPE specifications for measuring systems (MPE = maximum permissible error) are also not met. In general, it is checked whether at least one scale bar has been successfully measured, if scales are included in the template.
Check the number of points	Minimum number of points to be measured. The number is split into coded and non-coded targets. If the minimum number is not met, the result of the measurement is highlighted in **red**.

Table 8. Quality criteria for the measurement

Cameras

When a camera is newly created or edited, a window opens for entering all relevant camera data. The camera properties are split into the following sections:

- Camera data
- Calibration data
- Image transfer

These sections are described in the following chapters.

Camera data

The camera data to be entered depends of the selected camera type. If the type is C1, a camera ID has to be entered. Resolution, sensor size and focal length are completed automatically. If the type is user defined and no camera data or distortion parameters from previous calibrations are available, the image resolution and sensor size must be obtained from the camera description and the focal length of the used lens must be entered.

Lists the available information:

Information	Description
Camera name	Name of the camera. The camera is displayed under this name in the AMK software.
Camera description	Brief description of the camera (optional).
Camera type	Type of the used camera. Each type offers different options for the camera data and the image transfer. • C1 — 50 Megapixel (full resolution for larger distances) • C1 — 22 Megapixel (standard resolution for fast data transfer) • C1 — 12 Megapixel (low resolution for very fast data transfer) • User defined *For (very) fast data transfer, the standard and low resolution are recommended. Compared to the full resolution, these settings still provide a high data quality.*
Camera ID	Identification number of the camera. This number is required to establish a Wi-Fi connection for C1 cameras. Only for C1 camera types.
Resolution [pixels]	Width and height of the sensor in pixels. Only for *user defined* camera types.
Sensor size [mm]	Sensor dimensions in millimeters. Only for *user defined* camera types.
Focal length [mm]	The focal length depends on the selected lens. This information is normally indicated in the lens. Only for *user defined* camera types.

Table 9. Information for the camera data

Calibration data

The calibration data (distortion parameters) can be imported or entered manually. When a camera is imported, the calibration data is also transferred.

By activating/deactivating the checkboxes for the individual parameters, users can define which parameters are calibrated, i.e. calculated, during the evaluation. An appropriate selection of distortion parameters is required here. It is generally recommended that users adopt the standard configuration for the example shown in Figure 8.

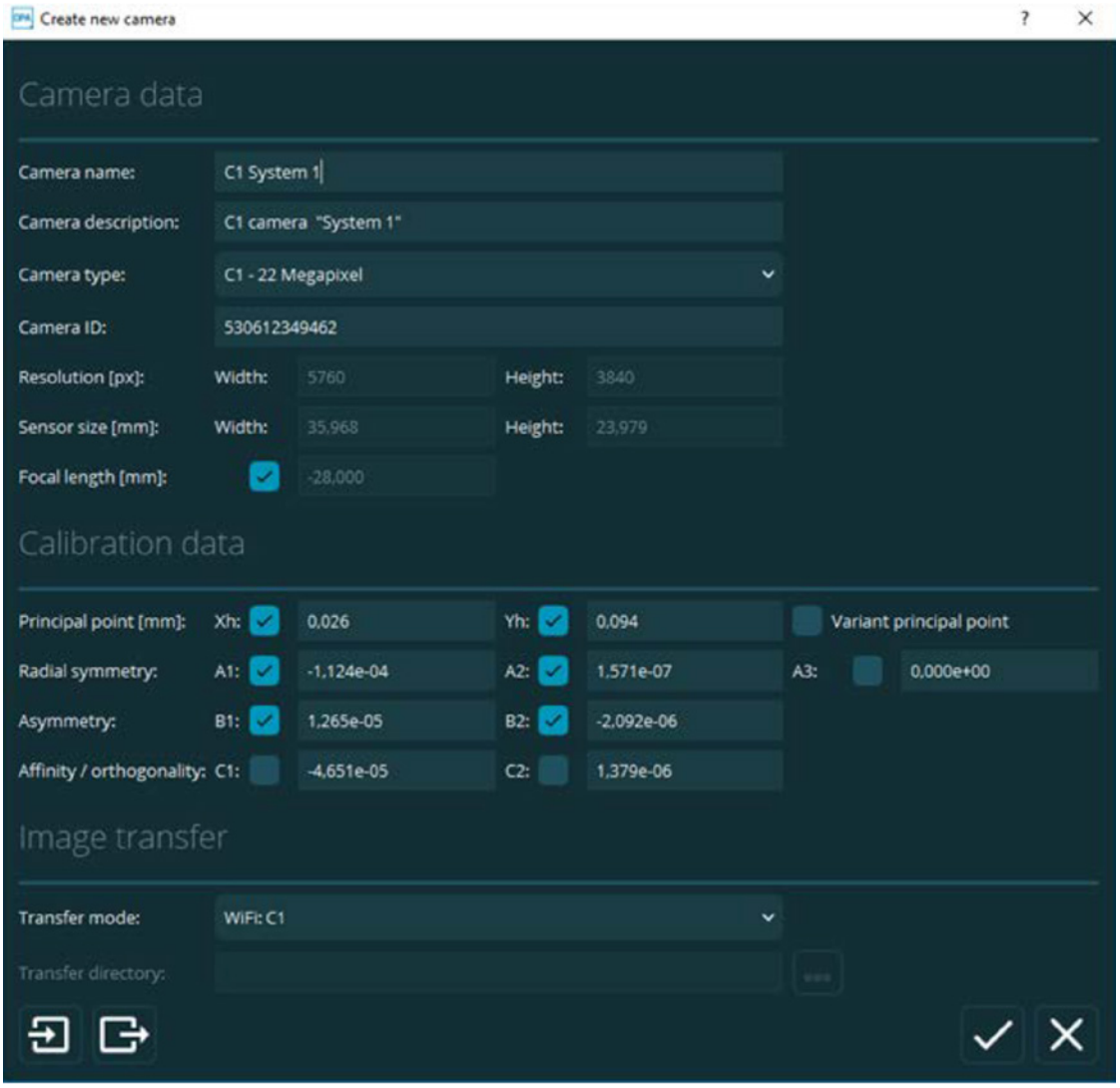


Figure 8. Camera data / Calibration data

For each AMK Professional system, special IOR data (interior orientation) is supplied that may deviate from the standard. This serves to increase the accuracy of measurements.

When working with a pre-calibrated camera system, the selections for the relevant parameters must be cancelled. This will ensure that the previously calibrated data is used in the evaluation.

Any calibration data that is not to influence the evaluation must be deactivated.

References

Points with a known geometry can be used as a reference in a measurement, either instead of or in combination with scales. When reference points are used, scales only serve to check the measurement results. References can contain coded and non-coded points.

When a reference is newly created or edited, a window opens for entering all relevant reference data.

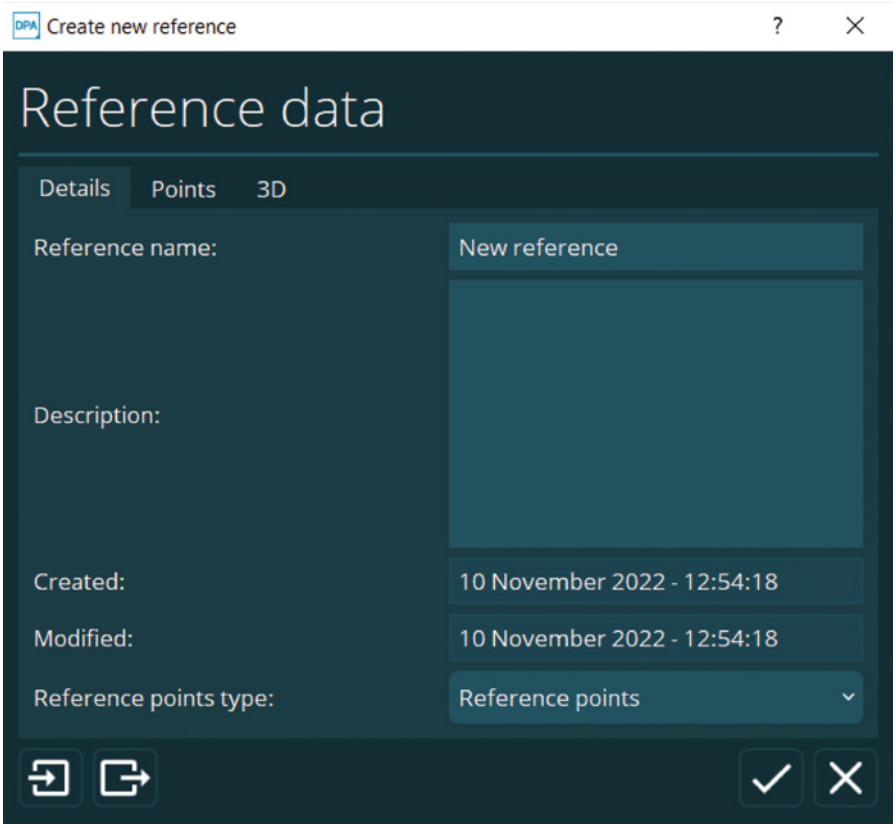


Figure 9. Creating a reference

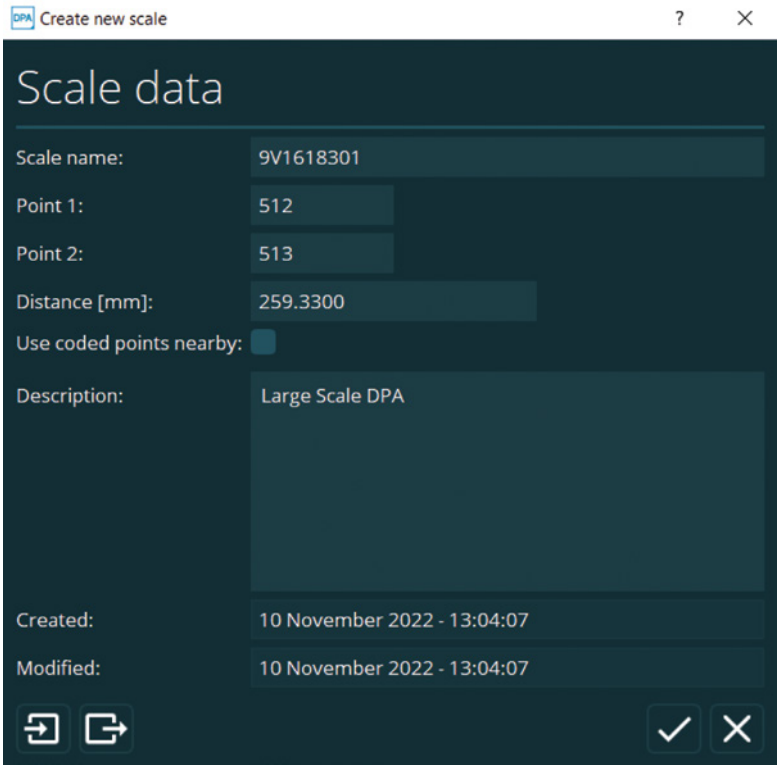
Lists the available tabs for defining a reference:

Tab	Function
Details	Entry of the name and (optional) description of the reference. Display of the creation and change date of the reference.
Points	Entry and editing of the coordinates of the reference object. Manual entry of the coordinates under Points. It is also possible to import/export the coordinates of the reference object from/into a coordinate file (*.obc). In this case, a file dialogue opens for selecting an .obc file to be imported. The data from the selected file is then displayed in the Data import window. In this window, the coordinates can be viewed and a unit selected for the data import. Individual rows can be specified to select only a part of the coordinates. The selected coordinates can then be imported using .
3D	Display of the point cloud of the reference object as well as rotation, zooming in/out and shifting of the point cloud using the functions described in the chapter 3D view.

Table 11. Creating a reference

Scales

Scales are objects with two coded or non-coded points at a defined distance from one another. Unlike the reference cross, the distance defined as the scale is included in the calculation as heavily weighted additional information. This information facilitates the high-precision scaling of the measurement object so that at least one scale must be specified when creating a measurement template.



When a scale is newly created or edited, a window opens for entering all relevant scale data.

To use the distances of the reference cross as a scale, these must also be introduced as a scale with×the corresponding point numbers. However, these distances are not calibrated with high precision.

Figure 10. Creating or editing a scale

Lists the available fields for creating or editing a scale:

Field	Description
Scale name	Entry of the name under which the scale is displayed in the list of available scales.
Point 1, Point 2	Entry of the numbers of the scale end points.
Distance [mm]	Entry of the distance between the end points specified on the scale (in [mm]).
Use non-coded targets nearby	Activating this option enables the measurement of a scale with non-coded end points. For this purpose, the fields Point 1 and Point 2 are used to specify which coded targets are in the proximity of the end points of the non-coded scale. In the vicinity of these coded targets, the nearest non-coded target is then assigned to the scale in the measurement and used to determine the distance.
Description	Entry of an optional description to enable easier identification of the scale, in the component selection for instance.
Create time / Change time	Automatic insertion of the creation and modified date.

Table 12. Creating or editing a scale

Settings

General settings for the AMK software can be made here.

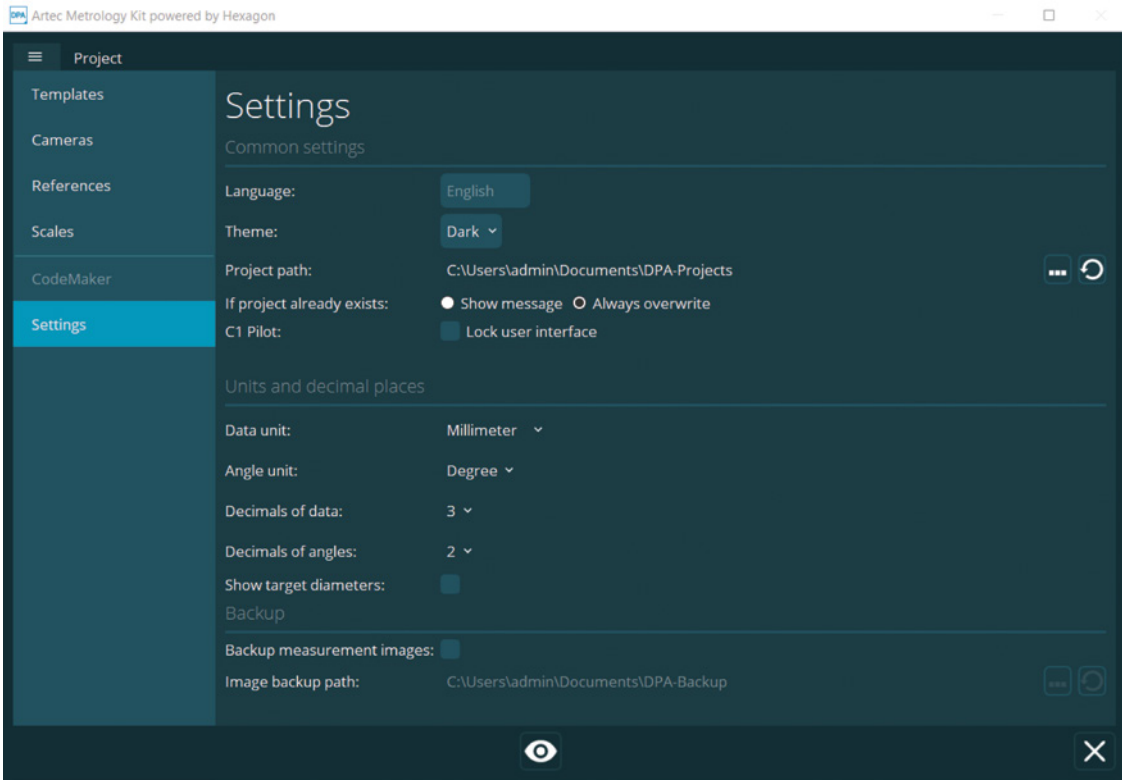


Figure 11. General settings

Lists the available settings:

Setting	Description
Language	Display language of the software. After changing this setting, the program must be restarted.
Theme	Switch between a light and dark theme for the user interface.
C1 Pilot	Lock the user interface of the C1 Pilot application for user interaction while it is used by AMK software.
Units and decimal places	Set the units and decimal places of data and angles.
Backup	Activate a backup of measurement images. All measurement images are saved in the selected directory. This is additional to the regular storage within the project file. *This setting leads to a higher memory consumption.*

Table 13. General settings for the AMK software

Camera settings

Before starting a measurement, the camera settings must be checked. The settings for the currently selected camera can be accessed on the component management window by clicking .

Before the actual measurement, two to three test images are taken of the signaled measurement object (from the front and at an angle). This ensures optimum capture of the measured images. This check is optional in the case of recurring measuring tasks or when measuring identical objects in direct succession.

This process is not essential when using retro targets since the influence of ambient light is negated by the camera settings and flash. When using standard targets, however, the measurement is affected by the ambient light. Test images should therefore be taken before every measurement in the case of changing conditions.

For this purpose, the camera is used with the currently selected template. In the displayed window (Figure 12), individual images captured with the selected camera can be viewed in full resolution.

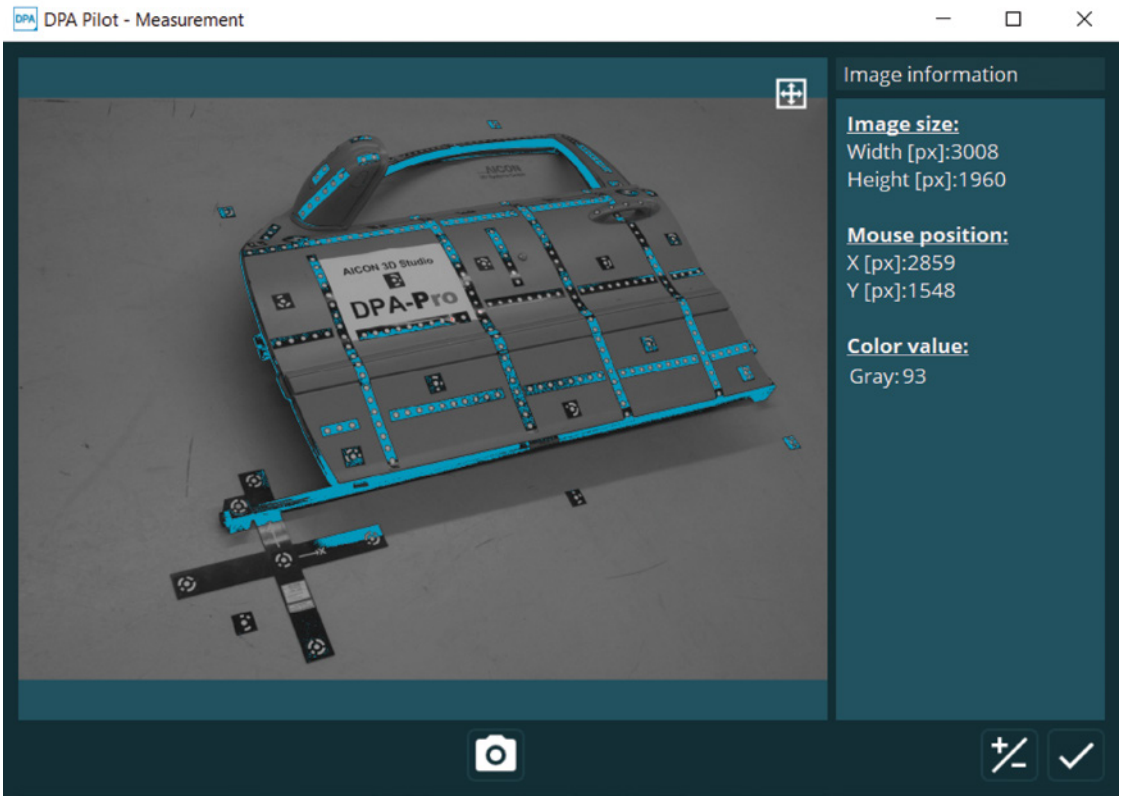


Figure 12. Camera settings with limit values highlighted in color

The used images can be loaded from a file or from an SD card using . Transfer via Wi-Fi is also possible. When using the Wi-Fi mode C1, an additional camera icon appears at the bottom left edge to indicate the connection status of the relevant camera: green indicates an established connection while red means that no connection is active.

Lists the functions for the camera settings:

Function	Description
Zoom	By pressing the right mouse button while simultaneously moving the mouse up and down, users can zoom in and out on the image atthe cursor position.
Contrast	To check the contrast, the cursor must be placed over the center ofxa target. The grey scale value in the status bar at the bottom left edge then changes. This process must be repeated for multiple measurement points and targets from different image areas should be checked. A grey scale value of 0 represents the color black, while 255 denotes white. If the majority of targets have a grey scale value between 100 and 200, this indicates good contrast. Targets that were captured at a significant angle always possess a slightly lower grey scale value than points facing directly towards the camera. Targets pointing directly towards the camera should thus have a grey scale value of around 200, while angled targets should have a value of around 130. If many points in the image have a grey scale value in excess of 220, the images will be overexposed, which can impair the accuracy of×the image measurement and thus the entire AMK evaluation. If the results are still unsatisfactory, changes should be made to thecamera settings. Camera settings for brightness adjustment: • Aperture • Flash intensity • Exposure time • ISO value
Focus	The focus can be checked by analyzing the image with a high zoom factor. If only one measurement point can still be seen, the edge pixels must be examined.  *Example of a well-focused image with a short stretch of the grey scale value* A very long stretch of the grey scale value between the measurement point and its environment indicates a blurred image. If the edges do not display a long stretch of the grey scale value and an abrupt change from white to black is visible (see Figure 30), this represents a well-focused image. Since the focus of the image depends on the distance from the camera position, different points at different distances from the camera position should be checked, e.g. in angled images. If a lack of focus is detected in test images, the focus of the camera must be readjusted.

Table 14. Example of a well-focused image with a short stretch of the grey scale value

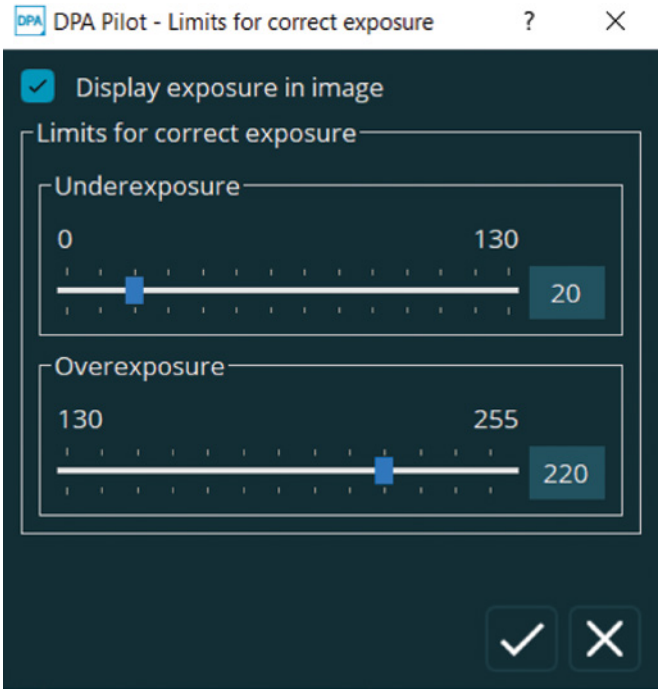


Figure 13. Settings for colored highlighting of borderline areas

To check the target grey scale values, coloring of those areas with borderline levels (too dark or too bright) can be activated via ±.

If the images or used camera settings are deemed to be acceptable, recording of the measurement images can commence.

Performing a measurement

Image selection

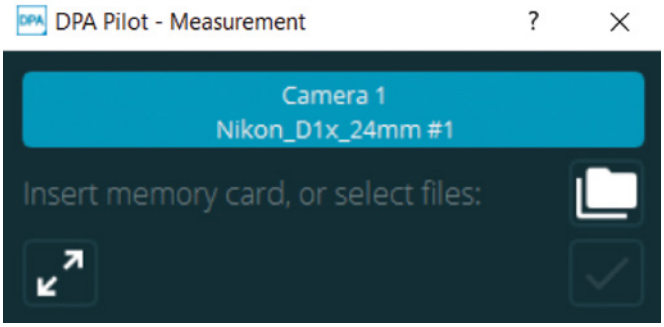


Figure 14. Selecting and loading images and starting the measurement

When working with files on a computer or SD card, an image selection window opens after starting the measurement. The images on a connected SD card are detected automatically. Alternatively, the images can be loaded from a directory by clicking Import. A dialogue box opens for sel cting the relevant files. Various common image formats can be processed. All formats of the digital cameras used by Artec 3D are implemented.

To ensure maximum accuracy, the JPG format must only be used with maximum quality or with the lowest compression (lossless)!

The measurement is started automatically by clicking ✓.

When a wired or wireless connection exists between the camera and PC, the measurement can be initiated while capturing the image. In this case, the window for selecting and loading images is skipped. To be able to use this function, the used camera must previously have been created with the correct transfer mode setting.

Dashboard

The progress of the measurement process is displayed on the Dashboard tab for all steps of the measurement.

The displays (from left to right) are as follows:

1. Overall progress of the measurement
2. Image measurement step
3. Pre-orientation step
4. Point assignment step
5. Adjustment step

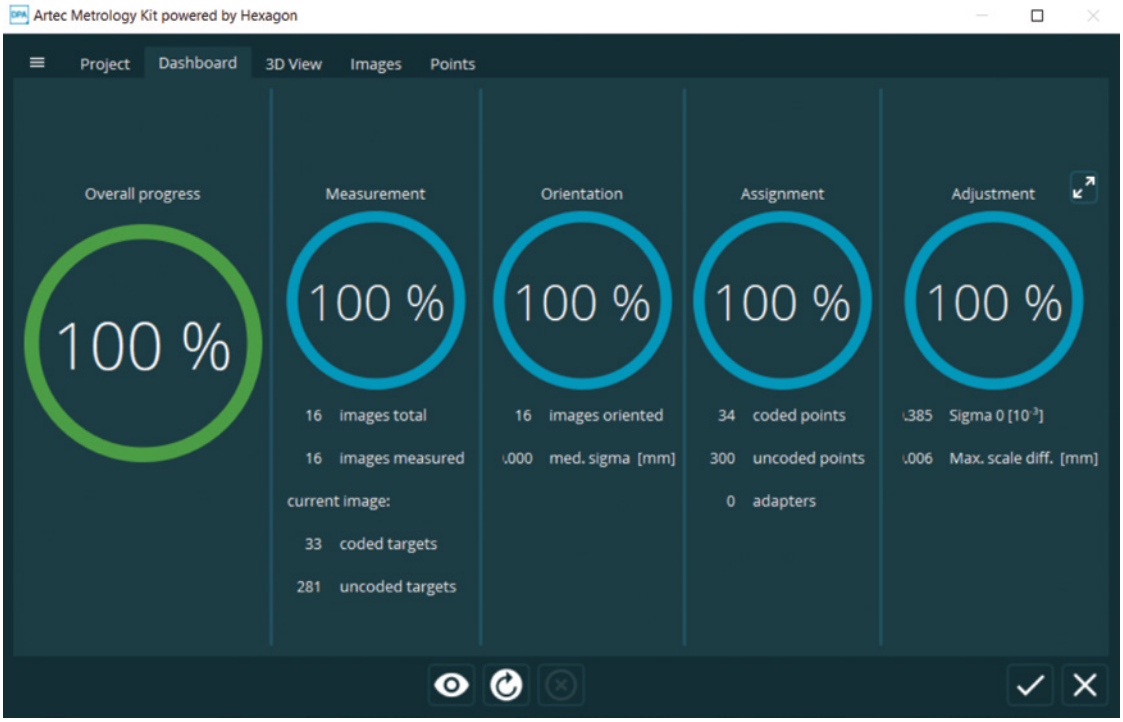


Figure 15. Progress of the measurement and the individual measurement steps

The overall progress disaply is color-coded:

Blue: in progress

Yellow: sufficiently completed

Green: successfully completed

Red: failed

The values for the color coding can be adjusted via the quality criteria defined for the template. Click the overall progress to display details regarding the quality criteria, i.e. which criteria are active and which criteria are met or not met.

Image measurement

During the image measurement, each image is examined for coded and non-coded points and measured. The result is a 2D coordinate in the image coordinate system. The number of measured points in an image is shown in the measured image overview on the Images tab. The accuracy of the image measurement is affected by the focus and camera angle in particular.

If no points are found in the image (e.g. in the case of retro targets captured without flash), the image is not included in the pre-orientation.

Pre-orientation

After the image measurement, the images are sorted and the pre-orientation starts. During this process, the camera positions of the measurement are determined and approximate 3D coordinates are calculated for all coded targets.

Orientation requires at least four well distributed and measured coded targets in the image.

To enable connection of the individual images, each image should contain around ten coded targets.

Images that could not be oriented are displayed with a **red** status bar in the measured image overview on the Images tab. Oriented images are indicated by a **green** status bar.

Point assignment

In the *point assignment* step, point numbers are automatically assigned to the non-coded targets. In the case of 12-bit and 14-bit coding, the non-coded point assignment starts with the number 1000. With 20-bit coding and the ANCO code, the assignment commences with the number 50000.

The Points tab displays the measured coordinates of the object points along with their standard deviations.

Adjustment

In the last step, all measured targets are recalculated in the context of a final *adjustment*. Multiple iterations are processed in this case. If the calculation is successful, the overall progress display for the adjustment is displayed in **green**. Otherwise, the progress indicator appears in **red**.

The information for analyzing the accuracy of an adjustment or AMK measurement is described in the chapter Quality criteria.

Below the adjustment progress indicator, the Sigma0 of the adjustment is displayed along with the maximum deviation of the measured scale distance from the predefined distance.

Individual quality criteria

The quality criteria set in the template are used to classify the status of the measurement as successful or unsuccessful.

If at least one of the activated criteria is not met, the status of the message appears in red. Details on the used criteria and whether or not they have been met can be checked by clicking the Overall progress indicator. This opens the Quality check results window, which displays an overview of the quality criteria.

Depending on whether they were met, active quality criteria are displayed in **red**, **green** or **yellow**. The values used to make this assessment are also displayed. Non-active criteria are displayed for control purposes, but do not feature any color highlighting. Additional information on the individual criteria is provided in the chapter Quality criteria.

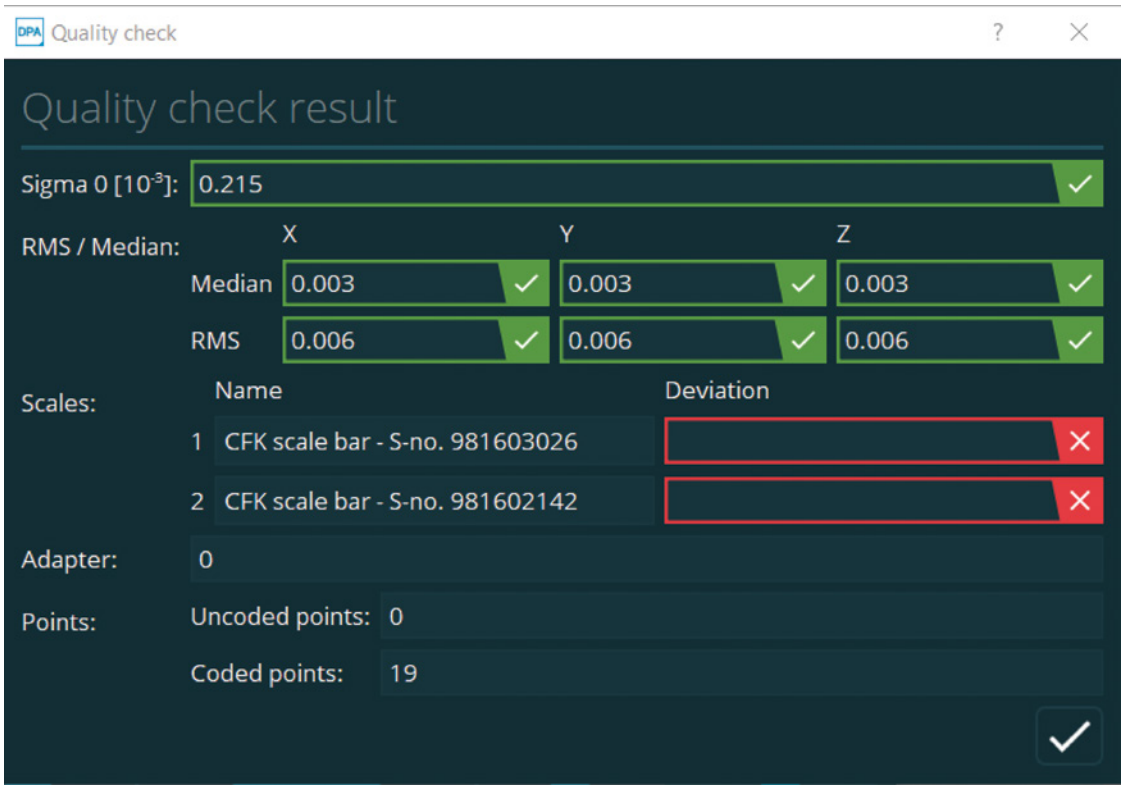


Figure 16. Individual quality criteria

3D view

On the 3D View tab, the measured 3D points are displayed in a 3D view along with the camera positions during image capture.

Right-click to open the context menu. Here the display of the point numbers, cameras and scales can be activated and deactivated. The content of the 3D view can also be centered.

Describes the functions of the icons in the 3D view:

Icon	Function
	Show / hide point numbers
	Show / hide cameras
	Show / hide scales
	Fit view to screen
	Rotate view

Table 15. Icons in the 3D view

Within the 3D view, various functions can be performed manually using the mouse. By default, these functions refer to the focal point of the graphic.

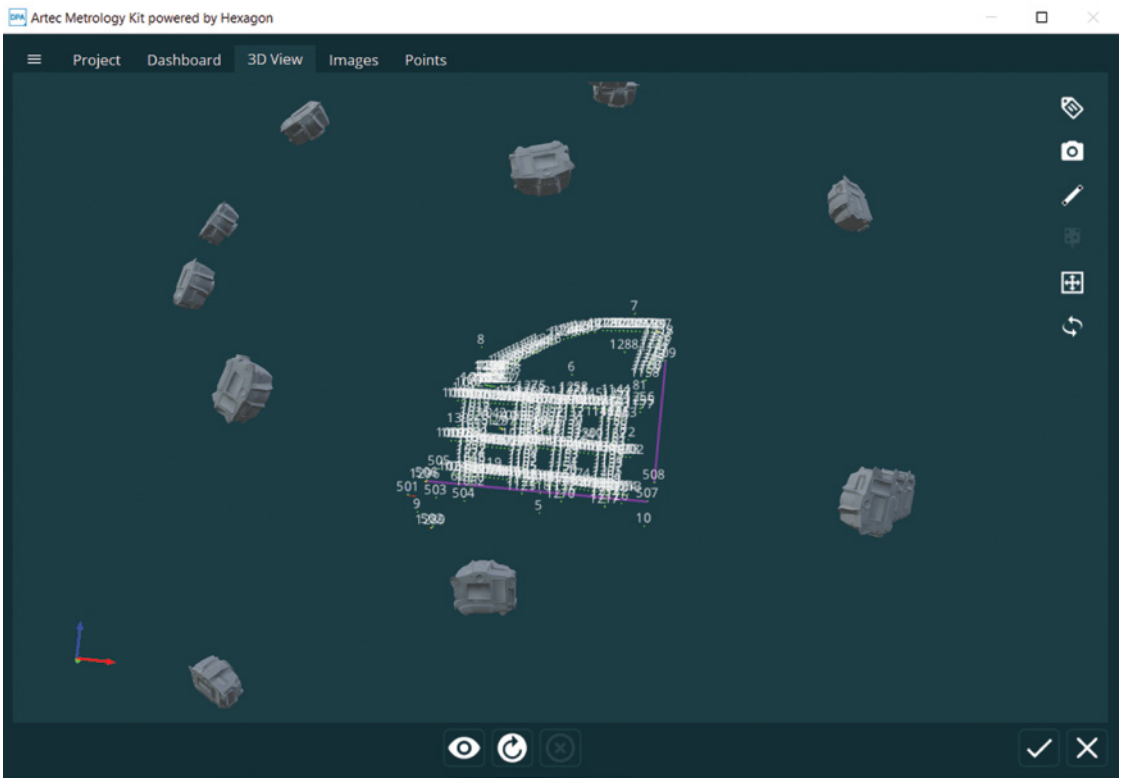


Figure 17. 3D view

Lists the functions:

Function	Description
Rotate (default: around focal point)	Left mouse button + free movement
Zoom to center of view	Right mouse button + upward and downward movement
Zoom to cursor position	Moving the mouse wheel (scrolling)
Shift	Shift key + left mouse button
Rotate around the screen axis	Right mouse button + left and right movement
Select individual points	Ctrl key + left-click
Select multiple points within a rectangle	Ctrl key + left-click + movement of the cursor
Zoom on a rectangular area	Alt key + left-click + movement of the cursor

Table 16. Control functions on the 3D view

Moving the cursor over a calculated point opens a window containing corresponding point information.

If the scales are displayed with cylinders, placing the cursor over these opens a window containing the target/actual length comparison.

The points in the displayed object point cloud are color-coded and represent the number of rays per object point or the status of the point. The minimum number of rays to be used is defined in the bundle adjustment settings.

Color	Number of rays
Green	> minimum quantity + 3
Yellow	Number is between minimum quantity and minimum quantity + 3
Red	< minimum quantity (point calculation may be inexact)
Blue	Selected point

Table 17. Color coding of points in the object point cloud

Click a 3D point to display the rays to the images in which the point has been found. A red ray means that the point in this image has been detected as inaccurate and was not included in the calculation. Click a camera to display the rays to all points that have been measured in this image. Double-click a camera to display the corresponding 2D image in a separate window. This function is only available after finishing the measurement process, not while the measurement process is running.

Measured images

The Images tab provides an overview of all the images used in the measurement. The images are shown in very small format. To the left of each overview image is a status bar the color coding of which indicates the current status of the measured image.

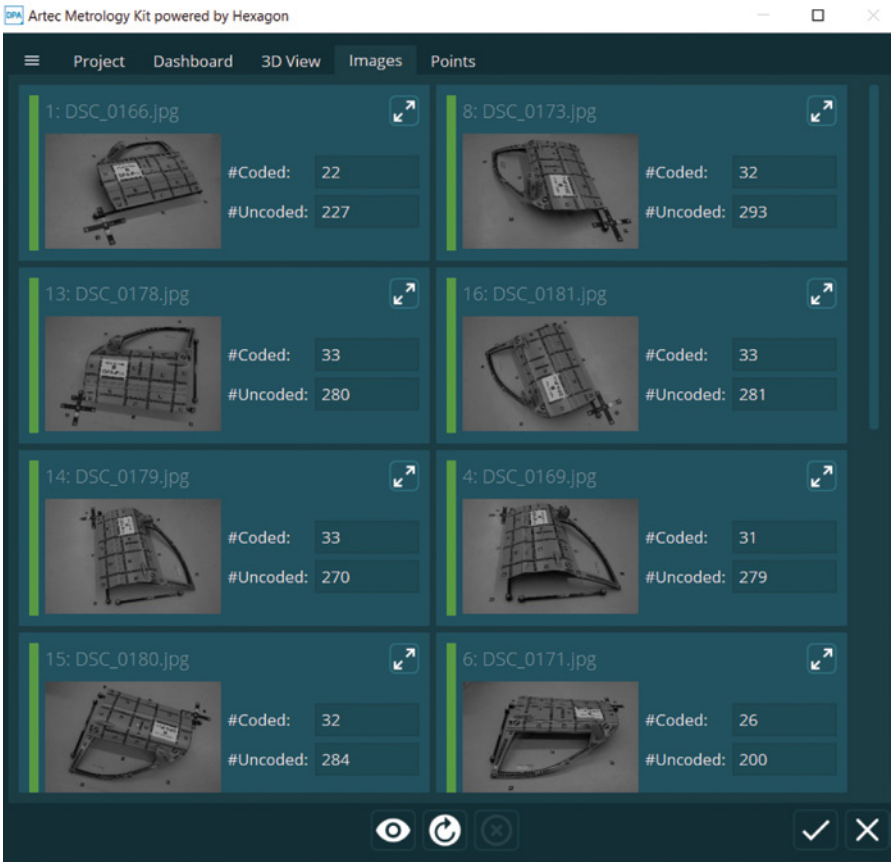


Figure 18. Overview of all measured images used Table

Lists the functions:

Color	Number of rays
White	Image not yet oriented
Green	Number of rays > minimum quantity + 3
Yellow	Number of rays is between minimum quantity and minimum quantity + 3
Red	Number of rays < minimum quantity (point calculation may be inexact)
Blue	Selected point

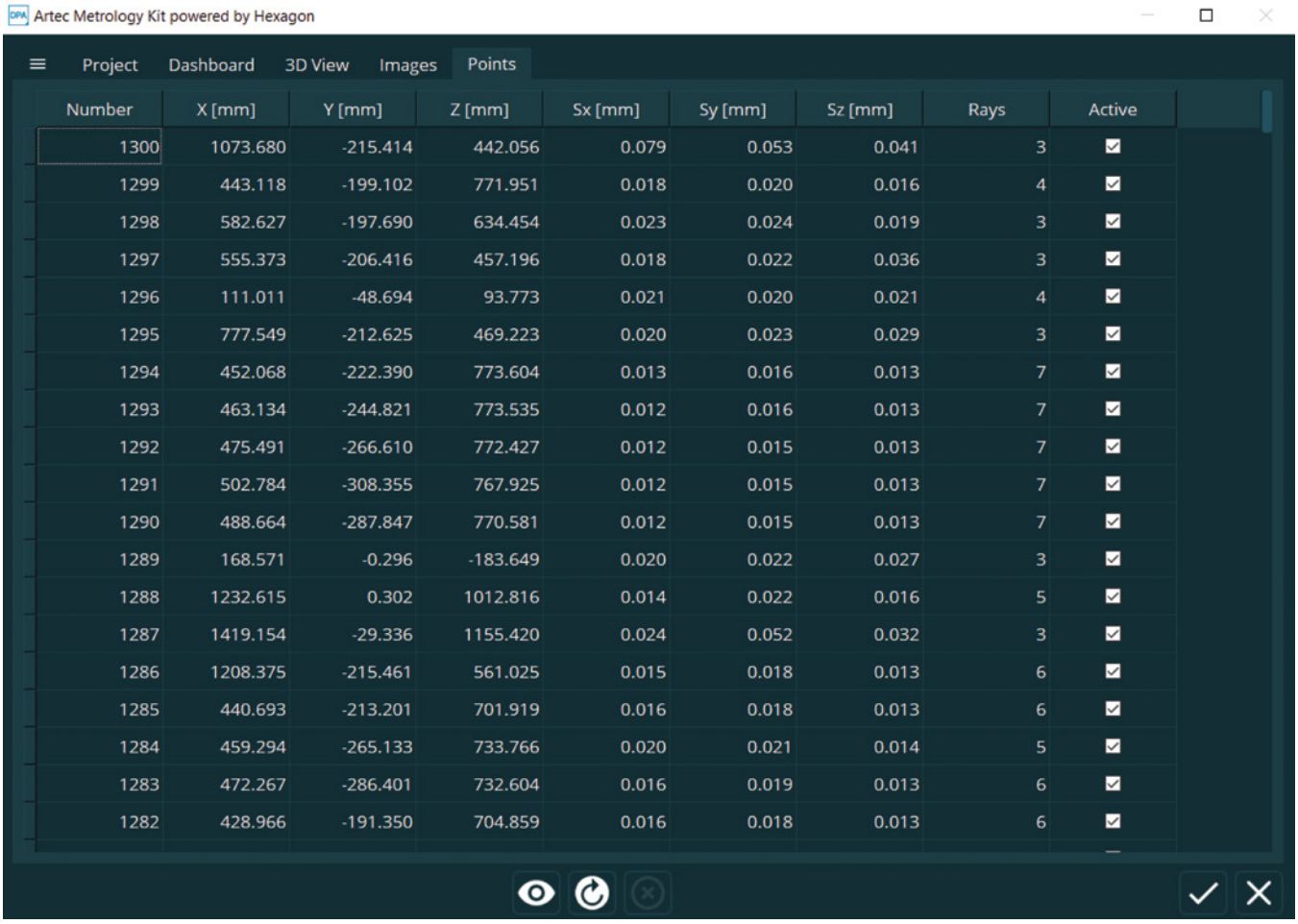
Table 18. Color coding of the status bars

Double-click an overview image or click ⤢ to open the relevant image in full resolution. For each image, the number of measured points is displayed (where available).

Points

After the adjustment, the 3D coordinates of the measured object points are displayed on the Points tab along with their standard deviations in the unit selected by the user. The table can be sorted by column.

The column Active is used to deactivate and activate points for the measurement. But the result of the measurement only changes if afterwards the recalculation is carried out again.



Number	X [mm]	Y [mm]	Z [mm]	Sx [mm]	Sy [mm]	Sz [mm]	Rays	Active
1300	1073.680	-215.414	442.056	0.079	0.053	0.041	3	☑
1299	443.118	-199.102	771.951	0.018	0.020	0.016	4	☑
1298	582.627	-197.690	634.454	0.023	0.024	0.019	3	☑
1297	555.373	-206.416	457.196	0.018	0.022	0.036	3	☑
1296	111.011	-48.694	93.773	0.021	0.020	0.021	4	☑
1295	777.549	-212.625	469.223	0.020	0.023	0.029	3	☑
1294	452.068	-222.390	773.604	0.013	0.016	0.013	7	☑
1293	463.134	-244.821	773.535	0.012	0.016	0.013	7	☑
1292	475.491	-266.610	772.427	0.012	0.015	0.013	7	☑
1291	502.784	-308.355	767.925	0.012	0.015	0.013	7	☑
1290	488.664	-287.847	770.581	0.012	0.015	0.013	7	☑
1289	168.571	-0.296	-183.649	0.020	0.022	0.027	3	☑
1288	1232.615	0.302	1012.816	0.014	0.022	0.016	5	☑
1287	1419.154	-29.336	1155.420	0.024	0.052	0.032	3	☑
1286	1208.375	-215.461	561.025	0.015	0.018	0.013	6	☑
1285	440.693	-213.201	701.919	0.016	0.018	0.013	6	☑
1284	459.294	-265.133	733.766	0.020	0.021	0.014	5	☑
1283	472.267	-286.401	732.604	0.016	0.019	0.013	6	☑
1282	428.966	-191.350	704.859	0.016	0.018	0.013	6	☑

Figure 19. 3D coordinates of the measured object points with their standard deviations

Evaluating results

Upon completion of the measurement, the individual results of the evaluation can be viewed on the different tabs (see chapter performing a measurement).

If the measurement was successful, the progress indicator of the entire measurement is displayed in green. The values of this evaluation can be viewed in the Quality check results window.

If the measurement failed, troubleshooting should be performed as described in the chapter Troubleshooting.

The currently calculated camera positions and measurement points are displayed in the 3D view. The points in the displayed object point cloud are color-coded and represent the number of rays per object point (see chapter 3D view). The minimum number of rays to be used is defined in the bundle adjustment settings.

Color	Number of rays
Green	> minimum quantity + 3
Yellow	Number is between minimum quantity and minimum quantity + 3
Red	< minimum quantity (point calculation may be inexact)

Table 19. Color coding of points in the object point cloud

If numerous yellow or red object points are visible in a specific area, an insufficient or marginal number of images exist for this area. The affected area should be supplemented with additional images from different camera positions.

Click a 3D point to display the rays from which the point was calculated. A red ray indicates that the point in this image is inaccurate.

Click a camera to display the rays for all points measured in this image.

Troubleshooting

If the calculation failed, the first step is to establish when the measurement was aborted.

Then check the possible error sources in Table 23. If the specified causes do not apply, please contact the support of Artec 3D.

Measurement failed during...	Cause	Solution
Pre-orientation	Incorrect reference cross/object selected in the template.	Change the reference object in the template (chapter Templates).
	Incorrect camera in the template.	Change the camera in the template (chapter Templates).
	Reference cross/object is too small or missing in the measured images.	Capture the area of the cross and its environment from additional, closer positions. Restart the measurement.
	Reference cross/object present or measured in too few images or no connection exists to other coded targets.	Stabilise the area of the cross with additional images. Restart the measurement with all images.
Adjustment	Object was not motionless, targets have moved	Eliminate movement/vibration. Repeat image capture and measurement.
	Selected scale is not in the object	Position the scale in the object. Repeat image capture.
	A point of the scale from the template was not calculated	Perform measurement without this scale (use modified template – chapter Templates). Stabilize the area of the scale with additional images.
	Scales were entered in the template with incorrect lengths or point numbers	Correct the scale. Repeat the measurement.

Table 20. Troubleshooting

Bundle report

The bundle report can be viewed by clicking the *Expand* ↙↗ next to the adjustment status display on the dashboard. A window opens containing the Scales and Bundle report tabs.

The *Scales* tab (see Figure 20) shows the values of the measured scales. The nominal and measured length are compared here. A median and a maximum value are also specified for the difference between the measured and nominal length.

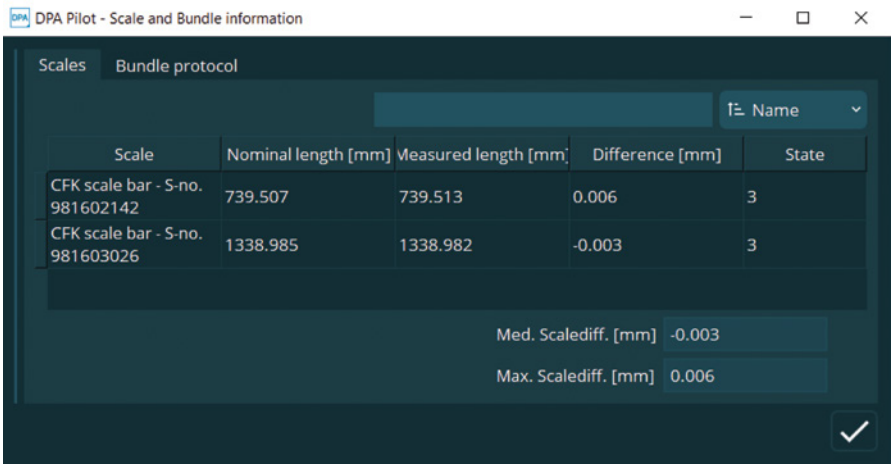


Figure 20. Overview of the measured scales

The Bundle report tab (see Figure 21) displays a comprehensive record of the bundle adjustment

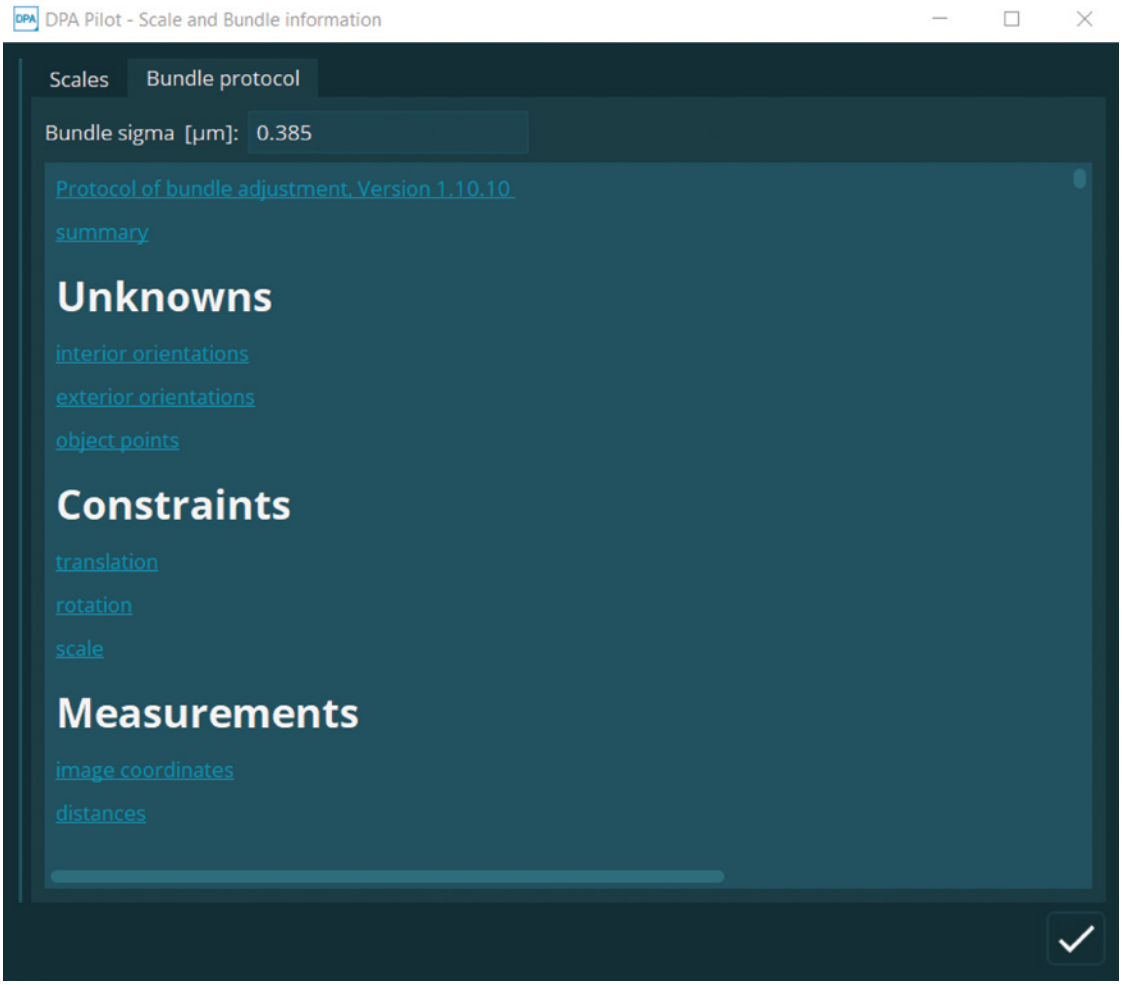


Figure 21. Bundle report

Post-processing and repeating a measurement

A completed message can be post-processed and repeated.

Click to display the options for post-processing a measurement.

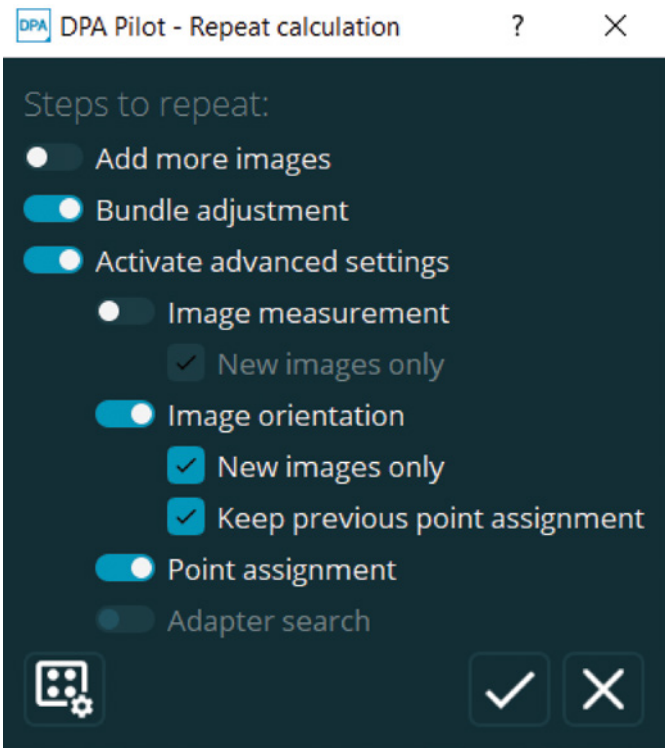


Figure 22. Post-processing and repeating a measurement

Lists the available options for post-processing a measurement:

Option		Description
Add more images		Inclusion of additional measured images. Addition of the images to the existing measurement.
Bundle adjustment		The bundle adjustment should be performed at the end of each measurement, before reusing or processing the measurement data. In many cases, only the bundle adjustment is repeated in order to exclude any inactive points from the calculation.
Enhanced settings		If the slide control is deactivated, all settings defined in Enhanced settings are deactivated. In this case, Add more images and Bundle adjustment are performed with the required default settings.
	Image measurement *New images only*	The image measurement can be performed for all images or only for newly selected or non-oriented images.
	Pre-orientation *New images only*	The pre-orientation can be performed for all images or only for newly selected images. This is subject to the prerequisite that an image measurement has previously been performed in the relevant images.
	Point assignment	The point assignment can also be repeated. Newly selected and oriented images are included in this case. If the Point assignment option is not selected, only 3D coordinates ofthe coded targets are calculated.

Table 21: Options for post-processing a measurement

The template settings of the current project can be accessed by clicking . Here, the template settings can be changed.

The selected processes can be started by clicking ✓. Following a successful calculation, the previous measurement results are overwritten with the new results.

Icon glossary

Icon	Function
	Adapter group add
	Adapter group
	Adapter multi pnts add
	Adapter multi pnts
	Adapter two pnts add
	Adapter two pnts
	Add from folder
	Alert outline
	Apply settings
	Arrow expand
	Assign by adapters
	Assign pointnumbers
	Breakpoint
	C1 settings
	Camera add
	Camera
	Camera iris
	Check
	Chevron down
	Chevron up
	Close circle outline
	Colored images
	Compress
	Content duplicate
	Coordinatesystem

Icon	Function
	Default retro
	Default standard
	Delete forever
	Export
	File export
	First
	Fixpoints
	Image add
	Image
	Image finished
	Import selection
	Information outline
	Invert colors
	Last
	Lock

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