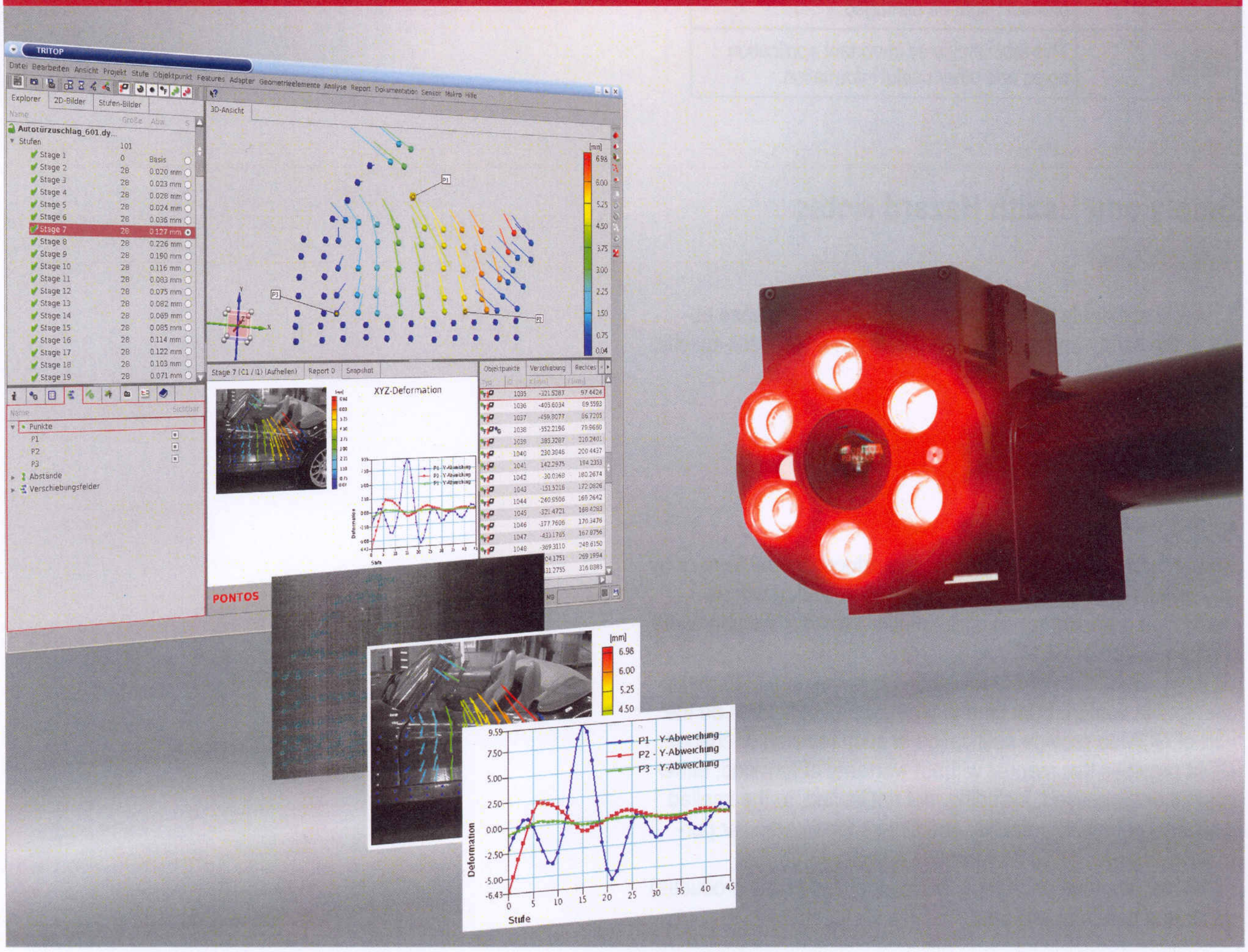
PONTOS

User Manual - Software



PONTOS v6.2

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Legal and Safety Notes

Symbols

In this user manual the following standard signal words may be used:

⚠ WARNING	This label points to a situation that might be dangerous and could lead to serious bodily harm or to death.
⚠ CAUTION	This label points to a situation that might be dangerous and could lead to light bodily harm.
NOTICE	This label points to a situation in which the product or an object in the vicinity of the product might be damaged.
Info	This label indicates important application notes and other useful information.

Safety and Health Hazard Notes

⚠ WARNING

To avoid accidents and damages to the devices, please observe the safety and health hazard notes in the sensor-specific User Information!

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About This User Manual

This user manual is intended for qualified personnel who has experience in handling measuring systems and basic PC knowledge (windows-based programs and operating systems).

In addition to this user manual, the software provides an Online Help. You may open the Online Help with the **?** icon or with the **F1** key.

While the Online Help for the most part describes the **How**, for example, how do I create a **New Deformation Project**, this user manual mainly informs about the **Why** and imparts basic strategic knowledge.

This user manual essentially is configured to the logical transfer of knowledge based on training concepts and standard measuring procedures.

Info

The scope of delivery of your software depends on the functions you bought according to your purchase contract. The user manuals and the Online Help describe the full scope of software functions. Therefore, it may happen that described functions are not included in your software package.

For being able to make optimum use of the system, we assume the ability to visualize in 3D and a color vision ability.

This user manual is divided into the following sections:

- Chapter A gives a brief introduction to the PONTOS system as well as basic knowledge about the Linux operating system and the PONTOS application software.
- Chapter B informs about the calibration of the measuring system and about adapting the sensor.
- Chapter C deals with the preparation of the measuring object and with carrying out a measurement.
- Chapter D informs about computation, components, stage transformation and identification.
- Chapter E informs about transformation methods and CAD import.
- Chapter F deals with result representation.
- Chapter G informs about report and documentation functions.
- Chapter H deals with automation and functional extensions.
- Chapter J informs about the support (troubleshooting).

PONTOS Software and Manuals for Measuring System or Evaluation Windows

Normally, the PONTOS software is used on Linux computers together with the measuring hardware. However, the same software is available as an option for Windows operating systems in order to be able to evaluate finished PONTOS measuring projects in this operating system environment as well. The scope of functions of the PONTOS software for Windows is restricted, e.g. no image recording is possible here.

This user manual describes the software for all operating systems. If sections or chapters of this manual are only valid for one operating system, they are marked with Measuring System or Evaluation Windows. If one section is marked, then this also applies to the respective subsections.

User Manual A-J

Chapter A - Table of Contents (rev-b)

A Basics

A 1 Brief Introduction to the PONTOS System

PONTOS is a non-contact optical 3D measuring system. It analyzes, computes and documents object deformations, rigid body movements and the dynamic behavior of a measuring object.

It is the task of the PONTOS software to precisely find ellipses (a perspective view of reference points) in all images and their 3D orientation.

With that, PONTOS provides a dynamic, precise and synchronous position detection for as many measuring markers (reference points) as you like which are applied to the object.

A digital stereo camera system records different load or movement states. The software assigns 3D coordinates to the image pixels, compares the digital images and computes the displacement of the reference points. Image recording is flexibly triggered and synchronized with the test setup, providing the possibility to additionally record and process analog values. The measuring results can be graphically represented in reports using colored deviation vectors and/or diagrams.

Most of the system functions are controlled by the software. Measuring, evaluation, display and print functions are available. All functions can be accessed via pull-down menus, hotkeys and dialog windows.

Info

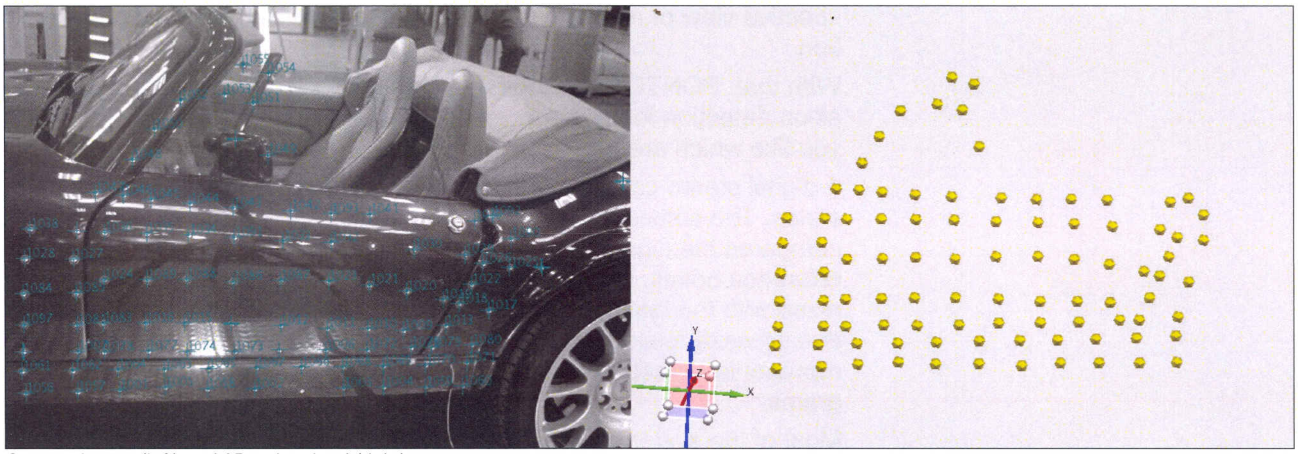
The PONTOS system is a measuring system that also addresses experts of digital optical measuring. Therefore, it is unavoidable that the PONTOS software contains menu items not intended for the standard user. Improper use of these menu items (expert parameters) may cause incorrect measurements.

A 1.1 Fields of Application

- 3D measurement of object movements, deformations and vibrations
- Verification of design concepts and simulation computations
- Checking the dynamic behavior, and the rise and fall of structural vibrations up to 250 Hz
- Load tests, creep tests and aging influences also for complex structures and viscoelastic elements
- Motion analysis
- Noise vibration harshness (NVH) tests in the automotive industry, also in a wind tunnel
- Recording of relative displacements
- Recording of gap size and flush changes
- Alternative for complex sensor technology like laser sensors, draw-wire sensors or accelerometers

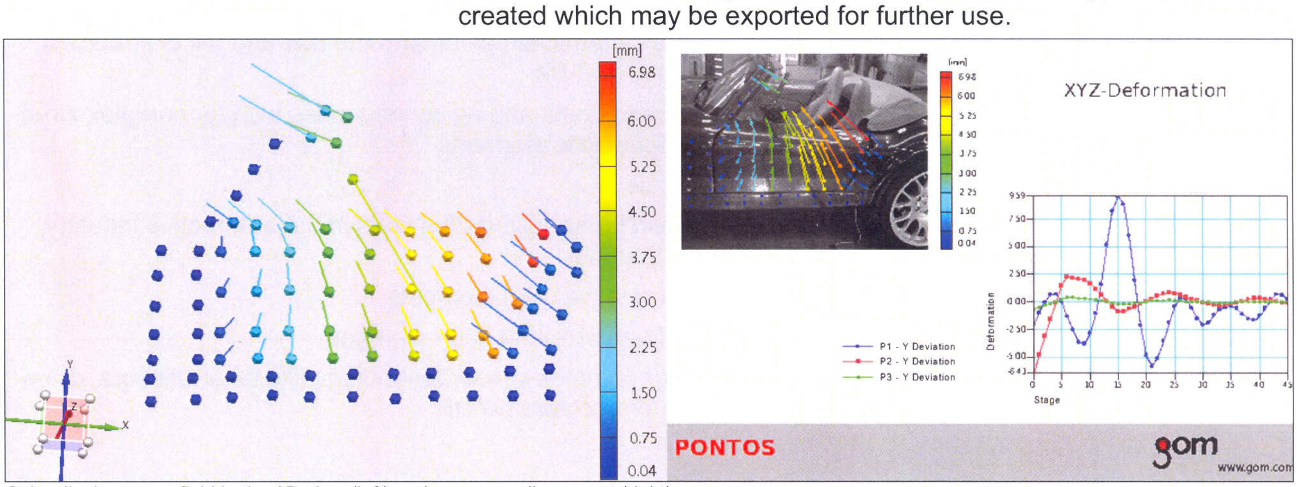
A 1.2 Typical Measuring Procedure Measuring System

Prepare the measuring object by applying the reference point markers and freely positioning the PONTOS sensor on a stand in front of the measuring object. After creating a new deformation project in the software, the system is calibrated and the desired images are recorded through a trigger during the deformation process. The software reads in these images as stages and automatically computes the 3D coordinates of the reference points and thus their position. They are displayed in the 3D view as a point cloud.



Camera image (left) and 3D point cloud (right)

In order to assess the deformation of the object, all stages are aligned to the reference stage based on components and fixed points which have to be specified. During the following identification, the IDs of the uncoded reference points which the system randomly assigns will be renumbered automatically so that the same points in all stages will have the same ID. A displacement field, to be defined by selecting an area of points, marks the area for which the software will display the computed deformation through all stages. The deformation is calculated automatically as soon as the stage is identified. Within the displacement field, the 3D view displays in color the deviation of the points from the stage selected as deformation reference. Measurements and further analyses may be carried out. Finally, a report is created which may be exported for further use.



Color displacement field in the 3D view (left) and corresponding report (right)

A 1.2.1 General Steps to Carry Out a Standard Measuring Project

For carrying out a standard measuring project using a calibrated PONTOS system, the following steps are required:

Step 1:	Start the PC and the PONTOS software.
Step 2:	Switch on the sensor controller and, if required, the additional existing power supply unit.
Step 3:	Create a new deformation project in the PONTOS software.
Step 4:	Use **Start/Stop Measurement Mode** to record images of the required deformation stages.
Step 5:	Compute all stages.
Step 6:	Define components and identification points.
Step 7:	Choose the component for stage transformation and identify the stages.
Step 8:	Determine coordinate system (if required).
Step 9:	Create a displacement field and carry out analyses.
Step 10:	Report generation.

A 1.3 Features

These are some of the most important PONTOS features:

- Non-contact acquisition of the precise 3D position of any number of measuring points Measuring System.
- Computation, visualization and display of the measuring points' position and displacement in different object states (stages).
- Image recording frequency independent of the number of the recorded reference points Measuring System.
- Flexible triggering of image recording, synchronized with the test setup (including recording of analog signals) Measuring System.
- Mobility and flexibility due to an easy and compact measuring system Measuring System.
- Robust against environmental influences like vibrations, light changes Measuring System.
- Easy and quick adaptation to different measuring volumes and measuring tasks Measuring System.
- Also suitable to measure large deformations (e.g. crash) Measuring System.
- Project transformations according to the 3-2-1 or best-fit method.
- 6DoF analyses
- The graphical representation of the measuring results provides an optimum understanding of the component behavior.
- Report generation and export functions for measuring and result data.
- Automation due to macro functions.
- In combination with the photogrammetric system TRITOP, PONTOS can also be used for large objects Measuring System.

- Several PONTOS systems can be combined to analyze large structures Measuring System.
- Option: Creation of user profiles for customer-specific adaptation of the user interface.

A 1.4 Main Hardware and Software Components

For information about the main hardware and software components, please refer to the Hardware User Information.

A 1.4.1 Basic Requirements Measuring System

In order to achieve full functionality when working with the PONTOS software, the following is required:

- GOM Linux operating system as of version 10
- One of the following computers: Dual Core Opteron (64 bit), Dual Opteron (64 bit) or
  □one of the following notebooks: Dell Precision M65, Dell Precision M70, Dell Precision M4300.
- PONTOS sensor
- USB Dongle: As of software version v6.1, the GOM applications will be delivered with a USB dongle (CodeMeter). This dongle is either integrated into the computer or can be plugged in separately. Generally, the dongle contains a single license. However, server licenses are available on request.

A 1.4.2 Basic Requirements Evaluation

- Operating system:

  Recommended:
  Windows XP SP2, Windows XP 64Bit Edition for large, computation intensive projects

  Also useable for:
  VISTA 64Bit (only with graphics card NVIDIA Quadro FX570, FX1700)

- Computer:

  Recommended configuration:
  Processors: Intel Core2Duo or AMD Dual Core Opteron,
  RAM: 4GB RAM, NVIDIA Quadro
  Graphics card: NVIDIA Quadro FX1100, FX1500, 128 MB
  Info The software has been tested with NVIDIA Quadro graphics cards. Certified NVIDIA graphics cards: FX570, FX1100, FX1300, FX1500, FX1700

  Minimum requirements:
  Processors: Pentium IV, 2GHz,
  RAM: 2 GB,
  Graphics card: OpenGL graphics card. 64 MB

- Current graphics card drivers

- In case of other graphics cards the scope of functions and performance may possibly be restricted!

- USB Dongle: As of software version v6.1, the GOM applications will be delivered with a USB dongle (CodeMeter). Generally, the dongle contains a single license. However, server licenses are available on request.

Graphics Cards and Driver Software for Windows

In order to ensure optimum hardware acceleration when rendering the 3D view (Open GL), an NVIDIA Quadro graphics card with current graphics card drivers is required. Only an appropriate hardware acceleration allows for comfortable rotating and zooming in the 3D view.

If your computer has a different graphics card or if you do not have the current drivers, the PONTOS software probably works with a considerably slower software rendering.

If your application does not run stable, please start the PONTOS software in the **Safe Mode** (mode with software rendering). Start the **Safe Mode** in the **Windows start menu ▶ Programs ▶ PONTOS vx.xx.x ▶ PONTOS (Safe Mode).**

Info

If you are not sure if your computer is equipped with a suitable graphics card, start the PONTOS software and choose **Help ▶ Graphics Board ▶ Reset.** A wizard leads you through the further steps. For further information, please refer to the Online Help.

A 2 The GOM Linux Operating System Measuring System

A 2.1 Starting the PC

When pressing the power switch, the Linux operating system starts automatically. If a second system like Windows is installed on the PC, first a menu appears to select the desired operating system.

The Linux operating system is factory-adjusted with the following default user and default password:

GOM Linux version	**as of v10**
Default user	user
Password	user

A default user has the rights for writing, reading and deleting data and directories he created.

This user manual does not deal with the Linux operating system in more detail. You only need superficial Linux knowledge to be able to work with the PONTOS software.

A 2.1.1 The KDE Start Menu

In the tool bar at the bottom of the Linux screen you may start different software, adapt system settings, etc. using the Linux KDE start menu, similar to operating systems based on Windows.

A 2.1.2 Home Directory

In your home directory, you will find all folders important for you.

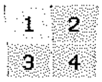
A 2.1.3 Text Console

In case you need support, it may happen that, on request, you need to enter a certain command syntax into the so-called text console. In that case, open the text console by clicking on the respective icon.

A 2.1.4 Internet

Using the Firefox web browser, you may establish a connection to the internet in order to, for example, download updates from the GOM web site.

A 2.1.5 Virtual Desktops



With Linux, you may use several equivalent desktops. The respective active desktop is displayed lighter than the others. Four virtual desktops are factory-preadjusted. Using the context menu of the right mouse button when clicking on the desktop icon, you may create more virtual desktops.

A 2.1.6 Loudspeakers

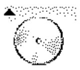
If loudspeakers are connected to your computer, this icon becomes active and you may adjust the volume here.

A 2.1.7 Linux Operating System Updates

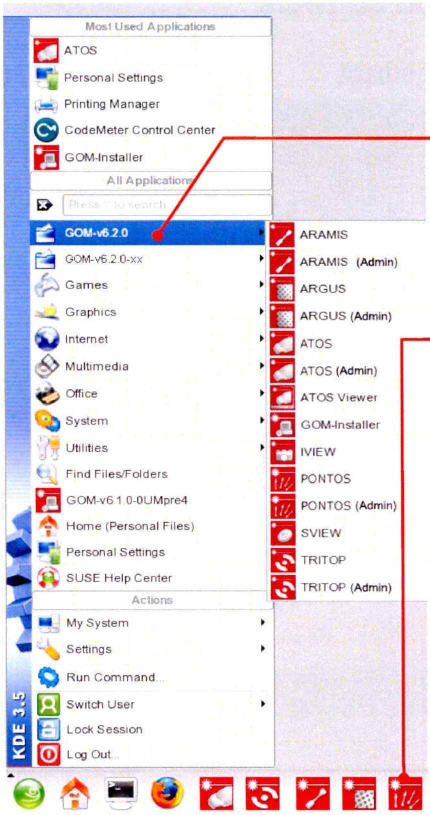
This icon indicates if new operating system updates are available. The blue icon means that there are no new updates. The orange icon indicates that new updates are available for the operating system. If you are connected to the GOM web site via the internet, you may start the update procedure by clicking on this icon.

A 2.1.8 Mounting and Unmounting CD/DVD and USB

When you insert a CD or another storage medium in your computer, the respective icon appears on the screen and the medium is automatically mounted. A little green arrow appears.



If you would like to remove the medium again, you need to unmount it by clicking with the right mouse button on the medium icon and selecting the respective entry from the context menu. For the CD, the little green arrow disappears, and in case of a USB stick the entire icon disappears.



A 2.1.9 Starting the PONTOS Software

You may start the software in two ways:

a) Using the KDE menu

Click on the KDE start icon and select the software from the directory **GOM-v6.2.x**. This directory is the master version and is automatically linked to the current software version (**GOM-v6.2.x-xx**) installed on your computer.

b) Using the software icon

Simply click on the respective icon in the KDE tool bar.
In case the icon is not available, click on the desired software in the master directory **GOM-v6.2.x**, keep the left mouse button (LMB) pressed and drag the icon in the tool bar.

Dongle with Administrator License:

If you have a dongle with administrator license (default as of software version v6.2), you can only administer the GOM software when starting it with **PONTOS (Admin)**. Only with this start routine you will reach the user profile management.

If you start **PONTOS** without the supplement **Admin**, you may test the user profile settings.

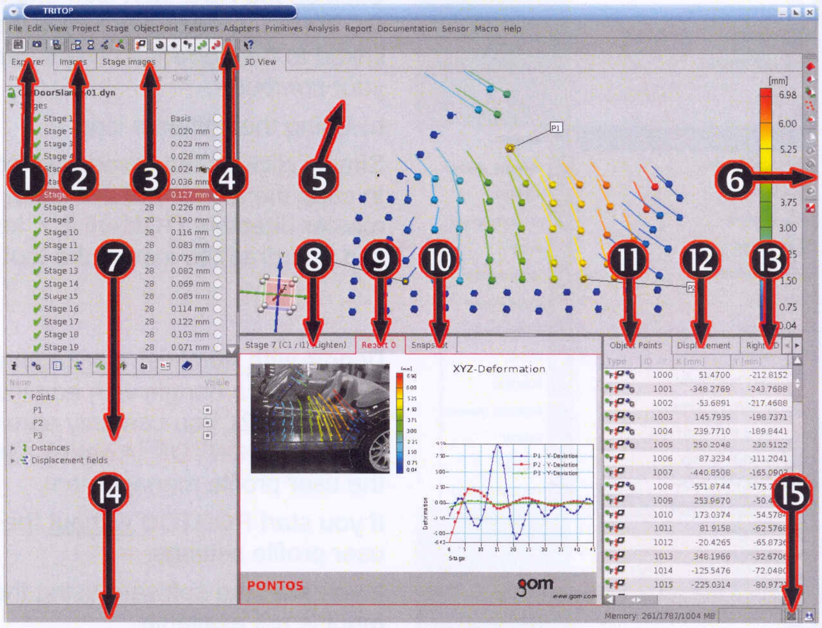
If you start the software using the icon, the user profile management is not available.

Dongle without Administrator License:

As in this case the user rights are restricted, it does not matter in which way you start the application (with or without the supplement **Admin**).

A 3 The PONTOS Application Software

A 3.1 The Default Screen Arrangement



Screen elements:

1	Tab **Explorer**. Here, you will find all stages of a deformation project. You may select the stages and thus switch the 3D view, the 2D view or report to the respective stage. **Symbols in the explorer:** The stop sign indicates that the stage was not computed. The red cross and the letters NT inform that the stage is neither identified nor transformed. The yellow cross indicates that the stage is transformed but not all fixed points were used or found. The green cross shows that the stage is transformed but not identified and that all fixed points were used. The yellow check mark informs that a stage was transformed but not by all fi-xed points, that it was renumbered successfully and thus is identified. The green check mark means that a stage transformed by all fixed points was renumbered successfully and thus is identified.
2	Tab **Images**. Here, for each stage, the first image of the first image group of the stage is displayed. If you click on the images, you change the stages like in the explorer it-self.
3	Tab **Stage Images**. Here, you will find all images of a stage.
4	Icon bar to select functions (enabling/disabling point types, compute stage, etc.). The tool bar and its scope of functions depend on the operating modes. The icon bar can be adapted individually (right mouse button click in the bar).
5	3D view
6	Icon bar to choose selection and deselection tools.

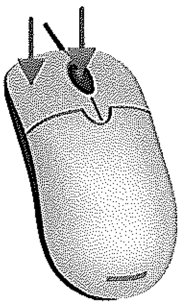
7	Sub-explorer with various tabs: Tab **Info**: Here, you will find information about the selected stage. Tab **Elements**. This tab shows an explorer view of different elements like analysis elements, primitives, adapters and features. Features are 3D objects that were created based on 2D images. You may select the elements, set them visible/invisible, and much more. Tab **Fixed Points**: This tab contains a list of all fixed points including their status for each stage. Tab **Stage Data**: This tab contains a list of all stage data for each stage. Tab **Image Series**: This tab contains a list of all image series that were created for the project. Tab **Reports**: This tab contains a list of all reports that were created for the project. Tab **Documentation**: This tab contains a list of all documentation data that were created for the project to be exported using **File ▶ Export ▶ Tables**.
8	Tab **Left 2D Image**. Displays the 2D camera image of the selected stage.
9	Tab for viewing and editing reports.
10	Tab for viewing and editing snapshots.
11	Display of the object point list for 3D points. Here, you get information about the 3D points and you may edit them (right mouse button click).
12	This tab displays the displacement for each object point for the selected stage.
13	Tab **Right 2D Image**. If, for defining a 3D point or a feature, a second image is required, you may select it here.
14	Status indicator line. Here, all important information about the project and the current commands are displayed.
15	Cancel button for computation-intensive operating steps.

A 3.2 Tool Bars

The software provides several tool bars (e.g. for the views, the selection or for snapshot editing etc.). You may enable or disable these tool bars using the context menu of the right mouse button (clicked on the tool bar area).

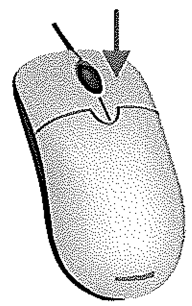
A 3.3 Mouse Functions

The software is mainly operated by using the mouse. The right, middle and left mouse button and the mouse wheel have functions assigned and are window-dependent. The middle mouse button and the mouse wheel are one common control element.



A 3.3.1 Functions of the Left and Middle Mouse Button

- When pressing the **left** mouse button (LMB) in the 3D view and dragging the mouse, you may rotate the object.
- When pressing the **Shift** key and the **left** mouse button (LMB) in the 3D view and dragging the mouse, you may rotate the object around the clicked point.
- A simple click with the **left** mouse button (LMB) on an element in the explorer, in the sub-explorer, in the 3D view or in a report selects this element.
- Clicking with the **left** mouse button (LMB) together with the **Shift** button on an element in the explorer or in the sub-explorer, selects several consecutive elements.
- Clicking with the **left** mouse button (LMB) together with the **Ctrl** button on elements in the explorer, in the sub-explorer, in the 3D view or in a report, selects several independent elements.
- Double clicking with the **left** mouse button (LMB) on an element in the explorer, in the sub-explorer, in the 3D view or in a report opens an element-specific dialog to edit the element properties.
- When pressing the **Ctrl** key and the **left** mouse button (LMB) in the 3D view or in a report and dragging the mouse, a selection frame becomes visible and all elements within this frame are selected.
- With **Ctrl** and **left** mouse button (LMB) you may make selections when dialog windows are open.
- When pressing the **middle** mouse button (mouse wheel) in the 3D view and dragging the mouse, you may move the object.
- When turning the **middle** mouse wheel, you may zoom the 3D object, the 2D image or the report.
- When pressing **Ctrl** and the **middle** mouse button in the 3D view, the 2D image or in a report and dragging the mouse, you may zoom the object to a specific detail.
- When turning the **mouse wheel** in a box of values [10.00 mm], you may change the values in steps of the default increment. The default increment depends on the parameters, is preset and cannot be changed.
- When turning the **mouse wheel** in a box of values [10.00 mm] and simultaneously press the **Shift** key, you may change the values in one tenth of a step of the default increment. The default increment depends on the parameters, is preset and cannot be changed.
- When turning the **mouse wheel** in a box of values [10.00 mm] and simultaneously press the **Ctrl** key, you may change the values in steps of ten of the default increment. The default increment depends on the parameters, is preset and cannot be changed.



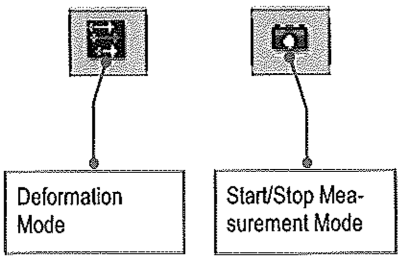
A 3.3.2 Functions of the Right Mouse Button (RMB)

The context menu functions of the right mouse button (RMB) depend on the element on which or the window/dialog in which you press the button. For example, you may edit elements, insert keywords, and much more.

A 3.4 Status Indicator Line

The status indicator line at the bottom left on the screen gives interesting and helpful information regarding the current functions.

A 3.5 Operating Modes



PONTOS generally works in two operating modes, the **Deformation Mode** and the **Start/Stop Measurement Mode**.

A 3.5.1 Deformation Mode

The **Deformation Mode** is used for creating deformation projects, processing and analyzing the measuring data, creating measurements, visualizing deformations, generating reports, etc.

A 3.5.2 Start/Stop Measurement Mode

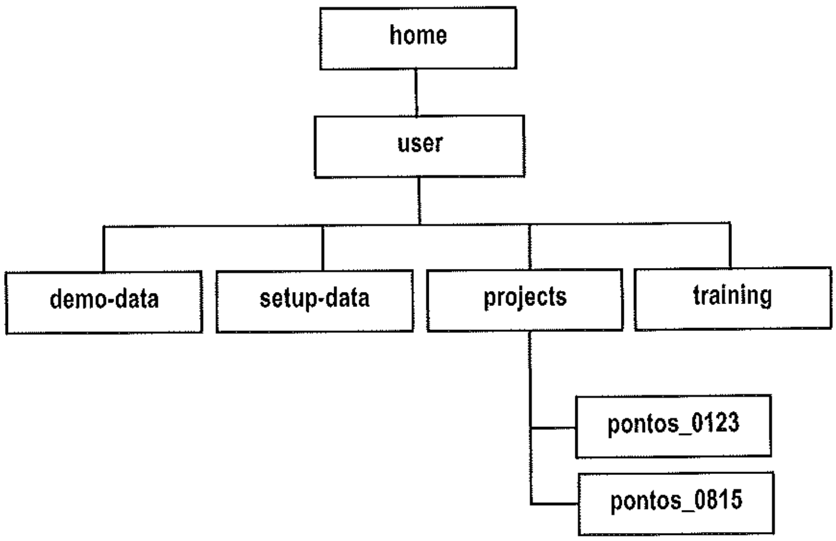
Change to the **Start/Stop Measurement Mode** by clicking on the corresponding button. Here, the 2D camera images are recorded. To quit the mode click on the icon again.

A 3.6 PONTOS Directory Structure Measuring System

As default user you are authorized to save and delete directories and files in the directory **user** (path: home/user).

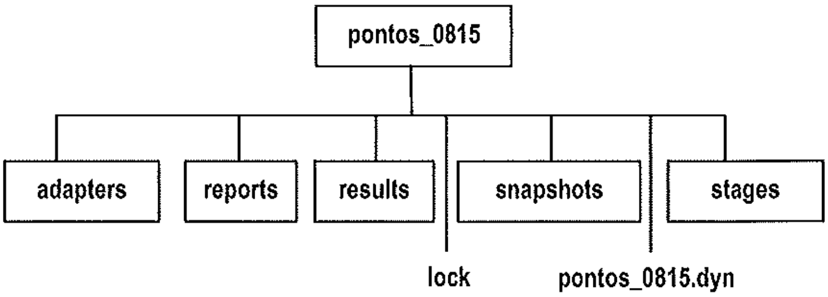
We recommend a structured filing of these data in order to be able to work with the measuring projects and the corresponding files and directories any time.

A 3.6.1 Recommended Directory Structure:



projects	Save your deformation projects here. For each measuring project, the software automatically creates a directory. The name of the directory is identical to the project name. A measuring project always consists of several files and directories (see A 3.6.2). The figure shows as an example the structure for two measuring projects (0815 and 0123).
setup-data	Here, save all setting files you would like to use additionally like calibration files from image series.
demo-data	Saved data for demonstration purposes only.
training	Saved data for training purposes only.

A 3.6.2 Automatically Created Project Directory



adapters	In this directory, adapter data, if available, is saved.
reports	Directory that contains all created reports.
results	Directory in which result data is stored. File export_elements.dat, for example, contains information about analysis elements or snapshots which you created in the software. In this directory, you may also save all files you export.
snapshots	Directory in which all image series created in the software are stored.
lock	Temporarily created file when a measuring project is open.
stages	Directory containing all stages and the corresponding images and files.
pontos_0815.dyn	Deformation project file. With this file, a deformation project is opened in PONTOS.

A 3.7 Save Data

The data from measuring projects are automatically stored in a directory Measuring System.

The name of the directory is the name of the project. The project data consist of several files and directories. The .dyn-file is the deformation project with which PONTOS is started when resuming the project. All primitives, distances and other measurements created in the deformation project, for example, are linked to this file.

NOTICE

Note that the software does not provide a possibility to undo operating steps!

A 3.7.1 Save Project Under a Different Name

Using function Save as you may save a copy of your project under a different name. This copy will immediately be opened and you can edit it.

A 3.7.2 Export Data-Reduced Project

The software offers the possibility to save a deformation project as a data-reduced version under a different name. Data-reduced here means that you may delete (stages and images) and/or compress (images) certain data. This is particularly suitable if you would like to pass on a project to be viewed with the PONTOS Viewer. You original project remains open and you may continue working with it.

NOTICE

Generally, a data-reduced project can no longer be recomputed as images either were deleted completely or compressed to a large extent so that the reference points can no longer be identified.

A 3.8 Record CD/DVD Measuring System

The CD/DVD drive allows for reading and recording CDs or DVDs. The system also supports re-writable CDs or DVDs. DVDs are recorded according to the DVD-R(W) standard. Each recording process generates at least a data block of approx. 1 GB on the DVD.

The recording program automatically finalizes all CDs and DVDs, i.e. additional recording of data at a later time is not possible.

If it is not possible to record the data on just one blank CD/DVD, the data is automatically recorded on several CD/DVDs.

Info

In case of 19" computers, make sure the door of the CD/DVD recorder is always open when recording data because the CD/DVD slide comes out for a short moment when checking the CD/DVD. If the CD/DVD slide is hindered when coming out, this might in rare cases cause a system crash!

A 3.9 Preferences

The software provides extensive settings for preferences to allow you adapting the software optimally to your needs. Most of the changes only take effect on new measuring projects!

The software also provides the possibility to save user-defined preferences in a file to optimally adapt to the measuring projects.

Info

You may restore the factory-adjusted settings any time.

A 4 User Profiles

User profiles are used to adapt the user interface of the GOM software to company-specific workflows. For this purpose, you can hide menu items of the software as well as GOM standard templates and add user-defined scripts to menus. Generally, a user profile is saved in a determined local directory. The configuration data of this directory are then available to the user. You need to set up this directory prior to creating a user profile.

You can define user profiles only in the Administration Mode of the GOM software. As of software version v6.2.0, the corresponding administrator license is integrated in your license dongle by default.

Info

A user profile is always fixed to a specific computer and not to the individual measuring projects or files!

For further information, please refer to the Online Help.

Features

- Special directory for user profiles
- Fixed to a specific computer
- Displaying and hiding menus and toolbars
- Inserting own scripts before or after menu items
- Including configuration files like templates and scripts
- Locking the editing of templates
- Hiding default GOM templates
- Special dongle for restricted user rights required

A 5 Summary

- Brief introduction
- Hardware and software components
- Linux operating system Measuring System
- Software operating structure
- Most important mouse functions
- Operating modes
- Directory structure
- Saving data
- Record CD/DVD
- User profiles

Chapter B - Table of Contents (rev-a)

B Sensor Measuring System

B 1 Calibration

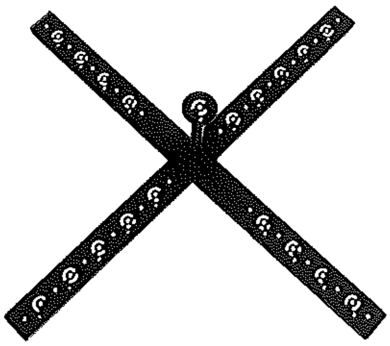
Calibration is a measuring process during which the measuring system with the help of calibration objects is adjusted such that the dimensional consistency of the measuring system is ensured.

B 1.1 Calibration Objects

For the PONTOS measuring system one calibration object (cross) is used. They are available in different sizes. Depending on the type of the system and the size they may differ slightly in their appearance. Calibration objects are equipped with so-called retro-reflective reference points.

Info

Prior to use the calibration cross, you need to screw it onto the supplied stand in camera height in order to easily rotate and tilt it.



Calibration cross

The calibration object contains the scale bar information. A calibration cross has two scale bars, that is the specified distance between two specific points on each cross axis.

B 1.1.1 Calibration Object Selection

Which calibration object you need to choose depends on the measuring volume you would like to use. The size of the calibration cross corresponds to the size of the measuring volume (see also the sensor configuration tables in the valid User Information – Hardware).

NOTICE

Calibrate the system only with the calibration object valid for the respective measuring volume as you otherwise will get wrong measuring results!

B 1.1.2 How to Handle Calibration Objects

NOTICE

Always handle the calibration objects with utmost care and prevent them from getting dirty and being scratched. Make sure you do not touch the surface of the calibration object if possible. After each use, accommodate the calibration objects at the places dedicated for that.

B 1.2 Calibration Conditions

B 1.2.1 When is Calibration Required?

- Before starting measurements for the first time, the respective PONTOS measuring volume needs to be calibrated.
- Also, if the adjustment of the camera lenses or the position of the cameras with respect to each other is changed (e.g. when changing the camera support to a different length), the system requires calibration again.

B 1.2.2 Prerequisites (e.g. Warm-Up)

A prerequisite for successful calibration is the correct setup of the sensor. For further information, please refer to the valid User Information – Hardware. The object to be measured defines the measuring volume and thus the set of lenses to be used.

Adjust the measuring distance to the calibration object accordingly, see also the sensor configuration tables in the valid User Information – Hardware.

B 1.3 Calibration Process

For the calibration process, you need to open the respective menu item in the software and select the correct calibration object from a list (see Online Help).

Info

Calibrate the system with the same lighting conditions as used for measuring.
Follow the instructions in the software.

B 1.3.1 Positioning of the Calibration Object (HS)

Place the calibration object in the center of the measuring volume such that the rays of the three laser pointers meet in the middle of the cross plane (not on the higher protruding point). Make sure the calibration cross fills the live video images of the cameras (see Online Help). Follow the instructions in the software.

In order to capture the entire measuring volume, you need to move the calibration cross during calibration. For this, the following general rule applies: You should move the calibration object by 1/3 of the measuring volume height closer to the sensor and by 1/2 of the measuring volume height further away – in each case starting from the center of the measuring volume.

Info

Make sure there is always enough space between the calibration object and the stand so that it cannot bump against the stand during the required movement.

B 1.4 Calibration Results

At the end of the calibration process, the software displays the calibration results.

Info

For a good calibration, the calibration deviation needs to be smaller or equal to 0.04 pixels.
In addition, for a calibration object (with the information of two scale bars), the deviation of the adjusted calibration scale bar must not be too high (less than 0.005% of the calibration scale bar). A high deviation indicates an incorrect calibration object or incorrect scale parameters.

B 2 Sensor Changes

B 2.1 Adapting the Sensor to Other Measuring Volumes

B 2.1.1 When is an Adaptation Required?

Ideally, the measuring object fits into the measuring volume. Depending on the size of your measuring object, you will find the correct measuring volume in the sensor configuration table in the Hardware User Information. Depending on what you would like to measure, you need to equip the sensor with the respective correct lenses.

For information about how to handle lenses, please refer to the User Information – Hardware.

B 2.2 Expert Calibration

B 2.2.1 Calibration Theory

During calibration, the sensor configuration is determined. This means that the distance of the cameras and the orientation of the cameras to each other are determined. In addition, the image characteristics of the cameras are determined (e.g. focus, lens distortions). Based on these settings, the software calculates from the reference points of the calibration object in the 2D camera image their 3D coordinates. The calculated 3D coordinates are then calculated back again into the 2D camera images. For the position of the reference points, this results in the so-called reference point deviation (intersection error).

B 2.2.2 Calibration Deviation

The calibration deviation is calculated from the average intersection error of all reference points recorded during the calibration process.

B 2.2.3 What Causes Decalibration of the System?

A decalibration occurs if the sensor configuration is changed. This might be, for example, changes of the camera angle to each other or changes in the image characteristics of the cameras (use of other lenses). If the sensor configuration changes, the calculated reference point deviation changes as well.

B 2.2.4 Quick Calibration

If during a measurement it is indicated that the system might be decalibrated (e.g. if you knocked against the cameras), you may perform a Quick Calibration.

During this process, the calibration object needs to be placed into three positions: in the center of the measuring volume. further away from the sensor, closer to the sensor. These three new images are combined with the original calibration and thus a new calibration is calculated for the following measurements.

This method is fast and can easily be used during recording a measuring project.

Info

However, the image characteristics of the cameras must not have changed! If, for example, you inserted new lenses, you need to perform a complete new calibration!

NOTICE

The calibration cross must not have been taken apart during the last calibration and the quick calibration!

B 3 Preparations for Expert Measuring Tasks

B 3.1 Lens Adjustment

B 3.1.1 Why do Lenses Need to be Adjusted?

Normally, the lenses are preadjusted for the respective measuring volumes and do not need to be changed. However, it might happen that you need to adjust the lenses under certain conditions, e.g.

- because the adjustment changed due to vibrations or
- because you would like to insert the lenses of one measuring volume for a different one.

For information about how to adjust lenses, please refer to the User Information – Hardware.

B 3.2 Changing the Camera Support

B 3.2.1 Why Should the Camera Support be Changed?

Change to a Different Length

If you would like to change your measuring system from a medium measuring volume to a large one, you need a longer camera support which allows for a larger distance between the two cameras. Therefore, you need to change the present camera support. The required steps are described in the User Information - Hardware.

B 3.3 Adjust Cameras

B 3.3.1 Why do Cameras Need to be Adjusted?

The correct angle between the cameras and the correct measuring distance are required to optimally capture the measuring object in the measuring volume.

If, for example, you adjusted your sensor to a new measuring volume or if you changed the camera support, the cameras need to be correctly adjusted again. The required steps are described in the User Information - Hardware.

B 4 Summary

- Calibration objects
- Calibration prerequisites
- Calibration process
- Calibration results
- Calibration theory
- Calibration deviation
- Quick calibration
- Adapting the sensor to other measuring volumes
- Lens adjustment
- Adjust cameras

Chapter C - Table of Contents (rev-b)

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C Measuring Measuring System

C 1 Measuring Procedure

C 1.1 Selecting the Correct Measuring Volume

The measuring volume depends on the size of the measuring object or on the size of the area you would like to analyze. Choose a measuring volume in which the measuring object or the measuring area fills the entire image as best as possible.

Info

Ensure that the measuring object or the measuring area remains within the measuring volume in all deformation stages!

C 1.2 Preparing the Measuring Object

Prior to start the deformation measurement, you need to prepare the measuring object. For this purpose, apply reference points to those areas you are interested in.

C 1.2.1 Reference Points – General Information

Reference points are self-adhesive marks (measuring markers) which are applied to the measuring object. They have a defined geometry and a high contrast (white circle on a black background).

For the PONTOS HS system retro-reflective markers are used. These markers reflect the light back in that direction from which it came. Thus, optimum light conditions are achieved when using the flash LEDs.

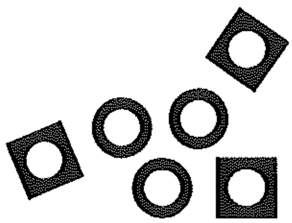
In a calibrated measuring setup, the PONTOS software computes the 3D coordinates of all reference points for each stage from the combination of both camera images.

You can analyze the displacement of a point by comparing its 3D coordinates through all stages.

We distinguish uncoded and coded reference points:

Uncoded reference points

PONTOS always works with uncoded reference points. Round and square measuring markers are available in different sizes. Select the corresponding reference point size according to the size of the measuring volume.



Uncoded reference points, square and round

Coded Reference Points

Coded reference points are mainly used in photogrammetry, i.e. for the TRITOP system. Around the circular point, they have a fixed defined bar code. Based on this bar code, the software can exactly identify the same reference point in the various camera images and thus is able to transform the individual 2D images into each other and determine the correct position of the measuring object and of the uncoded reference points which are also applied to the object.

For PONTOS, these markers are rarely used.

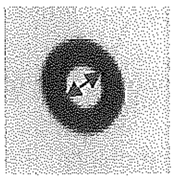
Coded reference points as used in the TRITOP system

C 1.2.2 Which is the Correct Reference Point Size?

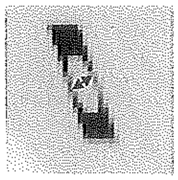
Choose a sufficient reference point diameter depending on the measuring volume used.

The size of the reference points (ellipses seen from a perspective view) recorded by the camera images should be at least 6 to 10 pixels such that the PONTOS system is able to identify them automatically in good quality.

The sensor configuration table of the valid User Information – Hardware contains an overview of the recommended measuring point sizes.



Ref. point automatically identifiable with a diameter of 10 pixels



Ref. point not identifiable with a diameter of 3 pixels

C 1.2.3 How are Reference Points Positioned Correctly?

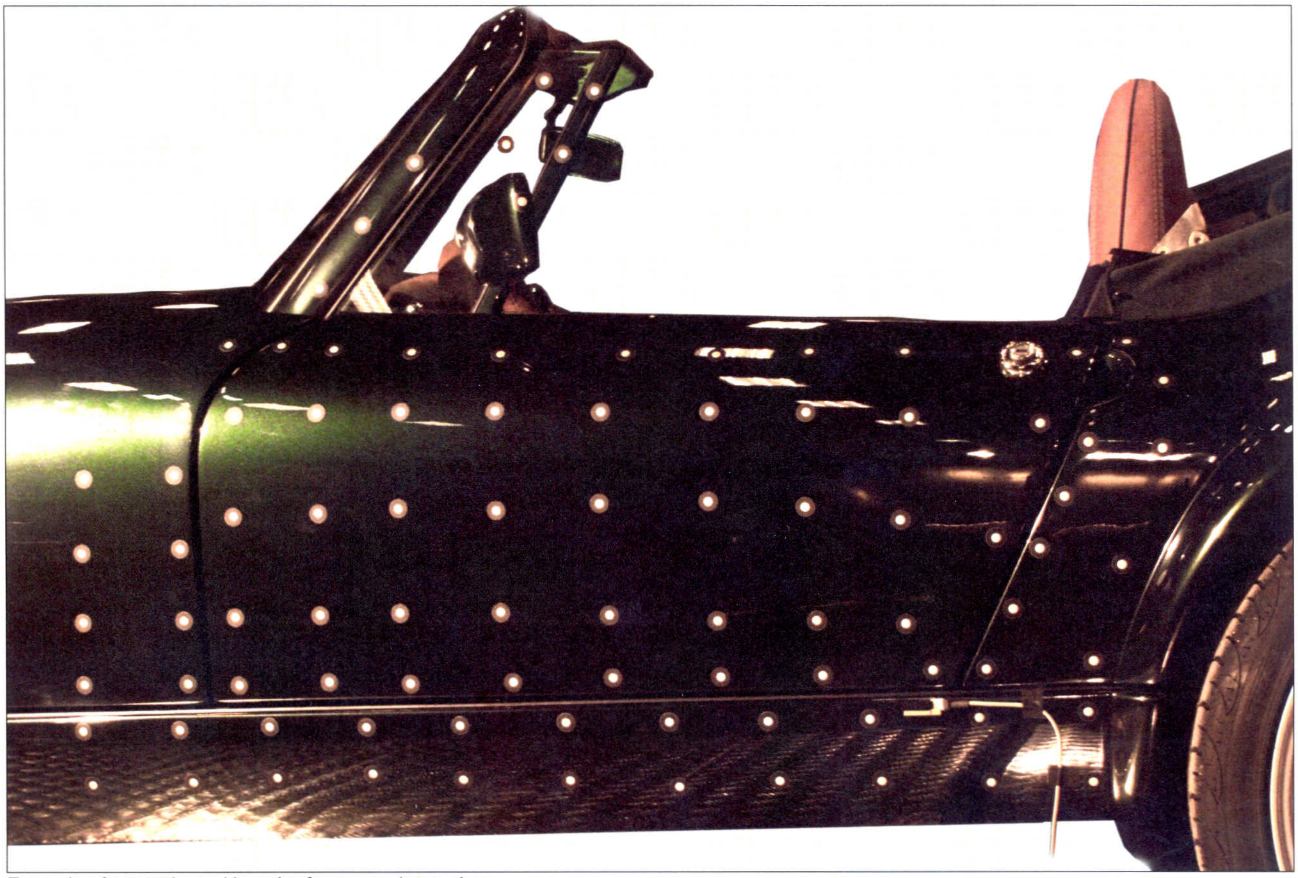
- Make sure the reference points are applied to plane or just slightly curved surfaces.
- Apply sufficient markers where you would like to measure deformations. Make sure you place the markers further away from each other than the expected deformation (at least double spacing). This ensures correct automatic renumbering through all stages later. In addition, these markers should not be applied in an exact horizontal line so that they can be identified correctly later. Avoid regular point patterns.
- Apply some markers in positions where you expect no or just insignificant deformations (relative deformation / relative movement,

compensation of rigid body movements). These points are later required as static points.

- In addition, apply the markers such that you may create components later (see Chapter D), if you would like to analyze certain parts of your measuring object separately. Make sure that within one component there are at least 3 reference points which move as little as possible with respect to each other and that form a clear pattern within the measuring project.
- You may apply some markers at points which you might need later e.g. for a 3-2-1 transformation in order to transform the entire project into a defined coordinate system.

Info

Make sure you apply the retro-reflective markers such that the angle of the incoming light is not larger that 45° as otherwise the reflected amount of light is too small for the software to identify the point.
We can just deal with this matter in a directive manner here.



Example of correctly positioned reference point markers

C 1.2.4 Using a Photoelectric Sensor

In order to precisely start a measurement in a certain moment, you may use a photoelectric sensor which releases the trigger signal for the measurement.

When using such a photoelectric sensor it needs to be positioned on the measuring object such that it activates the sensor controller at the required point in time. In our door slam example it is installed at the bottom of the door frame and activates the sensor controller just before the door hits the frame.

C 1.3 Creating a New Project

In order to analyze the deformation of an object, many camera images of the different deformation states are required. As all data collected during a measurement is automatically stored in a deformation project, you first need to create a **New Deformation Project** for your measuring task. A wizard in the software leads you through the individual steps.

The project name at the same time is the project directory (see also Chapter A, PONTOS directory structure). It is defined together with the project name.

How you create a project you will find in the Online Help.

C 1.3.1 What are Project Keywords?

When creating a new project, you have the opportunity to enter user-defined project information, so-called project keywords, which you may use later, for example, in reports to document your measuring results (e.g. inspector, date, part no. etc.). All information you enter there is automatically taken over into the preferences and thus is available for new projects later. For further information, please refer to the Online Help.

C 1.3.2 What are Project Parameters?

The project parameters contain all settings important for a project. They belong to the expert settings.

Info

Do not change the settings of these menus if you do not have any background knowledge!
For standard measuring projects, use the default settings of the project parameters.

Changed parameters only take effect on future measurements in the opened measuring project!

For further information, please refer to the Online Help.

C 1.4 How Do I Start the Measurement Mode?

Start the **Start/Stop Measurement Mode** using the respective icon in the tool bar.

Then, adjust all necessary settings (see C 1.5 and Online Help) and start the actual measurement using the start button.

C 1.5 Adjusting the Shutter Time

The shutter time is the time in which the camera chips in the sensor record image data. A wrong shutter time leads to underexposed (shutter time too short) or overexposed (shutter time too long) images.

In case of high-speed systems with flash LEDs, adjusting the shutter time is easy. Make sure both cameras can well record the measuring object by increasing the shutter time until you clearly see the object in the live camera images. Then, reduce the shutter time again.

Info

It must be below 10 ms and ideally should be below 5 ms. The typical flash duration of the flash LEDs is 100 μs (see User Information – Hardware).

In order to know whether you adjusted the shutter time correctly for systems without flash LEDs, you should display any overexposed areas in the live video image (context menu of the right mouse button). No overexposed areas should occur.

C 1.6 Standard Recording Modes

For a standard measuring project, the following two recording modes are sufficient:

C 1.6.1 Simple with AD

In this mode, only one image at a time is recorded and you always start measurement manually in the software by clicking on the respective icon. The image is immediately inserted into your project as a new stage. Via the sensor controller, existing analog voltage values will also be recorded.

Use this recording mode if, for example, you would like to carry out a static measurement and only need few images which you may compare later as stages. This mode is also suitable for adding individual images to an already recorded series of images.

For further information, please refer to the Online Help.

C 1.6.2 Fast Measurement (FG-Board Memory)

In case of a fast measurement, a sequence of many images is recorded the number of which you may define. As the images are first stored in the frame grabber boards, the maximum number of images to be recorded is limited by the maximum frame rate of the cameras.

Image recording is released via the sensor controller, i.e. a start pulse (a TTL pulse or a photoelectric sensor pulse) connected to the sensor controller or a trigger pulse from the measurement dialog releases the recording of one image sequence.

Info

Between the start of image recording and the first recorded image of the image series there might be delays of up to a few milliseconds.

The sensor controller releases the start pulse for image recording and also records existing analog voltage values.

After recording, you may load all or just selected images as stages into your measuring project.

Use this recording mode in a high-speed system if you would like to analyze dynamic processes.

For further information, please refer to the Online Help.

C 2 Advanced Measuring Methods

C 2.1 Sensor Controller

C 2.1.1 Tasks of the Sensor Controller

The sensor controller enables flexible starting of image recording for the measuring system at an exact time and controlled through analog values. In addition, it is the voltage source for the cameras.

To the sensor controller, you may connect simultaneously:

- External pushbutton trigger (manual start)
- Photoelectric sensor
- TTL signal
- Analog channels (require trigger lists)

For further information, please refer to the User Information - Hardware.

C 2.2 Analog Channels (AD Channels)

Analog channels are external analog voltage values (e.g. for force and distance signals of a test machine) which come from the test setup and are used as additional information to evaluate the deformation of the measuring object.

The GOM software reads these external analog values via the sensor controller and internally converts them into digital values. You may define a total of 7 different voltage values by means of the analog channels. For this purpose, a separate menu item is available in the software (see also Online Help).

In order to correctly interpret an analog channel and to enter it in diagrams, it is necessary to assign a correct unit to the voltage value and to transform it by a corresponding factor. You may define these parameters prior to measuring using menu item **AD Setup Mode** globally for all future stages or later for existing stages using tab **Stage Data** in the sub explorer.

C 2.3 Additional Recording Modes

C 2.3.1 External Trigger with AD

In this mode, whenever an external signal is received, an individual image is recorded. In addition to this image, the corresponding AD channels and a time signal are recorded. This mode is limited to one image per second.

Use this recording mode if you would like to record an image always at a certain point of time or in a certain situation (e.g. manually via a pushbutton trigger connected to the sensor controller or automatically via a determined signal from the test setup).

For further information, please refer to the Online Help.

C 2.3.2 Fast Measurement (Main Memory)

In this mode, a sequence of several images is recorded the number of which you may define. As the images are directly stored in the computer, the maximum number of images that can be recorded is limited to 40 images per second (40 Hz).

Image recording is released via the sensor controller, i.e. a start pulse (a TTL pulse or a photoelectric sensor pulse) connected to the sensor controller or a trigger pulse from the measurement dialog releases the recording of one image sequence.

Info

Between the start of image recording and the first recorded image of the image series there might be delays of up to a few milliseconds.

The sensor controller releases the start pulse for image recording and also records existing analog voltage values.

After recording, you may load all or just selected images as stages into your measuring project.

Use this recording mode if you need more images than can be stored in the frame grabber boards and no high-speed recording is required.

For further information, please refer to the Online Help.

C 3 Measuring For Experts

C 3.1 Trigger Lists

A trigger list is an automatically or manually created text file containing all commands to control the sensor controller and the measuring procedure. This means that after starting a measurement, the camera control etc. is entirely transferred to the sensor controller which then controls the complete measurement procedure.

The software contains some default trigger list macros and, in addition, provides the possibility to easily create an individual trigger list in the script editor.

For detailed information, please refer to the separate trigger list user information.

C 3.2 Slave Mode

In the special case that several measuring systems will be used simultaneously in order to record the deformation of a measuring object from different views, one computer is declared to be the master by selecting the required recording mode (e.g. Fast Measurement (FG Board Memory)). All additional computers are operated in the slave mode and exactly carry out the measurements of the master PC.

For further information, please refer to the Online Help.

C 4 Measuring with Adapters

C 4.1 What Are Adapters and What Are They Used For?

Adapters are auxiliary tools with an individual defined reference point constellation which is identified in a measuring project and which may create points, lines and other primitives throughout all stages.

With PONTOS, adapters are mainly used to measure areas which are difficult or impossible to access or to measure without the need to apply reference point markers to the measuring object at the spot of interest.

C 4.2 Adapter Types

There are preconstructed adapters available at GOM as an option such as edge, plane, cylinder or sphere adapters.

However, the software also provides the possibility for creating user-defined adapters.

Info

As for PONTOS projects in most cases very specific adapters are required for a special measuring task, mainly the user-defined adapters will be used.

C 4.3 Creating Adapters

C 4.3.1 Step 1 - Planning

Before you create an adapter, you need to know exactly the specific measuring task and consider how the adapter can be visible in all images and stages of the measuring project during the image recording process.

C 4.3.2 Step 2 - Adapter Preparation

Next, you need to apply reference point markers to the object you decided to be an adapter. Ensure that you apply a sufficient number of points which result in an unambiguous point constellation within the measuring project.

C 4.3.3 Step 3 - Measuring the Adapter

Measure the adapter with PONTOS so that you get a complete point cloud.

Info

Depending on the measuring task and the type of the adapter it might be necessary to record the adapter photogrammetrically using the TRITOP software.

C 4.3.4 Step 4 - Creating the Required Primitives

According to the measuring task, create the required primitives from the point cloud in order to get your real measuring point.

C 4.3.5 Step 5 - Creating the Adapter in the Software

Create the required adapter in the software using menu item **User-Defined Adapter**.

For further information, please refer to the Online Help.

C 4.3.6 Step 6 - Load Adapter Into Measuring Project and Identify It

Add the finished adapter to your measuring project using **Preferences** and identify it in the project.

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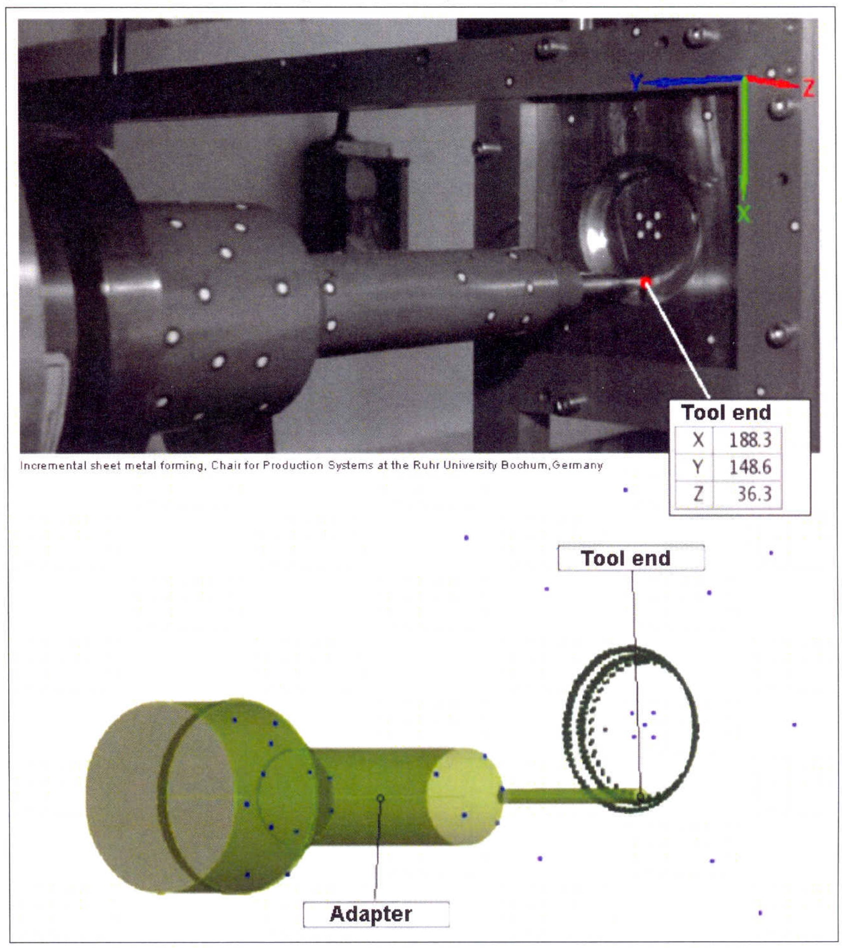
C 4.4 Application Examples

C 4.4.1 Flight Path of an Object

If, for example, you would like to measure the flight path of a ball in a room, apply reference point markers to the ball, measure it with the TRITOP software and create a best-fit sphere from the point cloud. Then, define an adapter which, based on the point constellation of the ball, calculates the center point of this sphere. If you then measure the flight of the ball with PONTOS, you may trace the center point identified by the adapter throughout all stages, and thus you may analyze the flight path.

C 4.4.2 Movement and Position of a Tool End

If, for example, you would like to determine the movement and position of a tool end but cannot apply reference point markers at this point, a user-defined adapter assists you during measurement.



Tool (top), constructed adapter in the 3D view (bottom)

C 5 Summary

- Selecting the measuring volume
- Preparation of the measuring object
- Positioning of the reference point markers
- Creating a new project
- Project keywords
- Project parameters
- Shutter times
- Standard recording modes – simple and fast measurement
- Sensor controller
- Analog channels
- Additional recording modes – external trigger and fast measurement
- Trigger lists
- Slave mode
- Adapters

Chapter D - Table of Contents (rev-a)

D Computation

D 1 Project Computation

After you recorded all measurement images, they are available in your deformation project as stages that are not yet bundled. Each stage consists of a right and a left camera image. From these images, the software now has to compute for each stage the respective 3D coordinates to provide data for the deformation analysis later.

Open the function using the respective icon. Select the standard setting **Compute all image points** and start the computation for all stages. The software now computes the 3D coordinates and assigns a fixed ID to each 3D point.

In the 3D view, the resulting point cloud is displayed and in the list **Object Points** all points are listed with their IDs.

This first stage is the **Basis** of the project to which all further computations will refer. Generally, it is also the **transformation reference stage** to which all other stages will be aligned to.

D 2 Components

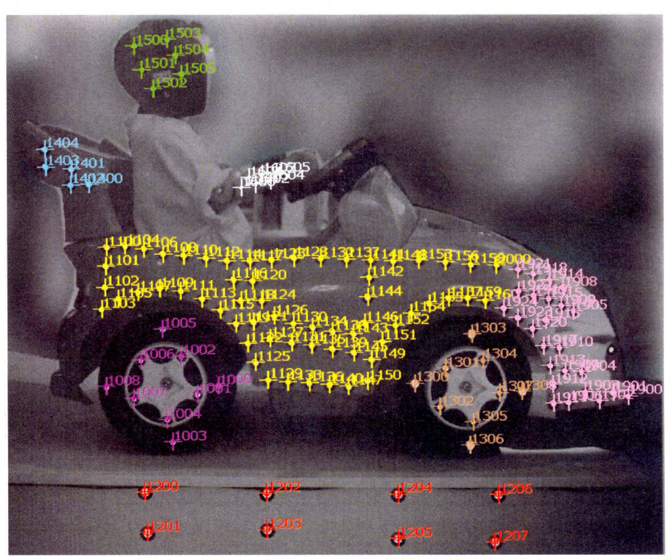
D 2.1 What are Components?

Typically, a deformation measuring project consists of different quasi rigid bodies. Each quasi rigid body might be of interest for the user. Therefore, it can be defined in a so-called **Component**.

A **Component** is a group of 3D points which, in a measuring project, represent such a quasi rigid body. The movement of the 3D points within a component is relatively small. However, the movement of different components with respect to each other can be quite large.

Info

Generally, define all components in the first stage of the project. Each component is automatically allocated a separate ID number range.



Measuring object with several components. For a better understanding, they are shown here in different colors.

D 2.1.1 Define Components

Info

All components and their respective parameters are always defined in menu item **Edit Components** or via the corresponding icon.

Defining a component includes the following steps:

- Create a new component.
- Select all points (at least three) which are supposed to form a component, and transfer these points into this component. Ensure that the points of a component are visible in all stages of the project, if possible.
- Select some of the component points (at least three) which clearly identify this component in the project.
- Adjust parameters (search radius, identification threshold)

For further information, please refer to the Online Help.

D 2.2 Standard Component "Static Points"

A standard deformation project should have at least one component so that the stages can be aligned to each other and identified, and the deformation can finally be computed. For this purpose, the software provides the standard component **Static Points**. At first, this component is empty and needs to be filled with points (identification points) which you select.

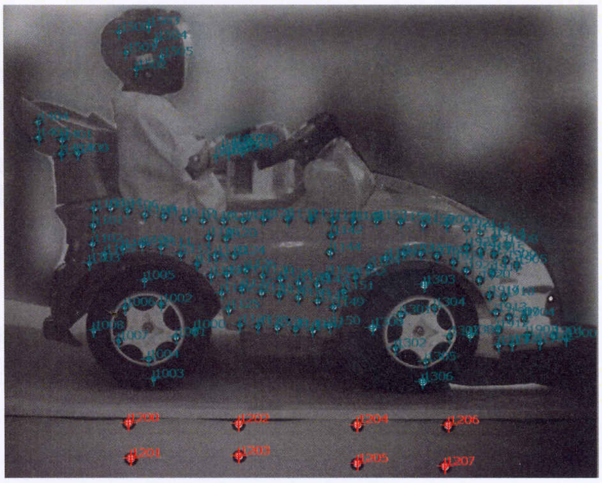
D 2.2.1 What are Static Points?

Static points are points in a measuring project which do not undergo any object deformations and which keep the distance between each other during the entire measuring process.

D 2.2.2 Selecting Static Points

Suitable static points are coded reference points (if available) and uncoded reference points which were not or just insignificantly displaced.

You need at least three static points for aligning the stages to each other correctly. These points must not lie on one line and should be steady with respect to each other. If more than three points are used, the software averages the values and thus the noise of individual points is less important. We therefore recommend defining about 5 to 10 points.



Example for reasonably selected static points (red)

D 2.3 Identification Points

D 2.3.1 What are Identification Points?

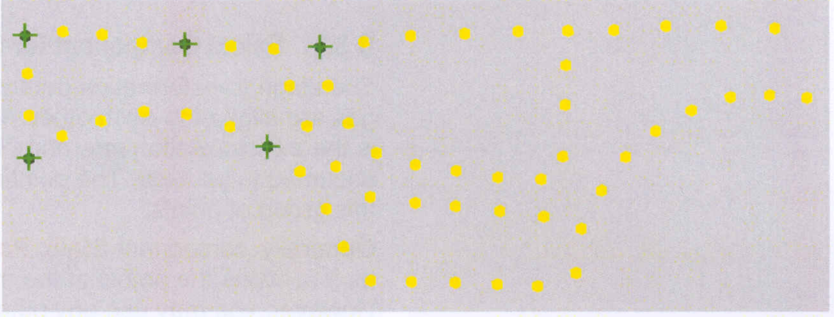
Identification points are points within a component with the help of which the software recognizes the component in all stages of the project. The software searches this point pattern in all stages and then tries to determine the remaining component points by means of a distance search. Thus, measuring points can be correctly assigned between the stages despite large object movements.

D 2.3.2 Choosing Identification Points

When defining a component, select points as identification points that move as little as possible with respect to each other and that form a clear pattern within the project.

At least three identification points are required to recognize a component. Identification points automatically are marked with a green cross.

For further information, please refer to the Online Help.



Example for reasonably selected identification points (green). For a better distinction, the remaining component points in this example were colored in yellow.

D 3 Identification

In order to assess the deformation of an object, all stages of a project need to be aligned, i.e. transformed, to a component of the transformation reference stage (the first stage of the project). Then, the respective component needs to be identified in each stage and its point IDs need to be assigned correctly. This is done by means of the defined identification points.

You start the entire computation process with menu item **Identify** or with the respective icon.

Identification is divided in three steps:

- Select components and determine identification order
- Select component for stage transformation
- Evaluate computation results

For further information, please refer to the Online Help.

D 3.1 Select Components and Determine Identification Order

All components and all adapters (if available) are automatically listed with information about type and number of reference points.

As a default, all elements available in this list are used for the identification process. You should disable components only if they do not exist in your current project.

Info

During identification, the software processes the list of components from top to bottom. Therefore, we recommend to move the component with the most points to the top. Thus, components with fewer points can be easily found in the remaining point cloud due to less ambiguities in the result.

Info

If adapters exist, they take precedence over the components in the identification process.

D 3.2 Select Component for Stage Transformation

The stage transformation determines in which way the individual stages are aligned to each other. As a default, the first stage of a project is the transformation reference stage. Certain points of this stage are assumed to be fixed. The points of all other stages are then aligned to this group of points.

Generally, component **Static Points** is used for stage transformation as it contains the points of the measuring project that do not move. However, you may use any other component for stage transformation if you would like to analyze the movement of the remaining points and components relative to this one.

Info

The identification points of the component selected for stage transformation in this case are called **Fixed Points**.

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D 3.3 Evaluate Computation Results

As soon as you click on button **Compute**, the results of the component identification and the stage transformation are listed as preview.

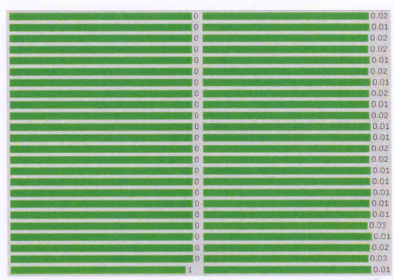
This list is created for each stage in each component and can be accessed via the individual tabs. In addition, there is the tab **Total**.

The list is divided into two columns and consists of color bars and numbers. One column informs about missing or not identified points while the second column contains information about the identification deviation or the transformation deviation. The color intensity and the length of the color bars combined with the respective values help you to assess these results. The color of all bars may continuously change from green (everything is ok) to red (bad).

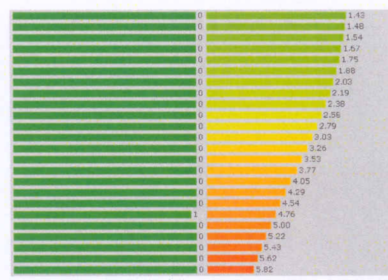
The meaning and interpretation of the color bars depend on whether you are in a component tab or in the tab **Total**.

In addition, icons in front of the stage and component names indicate the status of the components or stages.

For further information, please refer to the Online Help.



Example for good results



Example for bad results

If the preview results do not meet your expectations, you may here influence the values, for example, by changing the component parameters, before you confirm the results and accept them for your project.

D 4 Further Computation Parameters

D 4.1 Additional Stage Transformation Options

D 4.1.1 Stage Transformation Using Setting "Sensor"

If you do not have any chance to define static points (fixed points) in your measuring project because, for example, you would like to examine the movement or velocity of an object, you may choose setting **Sensor** for the stage transformation.

Info

For this type of transformation, the sensor must be fixed and must not be moved or just be moved in a defined manner!

In this case, the sensor represents a fixed point to which you measure relatively. No transformation is carried out, i.e. the stages will not be aligned to each other.

Info

If you select the sensor coordinate system as transformation basis, all previously made identifications and transformations are rejected and you will return to the original state of the project after image recording.

D 4.1.2 Manual Stage Transformation

Info

Only select this mode in really special cases!

In this case, you need to carry out the transformation manually for each stage by clicking transformation points in the transformation reference stage and in the current stage. If you already carried out a stage transformation with a component, the existing fixed points will be suggested for manual transformation.

Info

Manual stage transformation requires for the current and all following stages of the project a new identification. Make sure that for the identification in this case you select **No Transformation** as stage transformation.

For further information, please refer to the Online Help.

D 5 Summary

- Compute project
- Define components
- Static points and identification points
- Stage transformation and identification
- Transformation to the sensor coordinate system
- Manual stage transformation

Chapter E - Table of Contents (rev-a)

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E Transformations

E 1 Transform Project Data

Depending on the measurement task, the deformation data of a measuring project sometimes needs to be transformed into a defined coordinate system in order to be interpreted correctly.

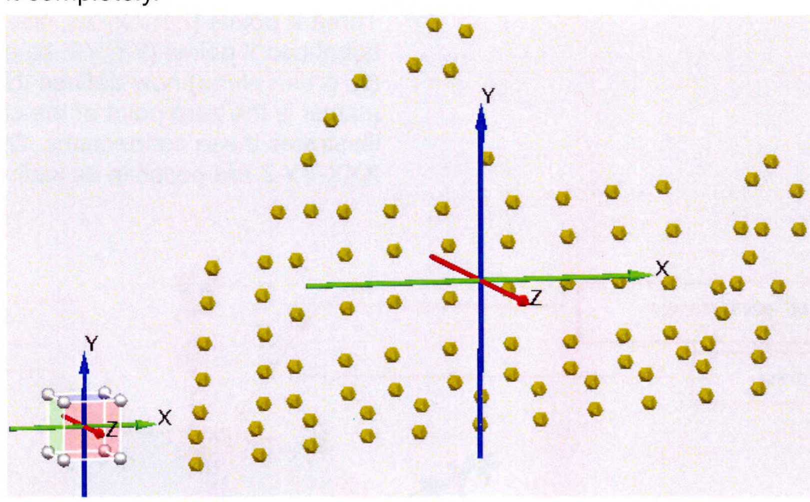
E 1.1 What is a Coordinate System?

A coordinate system is used to unambiguously describe the position of points in space by stating three numerical values (X, Y, Z coordinates). The point where all numerical values are 0 is called the origin of the coordinate system.

E 1.1.1 Visualization of the Coordinate System

PONTOS can show the coordinate system in the left bottom corner of the screen. It is displayed as a dice and serves as guide for easy rotating the measuring object. By clicking on the axes or the corner points you may rotate the measuring object into different views.

In addition, you may display the coordinate system in its origin or hide it completely.



Coordinate system in the left bottom corner and in the origin, without transformation

E 1.2 Views in the Software

The software offers several views. **View** shows the measuring object from top, bottom, left, right, front and back and **ISO View** displays the measuring object additionally in the respective diagonal views (see also Online Help).

E 1.3 Why is Transformation Required?

After calibration, the Z axis of the coordinate system in PONTOS points to the sensor. For a better understanding, or in order to be able to use the data, for example, for further processing by subsequent systems, they may be transformed into a defined coordinate system.

In order to put a coordinate system in a defined condition, the nominal coordinates of some reference points need to be known. This might be CAD data, data of other measuring projects or data determined by co-ordinate measuring machines.

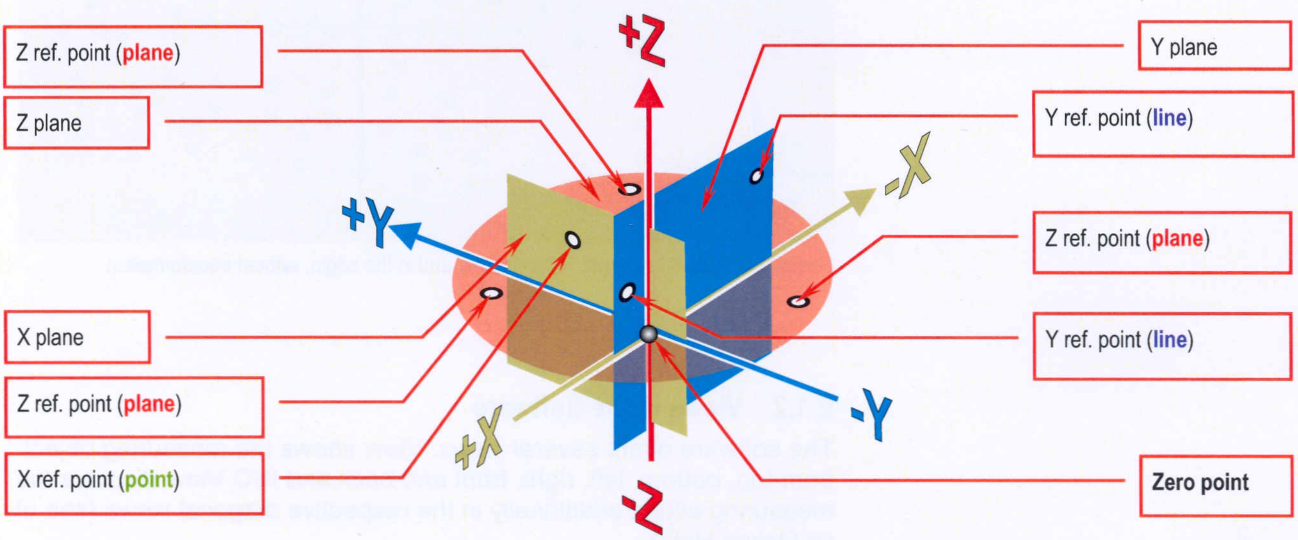
Depending on the measuring task, you need to define the coordinate system. Many manufacturers define, for example, the default coordinate system of a car in the middle of the front axle with the Z axis pointing towards the top, the X axis pointing to the back and the Y axis pointing to the right.

There are different transformation methods (e.g. 3-2-1 transformation, best-fit by reference points). Which method is preferred depends on the measuring project and the data available.

E 1.4 Principle of the 3-2-1 Transformation

The **3-2-1 Transformation** is the mostly used method in PONTOS. Therefore, we introduce the basics here.

3-2-1 means that three 3D points (Z1, Z2, Z3, located as far as possible from each other and not in a line) describe a plane, two additional 3D points describe a line (Y1, Y2, located as far as possible from each other in the X-axis) and one 3D point describes a point (X). For the transformation method ZZZ-YY-X means the following:
Three Z points (Z1, Z2, Z3, red plane) define the Z plane. The additional two Y points (Y1, Y2, blue plane) define the Y plane. The X point (X, green plane) now defines the X plane. At the intersection of the planes is the zero point of the coordinate system. The following figure illustrates these connections. Of course, other transformations like XXX-YY-Z are possible as well.

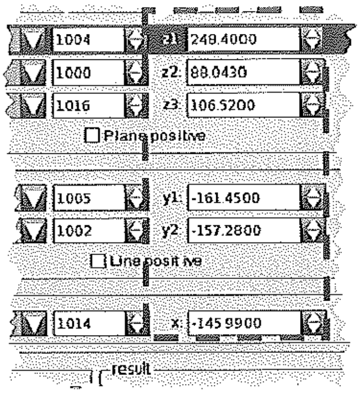


The above example shows the factual relations using the minimum number of points required fort his transformation method. You may use reference points or self-defined 3D points. In this case, the points define the coordinate system directly. It is important that the points reliably describe the required coordinate system.

E 1.4.1 Direction of the Coordinate Axes

The direction of the Z axes (positive or negative) depends on the order in which the three reference points are defined. It results from the sequence of the points and the resulting "sense of rotation" of the plane (points 1 to 3). The direction of the Z plane can be defined, independently of the "sense of rotation", by toggling menu item **Plane positive**.

The direction of the Y axis (positive or negative) depends on the order in which the two Y reference points are defined and results when defining the points 1 and 2 of the line. The direction of the Y plane can be defined, independently of the sequence of the points, by toggling menu item **Line positive**.



E 1.4.2 Indirect Determination of the Coordinate System

It is not always possible that points determine a coordinate system directly. Therefore, in case of the transformation method **ZZZ-YY-X**, you may enter alignment coordinates for each point with **z1**, **z2**, **z3**, **y1**, **y2**, **x**, which now define the respective plane, line or point.

E 1.4.3 Additional Points

You may define **additional points** in the software which will also be taken into account for the 3-2-1 transformation. The additional points may increase the accuracy of the coordinate system, for example, if you use four instead of three 3D points to define a plane. The plane now is overdetermined. However, as four or more 3D points in practice never lie on one ideal plane, the software determines the average value of the resulting differences.

E 1.4.4 3-2-1 Transformation in PONTOS

For typical PONTOS measurements, a defined component coordinate system is not necessarily required because mainly relative values (displacements) are measured. Here, only the correct direction but not the origin is important.

However, for further processing of the data e.g. in a simulation software, the data needs to be transformed into a defined coordinate system. This is typically done by measuring the points with a TRITOP system or with a coordinate measuring machine. Then, the transformation is made by entering the values into the 3-2-1 transformation menu.

E 2 Registration

In order to be able to use measuring data for a comparison to the nominal data (CAD data), they need to be transformed into the coordinate system of the CAD data. This is done by registration. There are different registration methods (pre-registration, best-fit registration). The import of CAD data is a prerequisite for all methods.

E 2.1 CAD Import

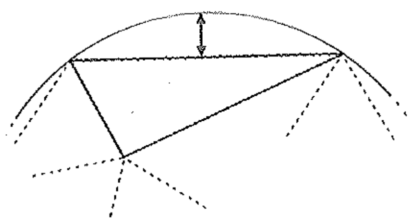
E 2.1.1 What Are CAD Data Needed For?

CAD data are the ideal design data according to which a component is manufactured. They contain all nominal elements and nominal values which are important for a component. However, PONTOS measures a really existing object. If you now would like to know how much the real object deviates from its nominal dimensions, you need the CAD data as reference data in order to carry our a respective analysis.

E 2.1.2 What do the Parameters Mean?

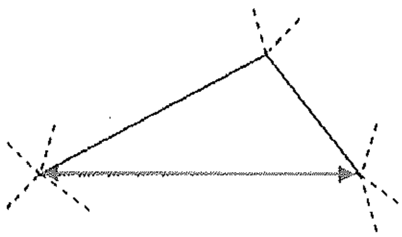
When importing the CAD data, they are converted into mesh polygons. In order to achieve an optimum result, several parameters need to be specified.

__Surface Tolerance__



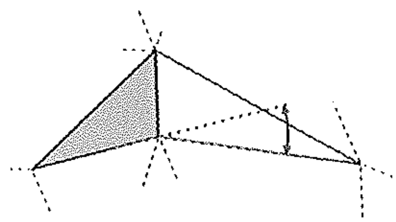
The surface tolerance describes the max. admissible chord error of triangles for freeform surfaces.

__Maximum Edge Length__



The maximum edge length describes the max. permissible length of a side of a triangle.

__Maximum Angle__

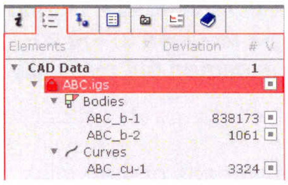


The maximum angle describes the max. admissible tilt angle of triangles for freeform surfaces.

Structure Repair Mode

This mode defines how the CAD data will be processed during the import. We recommend using **Mode 1 (default)**.

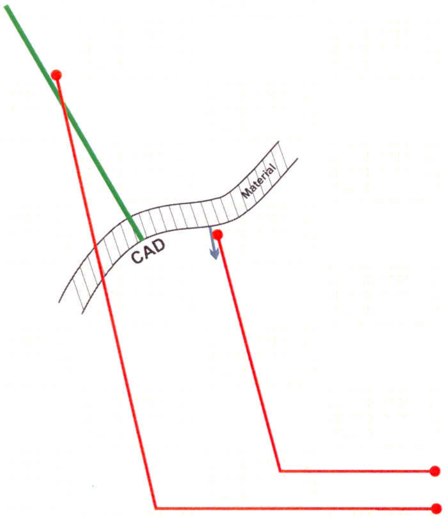
E 2.1.3 After the Import



After the import, the data are available in the sub-explorer and are split into so-called **Bodies** and **Curves**.

A **Body** is a single, coherent mesh. Depending on the original CAD data and on which structure repair mode you chose for the import, several bodies may be displayed. A body, again, may consist of several patches. A patch is a partial area of a body but adheres to it. The patches may have different colors.

Under **Curves**, auxiliary CAD lines are displayed which are mainly important for the design. Usually, these lines also contain the material thickness vector which is really important for a deviation analysis.

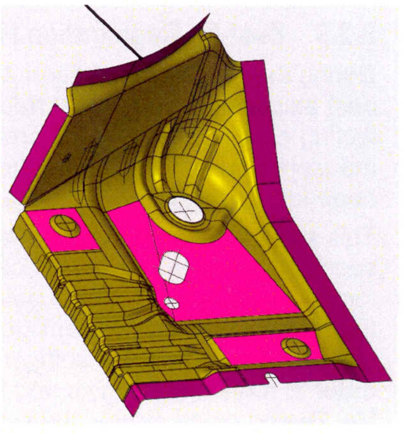


Material Thickness Vector / Surface Normal

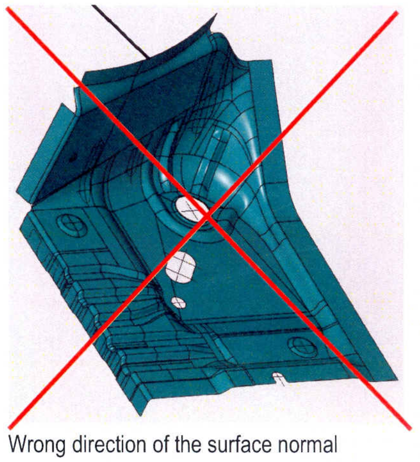
The material thickness vector states in which direction the material builds up. In most CAD applications, its direction in the CAD data is defined such that it points from the surface to the material. Its length is normally 100 times the material thickness. It runs opposite to the surface normal. The surface normal is a vector which is perpendicular on the surface and thus defines the front side of the mesh.

Check to which direction the material thickness vector in the CAD data points and whether the surface normal is opposite to this direction so that the front side is defined correctly. In the GOM software, the rear side of the mesh generally has a uniform color which is defined in the preferences.

- Surface normal
- Material thickness vector



Correct direction of the surface normal



Wrong direction of the surface normal

Now, you may decide if you measured the correct side or which side you would like to measure. Generally, you should measure the CAD front side. If, in special cases, you would like to measure the opposite side, you may do it by clicking with the right mouse button onto a body of the CAD data in the **Sub-Explorer** and select ► **Edit Properties** ►

tab **General ▶ Measure opposite side**. For this purpose, the CAD data are corrected by the material thickness of the sheet metal in normal direction by entering the correct value for the material thickness.

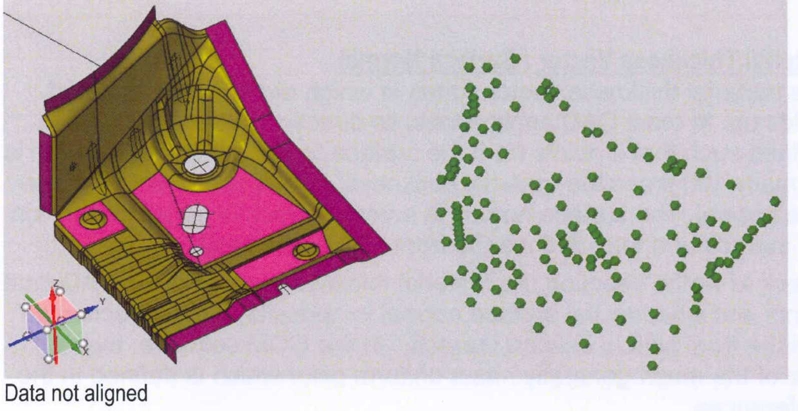
E 2.2 Pre-Registration

A pre-registration is the prerequisite for the best-fit registration. During the pre-registration, the measured data is brought as close to the coordinate system of the CAD data as possible It is carried out manually.

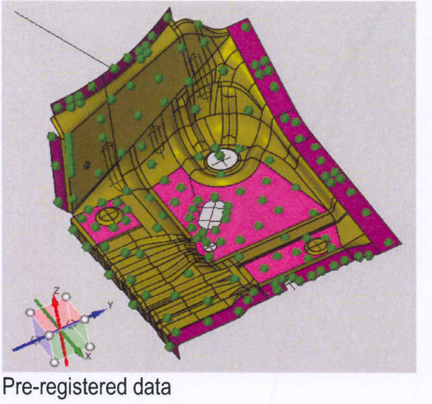
E 2.2.1 Pre-Registration Project

Using this function, you register two data sets by means of manually determined points. You define these points in the measuring data and in the CAD data. The points must not lie on one line and should be far away from each other in order to achieve a good pre-registration. As soon as at least three points are marked, the transformation is calculated and the deviation is displayed.

For further information, please refer to the Online Help.



Data not aligned

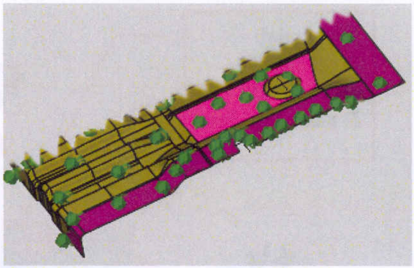


Pre-registered data

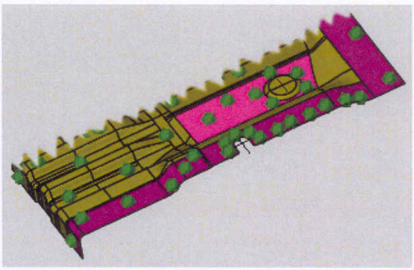
E 2.3 Best-Fit Registration Project

During the best-fit registration, the measured points are dragged as best as possible onto the surfaces of the CAD data. This requires selecting either certain best-fit areas on the measuring data or the entire measured points. Therefore, the best-fit registration leads to a user-dependent registration because the user may influence the selection.

This surface registration is based on a defined **Search radius** which specifies, how far in the CAD data corresponding points are searched for, i.e. in order to register a point of the measured data, all points of the reference mesh are considered that are within this given search radius. As a default, the software carries out several best-fit cycles in order to reduce this radius and to register the data as best as possible. During these cycles, the software adapts the number of used points automatically.



Detail view, pre-registration



Detail view, best-fit registration

E 3 Other Transformation Methods

E 3.1 Best-Fit by Reference Points

E 3.1.1 Prerequisite

For this method, the complete 3D coordinates of at least 3 arbitrary reference points need to be known. The function automatically identifies these points in the measuring project if the coordinates entered describe a reference point constellation that can be found in the measuring project as well. The measuring project then is transformed into the coordinate system of these points.

E 3.1.2 Procedure in PONTOS

If, for example, you have captured your measuring project in a complete TRITOP project prior to the deformation measurements, you may export defined points that shall be used to transform the project into the component coordinate system in a reference point file. Load this file into PONTOS using menu item **Best-Fit by Ref. Points** and thus transform your deformation project into the correct coordinate system.

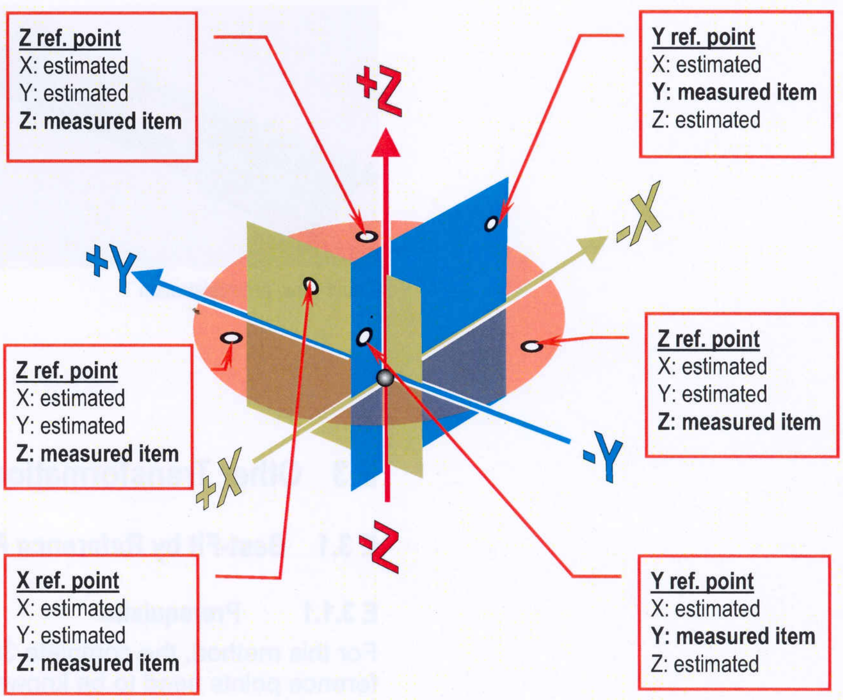
E 3.2 Weighted Points

Defining a coordinate system by means of weighted points is very similar to the 3-2-1 method.

Whereas for the 3-2-1- method you need, for example, three Z coordinates for the Z plane, two Y coordinates for the Y plane and one X coordinate for the X plane, the **Weighted Points** method requires all XYZ coordinates of at least 3 reference points, six of which must be measured precisely according to the 3-2-1 definition and the others are estimated. The estimated values should be in the range of approx. +-10 % of the maximum length of the measuring volume.

The direction of the coordinate system results from entering the complete coordinates.

For further information, please refer to the Online Help.



E 3.3 Transform Plane-Line-Point

With this function, you may carry out a transformation using the primitives plane, line and point that were derived from the measuring data and the reference data (CAD, ...). Equivalent primitives of the measuring data and the reference data are hierarchically assigned to each other (e.g. plane to reference plane, line to reference line and point to reference point). First, all elements need to be created in suitable areas according to the 3-2-1 rule.

This function allows aligning objects where the reference plane is not located in the planes of the reference coordinate system.

E 3.4 Transformation of Meshes

When you included polygonized meshes into your project (e.g. by converting CAD data into such meshes), you may align these meshes to your measured points such that they move together with the points in the stages according to the deformation.

Here as well, the pre-registration is the prerequisite for the best-fit registration.

E 3.4.1 Pre-Registration Mesh

The procedure is the same as for the **Pre-Registration Project** but you align an existing mesh to the measured points (see also **Fehler! Verweisquelle konnte nicht gefunden werden.**).

E 3.4.2 Best-Fit Registration Mesh

The procedure is the same as for the **Best-Fit Registration Project** but you align an existing mesh to the measured points (see also **Fehler! Verweisquelle konnte nicht gefunden werden.**).

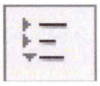
E 4 Summary

- Transform project data
- Coordinate system
- Transformation
- Basics of 3-2-1 transformation
- CAD import
- Pre-registration
- Best-fit registration
- Method best-fit by reference points
- Method weighted points
- Method transform plane-line-point
- Transformation of meshes

Chapter F - Table of Contents (rev-a)

F Result Creation

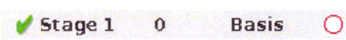
F 1 Analysis



In order to analyze the deformation of a measuring object with respect to a reference state, the software needs to display the deformation which was computed through all stage in color in the 3D view. For this purpose, you need to define an area which you are interested in. You may also obtain additional analysis data, for example, by examining the position of a point closer, by measuring the distance between a point and a line, and much more. All analysis data you create appear in the sub explorer under tab **Elements**.

F 1.1 Deformation Reference Stage

In order to define the reference state to which the deformation analysis shall refer, you may select a stage as deformation reference stage any time.



In the explorer, the deformation reference stage is always displayed in bold letters and with a filled (stage is currently visible) or with an empty (stage is currently not visible) red circle. Generally, the basic stage is also the deformation reference stage.

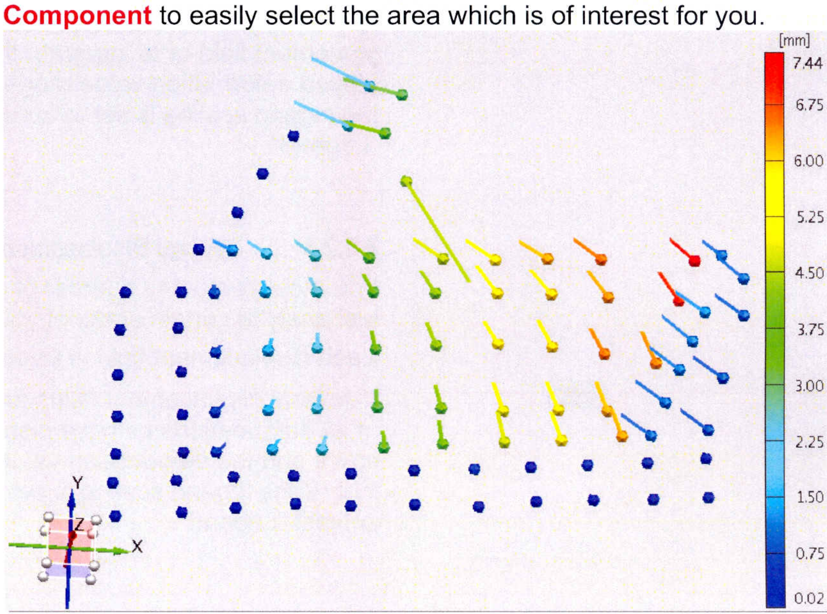
F 1.2 Displacement Fields

F 1.2.1 Defining a Displacement Field

A displacement field is a user-selected area of points, for which the deformation – i.e. the position offset of the points in the current stage compared to their position in the reference stage – is to be displayed in color in the 3D view. This means, a displacement field is a way to visualize deformations.

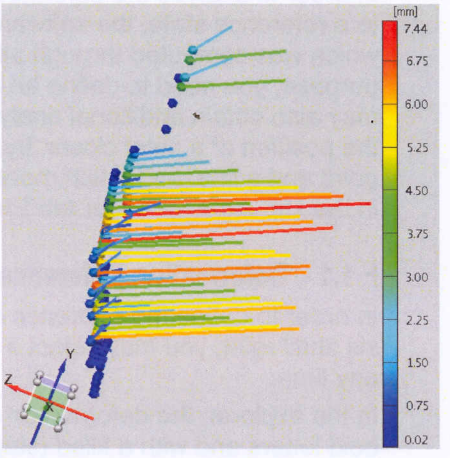
Info

If you use components, you may use the selection command **Select Component** to easily select the area which is of interest for you.



Displacement field over the entire measuring object

The color, direction and length of the vectors informs about the deformation of the object at individual measuring points. The stronger the deformation is the longer is the respective vector. You may adapt the length and scaling of the vectors in a displacement field individually but the length ratio of the vectors with respect to each other remains the same.



Side view of a displacement field

How you create a displacement field you will find in the Online Help.

F 1.2.2 Legend in a Displacement Field

Generally, the legend is set to **Automatic scaling**, i.e. the range of values for the deformation in the displacement fields is calculated over the entire color scale. Thus, a displacement field has an individual legend in each stage.

F 1.2.3 Editing a Displacement Field

Any time, you have the possibility to exclude certain points from a displacement field or to integrate the excluded points again. The displayed deformation value range of the legend changes accordingly if the legend scaling is set to automatic. See also Online Help, subject "Legend".

F 1.2.4 Several Displacement Fields

You may create any number of displacement fields, for example, to just analyze certain areas of your measuring object.

Each displacement field is listed separately in the sub explorer.

Info

If several displacement fields are visible at the same time, the values of all deformations in these displacement fields will be taken into account and the deformation value range of the legend changes accordingly if the legend scaling is set to automatic. See also Online Help, subject "Legend".

F 2 Extended Analysis

In addition to the displacement fields, you may evaluate the deformation at or between certain points. Menu item **Analysis** provides for various functions for distance and angle analyses.

Info

All analyses may also display the deviations of the measured points to CAD data. You may choose whether the CAD data is to be compared with the deformation reference stage or with the currently visible stage.

In addition, the software provides the possibility to analyze movements in space. For this purpose, menu items **6DoF** and **Relative 6DoF** are available.

You may use menu item **Primitives** to create auxiliary elements for analysis tasks.

F 2.1 Measure Point Positions, Distances and Angles

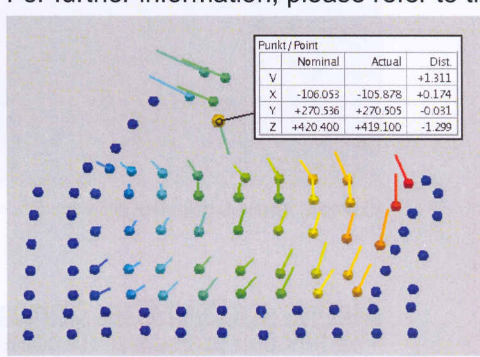
F 2.1.1 Measure Point Positions

Using the corresponding menu item, you may display the displacement of individual points with respect to the reference stage and document it with labels.

Info

If the text label in the 3D view does not display the desired parameters, you may change it with a right mouse button click on the label.

For further information, please refer to the Online Help.



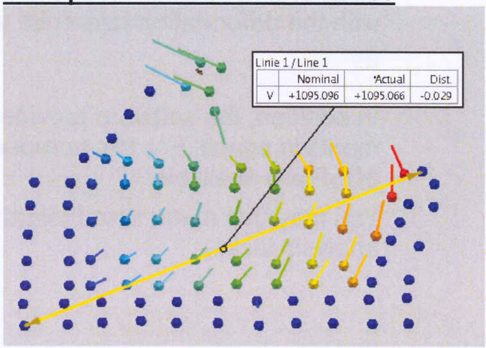
Example: Point position analysis

F 2.1.2 Measure Distances

Using the corresponding menu item you may carry out distance measurements and document them with labels.

Info If the text label in the 3D view does not display the desired parameters, you may change it with a right mouse button click on the label.

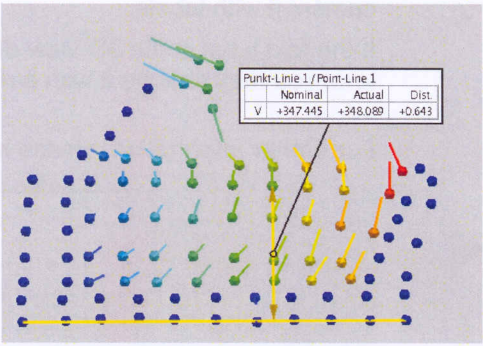
Example of a Point-Point Distance



Example: Analysis point-point distance

Example of a Point-Line Distance

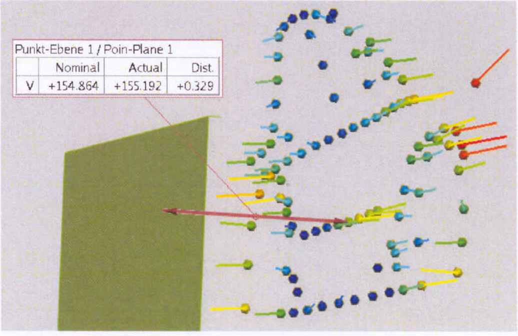
The function determines the perpendicular distance of a 3D point to a line.



Example: Analysis point-line distance

Example of a Point-Plane Distance

The function projects a 3D point perpendicularly onto a plane and determines the distance between these points.



Example: Analysis point-plane distance

F 2.1.3 Measure Angles

Using the corresponding menu item you may carry out angle measurements and document them with labels.

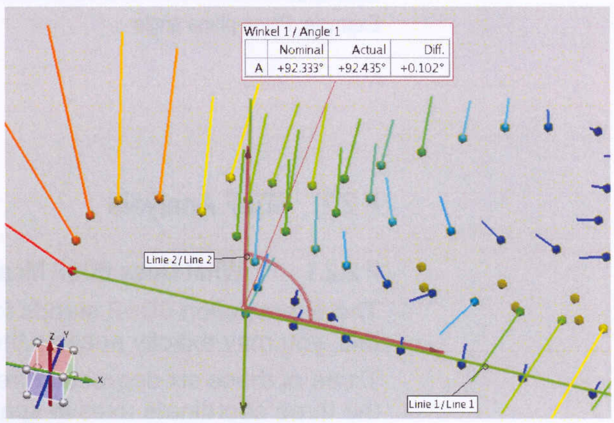
You may determine angles between the elements **Planes** and **Lines**.

Info

Angles in the 3D space are limited to 0° to 180°. Therefore, angle variances around zero are ambiguous. In order to prevent wrong analyses, you should not define angles close to 0° or 180° in the deformation reference stage.

Example of a Line-Line Angle

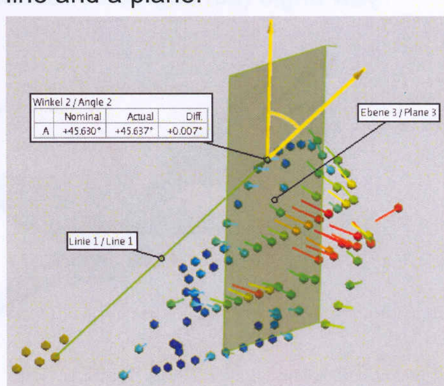
Using this menu item, you may measure angle variances between two lines.



Example: Line-line angel

Example of a Line-Plane Angle

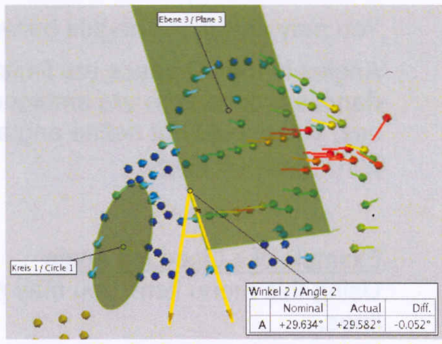
Using this menu item, you may measure angle variances between a line and a plane.



Example: Line-plane angle

Example of a Plane-Plane Angle

Using this menu item, you may measure angle variances between two planes.



Example: Plane-plane angle

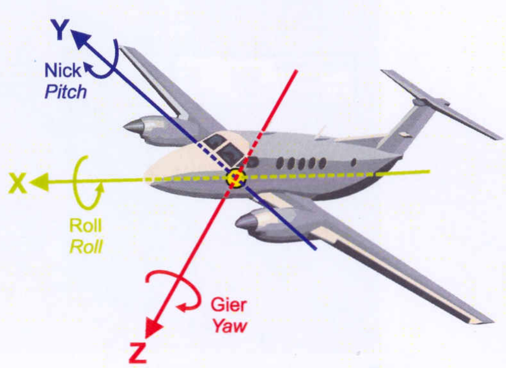
F 2.2 6DoF Analysis

F 2.2.1 What Does 6DoF Mean?

The abbreviation **6DoF** stands for "Six Degrees of Freedom". With this, you may exactly analyze the movement of an object in space.

Three of these six degrees of freedom refer to the **translation along** the three coordinate axes in space, i.e. an object may move back and forth (1st degree of freedom), up and down (2nd degree of freedom) and left or right (3rd degree of freedom).

The remaining three degrees of freedom refer to the **rotation around** the three coordinate axes. The resulting angles are also called roll angle (4th degree of freedom), pitch angle (5th degree of freedom) and yaw angle (6th degree of freedom).



Example for roll, pitch and yaw angle of an airplane coordinate system.

F 2.2.2 Determine Origin for Local Coordinate System

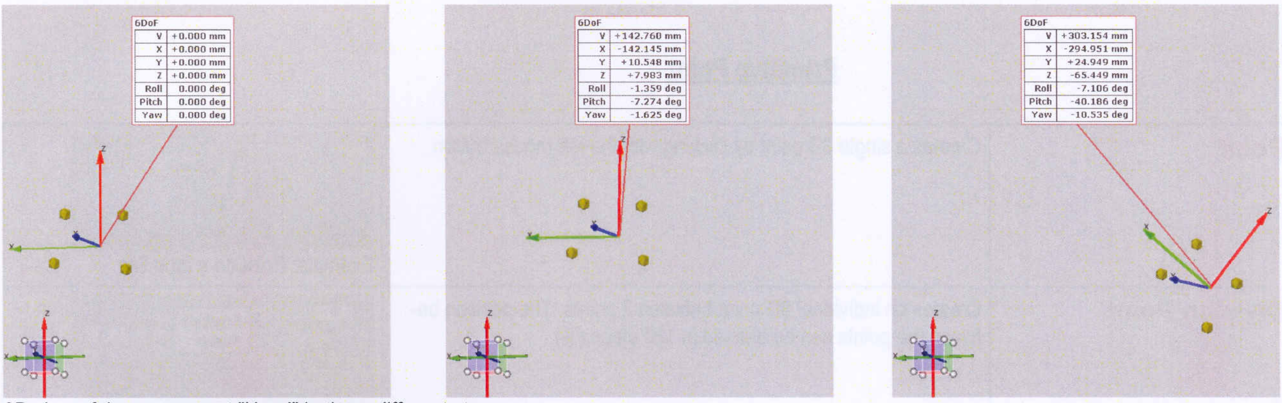
In order to create a 6DoF analysis for a component in PONTOS, you need to determine the origin of the local coordinate system. For this purpose, you may select individual points or, with the help of primitives, you may create the origin at a position which is of interest for you.

F 2.2.3 Define Direction of Local Coordinate System

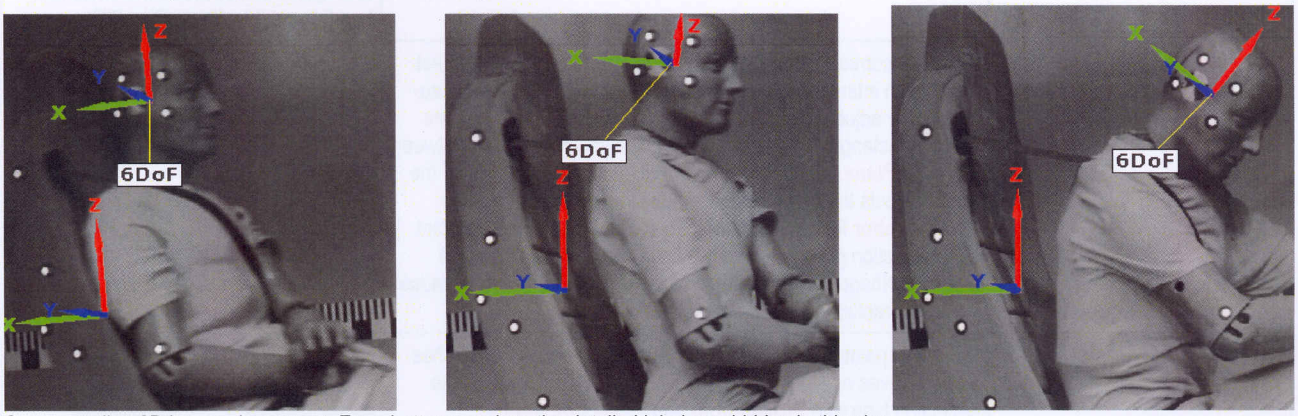
In order to evaluate your 6DoF analysis according to your measuring task, you need to decide if the local coordinate system shall correspond to the global coordinate system of your measuring project or if the direction of the coordinate axes need to be different. You may define the direction of the coordinate axes manually.

F 2.2.4 Example of a 6DoF Analysis

In this example, the movement of the dummy head in a crash test was examined. The origin of the local coordinate system is in the head's center of gravity. Its direction corresponds to the global coordinate system of the project. You may clearly see a displacement and rotation of the head.



3D view of the component "Head" in three different stages.



Corresponding 2D images in a report. For a better overview, the detailed label was hidden in this view.

F 2.2.5 Relative 6DoF Analysis

The software also offers the possibility to examine two 6DoF analyses relative to each other. Thus, you may analyze the relative movement of two different components with respect to each other.

F 2.3 Primitives

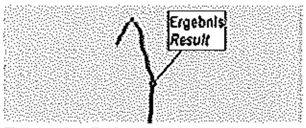
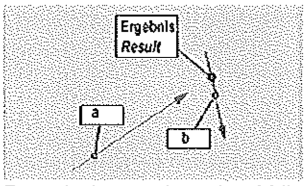
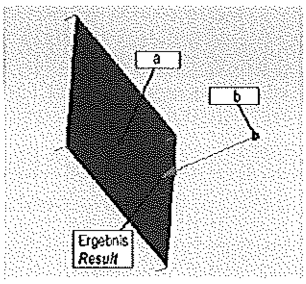
Primitives (points, lines, circles, planes, spheres, ...) are user-defined objects in the 3D view. You need primitives, for example, for transformation or inspection (documentation of measuring results) of a measuring object.

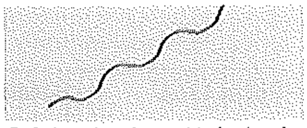
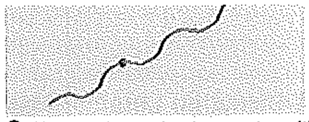
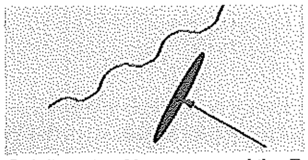
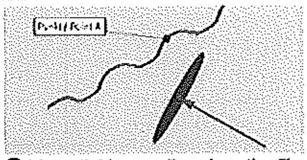
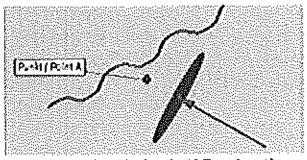
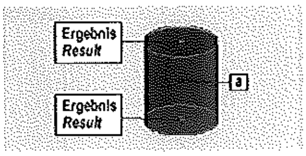
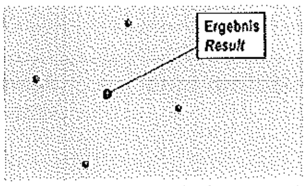
When clicking with the right mouse button on the defined primitive, you may edit the element. The following functions are available:

- Set or unset the primitive as reference
- Change the appearance of the primitive or the label
- Defining the normal direction

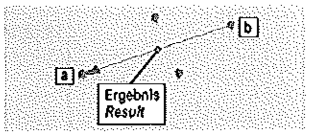
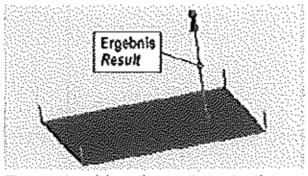
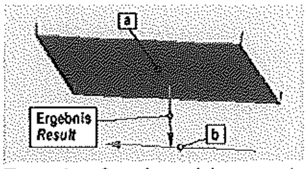
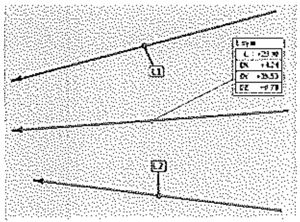
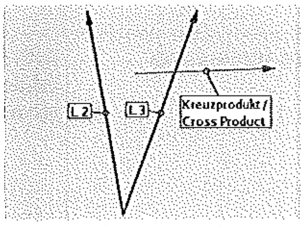
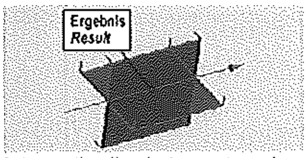
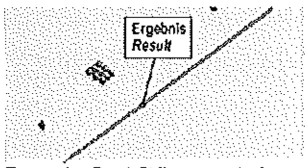
The following table informs you in extracts about possible primitives and particularities when creating them. All primitives are generated based on 3D points or 3D polygon meshes or other primitives (e.g. planes and lines). Use Ctrl and left mouse button in the 3D view to select points, planes, lines, etc. to create primitives or by directly clicking on the primitive's label with Ctrl and left mouse button. You may also select the elements directly from the explorer list.

Primitive Point

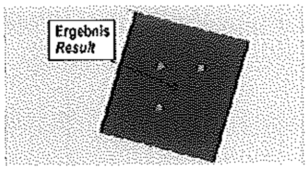
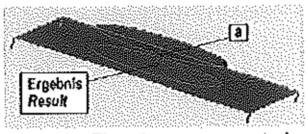
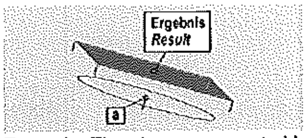
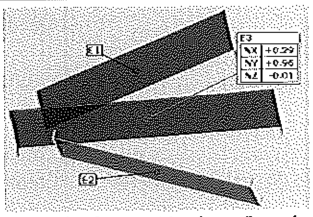
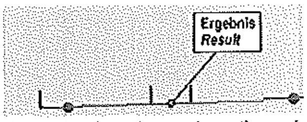
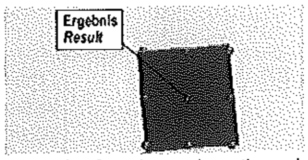
Point	Creates a single 3D point by clicking with the left mouse button.	 Example: Point on a tape line
Division Point	Creates an individual 3D point between 2 points. The position between the points can be defined in 100 steps (%).	 Example: Point between two circle centers (a) and (b) with position 50%.
Intersection Point	**Active if** corresponding primitives exist in the measuring project. Creates an intersection point between primitives. The system automatically adjusts the **Intersection type** under **Base elements.** Only for rectangular holes or slotted holes you can choose between **Line** and **Plane.** If under **Element** you select the mesh, and if the line intersects the mesh several times, choose the point under **Point number** for which you wish to create the intersection point. As intersection point between two lines, the center point of the shortest orthogonal distance between these lines is given because the lines practically never intersect each other.	 Example: Intersection point of 2 lines (a) and (b)
Projection Point	Projects a point of 3D meshes and primitives to other 3D meshes and primitives on the shortest possible way. You can adjust the projection type with **Project onto** and **Projection mode.** Projection modes: **Surface** creates a point on the surface of 3D meshes and bodies. **Point** only uses the junction points of the 3D meshes or the centers of circles and spheres. **Curve** uses the border lines. **Plane** uses the planes of circles or planes. **Line** uses the rotation axis of cones or cylinders.	 Example: Projection of point (b) onto plane (a).

Touch Point (Disc)	Projects a circular plane onto primitives, point clouds, sections, 3D meshes, ... and creates a point at the location of the initial touch. The function is similar to the **Disc Caliper** with the difference that here the result is a point instead of a distance.	 ❶ Select the element to be touched in the 3D view.  ❷ Choose the projection center with **Center** and determine the touch direction with **Direction**.  ❸ Adjust the **Clearance** and the **Radius** of the circular plane.  ❹After clicking on **Preview** the **Touch Point (Disc)** is displayed.  **Touch Point (Disc)**, if **Projection on direction vector** is enabled.
Points from Line	**Active if** corresponding primitives exist in the measuring project. Extracts the start or end points of lines, intersection lines and rotation axes of cylinders (a) and cones.	 Example: Extraction of start and end points of a cylinder rotation axis (a).
Best-Fit Point	Creates a geometrical average value from selected 3D points and/or 3D meshes.	 Example: The result is the geometrical average value.

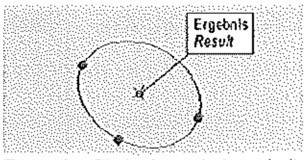
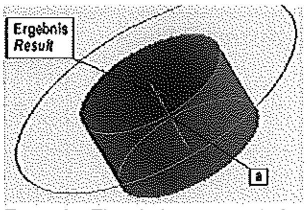
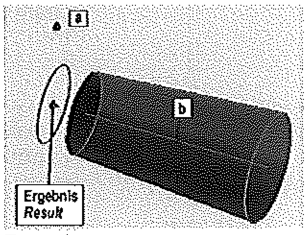
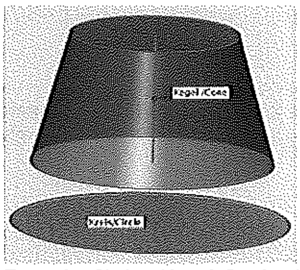
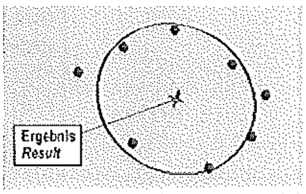
Primitive Line

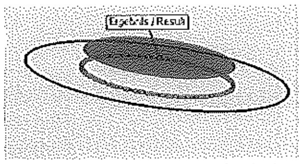
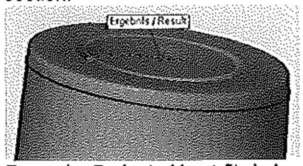
Point-Point Line	Creates a line between two points.	 Example: Line between two individual points
Point-Direction Line	Creates a line from the start point in a **Direction** to be defined. The length of the line in arrow direction can be defined with **Length**.	 Example: Line from the starting point on the plane in normal direction of the plane.
Perpendicular Line	**Active if** corresponding primitives exist in the measuring project. Creates a line from the start point (plane a) orthogonal to another line (b).	 Example: On plane (a), we selected a start point for the perpendicular line which runs perpendicular to line (b).
Symmetric Line	Creates a line symmetrically to two other elements which contain a line (e.g. line, cylinder, cone, etc.).	 Example: Symmetric line (here in red)
Line by Cross Product	Creates a line that is perpendicular to two other lines or direction vectors and has its origin in the point you clicked.	 Example: The cross product was created from lines 2 and 3. The new line is perpendicular to both other lines.
Intersection Line	**Active if** corresponding primitives exist in the measuring project. Creates intersection lines between surfaces of primitives.	 Intersection line between two planes.
Best-Fit Line	Creates a line according to the best-fit principle based on selected 3D meshes, sections and features. Based on the selected points, the line can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points. Using the statistical methods, measuring point outliers can be eliminated during the best-fit process.	 Example: Best-fit line, created on previously selected (red) points of a border line.

Primitive Plane

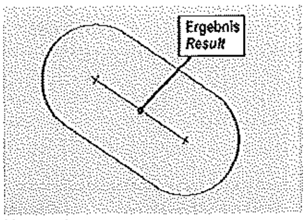
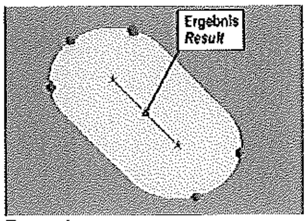
Point-Point-Point Plane	Creating a plane through 3 points.	 Example: The plane was created by selecting three points.
Point-Normal Plane	Creates a plane through one point in the direction of other objects like lines, cylinders, etc.	 Example: The plane was created using a point on the rotation axis of cylinder (a) and the normal direction of cylinder (a).
Parallel Plane	**Active if** corresponding primitives exist in the measuring project. Creates a plane parallel to a circle, a rectangular hole, a slotted hole or another plane. Use "Offset" to adjust the distance to the element you created the plane from.	 Example: The plane was created in parallel to circle (a), stating an offset value.
Symmetric Plane	Creates a plane symmetrically to two other elements which contain a plane (e.g. plane, circle, section, etc.).	 Example: Symmetric plane (here in red)
Plane in Viewing Direction	Creates a plane through two points or a temporary defined line (using the selection tool of the menu) in the current viewing direction.	 Example: Creating a plane through 2 points.
Best-Fit Plane	Creates a plane according to the best-fit principle based on selected 3D meshes, sections or features. Based on the selected points, the plane can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points. Using the statistical methods, measuring point outliers can be eliminated during the best-fit process.	 Example: Creating a plane through previously selected points.

Primitive Circle

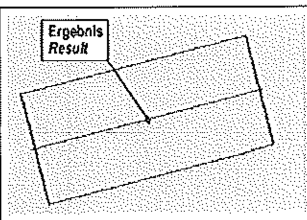
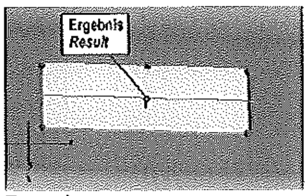
Point-Point-Point Circle	Creates a circle through three points.	 Example: Circle through three individual and selected points.
Point-Normal-Radius Circle	Creates a circle by defining the circle center and stating the rotation axis. The radius can be defined by selecting the points or by entering the radius value directly.	 Example: The circle was created using a point on the rotation axis of cylinder (a) and the normal direction of cylinder (a). The radius was directly entered as value.
Cylinder/Cone Intersection Circle	**Active if** corresponding primitives exist in the measuring project. Creates a circle on the rotation axis of cylinders or cones (b) by projecting a point (a) orthogonally onto this axis. This point is the center of the new circle. The radius of the circle is calculated from the radius of the cylinder or cone at the point of projection.	 Example
Cone-Radius Circle	Creates a circle with a defined radius based on a cone.	 Example: Circle with a defined radius (here in red).
Best-Fit Circle	Creates a circle according to the best-fit principle based on selected 3D meshes, sections or features. Based on the selected points, the circle can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points. Using the statistical methods, measuring point outliers can be eliminated during the best-fit process.	 Example: The circle was created through several selected points by means of the best-fit principle.

Projected Best-Fit Circle	Creates a circle according to the best-fit principle based on selected 3D meshes, sections or features and projects it onto a plane chosen by the user. Based on the selected points, the circle can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points. Using the statistical methods, measuring point outliers can be eliminated during the best-fit process.	 Example: Projected best-fit circle, created from the selected points (red) of a section.  Example: Projected best-fit circle with mesh data.

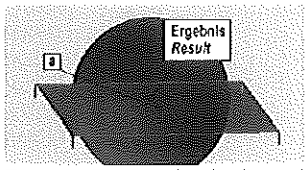
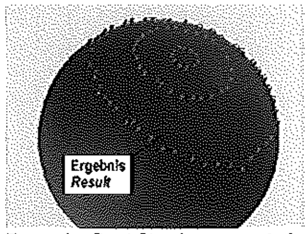
Primitive Slotted Hole

Point-Normal-Direction Slotted Hole	Creates a slotted hole based on externally entered values or derived from other primitives or feature elements. This function is mainly used for the nominal/actual comparison of a slotted hole if the nominal element is created manually by entering data. The function requires the following information: **Point** (center point coordinates), **Normal**, **Direction**, **Length**, **Width**.	 Example
5-Points Slotted Hole	Creates a slotted hole by clicking on five points on the edge (circular area) of a slotted hole in the CAD data. This function is used for the nominal/actual comparison of slotted holes.	 Example

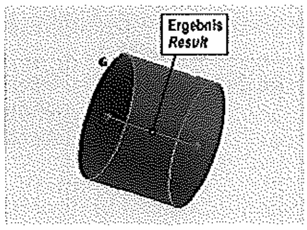
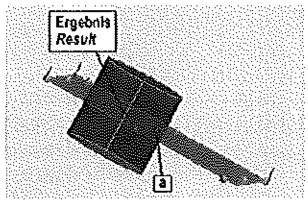
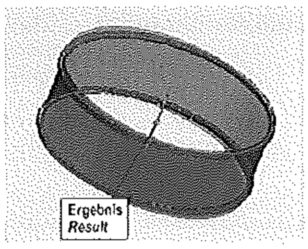
Primitive Rectangular Hole

Point-Normal-Direction Rectangular Hole	Creates a rectangular hole based on externally entered values or derived from other primitives or feature elements. This function is mainly used for the nominal/actual comparison of a rectangular hole if the nominal element is created manually by entering data. The function requires the following information: **Point** (center point coordinates), **Normal**, **Direction**, **Length**, **Width**.	 Example
5-Points Rectangular Hole	Creates a rectangular hole by clicking on five points on the edge of a rectangular hole in the CAD data. This function is used for the nominal/actual comparison of rectangular holes.	 Example

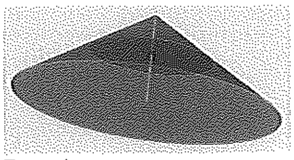
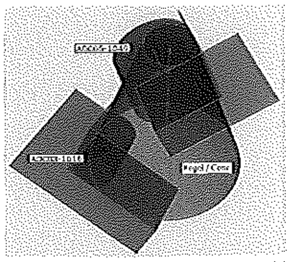
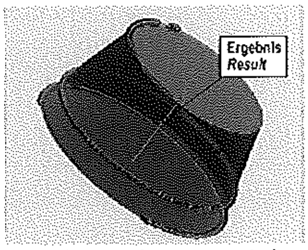
Primitive Sphere

Point-Radius Sphere	Creates a sphere by means of stating the center of the sphere and the radius. The radius can be defined by selecting the points or by entering the radius value directly.	 Example: Freely defined sphere with the center on plane (a). The center of the sphere was determined by selecting a point with Ctrl and left mouse button.
Best-Fit Sphere	Creates a sphere according to the best-fit principle based on selected 3D points or sections that can determine a sphere. If the radius of the sphere is known, you may enter it to support the best-fit function by means of **Radius**. Based on the selected points, the sphere can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points. Using the statistical methods, measuring point outliers can be eliminated during the best-fit process.	 Example: Best-fit sphere, created on a previously selected spherical point cloud.

Primitive Cylinder

Point-Point-Radius Cylinder	Creates a cylinder through two points. **Point 1** determines the beginning of the cylinder's rotation axis. **Point 2** determines the end point of the rotation axis. Use **Radius** to adjust the circumference of the cylinder.	 Example: The cylinder was created based on a line. The end points of the line were created with Ctrl and left mouse button. The radius was entered as value.
Point-Direction-Radius Cylinder	Creates an aligned cylinder by means of a point and a direction. **Point** determines the center of the cylinder. **Direction** determines the direction of the rotation axis. You can adjust the cylinder by means of **Radius** and **Length**.	 Example: Cylinder perpendicular to plane (a). The center of the cylinder is a point that was selected on the plane. This plane is also used to determine the direction.
Best-Fit Cylinder	Creates a cylinder according to the best-fit principle based on selected 3D points or sections that can determine a cylinder. Based on the selected points, the cylinder can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points. Using the statistical methods, measuring point outliers can be eliminated during the best-fit process. If the radius of the cylinder or/and the direction of the cylinder is known, you may enter these values to support the best-fit function by means Radius or Direction.	 Example: Best-fit cylinder, created on previously selected (red) points.

Primitive Cone

Point-Direction-Angle Cone	Creates a directed cone based on a **Point**, a **Direction** and an **Angle**. Under Construction conditions you can select the condition you would like to use. You define the circle radius of the cone around the defined point by using **Radius by point** or **Radius by value**. The **Length** of the cone can be manually adjusted as you like.	 Example
2-Cylinder-Adapter Cone	Creates a cone based on two cylinder adapters.	 Example: Cone (here displayed in red) which was created from 2 cylinder adapters.
Best-Fit Cone	Creates a cone according to the best-fit principle based on selected 3D points or sections that can determine a cone. Based on the selected points, the cone can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points. Using the statistical methods, measuring point outliers can be eliminated during the best-fit process. If the direction of the cone is known, you may enter it to support the best-fit function by means of Direction.	 Example: Best-fit cone, created on previously selected (red) points.

More Primitives

Best-Fit Paraboloid	Creates a paraboloid. Based on the selected points, the paraboloid can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points.	no figure

F 3 Export Documentation as Tables

Menu item **File ▶ Export ▶ Tables** provides for exporting all or selected data as complete result documentation or as data lists. For this purpose, different templates are available in ASCII, HTML and OpenOffice (open source software) format.

The export process is set up as a wizard.

You also have the possibility to create a user-defined export template with the data you are interested in. Hierarchy levels provide for structuring the data and for filling headers and footers for the individual paragraphs and/or for the entire export file in addition to their respective contents. The context menu of the right mouse button is used to insert the data available for the respective paragraph by means of keywords. In addition, you may insert control characters and other special characters.

The exported data then is available for further applications (e.g. Excel).

You will find additional information and an example of creating a simple user-defined ASCII export template in the Online Help.

F 4 Summary

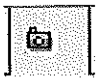
- Deformation reference stage
- Displacement fields
- Measure point positions
- Measure distances
- Measure angles
- 6DoF and relative 6DoF analysis
- Primitives
- Export tables

Chapter G - Table of Contents (rev-a)

G Reports and Documentation

G 1 Standard Reports

Deformation results can clearly be illustrated in reports. Several report templates are available. Based on these standard report templates you may easily present your measuring results. However, you may design reports individually and save them as user-defined templates.

All reports you create are available in the sub explorer under tab **Reports** and tab **Image Series**.

PONTOS standard reports may contain images and/or diagrams.

As image, automatically the selected image for each stage is inserted but the standard diagrams are empty and need to be filled with the data you are interested in. You may automatically include all analyses you made in your measuring projects into a report when creating the report or you may add them later.

For further information, please refer to the Online Help.

G 2 Extended Report Functions

G 2.1 Create and Edit User-Defined Reports

Using report template **Report (blank)**, you create a blank sheet of paper on which you may design your own report.

For designing a report, several elements are available. The software distinguishes between the following element types:

- Drawn elements (like lines, ellipses, etc.)
- Images
- Diagrams
- Legends
- Text labels
- Logos

You may modify each of these elements in position, appearance and shape. Double clicking on an element opens a dialog window with the editing options available for the selected element which are distributed to the respective tabs.

To certain elements (images or diagrams) you need to assign the data you are interested in so that they can be displayed accordingly in your report. This assignment is also done using the specific tabs.

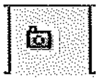
Legends always have to be connected with the element to which they refer.

You may use text labels to insert text information into a report. You may write free text or insert certain keywords using the context menu of the right mouse button.

For further information, please refer to the Online Help.

G 2.2 Image Series and Movies

An image series is a sequence of individual images (one file per image, file name is numbered consecutively) which is created, for example, from camera images, 2D images, the 3D view or from the images of a report. An image series may also contain images of an external camera which can be imported.



All image series are listed in the sub explorer under the respective tab. Camera image series and the image series from all created reports are available by default and do not need to be created separately.

You may integrate image series in reports. Thus, for example, it is possible to display 3D views interesting for you through all stages or the image series of an external camera for documentation purposes. In this case, however, the number of the external images must be identical to the number of stages in your project.

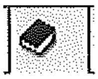
An internal image player provides for playing the image series and checking them prior to e.g. export them.

When exporting an image series, you may decide if you would like to export the series as individual images or as a movie (video). A video combines the images in the .avi or .mpeg format in one file which you may play also using an external player. You may define the format in the preferences.

For further information, please refer to the Online Help.

G 2.3 Snapshots

With the snapshot function you may save a screenshot of the 3D view or of the 2D images as an image in order to use it, for example, as reports and result representations. A snapshot is a static image that does not change through the stages. If you want to, you may also print a snapshot directly from the software. Several predefined default templates provide for easy editing of a snapshot for report purposes.



All snapshots are displayed in the sub-explorer under tab **Documentation**.

G 2.3.1 Advanced Snapshot Functions

<u>Creating Snapshot Templates</u>

In addition to the default snapshot templates supplied, you may create own templates any time. First, the software creates an empty snapshot that you may design individually by using the functions for editing snapshot elements. You may edit snapshot elements in the same way as report elements (see also G 2.1). If the template is ready, you may save it as template.

G 3 Documentation

When you have finished your measuring task including all the required steps, you may prepare a documentation from the available data which may contain image elements, text elements and value tables. Using such a documentation, you may present your measuring results demonstratively.

G 3.1 Documentation Preparation

Menu item **Documentation** offers different possibilities to prepare report documentation. The elements created here appear in the sub-explorer under **Documentation** with a corresponding headline. All elements that are listed may later be exported as tables in the order in which they appear in the explorer (see also Chapter F). You may change the order in the explorer using the right mouse button menu.

Info

Except for the snapshots, all elements listed in the documentation container are virtual export data and cannot be looked at in PONTOS.

G 3.1.1 Chapter Titles

The software provides for defining a chapter headline under which data selected later is to be listed in the documentation template.

G 3.1.2 Compiling Documentation Data

Using menu item **New Documentation Data**, you define which elements you would like to integrate into the documentation. For this purpose, select the respective elements in the explorer. They will then be added to the documentation container in the explorer.

G 4 Deformation Results on TRITOP Images

For very small deformations which can well be illustrated by means of a static image, you may display your PONTOS deformation results on a TRITOP camera image, provided you carried out a complete TRITOP measuring project prior to your deformation project. For this purpose, load the TRITOP project as new stage into your deformation project, transform it to the basic stage and identify it. Then, in your report, select the image of the TRITOP stage.

Info

For this function, you need a TRITOP license.

G 5 Summary

- Standard reports
- Create and edit reports
- Use image series and movies
- Creating snapshots
- Creating snapshot templates
- Preparing documentation data
- Display deformation results on TRITOP images

Chapter H - Table of Contents (rev-a)

H Automation and Functional Extensions

H 1 Macros

H 1.1 Automation

For recurrent deformation projects with very complex analysis elements, the PONTOS software provides for recording macro scripts based on Python. Thus, automation of individual processing steps is possible.

You may easily generate a new macro by creating a new, empty macro, start recording, carry out the desired operating steps, stop recording and save the macro.

You may modify macro commands in the editor any time using the context menu of the right mouse button on the respective command. If you have the necessary knowledge, you may also change the script directly in the syntax.

In addition, you may include a macro into another macro.

For more detailed information about scripts and programming, please refer to the expert manual "GOM Scripting Language".

H 1.2 Functional Extensions

For very exceptional and special measuring tasks, you may have user-specific macros created by GOM which extend the functions of the PONTOS software.

H 2 Summary

- Automation due to macros
- Functional extensions by macros

Chapter J - Table of Contents (rev-a)

J Support

J 1 Where Do You Find Help?

If you face a problem, you will find help at several places.

J 1.1 Manuals / Online Help

In the software, you will find in menu item **Help** not only the Online Help but also a document overview of all available manuals. If you do not have them as paper version, you may look at the texts here in pdf format.

J 1.2 FAQs

If you have the corresponding access information, you may reach the English FAQ area (Frequently Asked Questions) via the internet (http://support.gom.com/) and find responses to frequently asked questions.

J 1.3 Distributor

If you cannot solve a problem yourself and do not find answers in the other help sources, please contact your responsible distributor or your contact partner in your country first.

J 1.4 Support Form

If your problem cannot be solved using the above mentioned methods, you may send your support request to GOM using the request form available in the internet (http://support.gom.com/). This form is also available without login.

J 1.5 Direct Support

You also reach the GOM support by
email address: support@gom.com
or
phone number: +49 531 39029 0

J 2 Useful Support Data

J 2.1 Creating Support Data

If you have a technical problem (e.g. hardware or software crash) you may create a compressed analysis file using menu item **Help ▶ Collect Support Data** and entering the root password, and send this file to the GOM support.

J 2.2 Snapshots in Linux Measuring System

It might also be helpful to include in your support request a snapshot of your current screen.

Open the KDE start menu (see Chapter A) and navigate to **Utilities ▶ Desktop ▶ KSnapshot**. Create a snapshot and add it to your support request.

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J 2.3 Movies of Screen Actions in Linux Measuring System

In some cases it might be useful for handling your support request to document the order of certain screen action by means of a little movie.

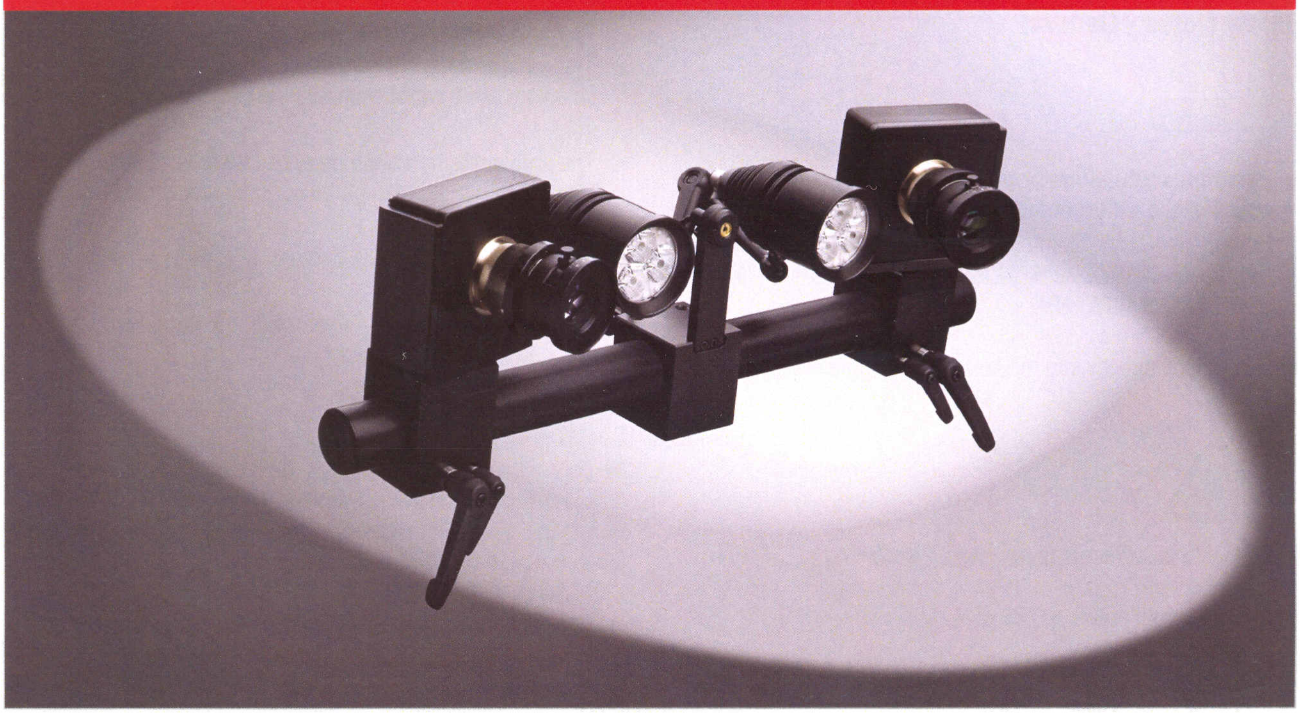
Click on the respective icon on your desktop. This starts recording. Now, carry out the required actions and finally stop the recording. Send the resulting two files to the GOM support.

J 3 Troubleshooting Measuring System

Problem:	Remedy:
The Linux PC is "frozen" but the mouse pointer can still be moved.	Press Ctrl and Alt and Backspace ← and log in again.
The Linux PC is "frozen" and the mouse pointer cannot be moved, or the mouse pointer can be moved but the keyboard does not respond.	Switch the PC off and on again.
The PONTOS software is "frozen" and other applications work.	Click with the mouse pointer on the open windows and press Escape. If necessary, repeat several times. If you do not succeed, press Ctrl and Alt and ← and log in again or use Ctrl, Alt, Esc and left mouse button to quit the application.
How can I change the language of the PONTOS application software?	For this purpose, open menu item **Edit ▶ Preferences ▶ Preferences ▶ General** and select the desired language in the selection list under **Language**. Confirm the selection with **OK**. When starting the program again, the application software appears in the newly selected language.
How can I change the language of the Project Keywords?	In the project keyword window click on button **Edit**, then click with the right mouse button onto the list and select **Add Defaults**. Select the required language and confirm with **OK**.
What shall I do if I cannot achieve the desired calibration values?	Check if the sensor is configured correctly. In addition, verify if the calibration object is screwed tight correctly and has not been moved.
How do I know if I need to calibrate the system again?	If in tab **Object Points** you move the horizontal scroll bar totally to the right, you may see the values of the **Intersection error**. If the value is too high, you should calibrate the system again.
I cannot work with the PONTOS project. The stages in the explorer are highlighted in gray.	The project is already open in a PONTOS application. This effect may occur after the computer crashed and thus, temporary **lock** files were not correctly deleted.
Loading CAD data is not possible with the CAD converter.	The CAD converter identifies the CAD data only by the file extension. Therefore, correct spelling of the file extension is absolutely required.
The best-fit function does not work correctly in connection with primitives.	The reason could be a wrong selection in the 3D view. Deselect all, then select again and repeat the best-fit function.
May I select an area for a displacement field in the 2D camera image as well?	Yes. You then select those points that were seen by the camera.
I cannot play the image series I saved in .mpeg format with external players, why?	You created an image series from the original camera images. You should not use the .mpeg format for that, as during the export, the original image size of the camera is used but the mpeg specification requires a lower resolution. For image series created from reports, the mpeg format does not cause any problems!
PONTOS cannot overwrite CD or DVD-RW media.	Delete the media completely by means of an external program.

PONTOS

User Information - Hardware



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PONTOS 5M (Adjustable Base)
PONTOS 4M (Adjustable Base)
PONTOS HS (Adjustable Base)

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gom
Optical Measuring Techniques

Legal and Safety Notes

Symbols

In this user manual the following standard signal words may be used:

⚠WARNING	This label points to a situation that might be dangerous and could lead to serious bodily harm or to death.
⚠CAUTION	This label points to a situation that might be dangerous and could lead to light bodily harm.
NOTICE	This label points to a situation in which the product or an object in the vicinity of the product might be damaged.
Info	This label indicates important application notes and other useful information.

Safety Notes - General

⚠WARNING

- **Hazardous situations or processes may result on account of the different test setups used for deformation tests.**
  Therefore, always observe the valid, pertinent accident prevention regulations.

- Do not look directly into the laser light, danger of retina burn.

- The used laser meets **laser class 1** according to DIN EN 60 825-1
  (optical output power < 0,39 mW,
  wavelength 650 nm).
- Do not use equipment connected to AC power during heavy thunderstorms. Due to voltage variations and transient voltages in the low-voltage network, malfunctions and dangerous voltages between housing and other components may occur.
- In extreme positions, stands with horizontal extension arms may fall over. Avoid such positions. Use the product only on a safe and steady ground.
- When measuring large objects, make sure you comply with the respective valid accident prevention regulations.

⚠CAUTION

- Operate the equipment only with the operating voltages printed on the housing. Using an incorrect operating voltage may cause malfunctions or the risk of fire.
- Check cables and, if damaged, replace them by all means. Protect the cables from mechanical load (squeezing, tension, etc.). Damaged cables may cause short-circuits and the risk of fire.
- AC power connection of the unit must comply with the valid regulations of the respective countries.
- Replace fuses only with components having the same specifications.

NOTICE

- Never unplug or connect cables during operation!
- The devices must not come into contact with water. For cleaning, use a moist cloth but first disconnect the power plug.
- The ambient temperature must be between +5 and +40 °C. Make sure no rapid temperature variations occur that might cause condensation.
- The housing may only be opened by experts when no voltage is applied.
- Do not stick any strange objects into the housing.

Legal Notes

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Table of Contents

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1. Introduction

This user information is intended for qualified personnel who has experience in handling measuring systems and basic PC knowledge (windows-based programs and operating systems).

This user information is configured to the transfer of knowledge of system installation, sensor settings, camera adjustment and other hardware relevant information.

Info

The PONTOS system is a measuring system that also addresses experts of digital optical deformation analysis. Therefore, it is unavoidable that the PONTOS software contains menu items not intended for the standard user. Improper use of these menu items (expert parameters) may cause incorrect measurements.
For being able to make optimum use of the system, we assume the ability to visualize in 3D and a color vision ability.

This user information is divided into the following sections:

- The first page informs about important safety aspects.
- Section 1 gives basic information about the PONTOS system.
- Section 2 describes the system variants.
- Section 3 contains tables with the sensor configurations.
- Section 4 informs about the sensor control elements.
- Section 5 describes the fast setup of the sensor.
- Section 6 describes the complete setup of the sensor.
- Section 7 describes how to adjust the polarization filters.
- Section 8 contains important user information about the PC.
- Section 9 describes the sensor controller.
- Section 10 informs about the calibration and contains calibration information for external image series that were not recorded with the PONTOS standard systems.
- Section 11 illustrates the sensor dimensions.
- Section 12 contains the cabling of the systems.

2. The PONTOS System Variants

System types	PONTOS 5M	PONTOS 4M	PONTOS HS
Measuring volume in mm^3	10x8 to 5000x4150	10x7 to 4000x2900	10x8 to 3500x2800
Camera resolution	2448 x 2050 pixels	2352 x 1728 pixels	1280 x 1024 pixels
Camera chip	2/3 inch, CCD	1 inch, CMOS	1 inch, CMOS
Connection camera to PC	Gigabit-Ethernet via sensor controller	Camera Link	Camera Link
Main hardware components	▪ 19" PC ▪ Sensor ▪ Sensor controller ▪ LED lighting	▪ 19" PC ▪ Sensor ▪ Sensor controller ▪ LED lighting	▪ 19" PC ▪ Sensor ▪ Sensor controller
Laser pointer	yes	yes	yes
LED lighting with polarization filters	yes (10° or 30°)	yes (30°)	no
Measuring results	3D coordinates, 3D displacements, deformation		
For further information see http://www.gom.com			

The maximum image rate is fixed for the 5M and 4M cameras. For the high-speed camera (HS), higher frame rates can be achieved by dividing the height of the image size in half. The following table shows the frame rates of the different cameras with the respective image size and informs about the typical max. possible number of images.

Camera	Image size	Frequency in Hz BV RAM	No. of images BV RAM	Frequency in Hz PC RAM	No. of images 16 GB PC RAM	No. of images 32 GB PC RAM
5M	1 (max. camera resolution)	-	-	15	600	1300
	2x2 Binning	-	-	29	600	1300
4M	1 (max. camera resolution)	-	-	60	700	1600
	1/2	-	-	120	1400	3200
	1/4	-	-	240	2800	6400
	1/8	-	-	480	5600	10000
HS	1 (max. camera resolution)	500	800	40	2550	5600
	1/2	1000	1600	40	5100	10000
	1/4	2000	3200	40	10000	10000
	1/8	4000	6387	40	10000	10000

2.1 Main Hardware and Software Components

- High-performance 64 bit PC
- Up to 1GB memory per frame grabber board (HS)
- Two (high-speed) cameras
- Stand for secure and steady hold of the cameras
- LED lighting (standard for PONTOS 4M and 5M)
- Sensor controller for power supply of the cameras and to control image recording
- Laser pointer for easy setup of the sensor
- PONTOS application software and Linux system software
- Calibration object

For directly operating the sensor with the PONTOS application software, a Linux operating system is required.

Info

As of software version 6.1.1, the PONTOS software is also available on Windows systems. In this case, you cannot connect sensors (cameras) and the sensor controller!

3. General Information

Prior to start measuring, the respective measuring volume has to be selected depending on the measuring object size and on the distance to the measuring object. The measuring volume determines the set of lenses.

The following tables give an overview of the calibrated measuring volumes which can be achieved with your system components.

3.1 Overview: Sensors, Lenses, Camera Support → Measuring Volumes

		Measuring volume			
Camera support		500 mm (lenght)		800 mm (lenght)	
Camera angle		25°	25°	25°	25°
Sensors	Lenses (f in mm)	Min. Range	Max. Range	Min. Range	Max. Range
		Length x Width in mm			
PONTOS 5M	**8**	190 x 180	900 x 820	190 x 180	1550 x 1400
	12	130 x 110	610 x 540	130 x 110	1050 x 930
	17	90 x 75	440 x 380	90 x 75	760 x 650
	23	60 x 50	320 x 270	60 x 50	560 x 480
	35	35 x 29	210 x 170	35 x 29	370 x 310
	50	17 x 14	140 x 120	17 x 14	250 x 210
	65	10 x 8	100 x 85	10 x 8	190 x 150
	100	10 x 8	60 x 50	10 x 8	120 x 100
PONTOS 4M	**20**	130 x 100	710 x 560	130 x 100	1250 x 980
	35	60 x 48	410 x 310	60 x 48	720 x 550
	50	29 x 21	280 x 200	29 x 21	500 x 370
	65	20 x 14	200 x 150	20 x 14	380 x 280
	100	10 x 7	120 x 90	10 x 7	240 x 170
PONTOS HS	**20**	110 x 95	640 x 540	110 x 95	1100 x 940
	28	75 x 60	450 x 380	75 x 60	800 x 660
	35	50 x 43	360 x 290	50 x 43	640 x 530
	50	22 x 17	250 x 200	22 x 17	450 x 360
	100	10 x 8	110 x 85	10 x 8	210 x 160

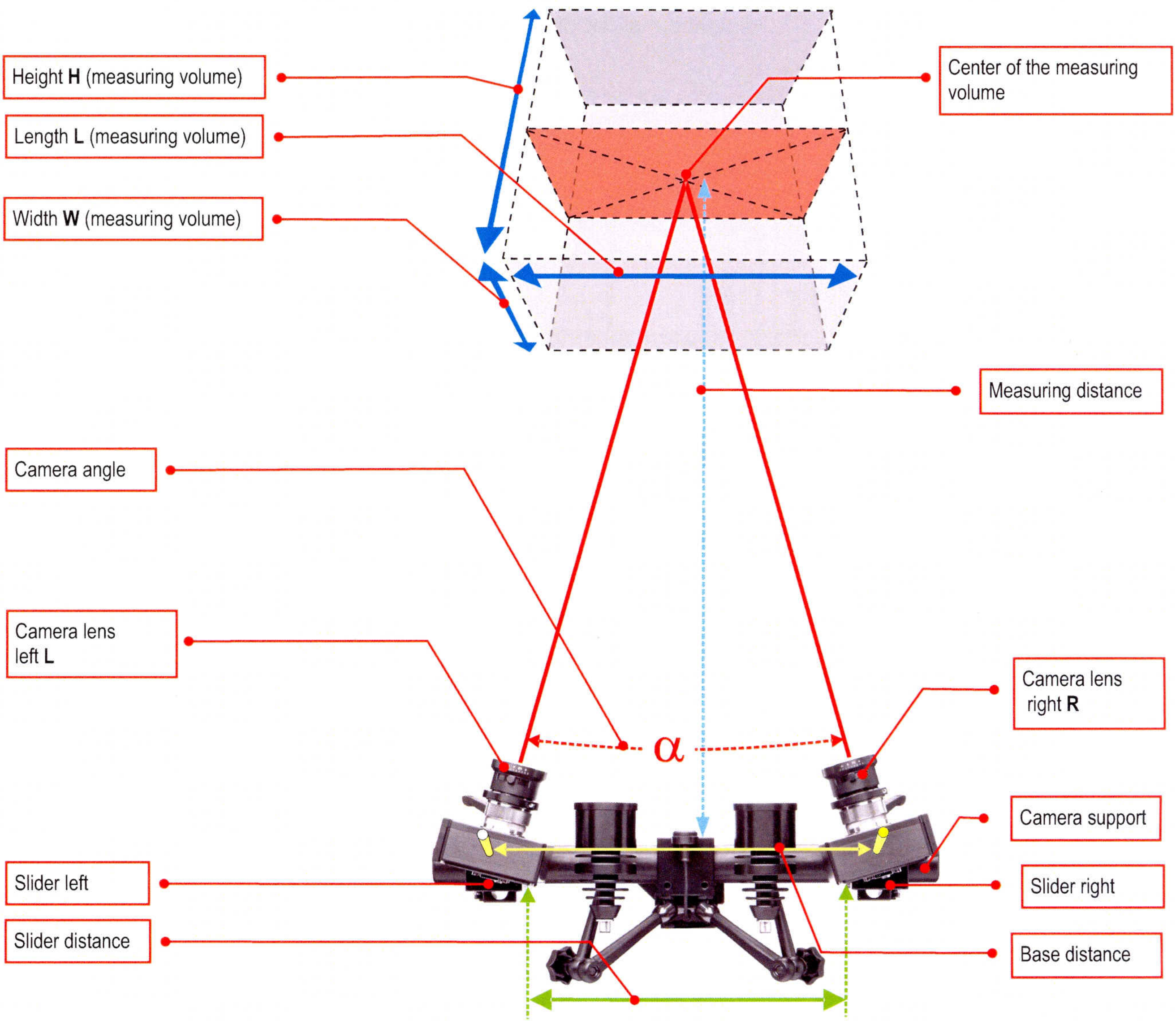
3.2 Overview: Calibration Objects → Measuring Volumes

Calibration objects	Measuring volume		
	PONTOS 4M	**PONTOS 5M**	**PONTOS HS**
	Length x Width [mm]	Length x Width [mm]	Length x Width [mm]
CQ 10x8	10 x 7 ... 13 x 10	9 x 8 ... 13 x 11	9 x 7 ... 13 x 10
CQ 15x12	15 x 11 ... 19 x 14	13 x 11 ... 19 x 16	14 x 11 ... 19 x 15
CQ 23x18	23 x 17 ... 29 x 21	21 x 18 ... 29 x 24	22 x 18 ... 29 x 23
CQ 30x24 **CP20 30x24**	30 x 22 ... 50 x 37	26 x 22 ... 50 x 42	28 x 22 ... 50 x 40
CQ 55x44 **CP20 55x44**	50 x 37 ... 90 x 65	44 x 37 ... 90 x 75	46 x 37 ... 90 x 70
CP20 90x72	90 x 65 ... 130 x 95	80 x 65 ... 130 x 110	80 x 65 ... 130 x 100
CP20 175x140	150 x 110 ... 200 x 150	130 x 110 ... 200 x 170	140 x 110 ... 200 x 160
CP20 250x200	230 x 170 ... 370 x 270	200 x 170 ... 370 x 310	210 x 170 ... 370 x 300
CP20 350x280	340 x 250 ... 500 x 370	300 x 250 ... 500 x 420	310 x 250 ... 500 x 400
CC20 500x400	530 x 390 ... 670 x 490	470 x 390 ... 670 x 560	490 x 390 ... 670 x 540
CC20 700x560	710 x 520 ... 890 x 650	620 x 520 ... 890 x 750	650 x 520 ... 890 x 710
CC20 1000x800	880 x 650 ... 1300 x 960	780 x 650 ... 1300 x 1100	810 x 650 ... 1300 x 1050
CC20 1400x1120	1250 x 920 ... 1600 x 1200	1100 x 920 ... 1600 x 1350	1150 x 920 ... 1600 x 1300
CC20 2000x1600	1750 x 1300 ... 2350 x 1750	1550 x 1300 ... 2350 x 1950	1650 x 1300 ... 2350 x 1900

Info Prior to initial commissioning of the PONTOS system, the sensor must be adjusted. The angle relations of the lenses, the focus and the aperture need to be set. Then, the complete system is calibrated by means of calibration panels or calibration crosses. If the measuring volume is adjusted successfully by calibration, you may start a measuring project.

Info In practice, depending on the measuring task, different measuring volumes might be required. You only need to adjust the sensor again if the measuring distance or the angle relations of the cameras or the adjustments of the camera lenses have to be changed because of a different measuring volume.

3.3 Definition of Terms



The figure shows a 3D sensor unit in top view.

3.4 Sensor Configuration Examples

3.4.1 Sensor Configuration Examples for PONTOS 4M (2358x1728 Pixel)

Info

The following table values are examples. The sensor may also operate with measuring volumes that result between the values stated in the table. In such a case, you need to interpret the values for the measuring distance and the slider distance accordingly.

When using these measuring volumes, it is important to keep the aperture as closed as possible to achieve a high depth of field. For the sensors, the following relation applies for a camera angle of 25°: Base distance = slider distance + 39 mm.

3.4.1.1 20 mm Lens (PONTOS 4M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
20mm, lens family A1 (Titanar)	125 x 90	1)	500	---	195	66	27	CP20 90x72	---	---	n.a.	n.a.	5.5	21	41	78	>125	>125
	150 x 110	1)	500	---	230	74	25	CP20 175x140	---	---	n.a.	2.9	18	41	72	130	>150	>150
	175 x 130	1)	500	---	260	88	25	CP20 175x140	---	---	n.a.	9.5	30	61	100	>175	>175	>175
	200 x 150	---	500	---	290	102	25	CP20 175x140	---	---	n.a.	18	44	86	140	>200	>200	>200
	250 x 180	---	500	---	355	130	25	CP20 250x200	---	---	12	43	85	150	>250	>250	>250	>250
	300 x 220	---	500	---	415	156	25	CP20 250x200	---	---	30	73	130	240	>300	>300	>300	>300
	350 x 260	---	500	---	480	186	25	CP20 350x280	---	---	54	110	200	>350	>350	>350	>350	>350
	400 x 290	---	500	---	545	214	25	CP20 350x280	---	---	85	170	290	>400	>400	>400	>400	>400
	500 x 370	---	500	---	670	270	25	CP20 350x280	---	---	160	300	>500	>500	>500	>500	>500	>500
	750 x 550	---	800	---	985	410	25	CC20 700x560	---	---	470	>750	>750	>750	>750	>750	>750	>750
	1000 x 730	---	800	---	1285	542	25	CC20 1000x800	---	---	970	>1000	>1000	>1000	>1000	>1000	>1000	>1000
	1250 x 920	---	800	---	1600	682	25	CC20 1400x1120	---	---	>1250	>1250	>1250	>1250	>1250	>1250	>1250	>1250
	1500 x 1100	---	800	---	1900	688	21	CC20 1400x1120	---	---	>1500	>1500	>1500	>1500	>1500	>1500	>1500	>1500

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.1.2 35 mm Lens (PONTOS 4M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
35mm, lens family A1 (Titanar)	65 x 48	1)	500	---	215	68	25	CQ/CP20 55x44	---	n.a.	n.a.	n.a.	n.a.	n.a.	5.1	14	---	---
	80 x 60	1)	500	---	240	80	25	CQ/CP20 55x44	---	n.a.	n.a.	n.a.	n.a.	2.1	9.6	22	---	---
	100 x 75	---	500	---	285	98	25	CP20 90x72	---	n.a.	n.a.	n.a.	n.a.	9	21	41	---	---
	125 x 90	---	500	---	335	120	25	CP20 90x72	---	n.a.	n.a.	n.a.	5.2	19	37	68	---	---
	150 x 110	---	500	---	385	144	25	CP20 175x140	---	n.a.	n.a.	n.a.	13	33	58	100	---	---
	175 x 130	---	500	---	440	168	25	CP20 175x140	---	n.a.	n.a.	5.6	24	51	86	150	---	---
	200 x 150	---	500	---	495	192	25	CP20 175x140	---	n.a.	n.a.	14	37	73	120	>200	---	---
	250 x 180	---	500	---	600	240	25	CP20 250x200	---	n.a.	6.6	34	70	130	200	>250	---	---
	300 x 220	---	500	---	705	286	25	CP20 250x200	---	n.a.	22	61	110	200	>300	>300	---	---
	350 x 260	---	500	---	810	332	25	CP20 350x280	---	7.9	43	95	170	280	>350	>350	---	---
	400 x 290	---	500	---	920	382	25	CP20 350x280	---	23	69	140	230	390	>400	>400	---	---
	500 x 370	---	800	---	1130	474	25	CP20 350x280	---	63	130	240	400	>500	>500	>500	---	---
	750 x 550	---	800	---	1660	688	24	CC20 700x560	---	230	390	650	>750	>750	>750	>750	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.1.3 50 mm Lens (PONTOS 4M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
50mm, lens family A1 (Titanar)	25 x 18	1)	500	25	205	66	26	CQ 23x18	---	---	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	---	---
	35 x 26	1)	500	12.5	225	70	25	CQ/CP20 30x24	---	---	n.a.	n.a.	n.a.	n.a.	n.a.	1.8	---	---
	50 x 37	1)	500	12.5	260	88	25	CQ/CP20 55x44	---	---	n.a.	n.a.	n.a.	n.a.	0.5	5.8	---	---
	65 x 48	---	500	---	305	108	25	CQ/CP20 55x44	---	---	n.a.	n.a.	n.a.	n.a.	4.6	13	---	---
	80 x 60	---	500	---	345	126	25	CQ/CP20 55x44	---	---	n.a.	n.a.	n.a.	2.1	9.6	22	---	---
	100 x 75	---	500	---	400	150	25	CP20 90x72	---	---	n.a.	n.a.	n.a.	7.6	19	38	---	---
	125 x 90	---	500	---	475	184	25	CP20 90x72	---	---	n.a.	n.a.	4.1	18	35	65	---	---
	150 x 110	---	500	---	550	216	25	CP20 175x140	---	---	n.a.	n.a.	12	32	57	99	---	---
	175 x 130	---	500	---	625	250	25	CP20 175x140	---	---	n.a.	4.6	22	49	82	140	---	---
	200 x 150	---	500	---	695	282	25	CP20 175x140	---	---	n.a.	11	34	68	110	190	---	---
	250 x 180	---	500	---	845	348	25	CP20 250x200	---	---	4.7	31	66	120	190	>250	---	---
	300 x 220	---	800	---	995	414	25	CP20 250x200	---	---	20	57	110	180	280	>300	---	---
	350 x 260	---	800	---	1140	480	25	CP20 350x280	---	---	38	88	160	260	>350	>350	---	---
	400 x 290	---	800	---	1290	546	25	CP20 350x280	---	---	62	130	220	350	>400	>400	---	---
	500 x 370	---	800	---	1590	678	25	CP20 350x280	---	---	120	230	370	>500	>500	>500	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

pontos_hw-5m-4m-hs-adjustable_en_rev-c 22-Sep-2009

3.4.1.4 65 mm Lens (PONTOS 4M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
65mm, lens family A1 (Titanar)	20 x 15	1)	500	50	260	86	25	CQ 15x12	---	---	---	---	---	---	---	n.a.	---	---
	25 x 18	---	500	37,5	270	92	25	CQ 23x18	---	---	---	---	---	---	---	n.a.	---	---
	35 x 26	---	500	25	295	104	25	CQ/CP20 30x24	---	---	---	---	---	---	---	1.3	---	---
	50 x 37	---	500	12,5	345	126	25	CQ/CP20 55x44	---	---	---	---	---	---	---	5.9	---	---
	65 x 48	---	500	12,5	395	148	25	CQ/CP20 55x44	---	---	---	---	---	---	---	12	---	---
	80 x 60	---	500	12,5	455	174	25	CQ/CP20 55x44	---	---	---	---	---	---	---	22	---	---
	100 x 75	---	500	---	530	208	25	CP20 90x72	---	---	---	---	---	---	---	38	---	---
	125 x 90	---	500	---	625	250	25	CP20 90x72	---	---	---	---	---	---	---	63	---	---
	150 x 110	---	500	---	720	292	25	CP20 175x140	---	---	---	---	---	---	---	95	---	---
	175 x 130	---	500	---	815	334	25	CP20 175x140	---	---	---	---	---	---	---	130	---	---
	200 x 150	---	500	---	915	378	25	CP20 175x140	---	---	---	---	---	---	---	180	---	---
	250 x 180	---	800	---	1105	462	25	CP20 250x200	---	---	---	---	---	---	---	>250	---	---
	300 x 220	---	800	---	1300	550	25	CP20 250x200	---	---	---	---	---	---	---	>300	---	---
	350 x 260	---	800	---	1495	636	25	CP20 350x280	---	---	---	---	---	---	---	>350	---	---
	400 x 290	---	800	---	1695	688	24	CP20 350x280	---	---	---	---	---	---	---	>400	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.1.5 100 mm Lens (PONTOS 4M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
100mm, lens family A2 (Titanar)	10 x 7	---	500	162,5	415	158	25	CQ 10x8	---	---	---	---	n.a.	n.a.	n.a.	n.a.	0.1	0.9
	15 x 11	---	500	112,5	390	146	25	CQ 15x12	---	---	---	---	n.a.	n.a.	n.a.	n.a.	0.3	2.4
	20 x 15	---	500	75	395	148	25	CQ 15x12	---	---	---	---	n.a.	n.a.	n.a.	n.a.	0.8	3.3
	25 x 18	---	500	62,5	410	154	25	CQ 23x18	---	---	---	---	n.a.	n.a.	n.a.	n.a.	1.9	5.5
	35 x 26	---	500	37,5	455	174	25	CQ/CP20 30x24	---	---	---	---	n.a.	n.a.	n.a.	1.7	5.4	12
	50 x 37	---	500	25	525	206	25	CQ/CP20 55x44	---	---	---	---	n.a.	n.a.	0.5	5.9	12	23
	65 x 48	---	500	25	605	242	25	CQ/CP20 55x44	---	---	---	---	n.a.	n.a.	4	13	23	40
	80 x 60	---	500	12,5	685	276	25	CQ/CP20 55x44	---	---	---	---	n.a.	1.6	8.9	21	36	60
	100 x 75	---	500	12,5	800	328	25	CP20 90x72	---	---	---	---	n.a.	7.1	18	37	59	97
	125 x 90	---	800	12,5	945	390	25	CP20 90x72	---	---	---	---	3.5	17	34	62	96	>125
	150 x 110	---	800	---	1085	452	25	CP20 175x140	---	---	---	---	11	29	53	93	140	>150
	175 x 130	---	800	---	1230	516	25	CP20 175x140	---	---	---	---	20	45	77	130	>175	>175
	200 x 150	---	800	---	1375	582	25	CP20 175x140	---	---	---	---	32	64	110	170	>200	>200
	250 x 180	---	800	---	1675	688	24	CP20 250x200	---	---	---	---	64	110	180	>250	>250	>250

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2 Sensor Configuration Examples for PONTOS 5M (2448x2050 Pixel)

Info

The following table values are examples. The sensor may also operate with measuring volumes that result between the values stated in the table. In such a case, you need to interpret the values for the measuring distance and the slider distance accordingly.

When using these measuring volumes, it is important to keep the aperture as closed as possible to achieve a high depth of field. For the sensors, the following relation applies for a camera angle of 25°: Base distance = slider distance + 50 mm.

3.4.2.1 8 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
8mm, lens family B	175 x 150	---	500	---	190	Mech. Stop	28	CP20 175x140	n.a.	18	45	89	160	>175	>175	---	---	---
	200 x 170	---	500	---	215	Mech. Stop	25	CP20 250x200	10	35	70	130	>200	>200	>200	---	---	---
	250 x 210	---	500	---	270	80	25	CP20 250x200	31	71	130	240	>250	>250	>250	---	---	---
	300 x 250	---	500	---	320	104	25	CP20 350x280	57	120	210	>300	>300	>300	>300	---	---	---
	350 x 290	---	500	---	375	128	25	CP20 350x280	93	180	320	>350	>350	>350	>350	---	---	---
	400 x 330	---	500	---	430	152	25	CP20 350x280	140	260	>400	>400	>400	>400	>400	---	---	---
	500 x 420	---	500	---	535	198	25	CC20 500x400	250	480	>500	>500	>500	>500	>500	---	---	---
	750 x 630	---	500	---	800	316	25	CC20 700x560	>750	>750	>750	>750	>750	>750	>750	---	---	---
	1000 x 840	---	800	---	1055	430	25	CC20 1000x800	>1000	>1000	>1000	>1000	>1000	>1000	>1000	---	---	---
	1250 x 1050	---	800	---	1320	546	25	CC20 1400x1120	>1250	>1250	>1250	>1250	>1250	>1250	>1250	---	---	---
	1500 x 1250	---	800	---	1570	660	25	CC20 1400x1120	>1500	>1500	>1500	>1500	>1500	>1500	>1500	---	---	---
	1750 x 1450	---	800	---	1820	688	23	CC20 2000x1600	>1750	>1750	>1750	>1750	>1750	>1750	>1750	---	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2.2 12 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
12mm, lens family B	125 x 100	---	500	---	205	Mech. Stop	26	CP20 90x72	n.a.	n.a.	11	29	54	94	>125	---	---	---
	150 x 130	---	500	---	245	70	25	CP20 175x140	n.a.	7.6	25	51	88	>150	>150	---	---	---
	175 x 150	---	500	---	280	86	25	CP20 175x140	n.a.	17	39	75	130	>175	>175	---	---	---
	200 x 170	---	500	---	320	104	25	CP20 250x200	6	28	59	110	180	>200	>200	---	---	---
	250 x 210	---	500	---	395	136	25	CP20 250x200	23	58	110	190	>250	>250	>250	---	---	---
	300 x 250	---	500	---	470	170	25	CP20 350x280	47	98	170	290	>300	>300	>300	---	---	---
	350 x 290	---	500	---	550	206	25	CP20 350x280	77	150	250	>350	>350	>350	>350	---	---	---
	400 x 330	---	500	---	625	238	25	CP20 350x280	110	210	350	>400	>400	>400	>400	---	---	---
	500 x 420	---	500	---	780	308	25	CC20 500x400	210	370	>500	>500	>500	>500	>500	---	---	---
	750 x 630	---	800	---	1160	476	25	CC20 700x560	590	>750	>750	>750	>750	>750	>750	---	---	---
	1000 x 840	---	800	---	1530	640	25	CC20 1000x800	>1000	>1000	>1000	>1000	>1000	>1000	>1000	---	---	---
	1250 x 1050	---	800	---	1915	688	22	CC20 1400x1120	>1250	>1250	>1250	>1250	>1250	>1250	>1250	---	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2.3 17 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm]: 1.4	2	2.8	4	5.6	8	11	16	22	32
17mm, lens family B	80 x 65	---	500	---	190	Mech. Stop	28	CP20 90x72	n.a.	n.a.	n.a.	3.4	13	27	45	---	---	---
	100 x 85	---	500	---	235	66	25	CP20 90x72	n.a.	n.a.	2.6	13	28	51	80	---	---	---
	125 x 100	---	500	---	290	90	25	CP20 90x72	n.a.	n.a.	11	27	50	86	>125	---	---	---
	150 x 130	---	500	---	340	112	25	CP20 175x140	n.a.	6	22	46	79	130	>150	---	---	---
	175 x 150	---	500	---	395	136	25	CP20 175x140	n.a.	15	36	69	120	>175	>175	---	---	---
	200 x 170	---	500	---	450	160	25	CP20 250x200	3.9	25	53	97	160	>200	>200	---	---	---
	250 x 210	---	500	---	555	208	25	CP20 250x200	20	53	97	170	>250	>250	>250	---	---	---
	300 x 250	---	500	---	660	254	25	CP20 350x280	41	89	150	260	>300	>300	>300	---	---	---
	350 x 290	---	500	---	765	300	25	CP20 350x280	69	130	220	>350	>350	>350	>350	---	---	---
	400 x 330	---	500	---	875	350	25	CP20 350x280	100	190	310	>400	>400	>400	>400	---	---	---
	500 x 420	---	800	---	1090	446	25	CC20 500x400	190	330	>500	>500	>500	>500	>500	---	---	---
	750 x 630	---	800	---	1620	680	25	CC20 700x560	520	>750	>750	>750	>750	>750	>750	---	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2.4 23 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm]: 1.4	2	2.8	4	5.6	8	11	16	22	32
23mm, lens family B	50 x 42	---	500	---	175	Mech. Stop	30	CQ/CP20 55x44	n.a.	n.a.	n.a.	n.a.	n.a.	5.3	12	---	---	---
	65 x 55	---	500	---	220	60	25	CQ/CP20 55x44	n.a.	n.a.	n.a.	0.6	6.7	16	28	---	---	---
	80 x 65	---	500	---	260	76	25	CP20 90x72	n.a.	n.a.	n.a.	4.7	14	27	44	---	---	---
	100 x 85	---	500	---	320	102	25	CP20 90x72	n.a.	n.a.	2.4	13	27	49	77	---	---	---
	125 x 100	---	500	---	390	134	25	CP20 90x72	n.a.	n.a.	9.9	26	48	82	>125	---	---	---
	150 x 130	---	500	---	460	164	25	CP20 175x140	n.a.	5.1	20	44	75	120	>150	---	---	---
	175 x 150	---	500	---	530	196	25	CP20 175x140	n.a.	13	34	65	110	>175	>175	---	---	---
	200 x 170	---	500	---	600	228	25	CP20 250x200	2.3	22	50	91	150	>200	>200	---	---	---
	250 x 210	---	500	---	745	292	25	CP20 250x200	18	49	92	160	250	>250	>250	---	---	---
	300 x 250	---	500	---	885	354	25	CP20 350x280	38	83	140	240	>300	>300	>300	---	---	---
	350 x 290	---	800	---	1030	418	25	CP20 350x280	65	130	210	350	>350	>350	>350	---	---	---
	400 x 330	---	800	---	1170	480	25	CP20 350x280	97	180	290	>400	>400	>400	>400	---	---	---
	500 x 420	---	800	---	1450	606	25	CC20 500x400	180	310	480	>500	>500	>500	>500	---	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2.5 35 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
35mm, lens family B	35 x 29	---	500	---	215	Mech. Stop	25	CQ/CP20 30x24	---	n.a.	n.a.	n.a.	n.a.	1.5	5	11	---	---
	50 x 42	---	500	---	275	84	25	CQ/CP20 55x44	---	n.a.	n.a.	n.a.	1.5	7	14	25	---	---
	65 x 55	---	500	---	340	110	25	CQ/CP20 55x44	---	n.a.	n.a.	0.5	6.5	15	27	46	---	---
	80 x 65	---	500	---	400	138	25	CP20 90x72	---	n.a.	n.a.	4.3	13	26	43	71	---	---
	100 x 85	---	500	---	485	176	25	CP20 90x72	---	n.a.	1.5	12	25	46	72	>100	---	---
	125 x 100	---	500	---	590	222	25	CP20 90x72	---	n.a.	8.7	24	45	77	120	>125	---	---
	150 x 130	---	500	---	700	272	25	CP20 175x140	---	4	19	42	72	120	>150	>150	---	---
	175 x 150	---	500	---	805	318	25	CP20 175x140	---	12	32	62	100	170	>175	>175	---	---
	200 x 170	---	500	---	910	364	25	CP20 250x200	---	21	47	87	140	>200	>200	>200	---	---
	250 x 210	---	800	---	1120	460	25	CP20 250x200	---	45	86	150	230	>250	>250	>250	---	---
	300 x 250	---	800	---	1340	556	25	CP20 350x280	---	80	140	230	>300	>300	>300	>300	---	---
	350 x 290	---	800	---	1550	650	25	CP20 350x280	---	120	200	320	>350	>350	>350	>350	---	---
	400 x 330	---	800	---	1770	688	23	CP20 350x280	---	180	280	>400	>400	>400	>400	>400	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2.6 50 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
50mm, lens family A1 (Titanar)	15 x 13	---	500	20	205	Mech. Stop	26	CQ 15x12	---	---	n.a.	n.a.	n.a.	n.a.	n.a.	0.9	---	---
	20 x 17	---	500	10	230	64	25	CQ 15x12	---	---	n.a.	n.a.	n.a.	n.a.	0.4	2.7	---	---
	25 x 21	---	500	10	250	74	25	CQ 23x18	---	---	n.a.	n.a.	n.a.	n.a.	1.4	4.5	---	---
	35 x 29	---	500	---	310	98	25	CQ/CP20 30x24	---	---	n.a.	n.a.	n.a.	1.5	5	11	---	---
	50 x 42	---	500	---	395	136	25	CQ/CP20 55x44	---	---	n.a.	n.a.	1.4	6.8	14	25	---	---
	65 x 55	---	500	---	485	176	25	CQ/CP20 55x44	---	---	n.a.	0.3	6.1	15	26	45	---	---
	80 x 65	---	500	---	575	216	25	CP20 90x72	---	---	n.a.	4.1	13	26	43	70	---	---
	100 x 85	---	500	---	695	270	25	CP20 90x72	---	---	1.2	11	25	45	70	>100	---	---
	125 x 100	---	500	---	845	336	25	CP20 90x72	---	---	8.3	24	45	76	120	>125	---	---
	150 x 130	---	800	---	995	402	25	CP20 175x140	---	---	18	40	70	110	>150	>150	---	---
	175 x 150	---	800	---	1150	472	25	CP20 175x140	---	---	31	61	100	160	>175	>175	---	---
	200 x 170	---	800	---	1300	540	25	CP20 250x200	---	---	46	85	140	>200	>200	>200	---	---
	250 x 210	---	800	---	1600	674	25	CP20 250x200	---	---	85	150	230	>250	>250	>250	---	---
	300 x 250	---	800	---	1920	688	21	CP20 350x280	---	---	150	230	>300	>300	>300	>300	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2.7 65 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
65mm, lens family A1 (Titanar)	10 x 8	---	500	40	250	72	25	CQ 10x8	---	---	---	---	---	---	---	0	---	---
	15 x 13	---	500	30	275	84	25	CQ 15x12	---	---	---	---	---	---	---	1.1	---	---
	20 x 17	---	500	20	305	96	25	CQ 15x12	---	---	---	---	---	---	---	2.6	---	---
	25 x 21	---	500	10	340	112	25	CQ 23x18	---	---	---	---	---	---	---	4.8	---	---
	35 x 29	---	500	10	410	142	25	CQ/CP20 30x24	---	---	---	---	---	---	---	11	---	---
	50 x 42	---	500	---	525	194	25	CQ/CP20 55x44	---	---	---	---	---	---	---	25	---	---
	65 x 55	---	500	---	640	246	25	CQ/CP20 55x44	---	---	---	---	---	---	---	44	---	---
	80 x 65	---	500	---	760	298	25	CP20 90x72	---	---	---	---	---	---	---	69	---	---
	100 x 85	---	500	---	915	366	25	CP20 90x72	---	---	---	---	---	---	---	>100	---	---
	125 x 100	---	800	---	1110	458	25	CP20 90x72	---	---	---	---	---	---	---	>125	---	---
	150 x 130	---	800	---	1310	542	25	CP20 175x140	---	---	---	---	---	---	---	>150	---	---
	175 x 150	---	800	---	1510	632	25	CP20 175x140	---	---	---	---	---	---	---	>175	---	---
	200 x 170	---	800	---	1720	688	24	CP20 250x200	---	---	---	---	---	---	---	>200	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2.8 100 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
100mm, lens family A2 (Titanar)	10 x 8	---	500	75	385	132	25	CQ 10x8	---	---	---	---	n.a.	n.a.	n.a.	0	0.9	2.4
	15 x 13	---	500	50	420	148	25	CQ 15x12	---	---	---	---	n.a.	n.a.	n.a.	1	2.6	5.4
	20 x 17	---	500	37,5	465	168	25	CQ 15x12	---	---	---	---	n.a.	n.a.	0.3	2.5	5.1	9.4
	25 x 21	---	500	25	520	192	25	CQ 23x18	---	---	---	---	n.a.	n.a.	1.5	4.7	8.6	15
	35 x 29	---	500	12,5	630	240	25	CQ/CP20 30x24	---	---	---	---	n.a.	1.5	5	11	18	30
	50 x 42	---	500	12,5	810	320	25	CQ/CP20 55x44	---	---	---	---	1.5	7	14	25	39	>50
	65 x 55	---	800	12,5	975	394	25	CQ/CP20 55x44	---	---	---	---	5.8	14	25	44	>65	>65
	80 x 65	---	800	---	1150	470	25	CP20 90x72	---	---	---	---	12	25	41	68	>80	>80
	100 x 85	---	800	---	1390	578	25	CP20 90x72	---	---	---	---	24	44	68	>100	>100	>100
	125 x 100	---	800	---	1690	688	24	CP20 90x72	---	---	---	---	44	75	110	>125	>125	>125

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.3 Sensor Configuration Examples for PONTOS HS (1280x1024 Pixel)

Info

The following table values are examples. The sensor may also operate with measuring volumes that result between the values stated in the table. In such a case, you need to interpret the values for the measuring distance and the slider distance accordingly.

When using these measuring volumes, it is important to keep the aperture as closed as possible to achieve a high depth of field. For the sensors, the following relation applies for a camera angle of 25°: Base distance = slider distance + 38 mm..

3.4.3.1 20 mm Lens (PONTOS HS)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
20mm, lens family A1 (Titanar)	100 x 80	1)	500	---	180	62	27	CP20 90x72	---	---	n.a.	n.a.	7.6	22	41	75	>100	>100
	125 x 100	1)	500	---	215	68	25	CP20 90x72	---	---	n.a.	6.8	21	43	73	>125	>125	>125
	150 x 120	1)	500	---	250	84	25	CP20 175x140	---	---	0.7	16	36	68	110	>150	>150	>150
	175 x 140	---	500	---	285	100	25	CP20 175x140	---	---	6.9	27	55	100	160	>175	>175	>175
	200 x 160	---	500	---	320	116	25	CP20 175x140	---	---	15	41	78	140	>200	>200	>200	>200
	250 x 200	---	500	---	390	146	25	CP20 250x200	---	---	37	78	140	240	>250	>250	>250	>250
	300 x 240	---	500	---	460	178	25	CP20 250x200	---	---	65	130	220	>300	>300	>300	>300	>300
	350 x 280	---	500	---	530	208	25	CP20 350x280	---	---	100	190	320	>350	>350	>350	>350	>350
	400 x 320	---	500	---	600	240	25	CP20 350x280	---	---	150	260	>400	>400	>400	>400	>400	>400
	500 x 400	---	500	---	745	304	25	CC20 500x400	---	---	270	470	>500	>500	>500	>500	>500	>500
	750 x 600	---	800	---	1095	460	25	CC20 700x560	---	---	740	>750	>750	>750	>750	>750	>750	>750
	1000 x 800	---	800	---	1435	610	25	CC20 1000x800	---	---	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000
	1250 x 1000	---	800	---	1790	688	23	CC20 1400x1120	---	---	>1250	>1250	>1250	>1250	>1250	>1250	>1250	>1250

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.3.2 28 mm Lens (PONTOS HS)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
28mm, lens family B	65 x 50	1)	500	---	180	62	27	CQ/CP20 55x44	---	n.a.	n.a.	n.a.	n.a.	3.2	10	23	---	---
	80 x 65	1)	500	---	210	66	25	CP20 90x72	---	n.a.	n.a.	n.a.	2	11	21	40	---	---
	100 x 80	1)	500	---	250	84	25	CP20 90x72	---	n.a.	n.a.	n.a.	8.2	22	39	68	---	---
	125 x 100	---	500	---	295	104	25	CP20 90x72	---	n.a.	n.a.	4.8	18	38	64	110	---	---
	150 x 120	---	500	---	345	126	25	CP20 175x140	---	n.a.	n.a.	13	33	62	100	>150	---	---
	175 x 140	---	500	---	390	146	25	CP20 175x140	---	n.a.	4.5	23	49	88	140	>175	---	---
	200 x 160	---	500	---	440	168	25	CP20 175x140	---	n.a.	12	37	70	120	190	>200	---	---
	250 x 200	---	500	---	535	210	25	CP20 250x200	---	6.6	32	70	120	210	>250	>250	---	---
	300 x 240	---	500	---	635	254	25	CP20 250x200	---	23	59	120	190	>300	>300	>300	---	---
	350 x 280	---	500	---	730	298	25	CP20 350x280	---	43	92	170	280	>350	>350	>350	---	---
	400 x 320	---	500	---	825	340	25	CP20 350x280	---	68	130	230	380	>400	>400	>400	---	---
	500 x 400	---	800	---	1020	426	25	CC20 500x400	---	130	240	400	>500	>500	>500	>500	---	---
	750 x 600	---	800	---	1500	640	25	CC20 700x560	---	390	640	>750	>750	>750	>750	>750	---	---
	1000 x 800	---	800	---	1980	688	21	CC20 1000x800	---	810	>1000	>1000	>1000	>1000	>1000	>1000	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.3.3 35 mm Lens (PONTOS HS)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
35mm, lens family A1 (Titanar)	50 x 40	1)	500	---	195	62	26	CQ/CP20 55x44	---	n.a.	n.a.	n.a.	n.a.	0.5	5.1	13	---	---
	65 x 50	1)	500	---	225	74	25	CQ/CP20 55x44	---	n.a.	n.a.	n.a.	n.a.	4	11	23	---	---
	80 x 65	---	500	---	260	88	25	CP20 90x72	---	n.a.	n.a.	n.a.	1.4	9.7	20	38	---	---
	100 x 80	---	500	---	310	110	25	CP20 90x72	---	n.a.	n.a.	n.a.	7.5	20	37	65	---	---
	125 x 100	---	500	---	365	136	25	CP20 90x72	---	n.a.	n.a.	3.8	17	36	60	100	---	---
	150 x 120	---	500	---	425	162	25	CP20 175x140	---	n.a.	n.a.	12	30	58	93	>150	---	---
	175 x 140	---	500	---	485	188	25	CP20 175x140	---	n.a.	3.7	22	47	85	130	>175	---	---
	200 x 160	---	500	---	545	216	25	CP20 175x140	---	n.a.	11	34	67	120	180	>200	---	---
	250 x 200	---	500	---	665	268	25	CP20 250x200	---	5.3	30	67	120	200	>250	>250	---	---
	300 x 240	---	500	---	785	322	25	CP20 250x200	---	20	56	110	180	>300	>300	>300	---	---
	350 x 280	---	500	---	905	376	25	CP20 350x280	---	40	88	160	260	>350	>350	>350	---	---
	400 x 320	---	800	---	1020	426	25	CP20 350x280	---	64	130	220	360	>400	>400	>400	---	---
	500 x 400	---	800	---	1260	532	25	CC20 500x400	---	130	230	380	>500	>500	>500	>500	---	---
	750 x 600	---	800	---	1870	688	22	CC20 700x560	---	400	630	>750	>750	>750	>750	>750	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.3.4 50 mm Lens (PONTOS HS)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
50mm, lens family A1 (Titanar)	20 x 16	1)	500	30	195	62	26	CQ 15x12	---	---	n.a.	n.a.	n.a.	n.a.	n.a.	0.2	---	---
	25 x 20	1)	500	20	205	64	25	CQ 23x18	---	---	n.a.	n.a.	n.a.	n.a.	n.a.	1.3	---	---
	35 x 28	1)	500	10	230	76	25	CQ/CP20 30x24	---	---	n.a.	n.a.	n.a.	n.a.	0.5	4.3	---	---
	50 x 40	---	500	10	275	96	25	CQ/CP20 55x44	---	---	n.a.	n.a.	n.a.	0.2	4.5	12	---	---
	65 x 50	---	500	---	325	118	25	CQ/CP20 55x44	---	---	n.a.	n.a.	n.a.	4.1	11	23	---	---
	80 x 65	---	500	---	370	138	25	CP20 90x72	---	---	n.a.	n.a.	0.9	8.9	19	36	---	---
	100 x 80	---	500	---	440	168	25	CP20 90x72	---	---	n.a.	n.a.	6.6	19	35	61	---	---
	125 x 100	---	500	---	520	204	25	CP20 90x72	---	---	n.a.	3.3	16	35	58	99	---	---
	150 x 120	---	500	---	605	242	25	CP20 175x140	---	---	n.a.	11	29	56	90	150	---	---
	175 x 140	---	500	---	685	278	25	CP20 175x140	---	---	2.3	20	44	80	130	>175	---	---
	200 x 160	---	500	---	770	314	25	CP20 175x140	---	---	9.2	32	63	110	170	>200	---	---
	250 x 200	---	800	---	940	390	25	CP20 250x200	---	---	27	63	110	190	>250	>250	---	---
	300 x 240	---	800	---	1105	464	25	CP20 250x200	---	---	51	100	170	280	>300	>300	---	---
	350 x 280	---	800	---	1275	538	25	CP20 350x280	---	---	82	150	250	>350	>350	>350	---	---
	400 x 320	---	800	---	1440	612	25	CP20 350x280	---	---	120	210	330	>400	>400	>400	---	---
	500 x 400	---	800	---	1790	688	23	CC20 500x400	---	---	230	370	>500	>500	>500	>500	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

pontos_hw-5m-4m-hs-adjustable_en_rev-c 22-Sep-2009

3.4.3.5 100 mm Lens (PONTOS HS)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
100mm, lens family A2 (Titanar)	10 x 8	---	500	137,5	395	148	25	CQ 10x8	---	---	---	---	n.a.	n.a.	n.a.	0.3	2.1	5
	15 x 12	---	500	100	385	146	25	CQ 15x12	---	---	---	---	n.a.	n.a.	n.a.	n.a.	1.1	3.2
	20 x 16	---	500	75	400	150	25	CQ 15x12	---	---	---	---	n.a.	n.a.	n.a.	0.6	2.6	5.9
	25 x 20	---	500	50	415	158	25	CQ 23x18	---	---	---	---	n.a.	n.a.	n.a.	1.3	3.9	8.2
	35 x 28	---	500	37,5	465	180	25	CQ/CP20 30x24	---	---	---	---	n.a.	n.a.	0.5	4.3	8.8	16
	50 x 40	---	500	25	555	220	25	CQ/CP20 55x44	---	---	---	---	n.a.	0.1	4.4	12	20	35
	65 x 50	---	500	12,5	645	260	25	CQ/CP20 55x44	---	---	---	---	n.a.	3.4	10	21	35	58
	80 x 65	---	500	12,5	740	302	25	CP20 90x72	---	---	---	---	0.5	8.4	18	35	55	>80
	100 x 80	---	500	12,5	870	360	25	CP20 90x72	---	---	---	---	5.5	18	32	58	88	>100
	125 x 100	---	800	---	1030	434	25	CP20 90x72	---	---	---	---	14	32	55	93	>125	>125
	150 x 120	---	800	---	1195	504	25	CP20 175x140	---	---	---	---	26	52	84	140	>150	>150
	175 x 140	---	800	---	1360	578	25	CP20 175x140	---	---	---	---	41	76	120	>175	>175	>175
	200 x 160	---	800	---	1525	650	25	CP20 175x140	---	---	---	---	60	100	160	>200	>200	>200
	250 x 200	---	800	---	1870	688	22	CP20 250x200	---	---	---	---	110	180	>250	>250	>250	>250

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.5 Size of the Reference Point Markers

The reference point markers are available in the following sizes:

0.4 mm, 0.8 mm, 1.5 mm, 3 mm, 5 mm, 8 mm, 12 mm, 18 mm, 25 mm

Using the following formula, you may calculate the typical reference point size for your measuring volume. To do so, use the length of the measuring volume (see also 3.3), i.e. the largest value of the respective volume.

PONTOS 5M	PONTOS 4M	PONTOS HS
Length of measuring volume x 0.004	Length of measuring volume x 0.004	Length of measuring volume x 0.008

Info

If your result is a reference point size which is not available, round to the next available size. We recommend using the next larger size.

Example:

For the measuring volume 125 x 90 with PONTOS 4M the following calculation results: 125 x 0.004 = 0.5

This means, you should use the reference point marker size 0.8 mm for your measuring task.

4. Sensor Control Elements

4.1 How to Handle Lenses

The lenses shown in this example may, in some cases, differ from those delivered in practice. Therefore, the statements made here have to be used correspondingly.

Select a set of lenses matching the required measuring volume and screw it into the cameras.

NOTICE

To avoid getting dirt into the cameras, always equip the devices with lenses or with a protective cap, even when switched off. When changing the lenses, fix the new lenses in place immediately.
Screw in the lenses carefully by hand.

4.1.1 Lens Family A (Titanar)

4.1.1.1 Lens Family A1

Screw thread; tighten carefully by hand in the housing!
While doing so, lock focus locking ring!

Focus locking ring with hex socket head locking screw

Aperture setting ring with manual locking screw.

Focal length. In this example 20 mm.

4.1.1.2 Lens Family A2 - 100 mm

Screw thread; tighten carefully by hand in the housing!
While doing so, lock focus locking ring!

When using distance rings, screw in the rings here.

Focus locking ring with hex socket head locking screw

Aperture setting ring with manual locking screw.

4.1.2 Lens Family B

Aperture setting ring with manual locking screw. Note: In the example shown, aperture value 11 means aperture closed and aperture value 1.4 means aperture open.	
Screw thread; tighten carefully by hand in the housing! While doing so, lock focus locking ring!	
Focus locking ring with hex socket head locking screw	
Focal length. In this example 17 mm.	

4.2 How to Handle Tommy Screws

<table>
<tr><td>Problem:
The freedom of movement of the small handle is limited by the large handle.</td><td colspan="3">Remedy:
Pull out the handle and turn it.</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">You may use the large handle in a similar way.</td></tr>
</table>

5. Fast Setup of the Sensor

In order to achieve the measuring volumes shown in the tables of section **Fehler! Verweisquelle konnte nicht gefunden werden.**3, you need to set up the PONTOS sensor accordingly. To adjust the sensor, the complete system including the PONTOS application software must be installed.

How to use the software is described in the PONTOS User Manual – Software.

In most cases, the recommended camera angle is 25° for PONTOS measuring volumes. Thus, a simplified setup of the sensor can be carried out for these measuring volumes.

NOTICE

This method requires that the camera angle was once adjusted to 25° and has not been changed later!
In this case, you just need the measuring distance of the required measuring volume from the sensor configuration tables.

General steps to adjust the sensor:

- Equip the cameras with the corresponding lenses required for the measuring volume.
- Adjust the measuring distance between object and sensor (see tables sectio n **Fehler! Verweisquelle konnte nicht gefunden werden.**3), and switch on the laser pointer.
- Adjust the cameras to the laser point with the help of the cross hairs in the live video images.
- Fine-adjust the camera tilt angle with the help of the live video images.
- Adjust the focus of the camera lenses.
- Option: Adjust the polarization filters of the cameras and the lighting.
- Adjust the aperture of the camera lenses.

5.1 Adjust the Software

After starting the PONTOS software, select in the deformation mode (**View ► Deformation Mode**) the camera icon **Start/Stop Measurement Mode** in order to get a live video of both cameras.

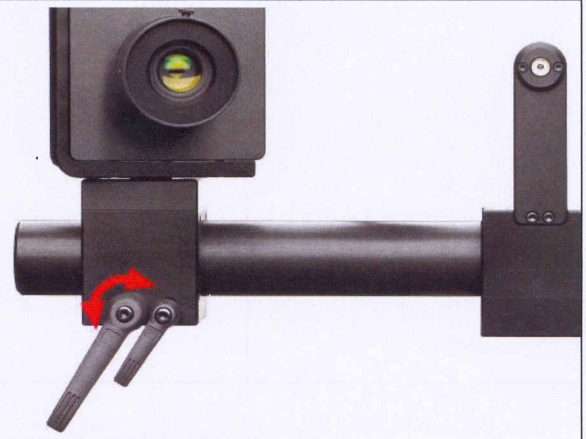
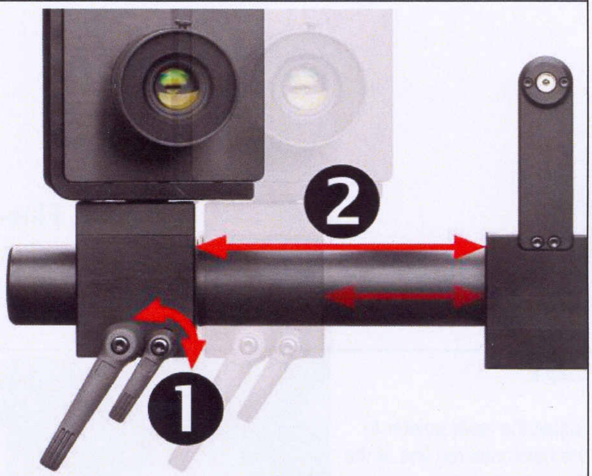
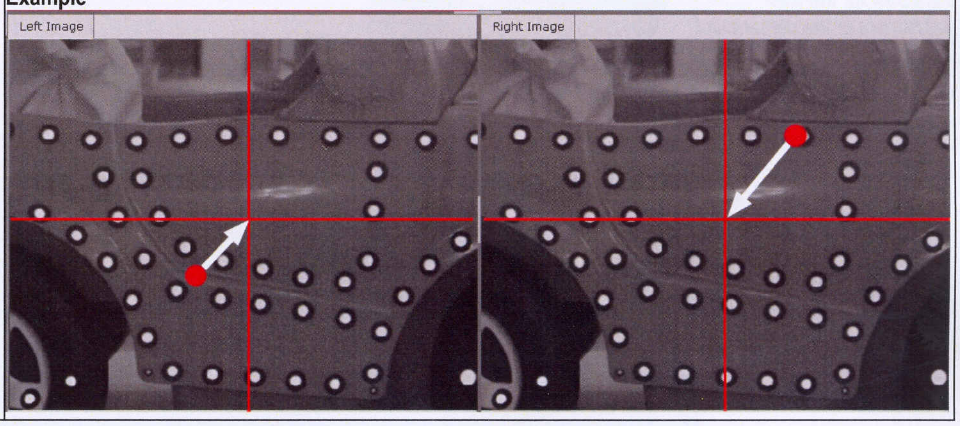
5.2 Adjust the Measuring Distance

Use the tables in section **Fehler! Verweisquelle konnte nicht gefunden werden.**3 to find the measuring distance which corresponds to the measuring volume (only for measuring volumes with a camera angle of 25°).

Switch on the laser pointer and direct it to an object which is placed at the measuring distance.

The measuring distance is determined by using a tape measure and results between the fixture of the camera support (in the middle) and the projected laser point on the measuring object, see 3.3.

5.3 Adjust Cameras Horizontally and Vertically

Step A Loosen the large handles! Now, the cameras can be moved in radial direction in a limited way.	
Step B Loosen the small handles! **NOTICE** Now, the cameras are no longer locked in radial and axial direction!	
Step C Display the laser pointer in the live video images of the cameras by means of a right mouse button click ▶ Image Display ▶ Overexposed and direct the cameras horizontally and vertically to the projected laser point with the help of the red cross hairs. **Info** You may later fine-adjust the vertical adjustment (camera tilt angle)!	**Example** 

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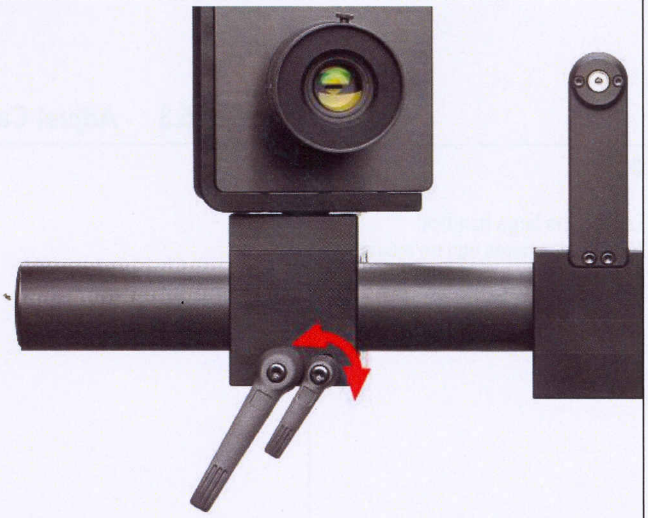
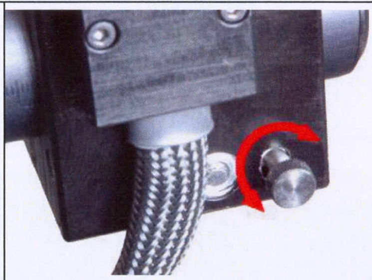
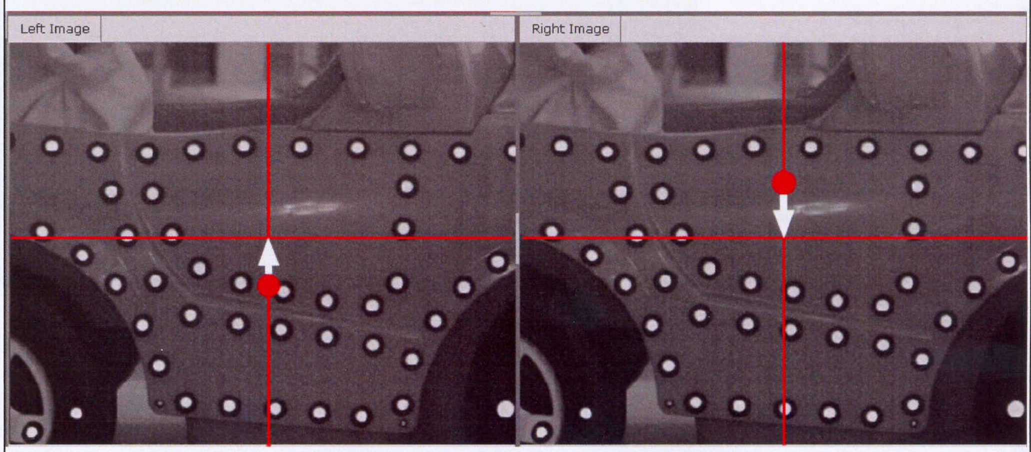
Step D Lock the position by means of the small handle.	

5.4 Fine-Adjust the Camera Tilt Angle

In section 5.3 step C, you already preadjusted the tilt angle (vertical adjustment to the laser point). Now, fine-adjust it.

Step E Adjust the laser pointer to the horizontal red line of the live video image by using the screw for the fine-adjustment of the camera tilt angle. **Info** If the fine-adjustment is at the end of its adjustment path, you first need to set it to its center position by means of the small handles, see 6.3 step B.	 **NOTICE** **Never completely remove the fine-adjustment screws!** There is risk of not being able to screw it in again. 

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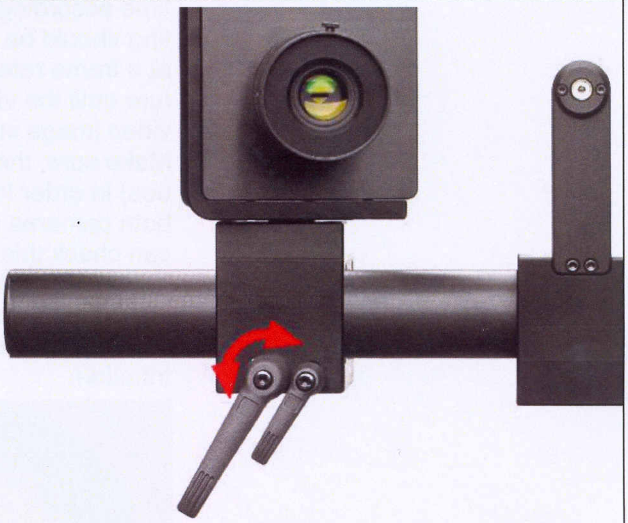
5.5 Lock Cameras

Now, lock the cameras by means of the large handles.

Step G	
Lock the cameras by means of the large handles!	

5.6 Adjust the Focus

If possible, adjust the focus with the aperture maximally opened. Place a text or a business card in the center and adjust the optimum focus.

The focus can also be adjusted using a calibration panel. This method provides a clear focus adjustment. In the overexposed mode (in the live image, click the right mouse button and select **Image Display ► Overexposed**), adjust the shutter time such that the white points appear overexposed (red). Now, adjust the focus to maximum red point size.

Then, lock the focus setting!

5.7 Adjust the Polarization Filters for the Lighting (Option)

Adjust the polarization filters according to 7.1.1.

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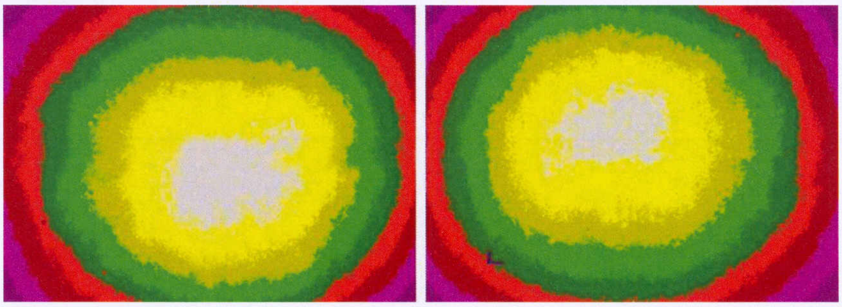
5.8 Adjust the Aperture

If you want to use the lighting, switch it on now. Choose the shutter time according to the expected test speed and recording rate, the setting should be clearly below the recording rate. Settings below 100 ms at a frame rate of 4 images per second are usual. Now close the aperture until the video images are free of overexposure. Red areas in the video image indicate overexposure and therefore should not occur. Make sure, the aperture is closed as far possible (high aperture values) in order to achieve a best possible depth of field. The aperture of both cameras should be closed to approximately the same extent. You can check this by means of the false-color mode of the video image. You enable the false-color mode by clicking with the right mouse button onto the video image and selecting **Image Display** ► **False color**. The video images should show approximately the same color distribution.



Left camera Right camera

After you finished the setup of the sensor, select **Start/Stop Measurement Mode**.

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6. Complete Setup of the Sensor

NOTICE

You always need to completely set up the sensor if the camera angle was not preadjusted to 25°!

Steps to completely adjust the sensor:

- Equip the cameras with the corresponding lenses required for the measuring volume.
- Adjust the measuring distance between object and sensor, and switch on the laser pointer.
- Adjust the slider distance between the cameras on the camera support symmetrically to the laser pointer.
- Adjust the camera angle with the help of the live video images.
- Adjust the camera tilt angle with the help of the live video images.
- Adjust the focus of the camera lenses.
- Adjust the aperture of the camera lenses.
- Option: Adjust the polarization filters of the cameras and the lighting.

6.1 Adjust the Software

After starting the PONTOS software, select in the deformation mode (**View ► Deformation Mode**) the camera icon **Start/Stop Measurement Mode** in order to get a live video of both cameras.

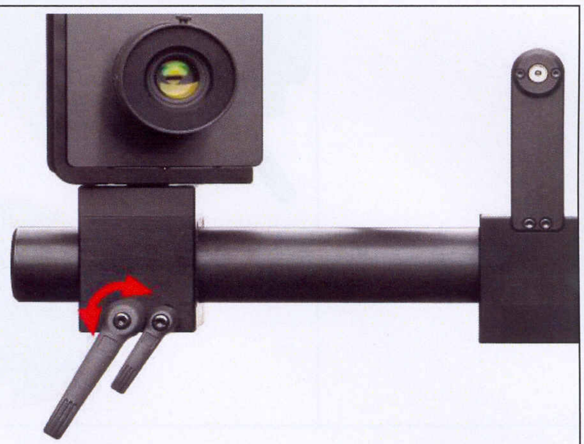
6.2 Adjust the Measuring Distance

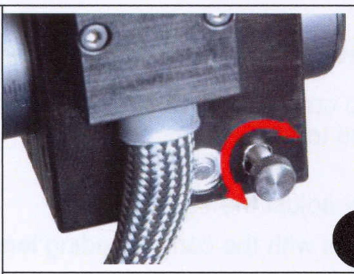
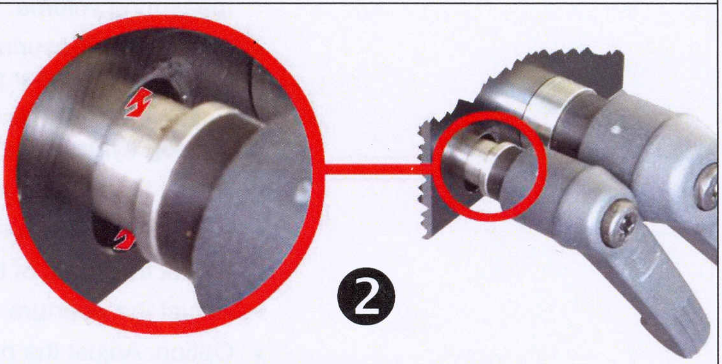
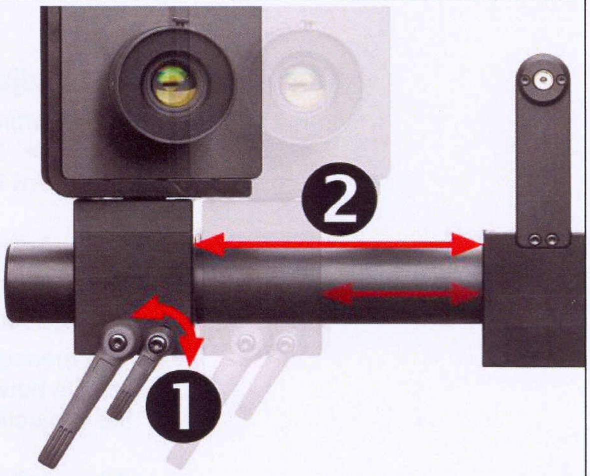
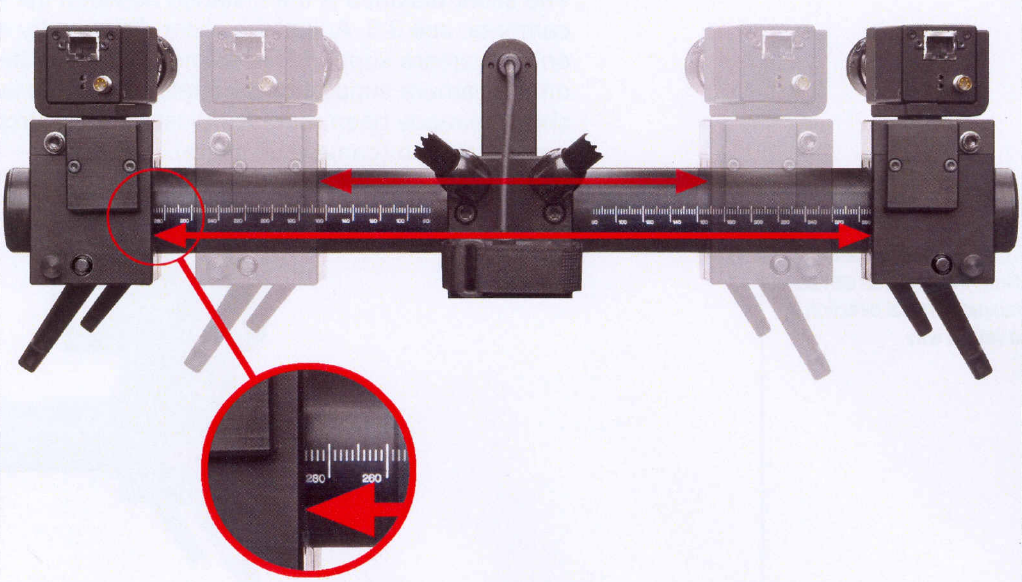
Switch on the laser pointer and direct it to an object which is placed at the measuring distance.

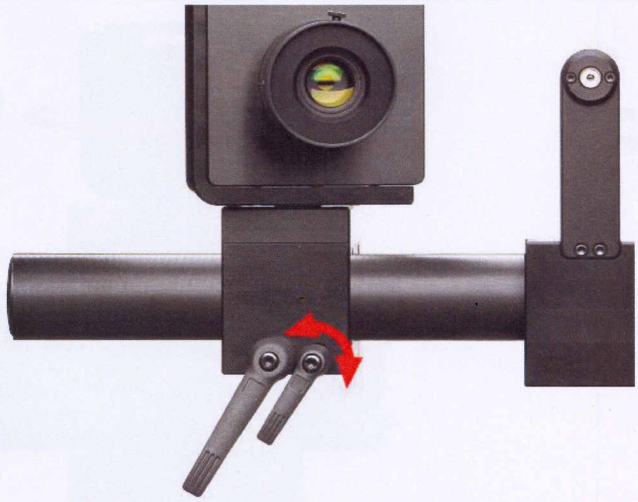
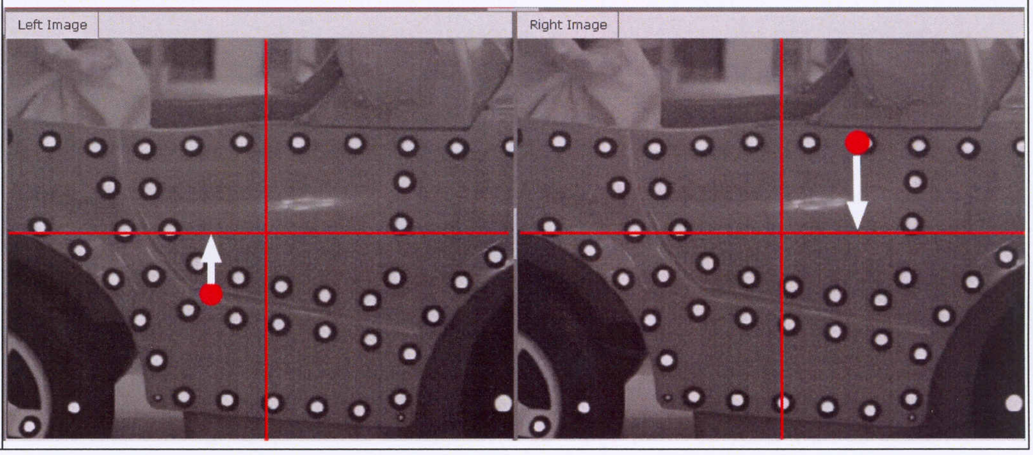
The measuring distance is determined by using a tape measure and results between the fixture of the camera support (in the middle) and the projected laser point on the measuring object, see 3.3.

6.3 Adjust Slider Distance

The slider distance is the distance between the slider units of the cameras, see 3.3. Adjust the slider distance by moving the cameras on the camera support. The cameras need to be set up symmetrically on the camera support or symmetrically to the laser pointer, and they should already been roughly adjusted to the projected laser point in radial direction (camera tilt angle).

Step A Loosen the large handles! Now, the cameras can be moved in radial direction in a limited way.	

Step B Adjust the small handles to their center position by means of the fine-adjustment screws for the camera tilt angle.	 **NOTICE** **Never completely remove the fine-adjustment screws!** There is risk of not being able to screw it in again. 
Step C Loosen the small handles. **NOTICE** Now, the cameras are no longer locked in radial and axial direction!	
Step D Move the cameras to the required slider distance.	

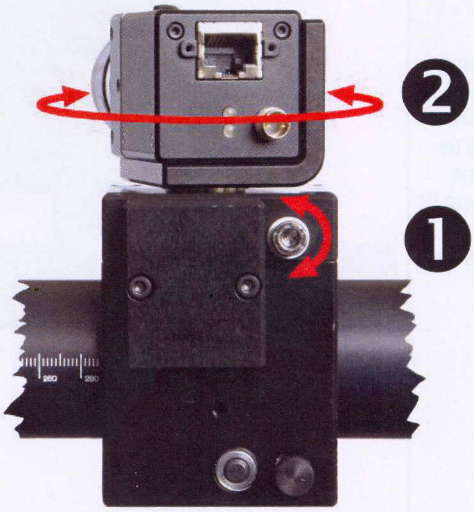
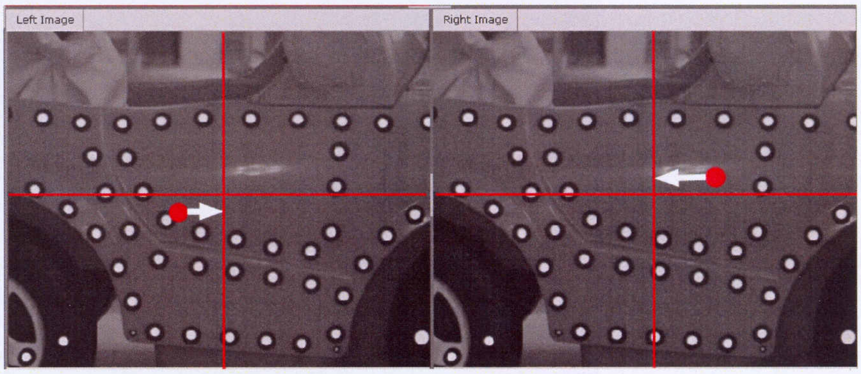
Step E	
Switch on the laser pointer and roughly adjust the laser point to the horizontal line of the live video image by using the screw for the fine-adjustment of the camera tilt angle. Lock the position by means of the small handle.	

6.4 Adjusting the Camera Angle

The camera angle α results when you point the cameras to the projected laser point in the live video images, see 3.3. If the live video images are too dark, too bright or not clear, first adjust the lenses with focus and aperture to optimum image impression.

Info

Adjust the vertical red line of the cross hairs in live video images to the projected laser point!

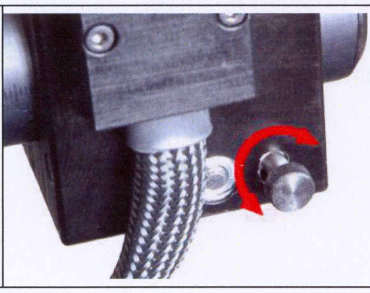
Step F Adjusting the camera angle: Switch on the laser pointer and adjust the laser point to the vertical line of the live video image.	 

6.5 Adjust the Camera Tilt Angle

During the adjustment of the slider distance, you already roughly adjusted the tilt angle. Now, fine-adjust it.

Info

Adjust the horizontal red line of the cross hairs in live video images to the projected laser point!

Step G Adjust the laser pointer to the horizontal line of the live video image by using the screw for the fine-adjustment of the camera tilt angle.	

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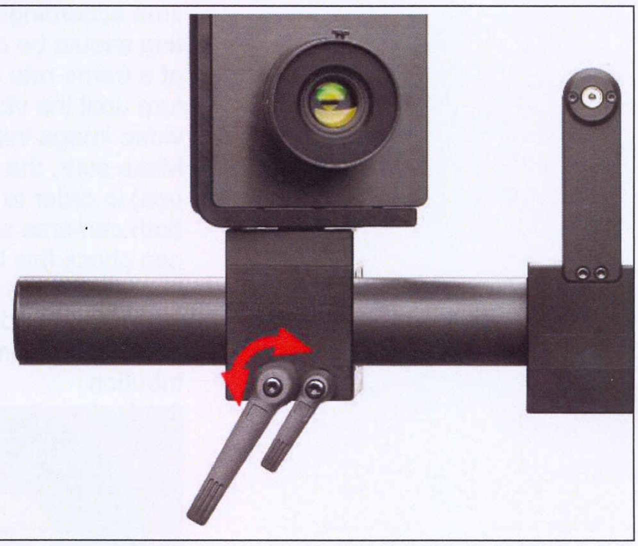
6.6 Lock Cameras

Now, lock the cameras by means of the large handles.

Step H Lock the cameras by means of the large handles.	

6.7 Adjust the Focus

If possible, adjust the focus with the aperture maximally opened. Place a text or a business card in the center and adjust the optimum focus.

The focus can also be adjusted using a calibration panel. This method provides a clear focus adjustment. In the overexposed mode (in the live image, click the right mouse button and select **Image Display** ▶ **Overexposed**), adjust the shutter time such that the white points appear overexposed (red). Now, adjust the focus to maximum red point size.

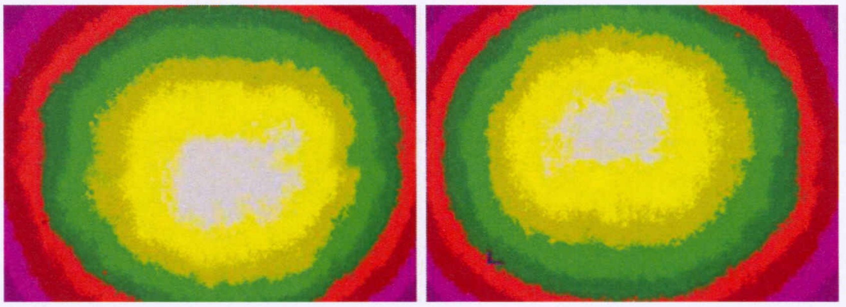
Then, lock the focus setting!

6.8 Adjust the Polarization Filters for the Lighting (Option)

Adjust the polarization filters according to 7.1.1.

6.9 Adjust the Aperture

If you want to use the lighting, switch it on now. Choose the shutter time according to the expected test speed and recording rate, the setting should be clearly below the recording rate. Settings below 100 ms at a frame rate of 4 images per second are usual. Now close the aperture until the video images are free of overexposure. Red areas in the video image indicate overexposure and therefore should not occur. Make sure, the aperture is closed as far possible (high aperture values) in order to achieve a best possible depth of field. The aperture of both cameras should be closed to approximately the same extent. You can check this by means of the false-color mode of the video image. You enable the false-color mode by clicking with the right mouse button onto the video image and selecting **Image Display ► False color**. The video images should show approximately the same color distribution.



Left camera Right camera

After you finished the setup of the sensor, select **Start/Stop Measurement Mode**.

7. Lighting (Option)

As lighting, two types of high-performance LED lamps are available:

- LED lamp with a beam angle of 10°
- LED lamp with a beam angle of 30°

This lighting is suitable for small measuring areas up to a maximum size of approx. 500 x 400 mm².

Sensor	Focal length of lens	Suitable LED lamp
4M	≥ 35 mm	Beam angle 30°
	≥ 65 mm	Beam angle 10°
5M	≥ 23 mm	Beam angle 30°
	≥ 35 mm	Beam angle 10°
HS	---	---

7.1 Adjust the Polarization Filters for the Lighting (Option)

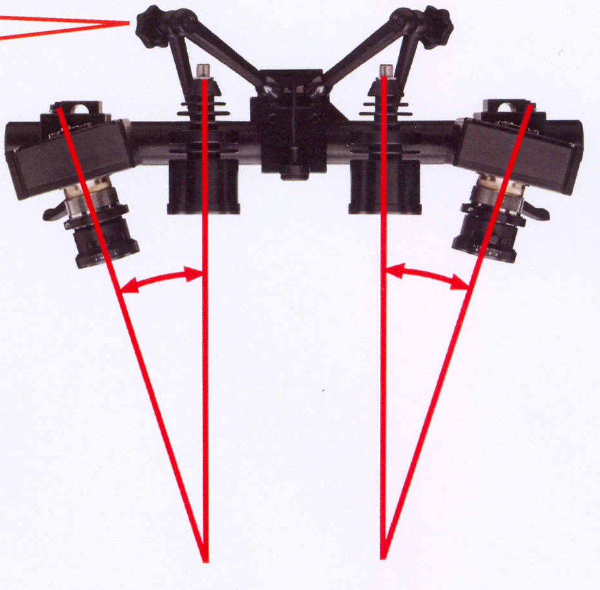
The polarization filters are used to avoid disturbing shiny points in the camera images.

All spotlights and cameras need to be equipped with a polarization filter.

Ensure that the angles between camera direction and spotlight direction are large enough in order to avoid disturbing reflections from the beginning.

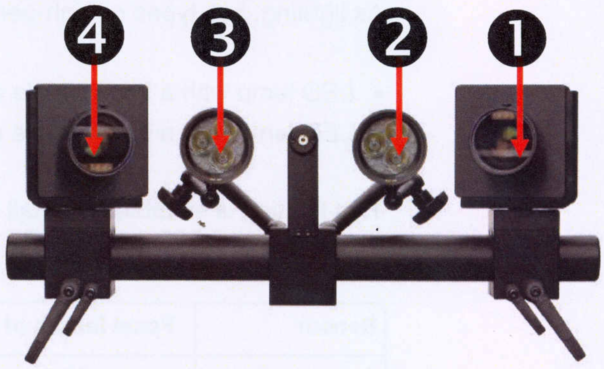
NOTICE

All joints of the lighting are locked or loosen by one common screw!



7.1.1 Adjustment Method for Polarization Filters

Switch on the LED lighting.



Step 1	The polarization filter ❶ of the left camera is not changed!
Step 2	Close down the spotlights ❸ (either turn the spotlight to the side or disconnect its power supply) and set the polarization filter ❷ to minimum intensity of shiny points in the <u>left</u> image of the live video.
Step 3	Activate the spotlight ❸ again (spotlight ❷ remains switched on) and set the polarization filter ❸ to minimum intensity of shiny points in the <u>left</u> image of the live video.
Step 4	Finally, in the <u>right</u> image of the live video, set the polarization filter ❹ to minimum intensity of shiny points.

Info Each time you change the camera or spotlight position, you need to readjust the polarization filters!

8. User Information About the PC

The computer is part of the measuring system.

Info

When connecting the computer with your local are network, please use the network port labeled as LAN0 on the rear side of the computer. This network port is being referred to as **eth0** in the YaST setup tool (system software).
Feel free to configure **eth0** but please leave all other network port settings as they are. An FAQ is available on our GOM support web page.

NOTICE

Please shut down the computer decently. Try to avoid using the reset button. A controlled shutdown of the computer is also possible by pressing the power on button on the front in the same way you would switch on the computer. A non-controlled shutdown may have an impact on the file system.

Only for 19" PCs:

In order to guarantee fewer problems using the computer, please remember to regularly clean the dust filters located in the front doors. We recommend cleaning them every four weeks or more often depending on the environment.

Removing filters:

9. The Sensor Controller

The sensor controller for the measuring system, serves to flexibly record images just-in-time and with analog value control for all applications (high-speed/low-speed).

In addition to the power supply unit for max. 2 cameras, the sensor controller includes a process computer for trigger signals, a DHCP server, as well as an A/D and D/A converter for analog force, distance and control signals. In connection with the different input interfaces and individual trigger lists, the sensor controller provides the trigger signals for the cameras and frame grabber boards of the PC. The camera images are intermediately stored in the evaluating computer.

The sensor controller has an own IP address (192.168.4.200). You may configure the sensor controller by means of the web interface. For more information see section 9.3.

9.1 Commissioning

After switching on the sensor controller (Power), the status LED lights up in orange for about 15 seconds. The sensor controller is ready for use if the LED changes to green. You may switch on and off the sensor controller in all operating states.

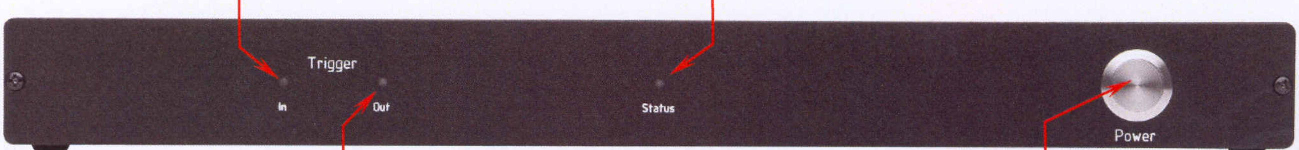
If the status LED is red, a hardware error occurred.

9.2 Brief Description

9.2.1 Sensor Controller Front Panel

Trigger In (LED) Illuminates in case of incoming trigger signals.

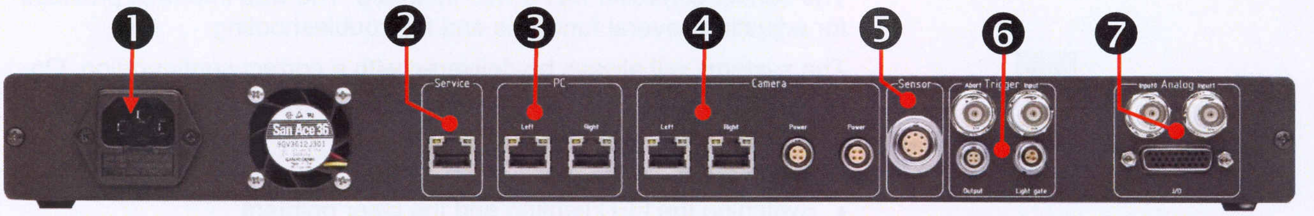
Status LED **green**: Sensor controller is ready for operation. **orange/red**: Switching on or off phase **red** (permanent): Hardware error



Trigger Out (LED) Illuminates in case of image recording.

On/off switch of the sensor controller

9.2.2 Sensor Controller Rear Panel



1			AC power connection, 115 /230 V, 50 to 60 Hz.
2	Service		**Info** GOM internal service interface. Do not use this interface!
3	PC	Left	Gigabit-Ethernet interface for the connection with the PC. • PONTOS 5M: Image transfer from left camera to PC and communication between PONTOS software and sensor controller. • PONTOS 4M or HS: Communication between PONTOS software and sensor controller.
		Right	Gigabit-Ethernet interface for the connection with the PC. • PONTOS 5M: Image transfer from right camera to PC • PONTOS 4M or HS: Not used.
4	Camera	Left	Gigabit-Ethernet interface for the connection to the left camera.
		Right	Gigabit-Ethernet interface for the connection to the right camera.
		Power	Power supply of one camera (PONTOS 4M or HS).
		Power	Power supply of one camera (PONTOS 4M or HS).
5	Sensor		Connection to the PONTOS sensor hub • PONTOS 5M: Power supply of cameras, laser pointer, LED lighting and trigger. • PONTOS 4M: Laser pointer, LED lighting. • PONTOS HS: Laser pointer.
6	Trigger	Abort	Direct push button connection (normally open switch) to abort a measuring procedure.
		Input	TTL input for trigger signals. In order to activate a switching action, the available signal must jump from low (0V) to high (+5V). This behavior may be inverted via the web interface, see section 9.3 (option).
		Output	• The PONTOS systems having separate frame grabber boards in the measuring computer (4M and HS) receive the trigger signals via this interface. • Synchronization of several measuring systems (option) • Control of external flash units (option, see also section 9.3)
		Light Gate	• Connection for a photoelectric sensor to trigger image recording, or • Push button connection (normally open switch) via an adapter, to start a trigger signal.
7	Analog	Input 0 Input 1	The analog inputs 0 to 1 are rated for recording analog signals during image recording between -10 V and +10 V, e.g. for force and distance signals of the test machine. These inputs can also be used to generate a trigger signal at a certain voltage value or at a gradient. The input signals are sampled with 16 bit.
		I/O (6 inputs)	If additional analog inputs are required, this interface together with an optional adapter cable provides for adding 6 inputs (BNC connector). The adapter cable provides the analog inputs Analog Input 2 to Analog Input 7. The analog inputs are rated for recording analog signals (max. -10 V to max. +10 V) during image recording, e.g. for force and distance signals of the test machine. The input signals are sampled with 16 bit.
		I/O (4 outputs)	The interface provides 4 analog outputs (max. 0V to max. +10V) for real-time sensor applications, e.g. to control test machines. The output signals are sampled with 12 bit.

9.3 Web Interface

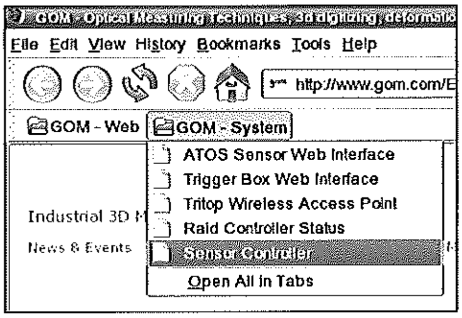
The sensor controller has a web interface. The web interface provides for adjusting several functions and for troubleshooting.

Info The systems will always be delivered with a correct configuration. Only use the web interface if it is absolutely required.

Possible applications:

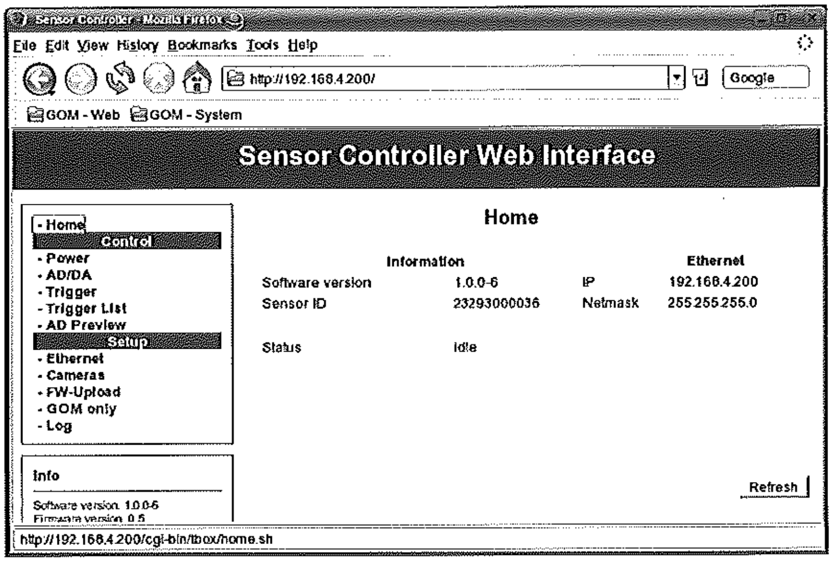
- Switching the LED lighting and the laser pointers
- Adjusting the trigger behavior
- Checking trigger lists
- Testing the AD channels
- Setting the IP address of the sensor controller
- Network configuration of Gigabit-Ethernet cameras

You reach the web interface, by starting a browser (e.g. Firefox) and entering the address `http://192.168.4.200` into the address line. As an alternative, you may use the corresponding Firefox bookmark.



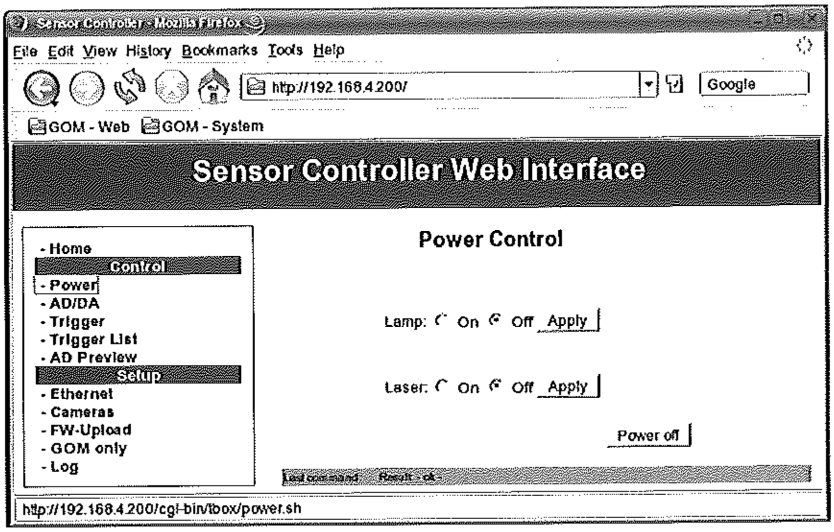
In the left frame, you may call different pages.
"Trigger" is a page important for special applications.
The pages "GOM only" and "Log" have no function for the user.

9.3.1 Home



Here you can see general information about the sensor controller.

9.3.2 Power



Here, you may switch the power supply.

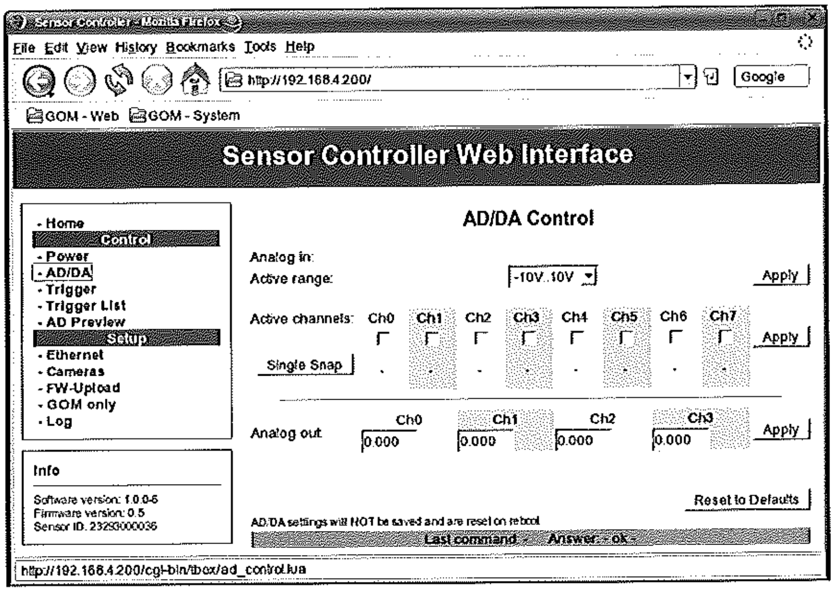
Lamp controls the LED illumination of the sensor.

Laser controls the laser pointers of the sensor.

Each setting has to be confirmed with **Apply**.

With **Power off** you switch off the sensor controller.

9.3.3 AD/DA



Here, you may test the functions of the A/D inputs and the D/A outputs.

Active range selects the range for the 16bit A/D conversion for the active A/D channels.

Active channels selects the channels to be measured.

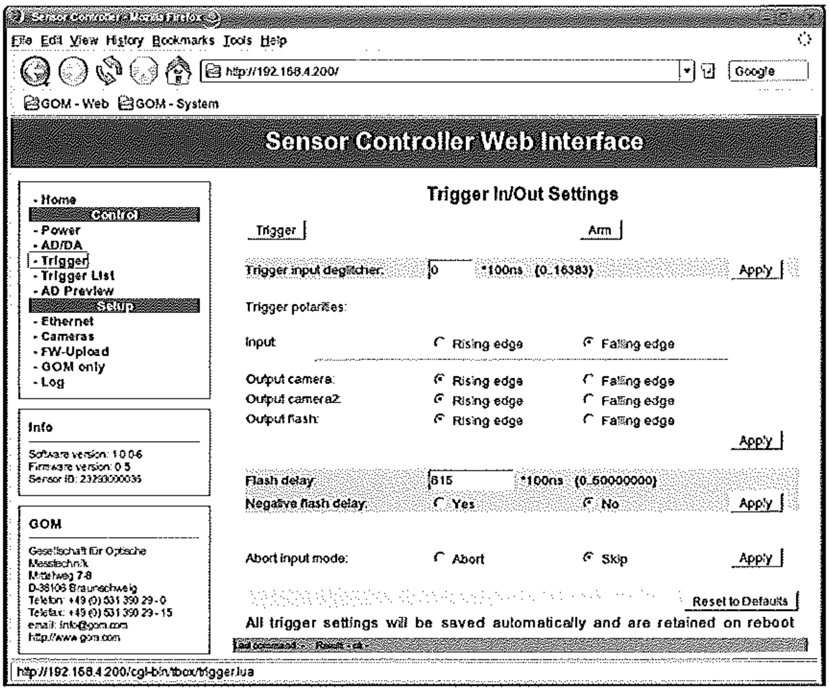
Single Snap starts a single measurement of the selected A/D channels in the selected range.

Analog out applies the specified voltage to the D/A outputs.

Each setting has to be confirmed with **Apply**.

Reset to Defaults restores the default settings.

9.3.4 Trigger



Trigger sends a trigger signal for test purposes (e.g. flashes). During a measurement (e.g. trigger list) a trigger is emitted. Depending on the trigger list element, this means triggering an internal event and/or an image.

Arm sets the ARM status active. During a trigger list measurement with an element for which "arm=true", only the next following trigger will be processed.

Trigger input deglitcher sets the deglitcher for the trigger input signal (e.g. for debouncing the pushbutton).

Input sets the polarity of the trigger input signal at the "Input" or "Light gate" connection of the sensor controller rear side.

Output camera sets the polarity of the camera trigger.

Info Depending on the camera used, the software sets this value and the user should not change it.

Output camera2 sets the polarity of the additional trigger output at the "Output" connection of the sensor controller rear side (for triggering, synchronizing of additional hardware).

Output flash sets the polarity of the delayed trigger output.

Flash delay sets the delay of the flash trigger with respect to the actual trigger signal.

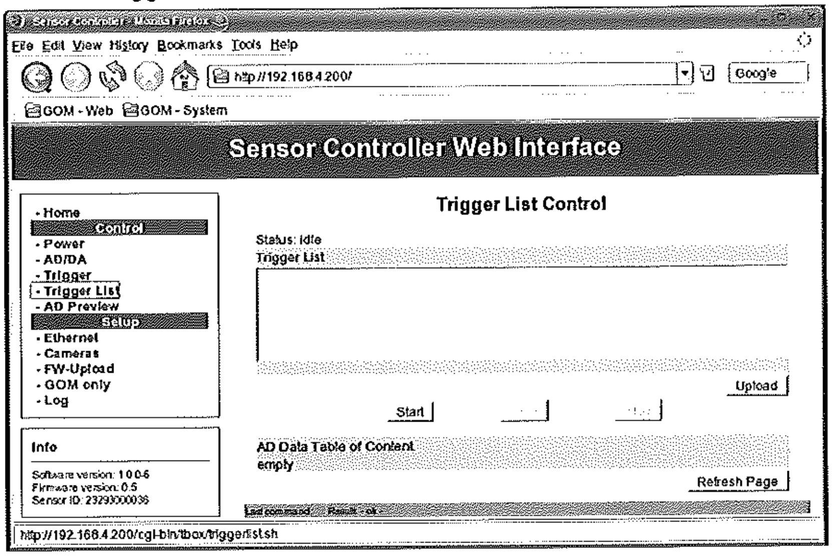
Negative flash delay inverts the trigger time of the flash trigger and the actual trigger.

Abort input mode sets the behavior of the abort button at the "Abort" connection of the sensor controller rear side. In case of **Abort** pressing a button aborts the entire trigger list, in case of **Skip** only the current element is aborted.

Each setting has to be confirmed with **Apply**.

Reset to Defaults restores the default settings.

9.3.5 Trigger List



Here, you may load manually created trigger lists into the sensor controller. Loaded trigger lists can be started, aborted or individual elements can be aborted.

Upload loads the trigger list in the **Trigger List** window into the sensor controller.

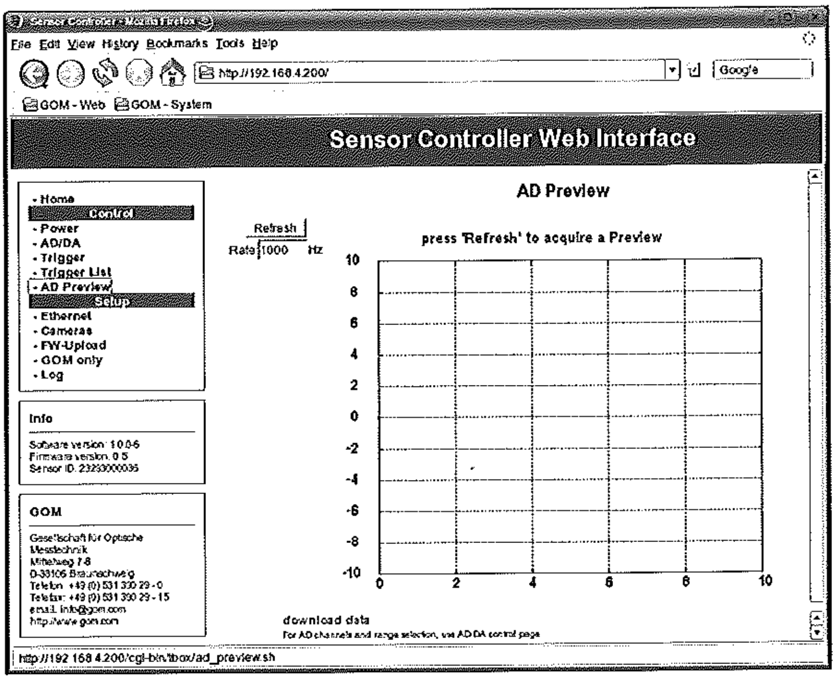
Start starts the trigger list in the sensor controller.

Skip aborts an individual element of the trigger list.

Stop aborts the trigger list.

Refresh Page loads the trigger list from the sensor controller into the **Trigger List** window.

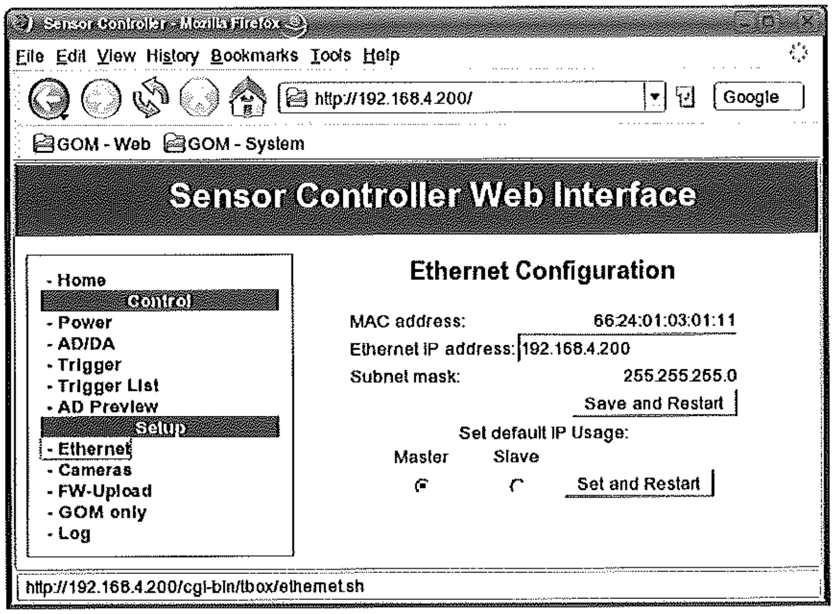
9.3.6 AD Preview



Here, you may measure the A/D channels activated in window "AD/DA" (see chapter 9.3.3) over a certain time period (e.g. in order to determine noise and offsets of the analog signals).

Refresh carries out a measurement with the specified measuring rate and plots the measured analog signals in a diagram.

9.3.7 Ethernet



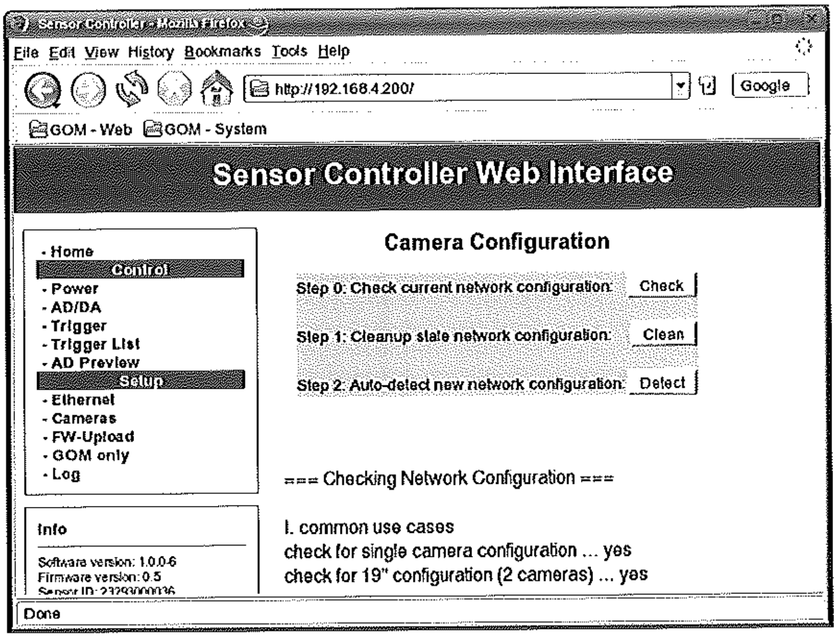
Here, you can manage the network configuration of the sensor controller.

Ethernet IP address sets the IP address of the sensor controller. You need to confirm this setting with **Save and Restart**. Then, the web interface can only be reached via the new IP address.

Info Only change the IP address of the sensor controller if the company network uses the same subnet mask and a computer with this IP already exists. The changed IP address must also be changed in the software (ARAMIS, PONTOS, IVIEW). In case of a support request, you need to announce this change.

Master / Slave sets the default settings of the sensor controller for a double sensor system. You need to confirm this setting with **Save and Restart**. In case of **Slave**, the web interface can only be reached via the IP address `192.168.14.200`.

9.3.8 Cameras



For Gigabit-Ethernet cameras, here the network configuration of the cameras is managed.

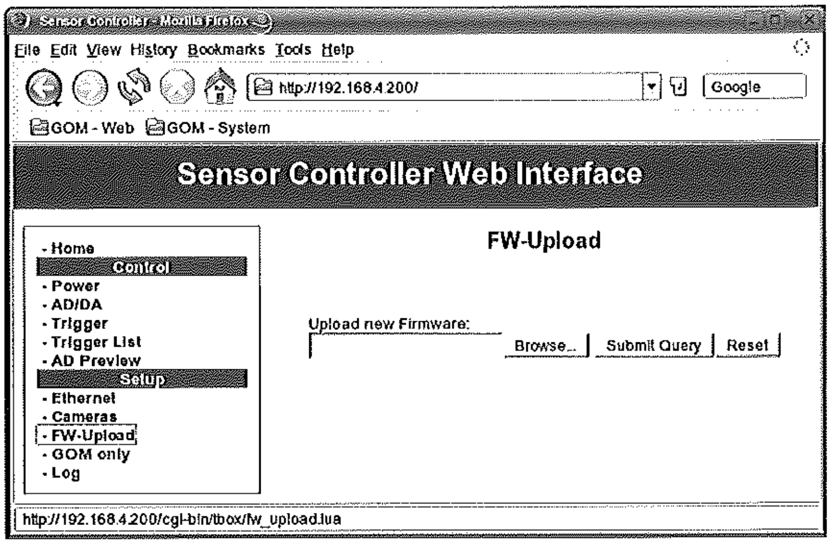
Info The systems will always be delivered with a correct configuration. Therefore, you should only adapt the configuration in case of an hardware exchange (**Clean / Detect**).

The sensor controller clearly identifies the cameras. Therefore, you have to repeat the configuration via **Clean / Detect** every time you change the cameras, this also includes interchanging the cameras or using cameras of a different sensor. The hardware configuration of the software (ARAMIS, PONTOS, IVIEW) is not affected.

Check verifies the existing camera configuration and returns information about this configuration (e.g. if the right and left camera were interchanged) in the web interface. **Clean** deletes the existing camera configuration. Then, you have to execute **Detect**.

Detect sets the IP address of the connected Gigabit-Ethernet cameras. Prior to that you need to execute **Clean**.

9.3.9 Firmware Upload



Here, you may update the firmware of the sensor controller.

Info Normally, a firmware update here is not required. Only update the firmware via the web interface if the GOM support explicitly instruct you to do so!

10. Calibration

Calibration is a measuring process during which the measuring system with the help of calibration objects is adjusted such that the dimensional consistency of the measuring system is ensured.

The calibration object also contains the scale bar information. The scale bar information is the specified distance between two defined reference points.

During calibration, the sensor configuration is determined. This means that the distance of the cameras and the orientation of the cameras to each other are determined. In addition, the image characteristics of the cameras are determined (e.g. focus, lens distortions). Based on these settings, the software calculates from the reference points of the calibration object in the 2D camera image their 3D coordinates.

10.1 Calibration Objects

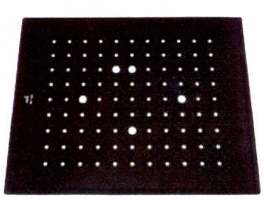
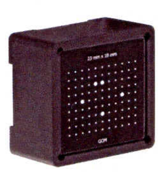
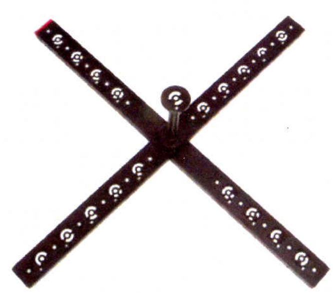
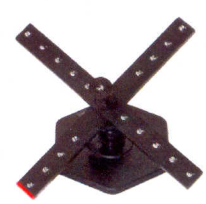
Two different calibration types (panel and cross) which are available in different sizes and versions are used. Depending on the version, a calibration panel has one or two scale bars. A calibration cross has two scale bars (on each cross section). For each standard measuring volume a corresponding calibration object is available. When registering a calibration object in the software, you need to select, in addition to the type (panel or cross), also the version of the calibration object (simple or coded).

How you can identify the versions is explained in the following tables.

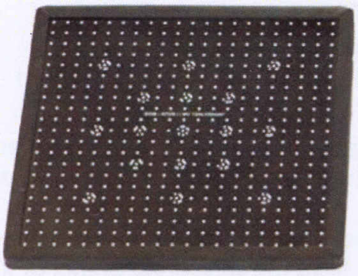
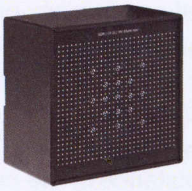
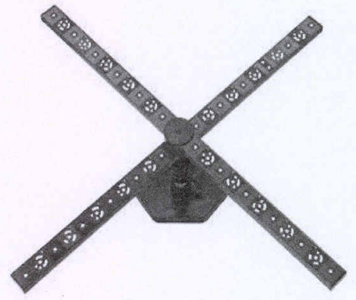
NOTICE

Treat the calibration objects with care. Avoid touching the surface of the calibration side with your hands. Some calibration objects (e.g. all cubes and some calibration panels) are made of ceramics. You cannot remove finger prints from ceramic surfaces without any remains.

10.1.1 Calibration Objects Simple (Version 1)

Icon in the software		Icon in the software	
			
Calibration panel with uncoded reference points and one scale bar value. Distinguishing characteristic: • No coded points	Calibration cube with uncoded reference points and one scale bar value. Distinguishing characteristic: • No coded points • Type label starts with **CQ**	Calibration cross with retro markers (uncoded points) and two scale bar values. Distinguishing characteristic: • On the rotation axis of the cross there is a coded reference point.	Calibration cross only with coded points and two scale bar values. Distinguishing characteristic: • On the rotation axis of the cross there is a coded reference point.

10.1.2 Calibration Objects Coded (Version 2)

Icon in the software		Icon in the software
		
Calibration panel with coded and uncoded reference points and two scale bar values. The coded reference point in the center of the plate identifies the object in the software. Distinguishing characteristic: • Type label starts with **CP** • Coded points	Calibration cube with coded and uncoded reference points and two scale bar values. The coded reference point in the center of the plate identifies the object in the software. Distinguishing characteristic: • Type label starts with **CQ** • Coded points	Calibration cross with coded and uncoded reference points and two scale bar values. One coded reference point close to the rotation point of the cross identifies the object in the software. Distinguishing characteristic: • On the rotation axis of the cross there is no reference point. • Type label starts with **CC**

10.2 Calibration Objects and Corresponding Measuring Volumes

Calibrate the system only with the calibration object valid for the respective measuring volume as you otherwise will get wrong measuring results!

For information about the calibration objects see also the sensor configuration tables in section 3.

10.3 Calibration of the PONTOS System

Before starting measurements for the first time, the system needs to be calibrated.

Also, if the adjustment of the camera lenses or the position of the cameras with respect to each other is changed, the system requires calibration.

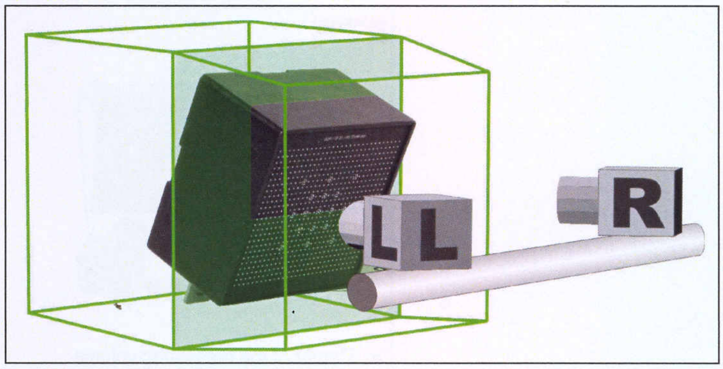
A prerequisite for successful calibration is the correct setup of the sensor, see section 5 or 6. The measuring object defines the measuring volume and thus the set of lenses to be used. The measuring distance to the calibration object has to be adjusted according to the camera lenses used and according to the available camera support, see Sensor Configurations section 3.

A wizard in the application software leads you through the individual calibration steps.

For further information about the calibrating process, please refer to the PONTOS User Manual – Software and the Online Help.

Info

If you carry out a panel calibration using a calibration cube, you need to perform the tilted position of the calibration object in calibration steps 4 and 5 opposite to the instructions (tilted 40°) of the application software.

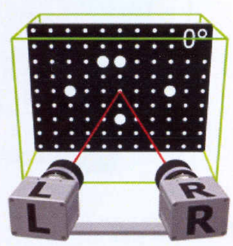
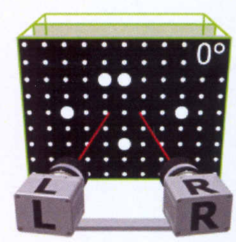
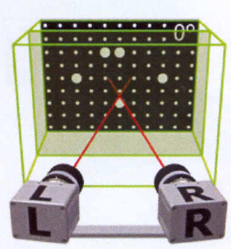
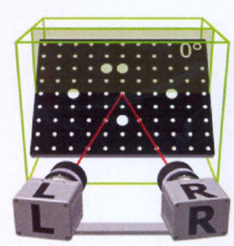


The opposite orientation of the cube is due to its design and does not affect the calibration result.

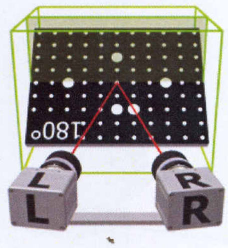
10.4 Calibration with External Image Series

For the special case you need to work with external image series which were not recorded with GOM standard sensor setups (e.g. for ultra high-speed applications), the necessary calibration steps are described in the following. In case of an external image series, the software cannot automatically guide you through the necessary calibration steps.

10.4.1 Steps for Calibration Object Panel – Simple

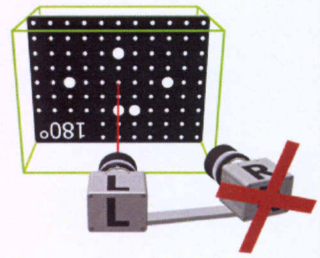
Calibration object panel - simple	
Step 1:  • Center of the measuring volume • Panel position 0°	**Step 2:**  • Closer to the sensor • Panel position 0°
Step 3:  • Further away from the sensor • Panel position 0°	**Step 4:**  • Center of the measuring volume • Panel position 0° • Single point tilted 40°

Step 5:



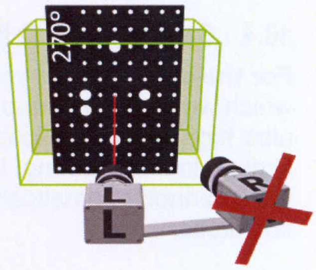
- Center of the measuring volume
- Panel position 180°
- Double points tilted 40°

Step 6:



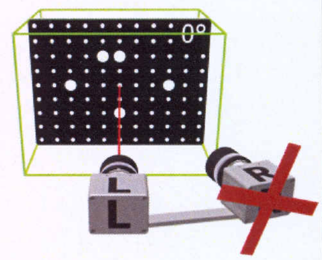
- Left camera only
- Panel position 180°

Step 7:



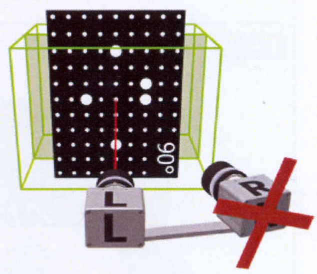
- Left camera only
- Panel position 270°

Step 8:



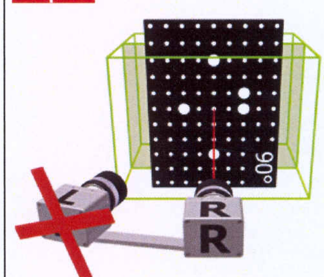
- Left camera only
- Panel position 0°

Step 9:



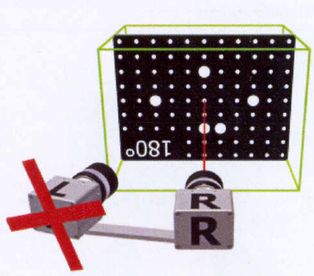
- Left camera only
- Panel position 90°

Step 10:



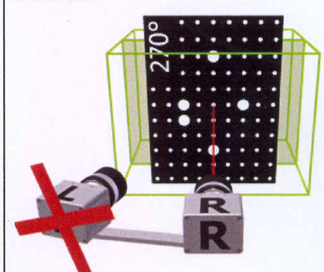
- Right camera only
- Panel position 90°

Step 11:



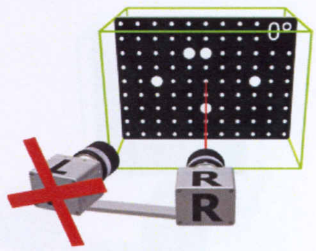
- Right camera only
- Panel position 180°

Step 12:



- Right camera only
- Panel position 270°

Step 13:

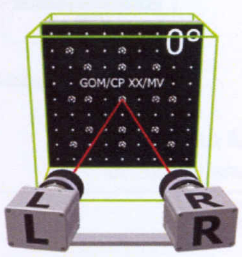


- Right camera only
- Panel position 0°

10.4.2 Steps for Calibration Object Panel – Coded

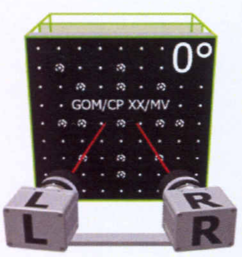
Calibration object panel - coded

Step 1:



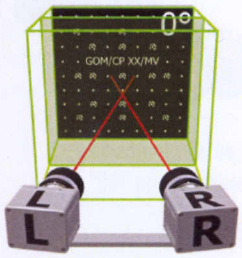
- Center of the measuring volume
- Panel position 0°

Step 2:



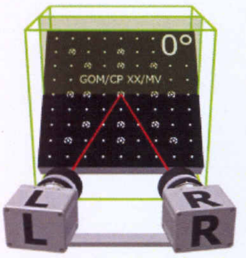
- Closer to the sensor
- Panel position 0°

Step 3:



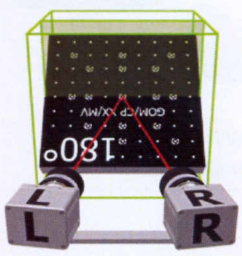
- Further away from the sensor
- Panel position 0°

Step 4:



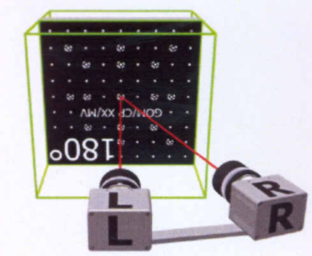
- Center of the measuring volume
- Panel position 0°
- Tilted 40°

Step 5:



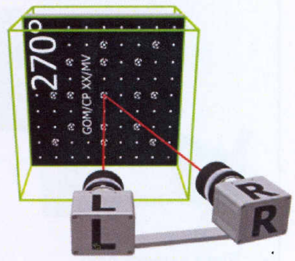
- Center of the measuring volume
- Panel position 0°
- Tilted 40°

Step 6:



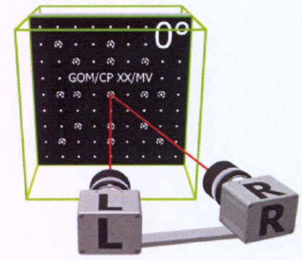
- Left camera normal
- Panel position 180°

Step 7:



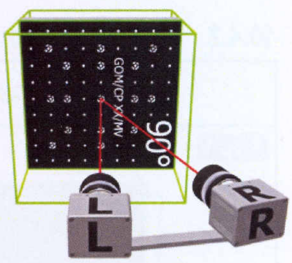
- Left camera normal
- Panel position 270°

Step 8:



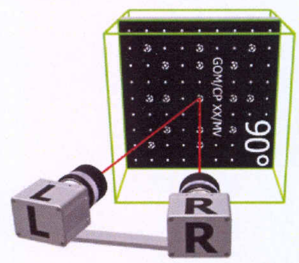
- Left camera normal
- Panel position 270°

Step 9:



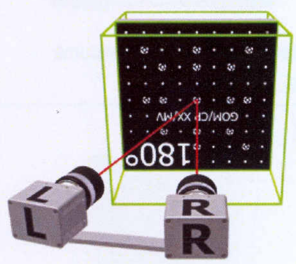
- Left camera normal
- Panel position 90°

Step 10:



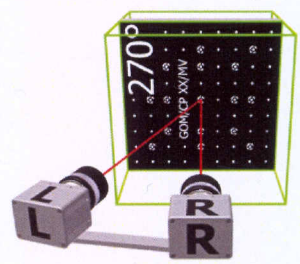
- Right camera normal
- Panel position 90°

Step 11:



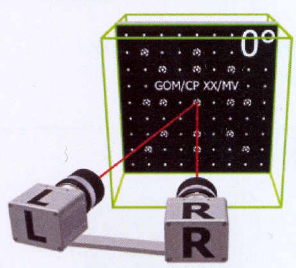
- Right camera normal
- Panel position 180°

Step 12:



- Right camera normal
- Panel position 270°

Step 13:

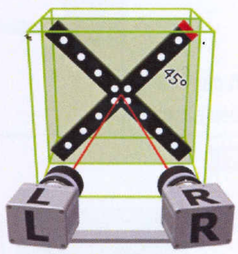


- Right camera normal
- Panel position 0°

10.4.3 Steps for Coded Calibration Object Cross – Coded

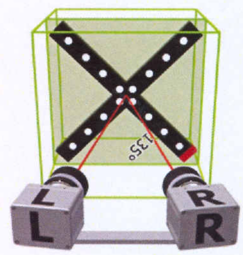
Calibration object cross - coded 

Step 1:



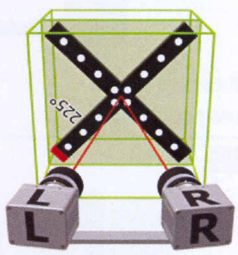
- Center of the measuring volume
- Cross position 45°

Step 2:



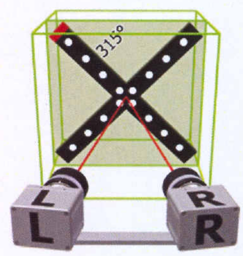
- Center of the measuring volume
- Cross position 135°

Step 3:



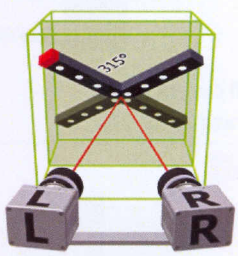
- Center of the measuring volume
- Cross position 225°

Step 4:



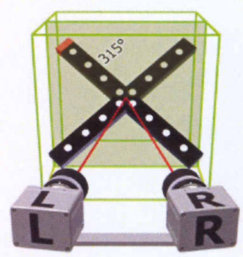
- Center of the measuring volume
- Cross position 315°

Step 5:



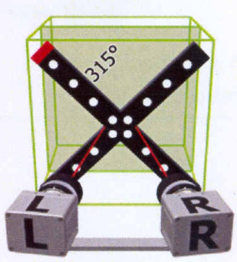
- Center of the measuring volume
- Cross position 315°
- Top tilted 40°

Step 6:



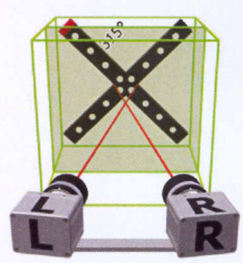
- Center of the measuring volume
- Cross position 315°
- Bottom tilted 40°

Step 7:



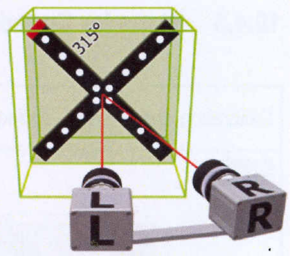
- Closer to the sensor
- Cross position 315°

Step 8:



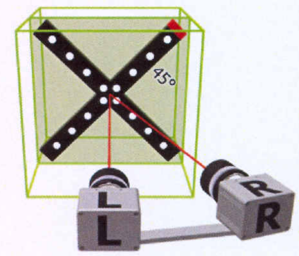
- Further away from the sensor
- Cross position 315°

Step 9:



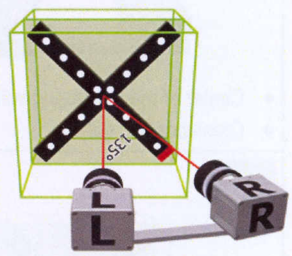
- Left camera normal
- Cross position 315°

Step 10:



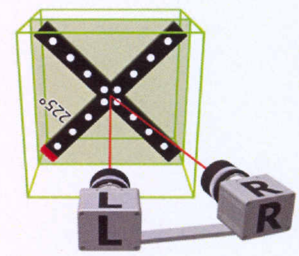
- Left camera normal
- Cross position 45°

Step 11:



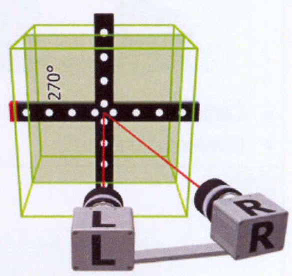
- Left camera normal
- Cross position 135°

Step 12:



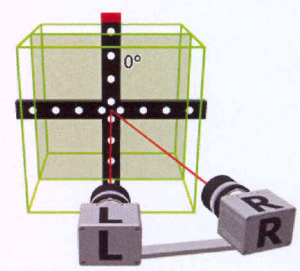
- Left camera normal
- Cross position 225°

Step 13:



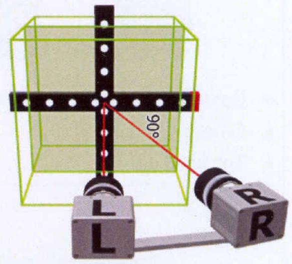
- Left camera normal
- Cross position 270°

Step 14:



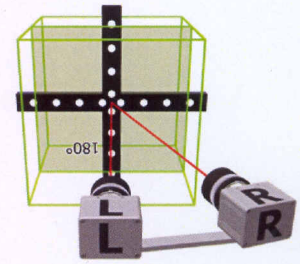
- Left camera normal
- Cross position 0°

Step 15:



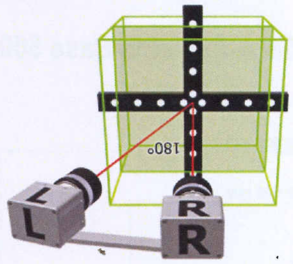
- Left camera normal
- Cross position 90°

Step 16:



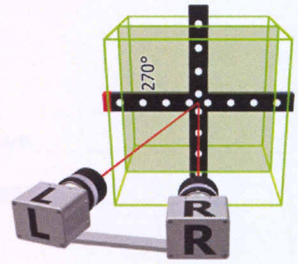
- Left camera normal
- Cross position 180°

Step 17:



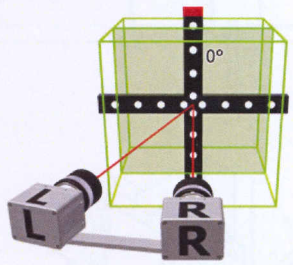
- Right camera normal
- Cross position 180°

Step 18:



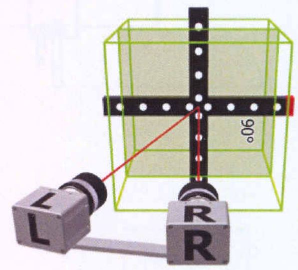
- Right camera normal
- Cross position 270°

Step 19:



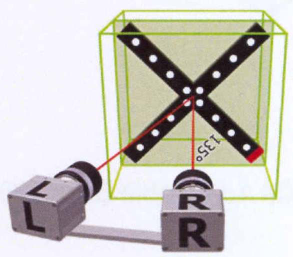
- Right camera normal
- Cross position 0°

Step 20:



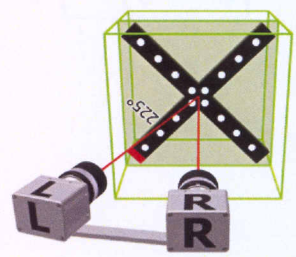
- Right camera normal
- Cross position 90°

Step 21:



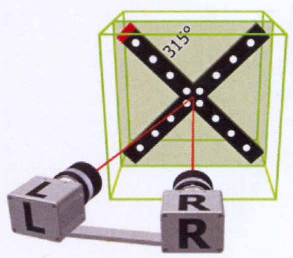
- Right camera normal
- Cross position 135°

Step 22:



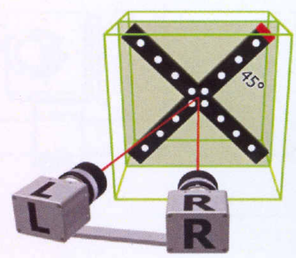
- Right camera normal
- Cross position 225°

Step 23:



- Right camera normal
- Cross position 315°

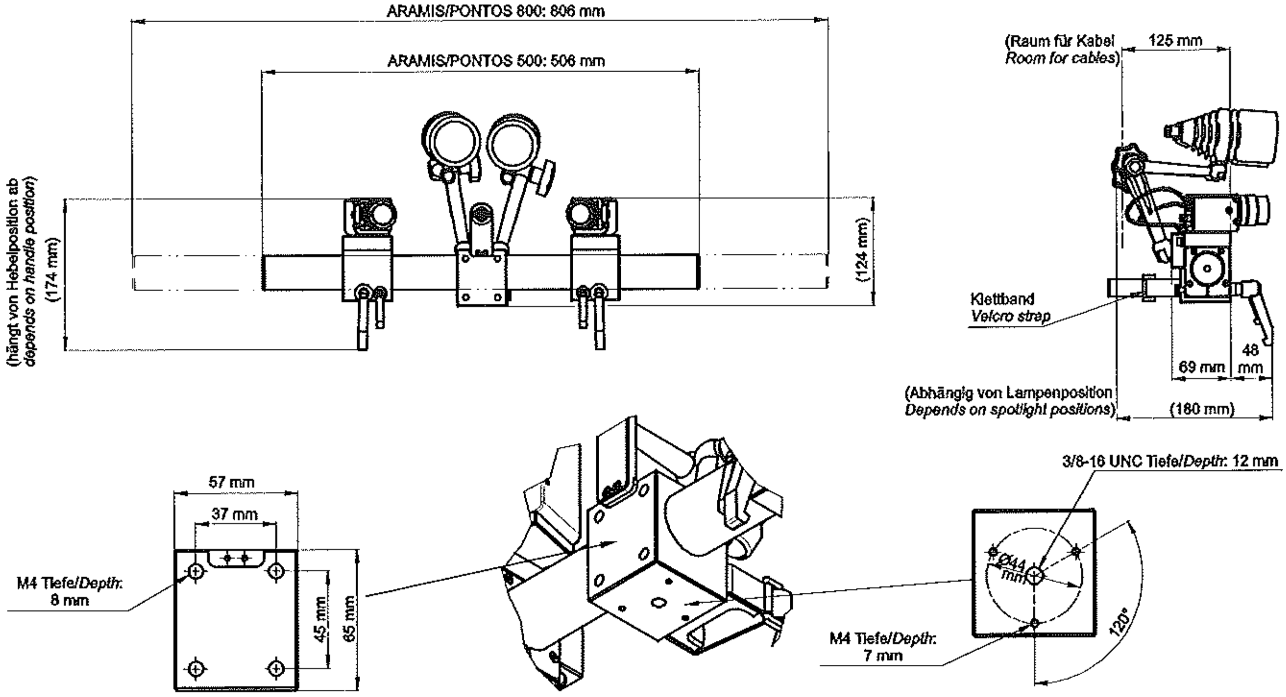
Step 24:



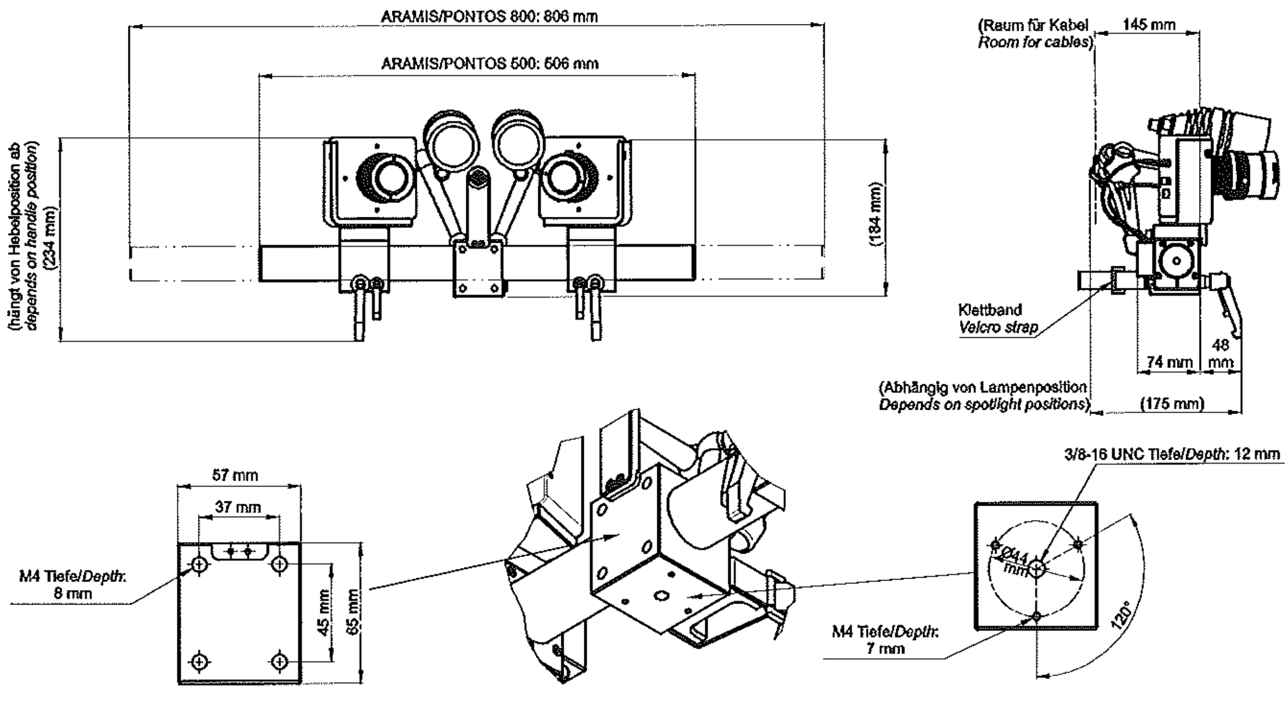
- Right camera normal
- Cross position 45°

11. Sensor Dimensions

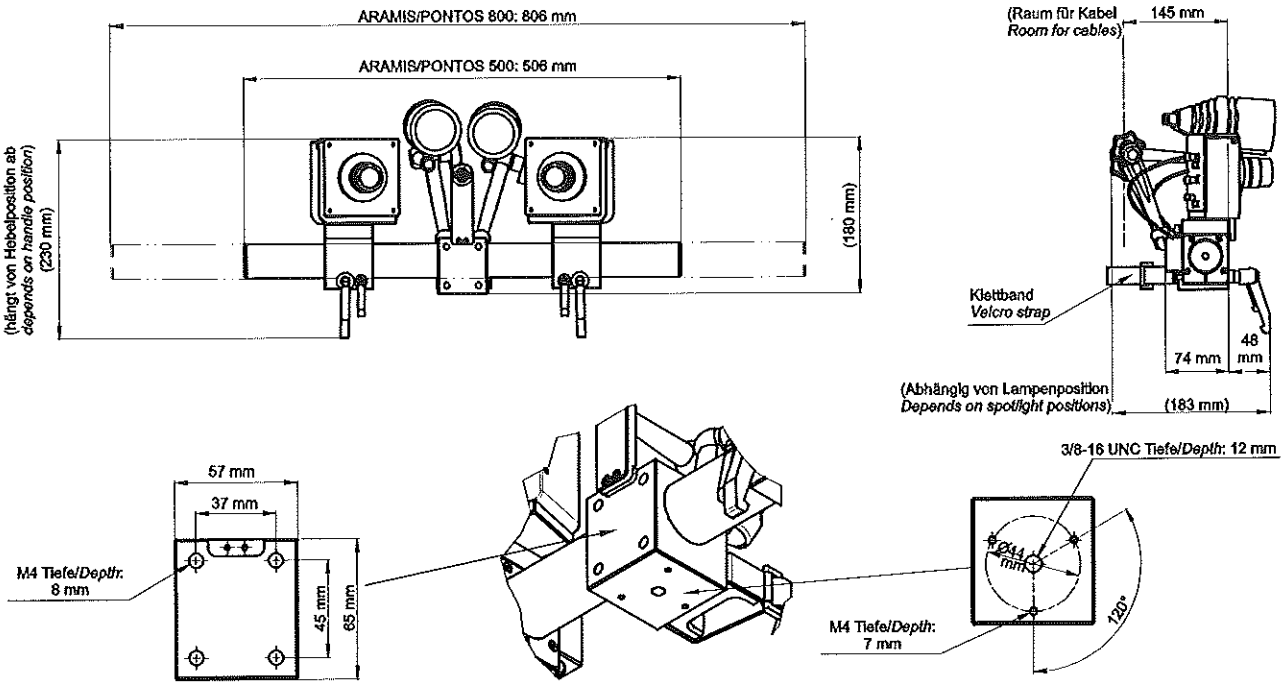
11.1 5M Adjustable Base 500/800



11.2 4M Adjustable Base 500/800



11.3 HS Adjustable Base 500/800

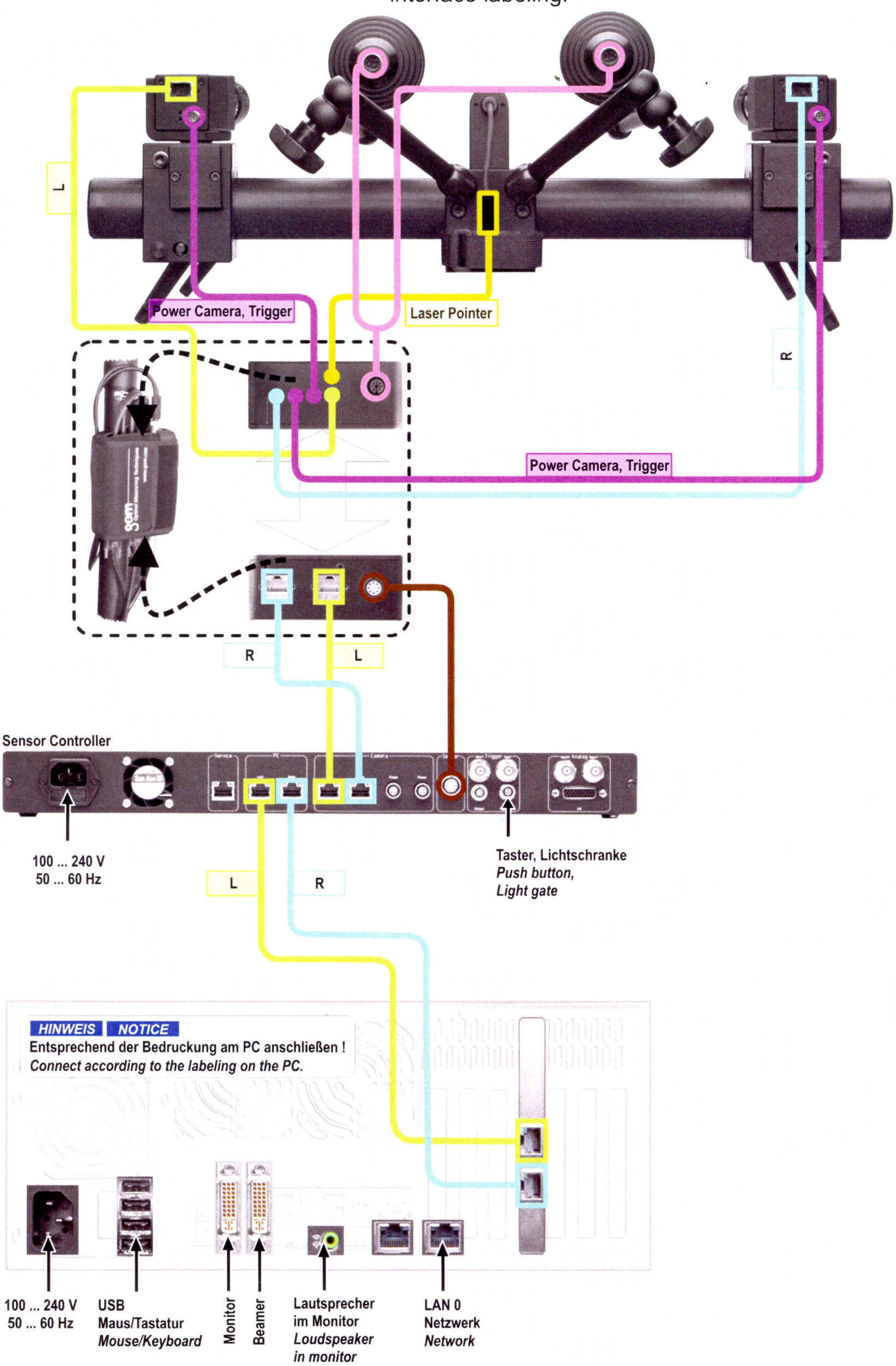


12. Cabling of the PONTOS Systems

12.1 5M Adjustable Base with 19" PC

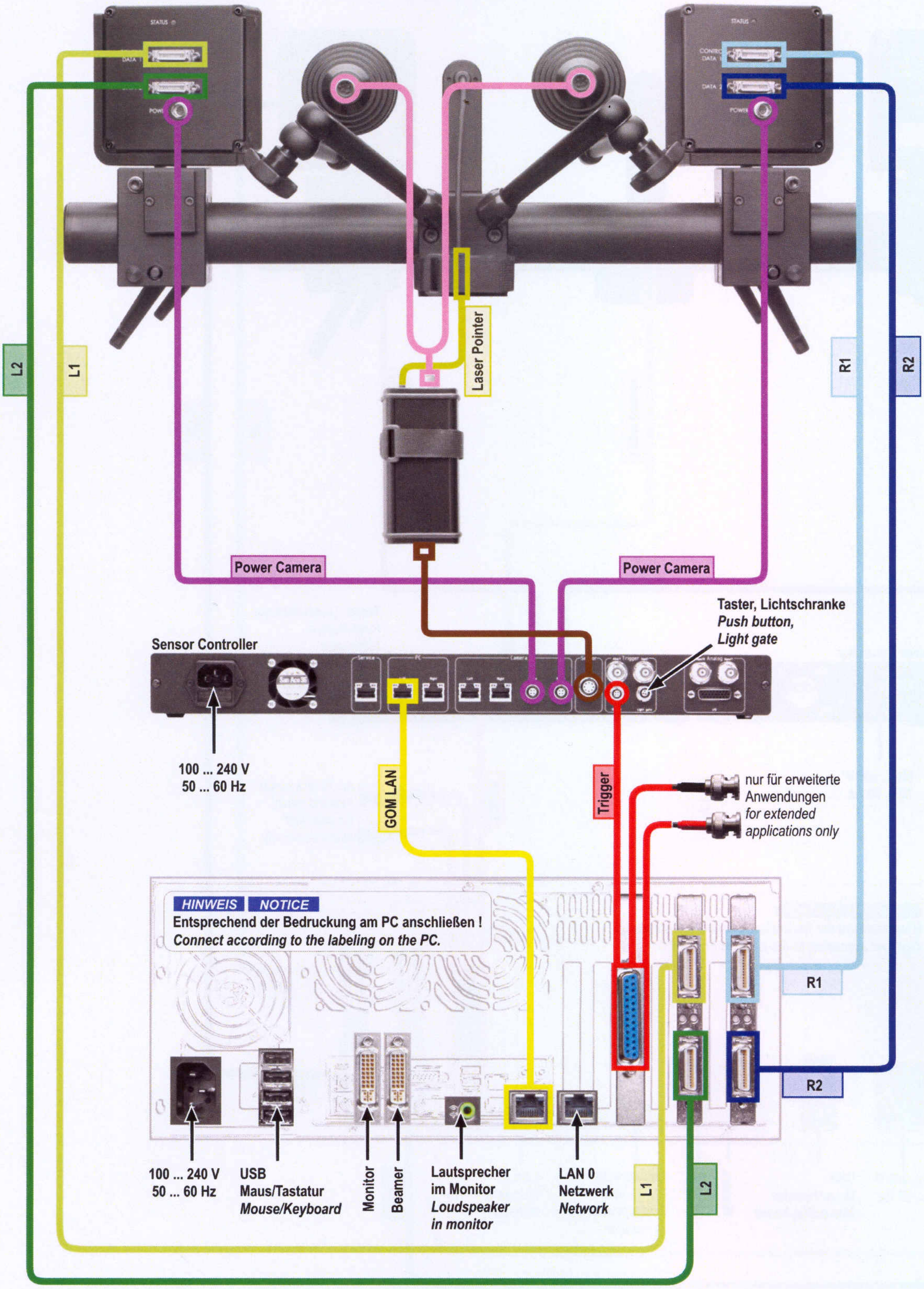
Info

During cabling, the devices need to be switched off! The PC connectors may be different from the illustration here. In this case, follow the interface labeling.



12.2 4M Adjustable Base with 19" PC

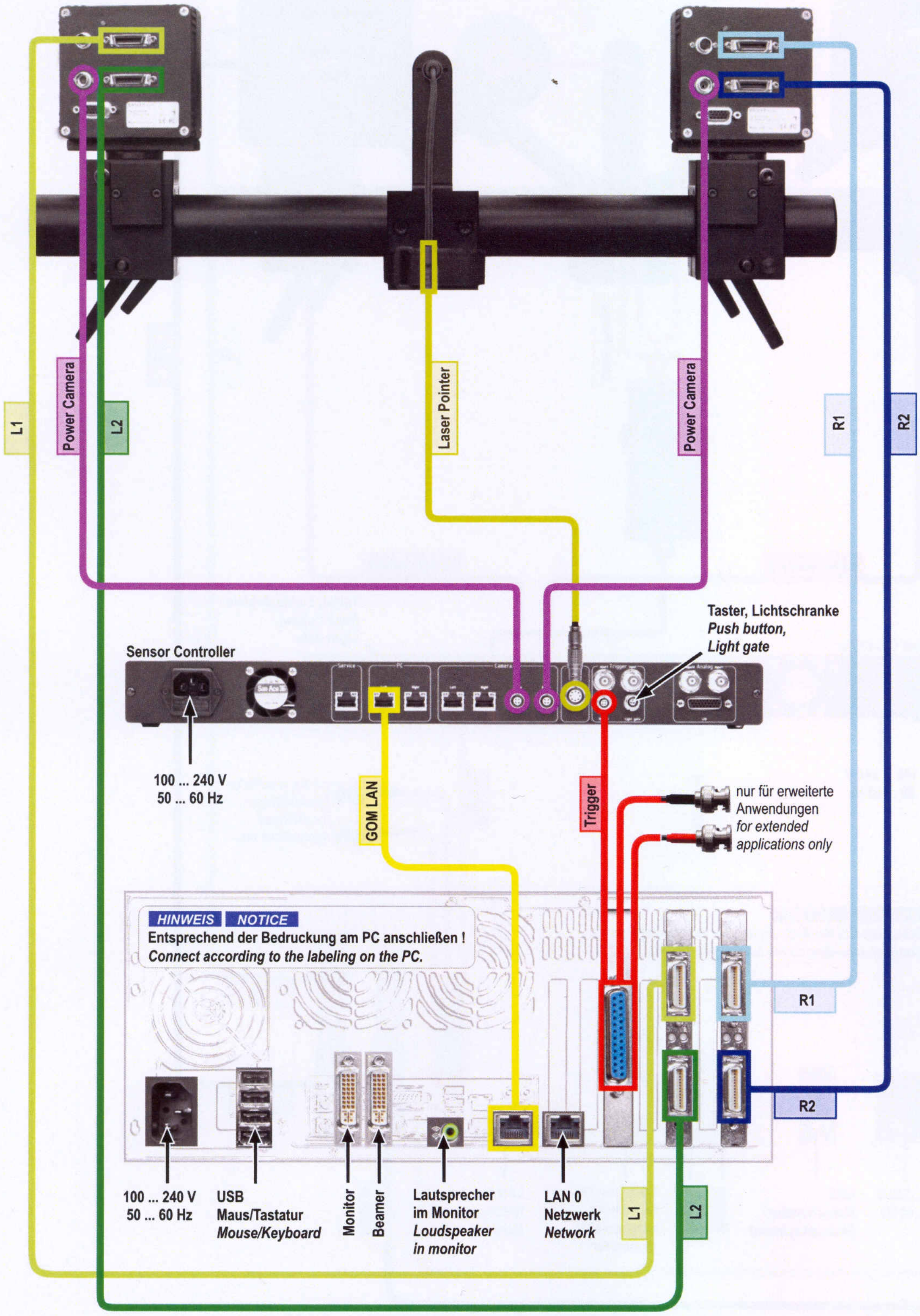
Info During cabling, the devices need to be switched off! The PC connectors may be different from the illustration here. In this case, follow the interface labeling.



12.3 HS Adjustable Base with 19" PC

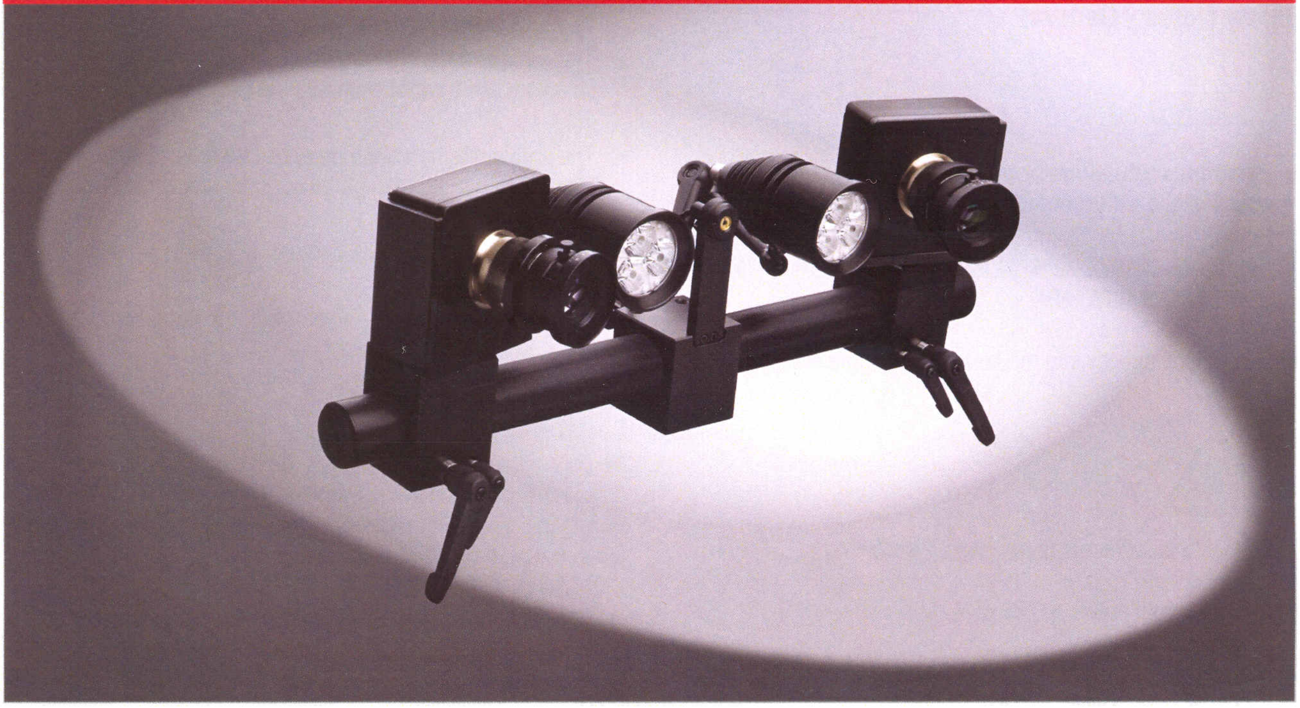
Info

During cabling, the devices need to be switched off! The PC connectors may be different from the illustration here. In this case, follow the interface labeling.



PONTOS

User Information - Hardware



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PONTOS 5M (Adjustable Base)
PONTOS 4M (Adjustable Base)
PONTOS HS (Adjustable Base)

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Legal and Safety Notes

Symbols

In this user manual the following standard signal words may be used:

⚠ WARNING	This label points to a situation that might be dangerous and could lead to serious bodily harm or to death.
⚠ CAUTION	This label points to a situation that might be dangerous and could lead to light bodily harm.
NOTICE	This label points to a situation in which the product or an object in the vicinity of the product might be damaged.
Info	This label indicates important application notes and other useful information.

Safety Notes - General

⚠ WARNING

- **Hazardous situations or processes may result on account of the different test setups used for deformation tests.**
  Therefore, always observe the valid, pertinent accident prevention regulations.

- Do not look directly into the laser light, danger of retina burn.

- The used laser meets **laser class 1** according to DIN EN 60 825-1
  (optical output power < 0,39 mW,
  wavelength 650 nm).
- Do not use equipment connected to AC power during heavy thunderstorms. Due to voltage variations and transient voltages in the low-voltage network, malfunctions and dangerous voltages between housing and other components may occur.
- In extreme positions, stands with horizontal extension arms may fall over. Avoid such positions. Use the product only on a safe and steady ground.
- When measuring large objects, make sure you comply with the respective valid accident prevention regulations.

⚠ CAUTION

- Operate the equipment only with the operating voltages printed on the housing. Using an incorrect operating voltage may cause malfunctions or the risk of fire.
- Check cables and, if damaged, replace them by all means. Protect the cables from mechanical load (squeezing, tension, etc.). Damaged cables may cause short-circuits and the risk of fire.
- AC power connection of the unit must comply with the valid regulations of the respective countries.
- Replace fuses only with components having the same specifications.

NOTICE

- Never unplug or connect cables during operation!
- The devices must not come into contact with water. For cleaning, use a moist cloth but first disconnect the power plug.
- The ambient temperature must be between +5 and +40 °C. Make sure no rapid temperature variations occur that might cause condensation.
- The housing may only be opened by experts when no voltage is applied.
- Do not stick any strange objects into the housing.

Legal Notes

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Table of Contents

1. Introduction

This user information is intended for qualified personnel who has experience in handling measuring systems and basic PC knowledge (windows-based programs and operating systems).

This user information is configured to the transfer of knowledge of system installation, sensor settings, camera adjustment and other hardware relevant information.

Info

The PONTOS system is a measuring system that also addresses experts of digital optical deformation analysis. Therefore, it is unavoidable that the PONTOS software contains menu items not intended for the standard user. Improper use of these menu items (expert parameters) may cause incorrect measurements.
For being able to make optimum use of the system, we assume the ability to visualize in 3D and a color vision ability.

This user information is divided into the following sections:

- The first page informs about important safety aspects.
- Section 1 gives basic information about the PONTOS system.
- Section 2 describes the system variants.
- Section 3 contains tables with the sensor configurations.
- Section 4 informs about the sensor control elements.
- Section 5 describes the fast setup of the sensor.
- Section 6 describes the complete setup of the sensor.
- Section 7 describes how to adjust the polarization filters.
- Section 8 contains important user information about the PC.
- Section 9 describes the sensor controller.
- Section 10 informs about the calibration and contains calibration information for external image series that were not recorded with the PONTOS standard systems.
- Section 11 illustrates the sensor dimensions.
- Section 12 contains the cabling of the systems.

2. The PONTOS System Variants

System types	PONTOS 5M	PONTOS 4M	PONTOS HS
Measuring volume in mm^3	10x8 to 5000x4150	10x7 to 4000x2900	10x8 to 3500x2800
Camera resolution	2448 x 2050 pixels	2352 x 1728 pixels	1280 x 1024 pixels
Camera chip	2/3 inch, CCD	1 inch, CMOS	1 inch, CMOS
Connection camera to PC	Gigabit-Ethernet via sensor controller	Camera Link	Camera Link
Main hardware components	▪ 19" PC ▪ Sensor ▪ Sensor controller ▪ LED lighting	▪ 19" PC ▪ Sensor ▪ Sensor controller ▪ LED lighting	▪ 19" PC ▪ Sensor ▪ Sensor controller
Laser pointer	yes	yes	yes
LED lighting with polarization filters	yes (10° or 30°)	yes (30°)	no
Measuring results	3D coordinates, 3D displacements, deformation		
For further information see http://www.gom.com			

The maximum image rate is fixed for the 5M and 4M cameras. For the high-speed camera (HS), higher frame rates can be achieved by dividing the height of the image size in half. The following table shows the frame rates of the different cameras with the respective image size and informs about the typical max. possible number of images.

Camera	Image size	Frequency in Hz BV RAM	No. of images BV RAM	Frequency in Hz PC RAM	No. of images 16 GB PC RAM	No. of images 32 GB PC RAM
5M	1 (max. camera resolution)	-	-	15	600	1300
	2x2 Binning	-	-	29	600	1300
4M	1 (max. camera resolution)	-	-	60	700	1600
	1/2	-	-	120	1400	3200
	1/4	-	-	240	2800	6400
	1/8	-	-	480	5600	10000
HS	1 (max. camera resolution)	500	800	40	2550	5600
	1/2	1000	1600	40	5100	10000
	1/4	2000	3200	40	10000	10000
	1/8	4000	6387	40	10000	10000

2.1 Main Hardware and Software Components

- High-performance 64 bit PC
- Up to 1GB memory per frame grabber board (HS)
- Two (high-speed) cameras
- Stand for secure and steady hold of the cameras
- LED lighting (standard for PONTOS 4M and 5M)
- Sensor controller for power supply of the cameras and to control image recording
- Laser pointer for easy setup of the sensor
- PONTOS application software and Linux system software
- Calibration object

For directly operating the sensor with the PONTOS application software, a Linux operating system is required.

Info

As of software version 6.1.1, the PONTOS software is also available on Windows systems. In this case, you cannot connect sensors (cameras) and the sensor controller!

3. General Information

Prior to start measuring, the respective measuring volume has to be selected depending on the measuring object size and on the distance to the measuring object. The measuring volume determines the set of lenses.

The following tables give an overview of the calibrated measuring volumes which can be achieved with your system components.

3.1 Overview: Sensors, Lenses, Camera Support → Measuring Volumes

		Measuring volume			
Camera support		500 mm (lenght)		800 mm (lenght)	
Camera angle		25°	25°	25°	25°
Sensors	Lenses (f in mm)	Min. Range	Max. Range	Min. Range	Max. Range
		Length x Width in mm			
PONTOS 5M	**8**	190 x 180	900 x 820	190 x 180	1550 x 1400
	12	130 x 110	610 x 540	130 x 110	1050 x 930
	17	90 x 75	440 x 380	90 x 75	760 x 650
	23	60 x 50	320 x 270	60 x 50	560 x 480
	35	35 x 29	210 x 170	35 x 29	370 x 310
	50	17 x 14	140 x 120	17 x 14	250 x 210
	65	10 x 8	100 x 85	10 x 8	190 x 150
	100	10 x 8	60 x 50	10 x 8	120 x 100
PONTOS 4M	**20**	130 x 100	710 x 560	130 x 100	1250 x 980
	35	60 x 48	410 x 310	60 x 48	720 x 550
	50	29 x 21	280 x 200	29 x 21	500 x 370
	65	20 x 14	200 x 150	20 x 14	380 x 280
	100	10 x 7	120 x 90	10 x 7	240 x 170
PONTOS HS	**20**	110 x 95	640 x 540	110 x 95	1100 x 940
	28	75 x 60	450 x 380	75 x 60	800 x 660
	35	50 x 43	360 x 290	50 x 43	640 x 530
	50	22 x 17	250 x 200	22 x 17	450 x 360
	100	10 x 8	110 x 85	10 x 8	210 x 160

3.2 Overview: Calibration Objects → Measuring Volumes

Calibration objects	Measuring volume		
	PONTOS 4M	**PONTOS 5M**	**PONTOS HS**
	Length x Width [mm]	Length x Width [mm]	Length x Width [mm]
CQ 10x8	10 x 7 ... 13 x 10	9 x 8 ... 13 x 11	9 x 7 ... 13 x 10
CQ 15x12	15 x 11 ... 19 x 14	13 x 11 ... 19 x 16	14 x 11 ... 19 x 15
CQ 23x18	23 x 17 ... 29 x 21	21 x 18 ... 29 x 24	22 x 18 ... 29 x 23
CQ 30x24 **CP20 30x24**	30 x 22 ... 50 x 37	26 x 22 ... 50 x 42	28 x 22 ... 50 x 40
CQ 55x44 **CP20 55x44**	50 x 37 ... 90 x 65	44 x 37 ... 90 x 75	46 x 37 ... 90 x 70
CP20 90x72	90 x 65 ... 130 x 95	80 x 65 ... 130 x 110	80 x 65 ... 130 x 100
CP20 175x140	150 x 110 ... 200 x 150	130 x 110 ... 200 x 170	140 x 110 ... 200 x 160
CP20 250x200	230 x 170 ... 370 x 270	200 x 170 ... 370 x 310	210 x 170 ... 370 x 300
CP20 350x280	340 x 250 ... 500 x 370	300 x 250 ... 500 x 420	310 x 250 ... 500 x 400
CC20 500x400	530 x 390 ... 670 x 490	470 x 390 ... 670 x 560	490 x 390 ... 670 x 540
CC20 700x560	710 x 520 ... 890 x 650	620 x 520 ... 890 x 750	650 x 520 ... 890 x 710
CC20 1000x800	880 x 650 ... 1300 x 960	780 x 650 ... 1300 x 1100	810 x 650 ... 1300 x 1050
CC20 1400x1120	1250 x 920 ... 1600 x 1200	1100 x 920 ... 1600 x 1350	1150 x 920 ... 1600 x 1300
CC20 2000x1600	1750 x 1300 ... 2350 x 1750	1550 x 1300 ... 2350 x 1950	1650 x 1300 ... 2350 x 1900

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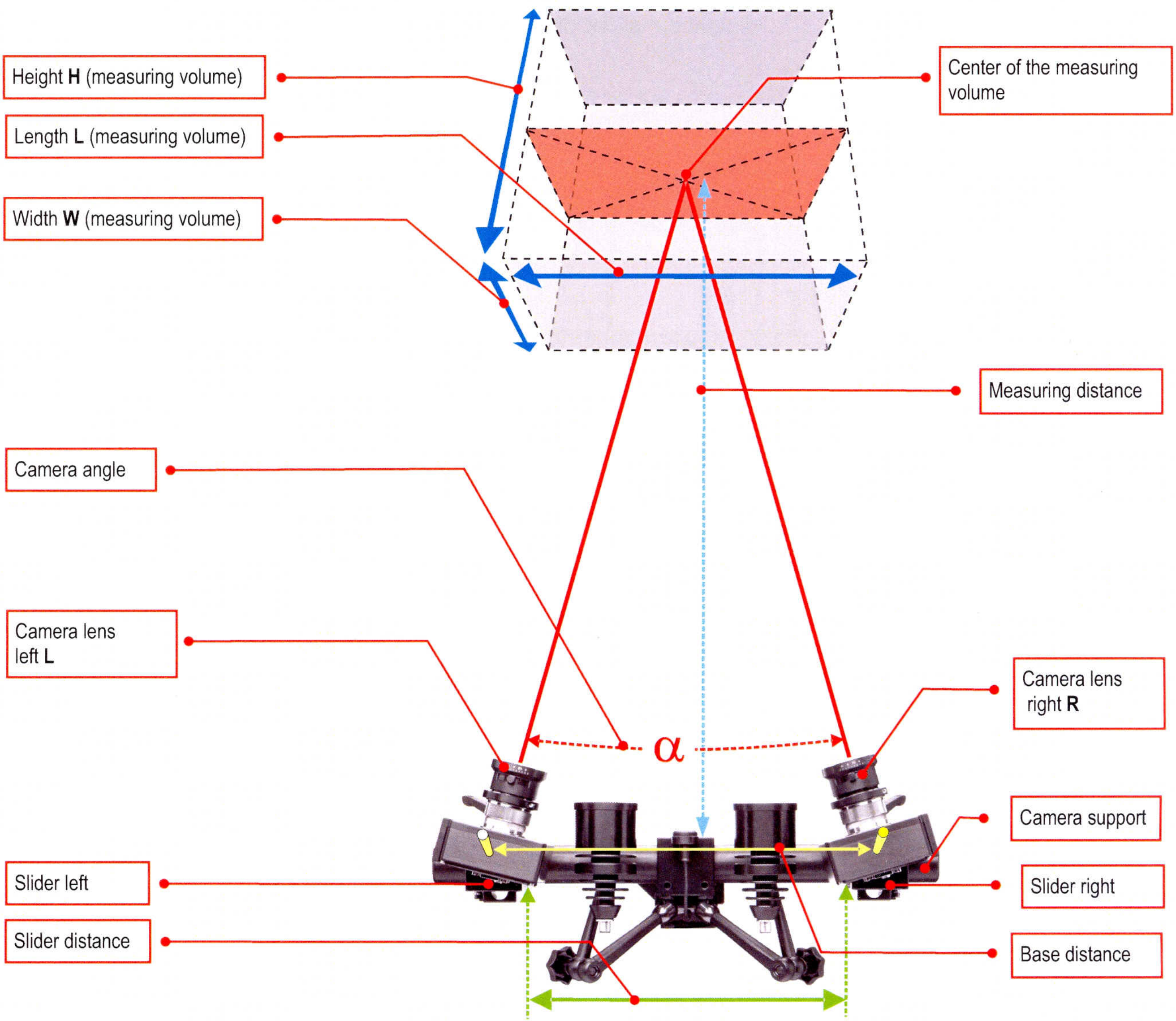
Info

Prior to initial commissioning of the PONTOS system, the sensor must be adjusted. The angle relations of the lenses, the focus and the aperture need to be set. Then, the complete system is calibrated by means of calibration panels or calibration crosses. If the measuring volume is adjusted successfully by calibration, you may start a measuring project.

Info

In practice, depending on the measuring task, different measuring volumes might be required. You only need to adjust the sensor again if the measuring distance or the angle relations of the cameras or the adjustments of the camera lenses have to be changed because of a different measuring volume.

3.3 Definition of Terms



The figure shows a 3D sensor unit in top view.

3.4 Sensor Configuration Examples

3.4.1 Sensor Configuration Examples for PONTOS 4M (2358x1728 Pixel)

Info

The following table values are examples. The sensor may also operate with measuring volumes that result between the values stated in the table. In such a case, you need to interpret the values for the measuring distance and the slider distance accordingly.

When using these measuring volumes, it is important to keep the aperture as closed as possible to achieve a high depth of field. For the sensors, the following relation applies for a camera angle of 25°: Base distance = slider distance + 39 mm.

3.4.1.1 20 mm Lens (PONTOS 4M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
20mm, lens family A1 (Titanar)	125 x 90	1)	500	---	195	66	27	CP20 90x72	---	---	n.a.	n.a.	5.5	21	41	78	>125	>125
	150 x 110	1)	500	---	230	74	25	CP20 175x140	---	---	n.a.	2.9	18	41	72	130	>150	>150
	175 x 130	1)	500	---	260	88	25	CP20 175x140	---	---	n.a.	9.5	30	61	100	>175	>175	>175
	200 x 150	---	500	---	290	102	25	CP20 175x140	---	---	n.a.	18	44	86	140	>200	>200	>200
	250 x 180	---	500	---	355	130	25	CP20 250x200	---	---	12	43	85	150	>250	>250	>250	>250
	300 x 220	---	500	---	415	156	25	CP20 250x200	---	---	30	73	130	240	>300	>300	>300	>300
	350 x 260	---	500	---	480	186	25	CP20 350x280	---	---	54	110	200	>350	>350	>350	>350	>350
	400 x 290	---	500	---	545	214	25	CP20 350x280	---	---	85	170	290	>400	>400	>400	>400	>400
	500 x 370	---	500	---	670	270	25	CP20 350x280	---	---	160	300	>500	>500	>500	>500	>500	>500
	750 x 550	---	800	---	985	410	25	CC20 700x560	---	---	470	>750	>750	>750	>750	>750	>750	>750
	1000 x 730	---	800	---	1285	542	25	CC20 1000x800	---	---	970	>1000	>1000	>1000	>1000	>1000	>1000	>1000
	1250 x 920	---	800	---	1600	682	25	CC20 1400x1120	---	---	>1250	>1250	>1250	>1250	>1250	>1250	>1250	>1250
	1500 x 1100	---	800	---	1900	688	21	CC20 1400x1120	---	---	>1500	>1500	>1500	>1500	>1500	>1500	>1500	>1500

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.1.2 35 mm Lens (PONTOS 4M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
35mm, lens family A1 (Titanar)	65 x 48	1)	500	---	215	68	25	CQ/CP20 55x44	---	n.a.	n.a.	n.a.	n.a.	n.a.	5.1	14	---	---
	80 x 60	1)	500	---	240	80	25	CQ/CP20 55x44	---	n.a.	n.a.	n.a.	n.a.	2.1	9.6	22	---	---
	100 x 75	---	500	---	285	98	25	CP20 90x72	---	n.a.	n.a.	n.a.	n.a.	9	21	41	---	---
	125 x 90	---	500	---	335	120	25	CP20 90x72	---	n.a.	n.a.	n.a.	5.2	19	37	68	---	---
	150 x 110	---	500	---	385	144	25	CP20 175x140	---	n.a.	n.a.	n.a.	13	33	58	100	---	---
	175 x 130	---	500	---	440	168	25	CP20 175x140	---	n.a.	n.a.	5.6	24	51	86	150	---	---
	200 x 150	---	500	---	495	192	25	CP20 175x140	---	n.a.	n.a.	14	37	73	120	>200	---	---
	250 x 180	---	500	---	600	240	25	CP20 250x200	---	n.a.	6.6	34	70	130	200	>250	---	---
	300 x 220	---	500	---	705	286	25	CP20 250x200	---	n.a.	22	61	110	200	>300	>300	---	---
	350 x 260	---	500	---	810	332	25	CP20 350x280	---	7.9	43	95	170	280	>350	>350	---	---
	400 x 290	---	500	---	920	382	25	CP20 350x280	---	23	69	140	230	390	>400	>400	---	---
	500 x 370	---	800	---	1130	474	25	CP20 350x280	---	63	130	240	400	>500	>500	>500	---	---
	750 x 550	---	800	---	1660	688	24	CC20 700x560	---	230	390	650	>750	>750	>750	>750	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.1.3 50 mm Lens (PONTOS 4M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
50mm, lens family A1 (Titanar)	25 x 18	1)	500	25	205	66	26	CQ 23x18	---	---	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	---	---
	35 x 26	1)	500	12.5	225	70	25	CQ/CP20 30x24	---	---	n.a.	n.a.	n.a.	n.a.	n.a.	1.8	---	---
	50 x 37	1)	500	12.5	260	88	25	CQ/CP20 55x44	---	---	n.a.	n.a.	n.a.	n.a.	0.5	5.8	---	---
	65 x 48	---	500	---	305	108	25	CQ/CP20 55x44	---	---	n.a.	n.a.	n.a.	n.a.	4.6	13	---	---
	80 x 60	---	500	---	345	126	25	CQ/CP20 55x44	---	---	n.a.	n.a.	n.a.	2.1	9.6	22	---	---
	100 x 75	---	500	---	400	150	25	CP20 90x72	---	---	n.a.	n.a.	n.a.	7.6	19	38	---	---
	125 x 90	---	500	---	475	184	25	CP20 90x72	---	---	n.a.	n.a.	4.1	18	35	65	---	---
	150 x 110	---	500	---	550	216	25	CP20 175x140	---	---	n.a.	n.a.	12	32	57	99	---	---
	175 x 130	---	500	---	625	250	25	CP20 175x140	---	---	n.a.	4.6	22	49	82	140	---	---
	200 x 150	---	500	---	695	282	25	CP20 175x140	---	---	n.a.	11	34	68	110	190	---	---
	250 x 180	---	500	---	845	348	25	CP20 250x200	---	---	4.7	31	66	120	190	>250	---	---
	300 x 220	---	800	---	995	414	25	CP20 250x200	---	---	20	57	110	180	280	>300	---	---
	350 x 260	---	800	---	1140	480	25	CP20 350x280	---	---	38	88	160	260	>350	>350	---	---
	400 x 290	---	800	---	1290	546	25	CP20 350x280	---	---	62	130	220	350	>400	>400	---	---
	500 x 370	---	800	---	1590	678	25	CP20 350x280	---	---	120	230	370	>500	>500	>500	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.1.4 65 mm Lens (PONTOS 4M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
65mm, lens family A1 (Titanar)	20 x 15	1)	500	50	260	86	25	CQ 15x12	---	---	---	---	---	---	---	n.a.	---	---
	25 x 18	---	500	37,5	270	92	25	CQ 23x18	---	---	---	---	---	---	---	n.a.	---	---
	35 x 26	---	500	25	295	104	25	CQ/CP20 30x24	---	---	---	---	---	---	---	1.3	---	---
	50 x 37	---	500	12,5	345	126	25	CQ/CP20 55x44	---	---	---	---	---	---	---	5.9	---	---
	65 x 48	---	500	12,5	395	148	25	CQ/CP20 55x44	---	---	---	---	---	---	---	12	---	---
	80 x 60	---	500	12,5	455	174	25	CQ/CP20 55x44	---	---	---	---	---	---	---	22	---	---
	100 x 75	---	500	---	530	208	25	CP20 90x72	---	---	---	---	---	---	---	38	---	---
	125 x 90	---	500	---	625	250	25	CP20 90x72	---	---	---	---	---	---	---	63	---	---
	150 x 110	---	500	---	720	292	25	CP20 175x140	---	---	---	---	---	---	---	95	---	---
	175 x 130	---	500	---	815	334	25	CP20 175x140	---	---	---	---	---	---	---	130	---	---
	200 x 150	---	500	---	915	378	25	CP20 175x140	---	---	---	---	---	---	---	180	---	---
	250 x 180	---	800	---	1105	462	25	CP20 250x200	---	---	---	---	---	---	---	>250	---	---
	300 x 220	---	800	---	1300	550	25	CP20 250x200	---	---	---	---	---	---	---	>300	---	---
	350 x 260	---	800	---	1495	636	25	CP20 350x280	---	---	---	---	---	---	---	>350	---	---
	400 x 290	---	800	---	1695	688	24	CP20 350x280	---	---	---	---	---	---	---	>400	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.1.5 100 mm Lens (PONTOS 4M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
100mm, lens family A2 (Titanar)	10 x 7	---	500	162,5	415	158	25	CQ 10x8	---	---	---	---	n.a.	n.a.	n.a.	n.a.	0.1	0.9
	15 x 11	---	500	112,5	390	146	25	CQ 15x12	---	---	---	---	n.a.	n.a.	n.a.	n.a.	0.3	2.4
	20 x 15	---	500	75	395	148	25	CQ 15x12	---	---	---	---	n.a.	n.a.	n.a.	n.a.	0.8	3.3
	25 x 18	---	500	62,5	410	154	25	CQ 23x18	---	---	---	---	n.a.	n.a.	n.a.	n.a.	1.9	5.5
	35 x 26	---	500	37,5	455	174	25	CQ/CP20 30x24	---	---	---	---	n.a.	n.a.	n.a.	1.7	5.4	12
	50 x 37	---	500	25	525	206	25	CQ/CP20 55x44	---	---	---	---	n.a.	n.a.	0.5	5.9	12	23
	65 x 48	---	500	25	605	242	25	CQ/CP20 55x44	---	---	---	---	n.a.	n.a.	4	13	23	40
	80 x 60	---	500	12,5	685	276	25	CQ/CP20 55x44	---	---	---	---	n.a.	1.6	8.9	21	36	60
	100 x 75	---	500	12,5	800	328	25	CP20 90x72	---	---	---	---	n.a.	7.1	18	37	59	97
	125 x 90	---	800	12,5	945	390	25	CP20 90x72	---	---	---	---	3.5	17	34	62	96	>125
	150 x 110	---	800	---	1085	452	25	CP20 175x140	---	---	---	---	11	29	53	93	140	>150
	175 x 130	---	800	---	1230	516	25	CP20 175x140	---	---	---	---	20	45	77	130	>175	>175
	200 x 150	---	800	---	1375	582	25	CP20 175x140	---	---	---	---	32	64	110	170	>200	>200
	250 x 180	---	800	---	1675	688	24	CP20 250x200	---	---	---	---	64	110	180	>250	>250	>250

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2 Sensor Configuration Examples for PONTOS 5M (2448x2050 Pixel)

Info

The following table values are examples. The sensor may also operate with measuring volumes that result between the values stated in the table. In such a case, you need to interpret the values for the measuring distance and the slider distance accordingly.

When using these measuring volumes, it is important to keep the aperture as closed as possible to achieve a high depth of field. For the sensors, the following relation applies for a camera angle of 25°: Base distance = slider distance + 50 mm.

3.4.2.1 8 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
8mm, lens family B	175 x 150	---	500	---	190	Mech. Stop	28	CP20 175x140	n.a.	18	45	89	160	>175	>175	---	---	---
	200 x 170	---	500	---	215	Mech. Stop	25	CP20 250x200	10	35	70	130	>200	>200	>200	---	---	---
	250 x 210	---	500	---	270	80	25	CP20 250x200	31	71	130	240	>250	>250	>250	---	---	---
	300 x 250	---	500	---	320	104	25	CP20 350x280	57	120	210	>300	>300	>300	>300	---	---	---
	350 x 290	---	500	---	375	128	25	CP20 350x280	93	180	320	>350	>350	>350	>350	---	---	---
	400 x 330	---	500	---	430	152	25	CP20 350x280	140	260	>400	>400	>400	>400	>400	---	---	---
	500 x 420	---	500	---	535	198	25	CC20 500x400	250	480	>500	>500	>500	>500	>500	---	---	---
	750 x 630	---	500	---	800	316	25	CC20 700x560	>750	>750	>750	>750	>750	>750	>750	---	---	---
	1000 x 840	---	800	---	1055	430	25	CC20 1000x800	>1000	>1000	>1000	>1000	>1000	>1000	>1000	---	---	---
	1250 x 1050	---	800	---	1320	546	25	CC20 1400x1120	>1250	>1250	>1250	>1250	>1250	>1250	>1250	---	---	---
	1500 x 1250	---	800	---	1570	660	25	CC20 1400x1120	>1500	>1500	>1500	>1500	>1500	>1500	>1500	---	---	---
	1750 x 1450	---	800	---	1820	688	23	CC20 2000x1600	>1750	>1750	>1750	>1750	>1750	>1750	>1750	---	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2.2 12 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
12mm, lens family B	125 x 100	---	500	---	205	Mech. Stop	26	CP20 90x72	n.a.	n.a.	11	29	54	94	>125	---	---	---
	150 x 130	---	500	---	245	70	25	CP20 175x140	n.a.	7.6	25	51	88	>150	>150	---	---	---
	175 x 150	---	500	---	280	86	25	CP20 175x140	n.a.	17	39	75	130	>175	>175	---	---	---
	200 x 170	---	500	---	320	104	25	CP20 250x200	6	28	59	110	180	>200	>200	---	---	---
	250 x 210	---	500	---	395	136	25	CP20 250x200	23	58	110	190	>250	>250	>250	---	---	---
	300 x 250	---	500	---	470	170	25	CP20 350x280	47	98	170	290	>300	>300	>300	---	---	---
	350 x 290	---	500	---	550	206	25	CP20 350x280	77	150	250	>350	>350	>350	>350	---	---	---
	400 x 330	---	500	---	625	238	25	CP20 350x280	110	210	350	>400	>400	>400	>400	---	---	---
	500 x 420	---	500	---	780	308	25	CC20 500x400	210	370	>500	>500	>500	>500	>500	---	---	---
	750 x 630	---	800	---	1160	476	25	CC20 700x560	590	>750	>750	>750	>750	>750	>750	---	---	---
	1000 x 840	---	800	---	1530	640	25	CC20 1000x800	>1000	>1000	>1000	>1000	>1000	>1000	>1000	---	---	---
	1250 x 1050	---	800	---	1915	688	22	CC20 1400x1120	>1250	>1250	>1250	>1250	>1250	>1250	>1250	---	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2.3 17 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
17mm, lens family B	80 x 65	---	500	---	190	Mech. Stop	28	CP20 90x72	n.a.	n.a.	n.a.	3.4	13	27	45	---	---	---
	100 x 85	---	500	---	235	66	25	CP20 90x72	n.a.	n.a.	2.6	13	28	51	80	---	---	---
	125 x 100	---	500	---	290	90	25	CP20 90x72	n.a.	n.a.	11	27	50	86	>125	---	---	---
	150 x 130	---	500	---	340	112	25	CP20 175x140	n.a.	6	22	46	79	130	>150	---	---	---
	175 x 150	---	500	---	395	136	25	CP20 175x140	n.a.	15	36	69	120	>175	>175	---	---	---
	200 x 170	---	500	---	450	160	25	CP20 250x200	3.9	25	53	97	160	>200	>200	---	---	---
	250 x 210	---	500	---	555	208	25	CP20 250x200	20	53	97	170	>250	>250	>250	---	---	---
	300 x 250	---	500	---	660	254	25	CP20 350x280	41	89	150	260	>300	>300	>300	---	---	---
	350 x 290	---	500	---	765	300	25	CP20 350x280	69	130	220	>350	>350	>350	>350	---	---	---
	400 x 330	---	500	---	875	350	25	CP20 350x280	100	190	310	>400	>400	>400	>400	---	---	---
	500 x 420	---	800	---	1090	446	25	CC20 500x400	190	330	>500	>500	>500	>500	>500	---	---	---
	750 x 630	---	800	---	1620	680	25	CC20 700x560	520	>750	>750	>750	>750	>750	>750	---	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2.4 23 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
23mm, lens family B	50 x 42	---	500	---	175	Mech. Stop	30	CQ/CP20 55x44	n.a.	n.a.	n.a.	n.a.	n.a.	5.3	12	---	---	---
	65 x 55	---	500	---	220	60	25	CQ/CP20 55x44	n.a.	n.a.	n.a.	0.6	6.7	16	28	---	---	---
	80 x 65	---	500	---	260	76	25	CP20 90x72	n.a.	n.a.	n.a.	4.7	14	27	44	---	---	---
	100 x 85	---	500	---	320	102	25	CP20 90x72	n.a.	n.a.	2.4	13	27	49	77	---	---	---
	125 x 100	---	500	---	390	134	25	CP20 90x72	n.a.	n.a.	9.9	26	48	82	>125	---	---	---
	150 x 130	---	500	---	460	164	25	CP20 175x140	n.a.	5.1	20	44	75	120	>150	---	---	---
	175 x 150	---	500	---	530	196	25	CP20 175x140	n.a.	13	34	65	110	>175	>175	---	---	---
	200 x 170	---	500	---	600	228	25	CP20 250x200	2.3	22	50	91	150	>200	>200	---	---	---
	250 x 210	---	500	---	745	292	25	CP20 250x200	18	49	92	160	250	>250	>250	---	---	---
	300 x 250	---	500	---	885	354	25	CP20 350x280	38	83	140	240	>300	>300	>300	---	---	---
	350 x 290	---	800	---	1030	418	25	CP20 350x280	65	130	210	350	>350	>350	>350	---	---	---
	400 x 330	---	800	---	1170	480	25	CP20 350x280	97	180	290	>400	>400	>400	>400	---	---	---
	500 x 420	---	800	---	1450	606	25	CC20 500x400	180	310	480	>500	>500	>500	>500	---	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2.5 35 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
35mm, lens family B	35 x 29	---	500	---	215	Mech. Stop	25	CQ/CP20 30x24	---	n.a.	n.a.	n.a.	n.a.	1.5	5	11	---	---
	50 x 42	---	500	---	275	84	25	CQ/CP20 55x44	---	n.a.	n.a.	n.a.	1.5	7	14	25	---	---
	65 x 55	---	500	---	340	110	25	CQ/CP20 55x44	---	n.a.	n.a.	0.5	6.5	15	27	46	---	---
	80 x 65	---	500	---	400	138	25	CP20 90x72	---	n.a.	n.a.	4.3	13	26	43	71	---	---
	100 x 85	---	500	---	485	176	25	CP20 90x72	---	n.a.	1.5	12	25	46	72	>100	---	---
	125 x 100	---	500	---	590	222	25	CP20 90x72	---	n.a.	8.7	24	45	77	120	>125	---	---
	150 x 130	---	500	---	700	272	25	CP20 175x140	---	4	19	42	72	120	>150	>150	---	---
	175 x 150	---	500	---	805	318	25	CP20 175x140	---	12	32	62	100	170	>175	>175	---	---
	200 x 170	---	500	---	910	364	25	CP20 250x200	---	21	47	87	140	>200	>200	>200	---	---
	250 x 210	---	800	---	1120	460	25	CP20 250x200	---	45	86	150	230	>250	>250	>250	---	---
	300 x 250	---	800	---	1340	556	25	CP20 350x280	---	80	140	230	>300	>300	>300	>300	---	---
	350 x 290	---	800	---	1550	650	25	CP20 350x280	---	120	200	320	>350	>350	>350	>350	---	---
	400 x 330	---	800	---	1770	688	23	CP20 350x280	---	180	280	>400	>400	>400	>400	>400	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2.6 50 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
50mm, lens family A1 (Titanar)	15 x 13	---	500	20	205	Mech. Stop	26	CQ 15x12	---	---	n.a.	n.a.	n.a.	n.a.	n.a.	0.9	---	---
	20 x 17	---	500	10	230	64	25	CQ 15x12	---	---	n.a.	n.a.	n.a.	n.a.	0.4	2.7	---	---
	25 x 21	---	500	10	250	74	25	CQ 23x18	---	---	n.a.	n.a.	n.a.	n.a.	1.4	4.5	---	---
	35 x 29	---	500	---	310	98	25	CQ/CP20 30x24	---	---	n.a.	n.a.	n.a.	1.5	5	11	---	---
	50 x 42	---	500	---	395	136	25	CQ/CP20 55x44	---	---	n.a.	n.a.	1.4	6.8	14	25	---	---
	65 x 55	---	500	---	485	176	25	CQ/CP20 55x44	---	---	n.a.	0.3	6.1	15	26	45	---	---
	80 x 65	---	500	---	575	216	25	CP20 90x72	---	---	n.a.	4.1	13	26	43	70	---	---
	100 x 85	---	500	---	695	270	25	CP20 90x72	---	---	1.2	11	25	45	70	>100	---	---
	125 x 100	---	500	---	845	336	25	CP20 90x72	---	---	8.3	24	45	76	120	>125	---	---
	150 x 130	---	800	---	995	402	25	CP20 175x140	---	---	18	40	70	110	>150	>150	---	---
	175 x 150	---	800	---	1150	472	25	CP20 175x140	---	---	31	61	100	160	>175	>175	---	---
	200 x 170	---	800	---	1300	540	25	CP20 250x200	---	---	46	85	140	>200	>200	>200	---	---
	250 x 210	---	800	---	1600	674	25	CP20 250x200	---	---	85	150	230	>250	>250	>250	---	---
	300 x 250	---	800	---	1920	688	21	CP20 350x280	---	---	150	230	>300	>300	>300	>300	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2.7 65 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
65mm, lens family A1 (Titanar)	10 x 8	---	500	40	250	72	25	CQ 10x8	---	---	---	---	---	---	---	0	---	---
	15 x 13	---	500	30	275	84	25	CQ 15x12	---	---	---	---	---	---	---	1.1	---	---
	20 x 17	---	500	20	305	96	25	CQ 15x12	---	---	---	---	---	---	---	2.6	---	---
	25 x 21	---	500	10	340	112	25	CQ 23x18	---	---	---	---	---	---	---	4.8	---	---
	35 x 29	---	500	10	410	142	25	CQ/CP20 30x24	---	---	---	---	---	---	---	11	---	---
	50 x 42	---	500	---	525	194	25	CQ/CP20 55x44	---	---	---	---	---	---	---	25	---	---
	65 x 55	---	500	---	640	246	25	CQ/CP20 55x44	---	---	---	---	---	---	---	44	---	---
	80 x 65	---	500	---	760	298	25	CP20 90x72	---	---	---	---	---	---	---	69	---	---
	100 x 85	---	500	---	915	366	25	CP20 90x72	---	---	---	---	---	---	---	>100	---	---
	125 x 100	---	800	---	1110	458	25	CP20 90x72	---	---	---	---	---	---	---	>125	---	---
	150 x 130	---	800	---	1310	542	25	CP20 175x140	---	---	---	---	---	---	---	>150	---	---
	175 x 150	---	800	---	1510	632	25	CP20 175x140	---	---	---	---	---	---	---	>175	---	---
	200 x 170	---	800	---	1720	688	24	CP20 250x200	---	---	---	---	---	---	---	>200	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.2.8 100 mm Lens (PONTOS 5M)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
100mm, lens family A2 (Titanar)	10 x 8	---	500	75	385	132	25	CQ 10x8	---	---	---	---	n.a.	n.a.	n.a.	0	0.9	2.4
	15 x 13	---	500	50	420	148	25	CQ 15x12	---	---	---	---	n.a.	n.a.	n.a.	1	2.6	5.4
	20 x 17	---	500	37.5	465	168	25	CQ 15x12	---	---	---	---	n.a.	n.a.	0.3	2.5	5.1	9.4
	25 x 21	---	500	25	520	192	25	CQ 23x18	---	---	---	---	n.a.	n.a.	1.5	4.7	8.6	15
	35 x 29	---	500	12.5	630	240	25	CQ/CP20 30x24	---	---	---	---	n.a.	1.5	5	11	18	30
	50 x 42	---	500	12.5	810	320	25	CQ/CP20 55x44	---	---	---	---	1.5	7	14	25	39	>50
	65 x 55	---	800	12.5	975	394	25	CQ/CP20 55x44	---	---	---	---	5.8	14	25	44	>65	>65
	80 x 65	---	800	---	1150	470	25	CP20 90x72	---	---	---	---	12	25	41	68	>80	>80
	100 x 85	---	800	---	1390	578	25	CP20 90x72	---	---	---	---	24	44	68	>100	>100	>100
	125 x 100	---	800	---	1690	688	24	CP20 90x72	---	---	---	---	44	75	110	>125	>125	>125

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.3 Sensor Configuration Examples for PONTOS HS (1280x1024 Pixel)

Info

The following table values are examples. The sensor may also operate with measuring volumes that result between the values stated in the table. In such a case, you need to interpret the values for the measuring distance and the slider distance accordingly.

When using these measuring volumes, it is important to keep the aperture as closed as possible to achieve a high depth of field. For the sensors, the following relation applies for a camera angle of 25°: Base distance = slider distance + 38 mm..

3.4.3.1 20 mm Lens (PONTOS HS)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
20mm, lens family A1 (Titanar)	100 x 80	1)	500	---	180	62	27	CP20 90x72	---	---	n.a.	n.a.	7.6	22	41	75	>100	>100
	125 x 100	1)	500	---	215	68	25	CP20 90x72	---	---	n.a.	6.8	21	43	73	>125	>125	>125
	150 x 120	1)	500	---	250	84	25	CP20 175x140	---	---	0.7	16	36	68	110	>150	>150	>150
	175 x 140	---	500	---	285	100	25	CP20 175x140	---	---	6.9	27	55	100	160	>175	>175	>175
	200 x 160	---	500	---	320	116	25	CP20 175x140	---	---	15	41	78	140	>200	>200	>200	>200
	250 x 200	---	500	---	390	146	25	CP20 250x200	---	---	37	78	140	240	>250	>250	>250	>250
	300 x 240	---	500	---	460	178	25	CP20 250x200	---	---	65	130	220	>300	>300	>300	>300	>300
	350 x 280	---	500	---	530	208	25	CP20 350x280	---	---	100	190	320	>350	>350	>350	>350	>350
	400 x 320	---	500	---	600	240	25	CP20 350x280	---	---	150	260	>400	>400	>400	>400	>400	>400
	500 x 400	---	500	---	745	304	25	CC20 500x400	---	---	270	470	>500	>500	>500	>500	>500	>500
	750 x 600	---	800	---	1095	460	25	CC20 700x560	---	---	740	>750	>750	>750	>750	>750	>750	>750
	1000 x 800	---	800	---	1435	610	25	CC20 1000x800	---	---	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000
	1250 x 1000	---	800	---	1790	688	23	CC20 1400x1120	---	---	>1250	>1250	>1250	>1250	>1250	>1250	>1250	>1250

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.3.2 28 mm Lens (PONTOS HS)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm]									
									1.4	2	2.8	4	5.6	8	11	16	22	32
28mm, lens family B	65 x 50	1)	500	---	180	62	27	CQ/CP20 55x44	---	n.a.	n.a.	n.a.	n.a.	3.2	10	23	---	---
	80 x 65	1)	500	---	210	66	25	CP20 90x72	---	n.a.	n.a.	n.a.	2	11	21	40	---	---
	100 x 80	1)	500	---	250	84	25	CP20 90x72	---	n.a.	n.a.	n.a.	8.2	22	39	68	---	---
	125 x 100	---	500	---	295	104	25	CP20 90x72	---	n.a.	n.a.	4.8	18	38	64	110	---	---
	150 x 120	---	500	---	345	126	25	CP20 175x140	---	n.a.	n.a.	13	33	62	100	>150	---	---
	175 x 140	---	500	---	390	146	25	CP20 175x140	---	n.a.	4.5	23	49	88	140	>175	---	---
	200 x 160	---	500	---	440	168	25	CP20 175x140	---	n.a.	12	37	70	120	190	>200	---	---
	250 x 200	---	500	---	535	210	25	CP20 250x200	---	6.6	32	70	120	210	>250	>250	---	---
	300 x 240	---	500	---	635	254	25	CP20 250x200	---	23	59	120	190	>300	>300	>300	---	---
	350 x 280	---	500	---	730	298	25	CP20 350x280	---	43	92	170	280	>350	>350	>350	---	---
	400 x 320	---	500	---	825	340	25	CP20 350x280	---	68	130	230	380	>400	>400	>400	---	---
	500 x 400	---	800	---	1020	426	25	CC20 500x400	---	130	240	400	>500	>500	>500	>500	---	---
	750 x 600	---	800	---	1500	640	25	CC20 700x560	---	390	640	>750	>750	>750	>750	>750	---	---
	1000 x 800	---	800	---	1980	688	21	CC20 1000x800	---	810	>1000	>1000	>1000	>1000	>1000	>1000	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.3.3 35 mm Lens (PONTOS HS)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
35mm, lens family A1 (Titanar)	50 x 40	1)	500	---	195	62	26	CQ/CP20 55x44	---	n.a.	n.a.	n.a.	n.a.	0.5	5.1	13	---	---
	65 x 50	1)	500	---	225	74	25	CQ/CP20 55x44	---	n.a.	n.a.	n.a.	n.a.	4	11	23	---	---
	80 x 65	---	500	---	260	88	25	CP20 90x72	---	n.a.	n.a.	n.a.	1.4	9.7	20	38	---	---
	100 x 80	---	500	---	310	110	25	CP20 90x72	---	n.a.	n.a.	n.a.	7.5	20	37	65	---	---
	125 x 100	---	500	---	365	136	25	CP20 90x72	---	n.a.	n.a.	3.8	17	36	60	100	---	---
	150 x 120	---	500	---	425	162	25	CP20 175x140	---	n.a.	n.a.	12	30	58	93	>150	---	---
	175 x 140	---	500	---	485	188	25	CP20 175x140	---	n.a.	3.7	22	47	85	130	>175	---	---
	200 x 160	---	500	---	545	216	25	CP20 175x140	---	n.a.	11	34	67	120	180	>200	---	---
	250 x 200	---	500	---	665	268	25	CP20 250x200	---	5.3	30	67	120	200	>250	>250	---	---
	300 x 240	---	500	---	785	322	25	CP20 250x200	---	20	56	110	180	>300	>300	>300	---	---
	350 x 280	---	500	---	905	376	25	CP20 350x280	---	40	88	160	260	>350	>350	>350	---	---
	400 x 320	---	800	---	1020	426	25	CP20 350x280	---	64	130	220	360	>400	>400	>400	---	---
	500 x 400	---	800	---	1260	532	25	CC20 500x400	---	130	230	380	>500	>500	>500	>500	---	---
	750 x 600	---	800	---	1870	688	22	CC20 700x560	---	400	630	>750	>750	>750	>750	>750	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.3.4 50 mm Lens (PONTOS HS)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects (coded)	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
50mm, lens family A1 (Titanar)	20 x 16	1)	500	30	195	62	26	CQ 15x12	---	---	n.a.	n.a.	n.a.	n.a.	n.a.	0.2	---	---
	25 x 20	1)	500	20	205	64	25	CQ 23x18	---	---	n.a.	n.a.	n.a.	n.a.	n.a.	1.3	---	---
	35 x 28	1)	500	10	230	76	25	CQ/CP20 30x24	---	---	n.a.	n.a.	n.a.	n.a.	0.5	4.3	---	---
	50 x 40	---	500	10	275	96	25	CQ/CP20 55x44	---	---	n.a.	n.a.	n.a.	0.2	4.5	12	---	---
	65 x 50	---	500	---	325	118	25	CQ/CP20 55x44	---	---	n.a.	n.a.	n.a.	4.1	11	23	---	---
	80 x 65	---	500	---	370	138	25	CP20 90x72	---	---	n.a.	n.a.	0.9	8.9	19	36	---	---
	100 x 80	---	500	---	440	168	25	CP20 90x72	---	---	n.a.	n.a.	6.6	19	35	61	---	---
	125 x 100	---	500	---	520	204	25	CP20 90x72	---	---	n.a.	3.3	16	35	58	99	---	---
	150 x 120	---	500	---	605	242	25	CP20 175x140	---	---	n.a.	11	29	56	90	150	---	---
	175 x 140	---	500	---	685	278	25	CP20 175x140	---	---	2.3	20	44	80	130	>175	---	---
	200 x 160	---	500	---	770	314	25	CP20 175x140	---	---	9.2	32	63	110	170	>200	---	---
	250 x 200	---	800	---	940	390	25	CP20 250x200	---	---	27	63	110	190	>250	>250	---	---
	300 x 240	---	800	---	1105	464	25	CP20 250x200	---	---	51	100	170	280	>300	>300	---	---
	350 x 280	---	800	---	1275	538	25	CP20 350x280	---	---	82	150	250	>350	>350	>350	---	---
	400 x 320	---	800	---	1440	612	25	CP20 350x280	---	---	120	210	330	>400	>400	>400	---	---
	500 x 400	---	800	---	1790	688	23	CC20 500x400	---	---	230	370	>500	>500	>500	>500	---	---

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.4.3.5 100 mm Lens (PONTOS HS)

Lens	Measuring volume [mm x mm]	Comment	Min. length camera support [mm]	Distance ring [mm]	Measuring distance [mm]	Slider distance [mm]	Camera angle [°]	Calibration objects	Aperture-dependent depth of field [mm] 1.4	2	2.8	4	5.6	8	11	16	22	32
100mm, lens family A2 (Titanar)	10 x 8	---	500	137,5	395	148	25	CQ 10x8	---	---	---	---	n.a.	n.a.	n.a.	0.3	2.1	5
	15 x 12	---	500	100	385	146	25	CQ 15x12	---	---	---	---	n.a.	n.a.	n.a.	n.a.	1.1	3.2
	20 x 16	---	500	75	400	150	25	CQ 15x12	---	---	---	---	n.a.	n.a.	n.a.	0.6	2.6	5.9
	25 x 20	---	500	50	415	158	25	CQ 23x18	---	---	---	---	n.a.	n.a.	n.a.	1.3	3.9	8.2
	35 x 28	---	500	37,5	465	180	25	CQ/CP20 30x24	---	---	---	---	n.a.	n.a.	0.5	4.3	8.8	16
	50 x 40	---	500	25	555	220	25	CQ/CP20 55x44	---	---	---	---	n.a.	0.1	4.4	12	20	35
	65 x 50	---	500	12,5	645	260	25	CQ/CP20 55x44	---	---	---	---	n.a.	3.4	10	21	35	58
	80 x 65	---	500	12,5	740	302	25	CP20 90x72	---	---	---	---	0.5	8.4	18	35	55	>80
	100 x 80	---	500	12,5	870	360	25	CP20 90x72	---	---	---	---	5.5	18	32	58	88	>100
	125 x 100	---	800	---	1030	434	25	CP20 90x72	---	---	---	---	14	32	55	93	>125	>125
	150 x 120	---	800	---	1195	504	25	CP20 175x140	---	---	---	---	26	52	84	140	>150	>150
	175 x 140	---	800	---	1360	578	25	CP20 175x140	---	---	---	---	41	76	120	>175	>175	>175
	200 x 160	---	800	---	1525	650	25	CP20 175x140	---	---	---	---	60	100	160	>200	>200	>200
	250 x 200	---	800	---	1870	688	22	CP20 250x200	---	---	---	---	110	180	>250	>250	>250	>250

Legend: 1) without laser pointer

--- Lens cannot be adjusted to the aperture value.
n.a. It is not possible to focus the complete measuring volume.

3.5 Size of the Reference Point Markers

The reference point markers are available in the following sizes:

0.4 mm, 0.8 mm, 1.5 mm, 3 mm, 5 mm, 8 mm, 12 mm, 18 mm, 25 mm

Using the following formula, you may calculate the typical reference point size for your measuring volume. To do so, use the length of the measuring volume (see also 3.3), i.e. the largest value of the respective volume.

PONTOS 5M	PONTOS 4M	PONTOS HS
Length of measuring volume x 0.004	Length of measuring volume x 0.004	Length of measuring volume x 0.008

Info

If your result is a reference point size which is not available, round to the next available size. We recommend using the next larger size.

Example:

For the measuring volume 125 x 90 with PONTOS 4M the following calculation results: 125 x 0.004 = 0.5

This means, you should use the reference point marker size 0.8 mm for your measuring task.

4. Sensor Control Elements

4.1 How to Handle Lenses

The lenses shown in this example may, in some cases, differ from those delivered in practice. Therefore, the statements made here have to be used correspondingly.

Select a set of lenses matching the required measuring volume and screw it into the cameras.

NOTICE

To avoid getting dirt into the cameras, always equip the devices with lenses or with a protective cap, even when switched off. When changing the lenses, fix the new lenses in place immediately.
Screw in the lenses carefully by hand.

4.1.1 Lens Family A (Titanar)

4.1.1.1 Lens Family A1

Screw thread; tighten carefully by hand in the housing!
While doing so, lock focus locking ring!

Focus locking ring with hex socket head locking screw

Aperture setting ring with manual locking screw.

Focal length. In this example 20 mm.

4.1.1.2 Lens Family A2 - 100 mm

Screw thread; tighten carefully by hand in the housing!
While doing so, lock focus locking ring!

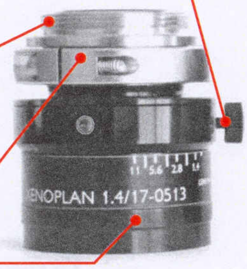
When using distance rings, screw in the rings here.

Focus locking ring with hex socket head locking screw

Aperture setting ring with manual locking screw.

4.1.2 Lens Family B

- Aperture setting ring with manual locking screw. Note: In the example shown, aperture value 11 means aperture closed and aperture value 1.4 means aperture open.
- Screw thread; tighten carefully by hand in the housing! While doing so, lock focus locking ring!
- Focus locking ring with hex socket head locking screw
- Focal length. In this example 17 mm.



4.2 How to Handle Tommy Screws

Problem:	Remedy:
The freedom of movement of the small handle is limited by the large handle.	Pull out the handle and turn it.

You may use the large handle in a similar way.

5. Fast Setup of the Sensor

In order to achieve the measuring volumes shown in the tables of section **Fehler! Verweisquelle konnte nicht gefunden werden.**3, you need to set up the PONTOS sensor accordingly. To adjust the sensor, the complete system including the PONTOS application software must be installed.

How to use the software is described in the PONTOS User Manual – Software.

In most cases, the recommended camera angle is 25° for PONTOS measuring volumes. Thus, a simplified setup of the sensor can be carried out for these measuring volumes.

NOTICE

This method requires that the camera angle was once adjusted to 25° and has not been changed later!
In this case, you just need the measuring distance of the required measuring volume from the sensor configuration tables.

General steps to adjust the sensor:

- Equip the cameras with the corresponding lenses required for the measuring volume.
- Adjust the measuring distance between object and sensor (see tables sectio n **Fehler! Verweisquelle konnte nicht gefunden werden.**3), and switch on the laser pointer.
- Adjust the cameras to the laser point with the help of the cross hairs in the live video images.
- Fine-adjust the camera tilt angle with the help of the live video images.
- Adjust the focus of the camera lenses.
- Option: Adjust the polarization filters of the cameras and the lighting.
- Adjust the aperture of the camera lenses.

5.1 Adjust the Software

After starting the PONTOS software, select in the deformation mode (**View ► Deformation Mode**) the camera icon **Start/Stop Measurement Mode** in order to get a live video of both cameras.

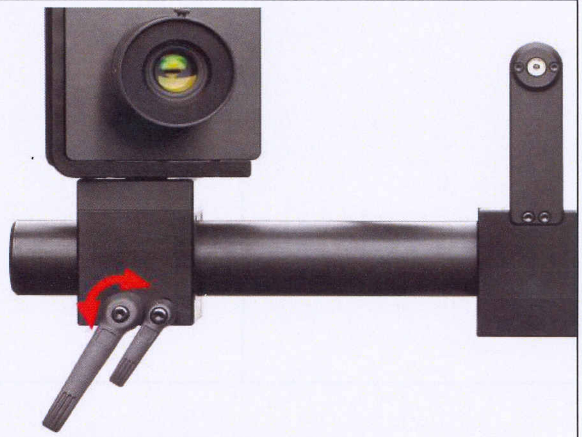
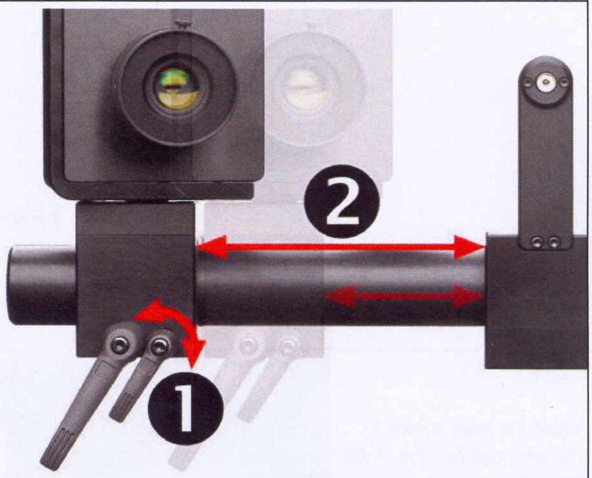
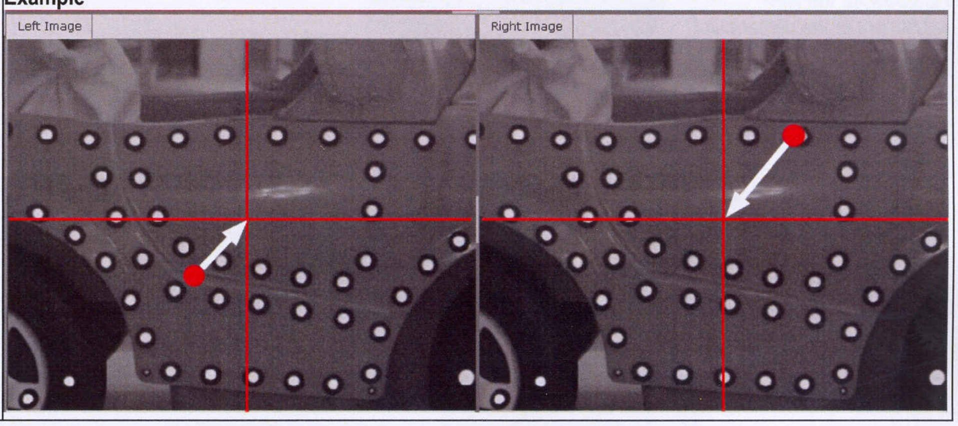
5.2 Adjust the Measuring Distance

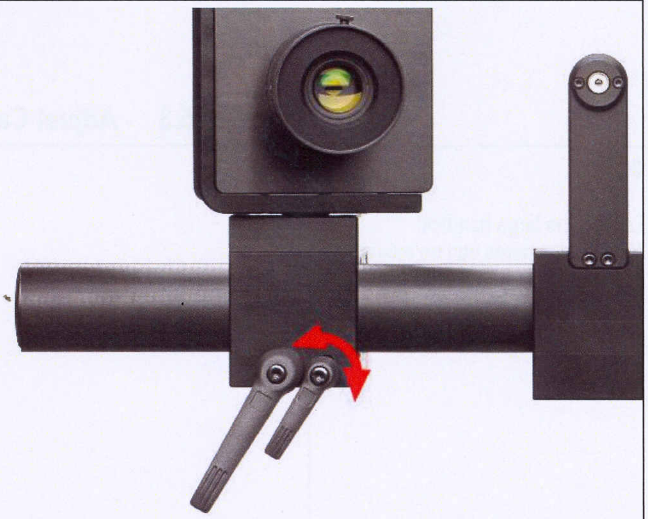
Use the tables in section **Fehler! Verweisquelle konnte nicht gefunden werden.**3 to find the measuring distance which corresponds to the measuring volume (only for measuring volumes with a camera angle of 25°).

Switch on the laser pointer and direct it to an object which is placed at the measuring distance.

The measuring distance is determined by using a tape measure and results between the fixture of the camera support (in the middle) and the projected laser point on the measuring object, see 3.3.

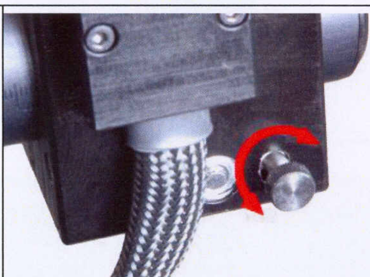
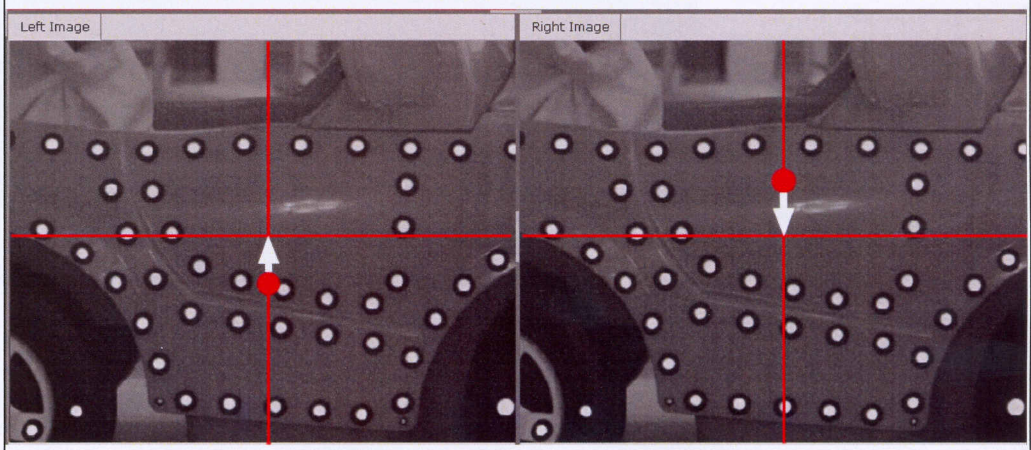
5.3 Adjust Cameras Horizontally and Vertically

Step A Loosen the large handles! Now, the cameras can be moved in radial direction in a limited way.	
Step B Loosen the small handles! **NOTICE** Now, the cameras are no longer locked in radial and axial direction!	
Step C Display the laser pointer in the live video images of the cameras by means of a right mouse button click ▶ **Image Display** ▶ **Overexposed** and direct the cameras horizontally and vertically to the projected laser point with the help of the red cross hairs. **Info** You may later fine-adjust the vertical adjustment (camera tilt angle)!	**Example** 

Step D	
Lock the position by means of the small handle.	

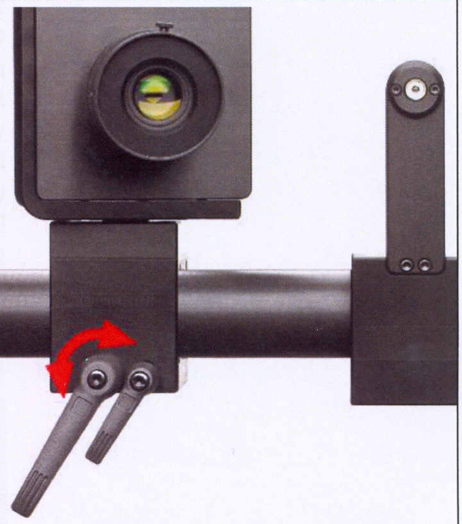
5.4 Fine-Adjust the Camera Tilt Angle

In section 5.3 step C, you already preadjusted the tilt angle (vertical adjustment to the laser point). Now, fine-adjust it.

Step E	
Adjust the laser pointer to the horizontal red line of the live video image by using the screw for the fine-adjustment of the camera tilt angle. **Info** If the fine-adjustment is at the end of its adjustment path, you first need to set it to its center position by means of the small handles, see 6.3 step B.	 **NOTICE** **Never completely remove the fine-adjustment screws!** There is risk of not being able to screw it in again. 

5.5 Lock Cameras

Now, lock the cameras by means of the large handles.

Step G Lock the cameras by means of the large handles!	

5.6 Adjust the Focus

If possible, adjust the focus with the aperture maximally opened. Place a text or a business card in the center and adjust the optimum focus.

The focus can also be adjusted using a calibration panel. This method provides a clear focus adjustment. In the overexposed mode (in the live image, click the right mouse button and select **Image Display ► Overexposed**), adjust the shutter time such that the white points appear overexposed (red). Now, adjust the focus to maximum red point size.

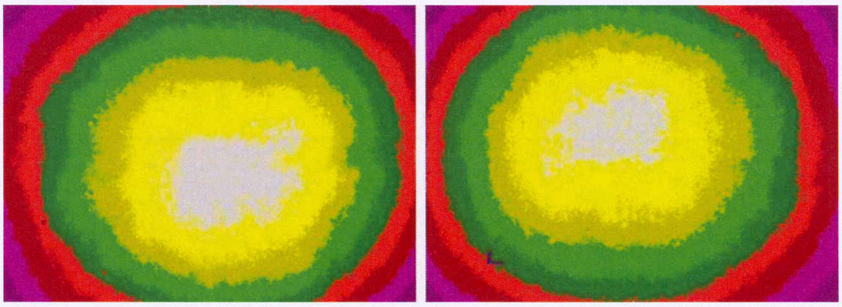
Then, lock the focus setting!

5.7 Adjust the Polarization Filters for the Lighting (Option)

Adjust the polarization filters according to 7.1.1.

5.8 Adjust the Aperture

If you want to use the lighting, switch it on now. Choose the shutter time according to the expected test speed and recording rate, the setting should be clearly below the recording rate. Settings below 100 ms at a frame rate of 4 images per second are usual. Now close the aperture until the video images are free of overexposure. Red areas in the video image indicate overexposure and therefore should not occur. Make sure, the aperture is closed as far possible (high aperture values) in order to achieve a best possible depth of field. The aperture of both cameras should be closed to approximately the same extent. You can check this by means of the false-color mode of the video image. You enable the false-color mode by clicking with the right mouse button onto the video image and selecting **Image Display ► False color**. The video images should show approximately the same color distribution.



Left camera Right camera

After you finished the setup of the sensor, select **Start/Stop Measurement Mode**.

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6. Complete Setup of the Sensor

NOTICE

You always need to completely set up the sensor if the camera angle was not preadjusted to 25°!

Steps to completely adjust the sensor:

- Equip the cameras with the corresponding lenses required for the measuring volume.
- Adjust the measuring distance between object and sensor, and switch on the laser pointer.
- Adjust the slider distance between the cameras on the camera support symmetrically to the laser pointer.
- Adjust the camera angle with the help of the live video images.
- Adjust the camera tilt angle with the help of the live video images.
- Adjust the focus of the camera lenses.
- Adjust the aperture of the camera lenses.
- Option: Adjust the polarization filters of the cameras and the lighting.

6.1 Adjust the Software

After starting the PONTOS software, select in the deformation mode (**View ► Deformation Mode**) the camera icon **Start/Stop Measurement Mode** in order to get a live video of both cameras.

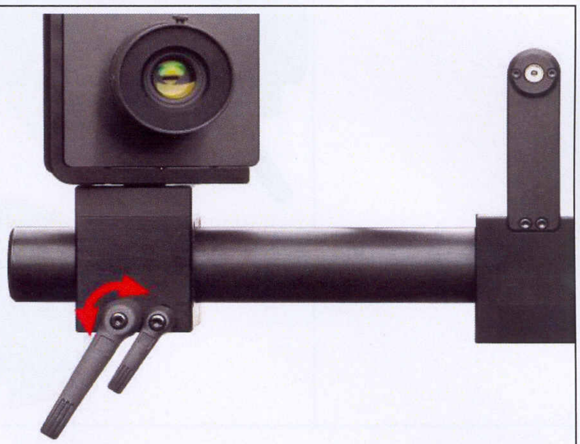
6.2 Adjust the Measuring Distance

Switch on the laser pointer and direct it to an object which is placed at the measuring distance.

The measuring distance is determined by using a tape measure and results between the fixture of the camera support (in the middle) and the projected laser point on the measuring object, see 3.3.

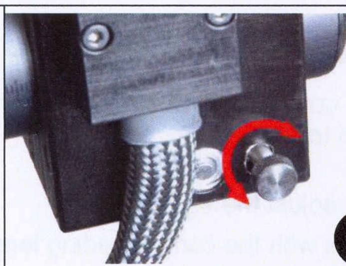
6.3 Adjust Slider Distance

The slider distance is the distance between the slider units of the cameras, see 3.3. Adjust the slider distance by moving the cameras on the camera support. The cameras need to be set up symmetrically on the camera support or symmetrically to the laser pointer, and they should already been roughly adjusted to the projected laser point in radial direction (camera tilt angle).

Step A Loosen the large handles! Now, the cameras can be moved in radial direction in a limited way.	

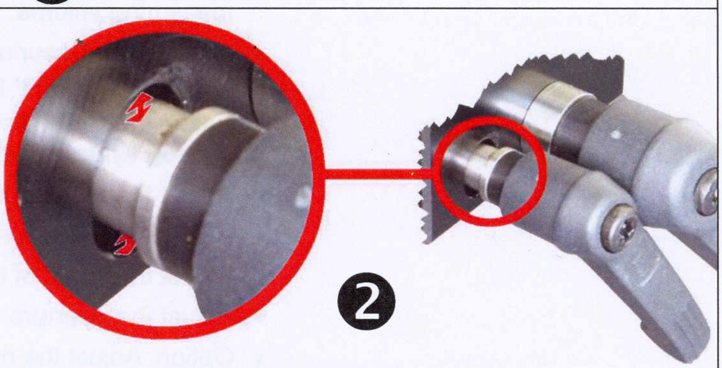
Step B

Adjust the small handles to their center position by means of the fine-adjustment screws for the camera tilt angle.



NOTICE

Never completely remove the fine-adjustment screws!
There is risk of not being able to screw it in again.

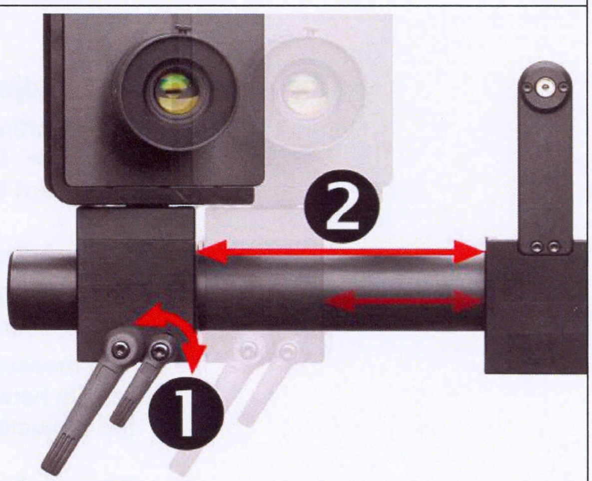


Step C

Loosen the small handles.

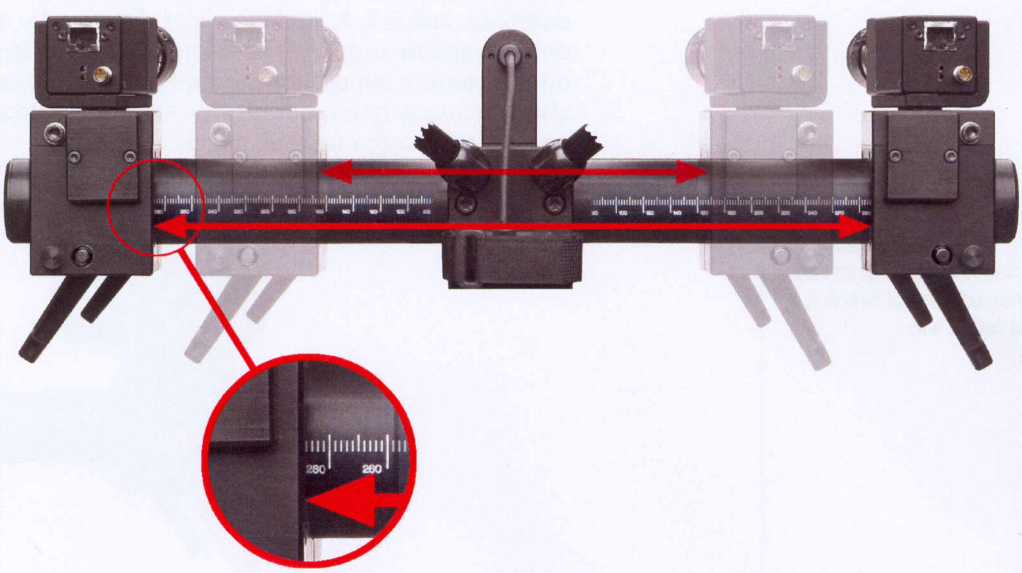
NOTICE

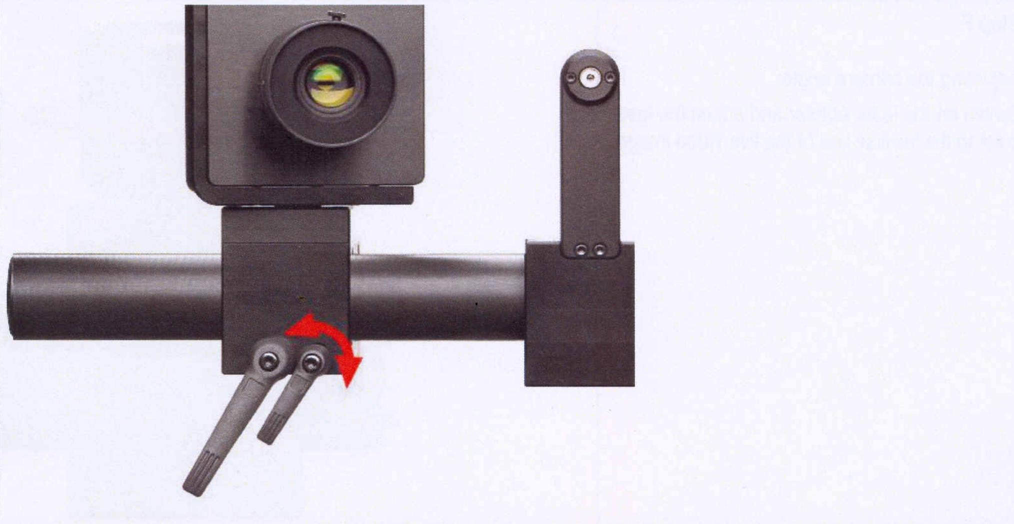
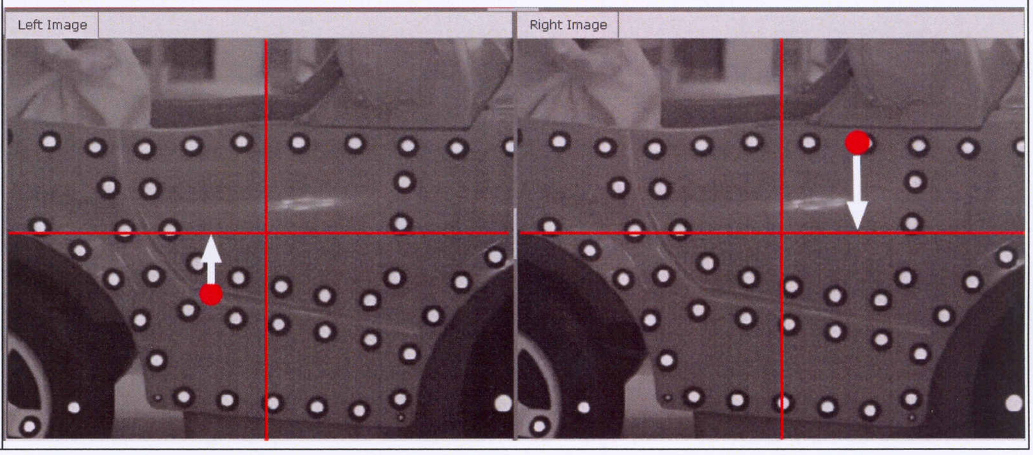
Now, the cameras are no longer locked in radial and axial direction!



Step D

Move the cameras to the required slider distance.



Step E Switch on the laser pointer and roughly adjust the laser point to the horizontal line of the live video image by using the screw for the fine-adjustment of the camera tilt angle. Lock the position by means of the small handle.	 

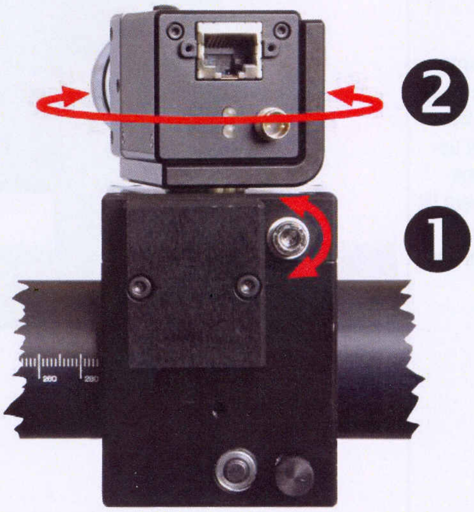
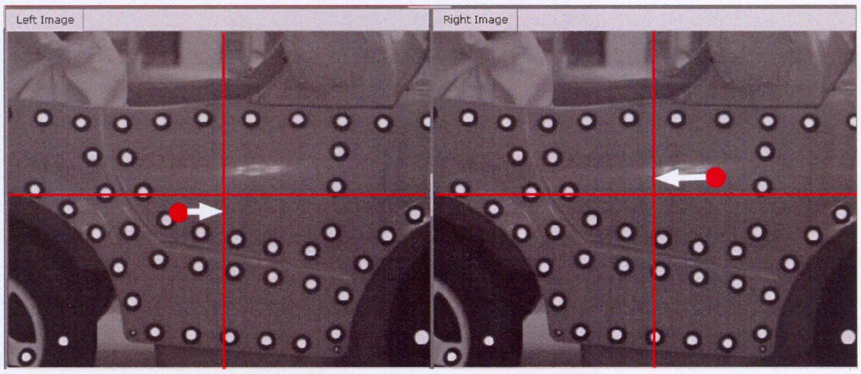
6.4 Adjusting the Camera Angle

The camera angle α results when you point the cameras to the projected laser point in the live video images, see 3.3. If the live video images are too dark, too bright or not clear, first adjust the lenses with focus and aperture to optimum image impression.

Info

Adjust the vertical red line of the cross hairs in live video images to the projected laser point!

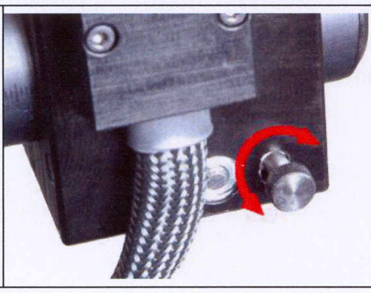
pontos_hw-5m-4m-hs-adjustable_en_rev-c 22-Sep-2009

Step F Adjusting the camera angle: Switch on the laser pointer and adjust the laser point to the vertical line of the live video image.	 

6.5 Adjust the Camera Tilt Angle

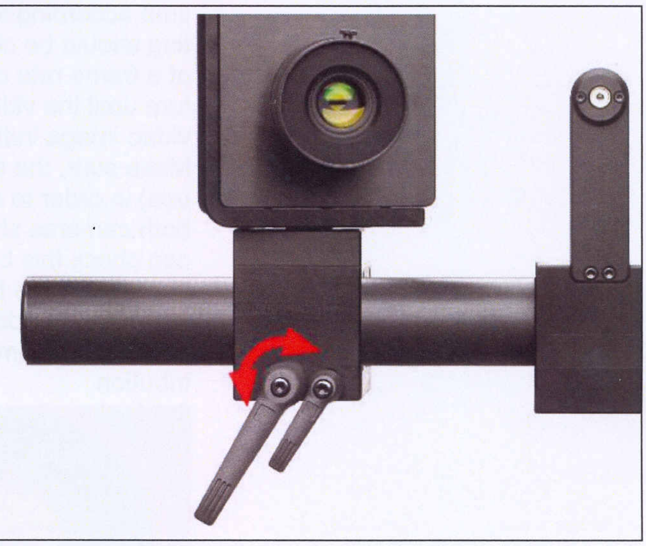
During the adjustment of the slider distance, you already roughly adjusted the tilt angle. Now, fine-adjust it.

Info Adjust the horizontal red line of the cross hairs in live video images to the projected laser point!

Step G Adjust the laser pointer to the horizontal line of the live video image by using the screw for the fine-adjustment of the camera tilt angle.	

6.6 Lock Cameras

Now, lock the cameras by means of the large handles.

Step H Lock the cameras by means of the large handles.	

6.7 Adjust the Focus

If possible, adjust the focus with the aperture maximally opened. Place a text or a business card in the center and adjust the optimum focus.

The focus can also be adjusted using a calibration panel. This method provides a clear focus adjustment. In the overexposed mode (in the live image, click the right mouse button and select **Image Display** ► **Overexposed**), adjust the shutter time such that the white points appear overexposed (red). Now, adjust the focus to maximum red point size.

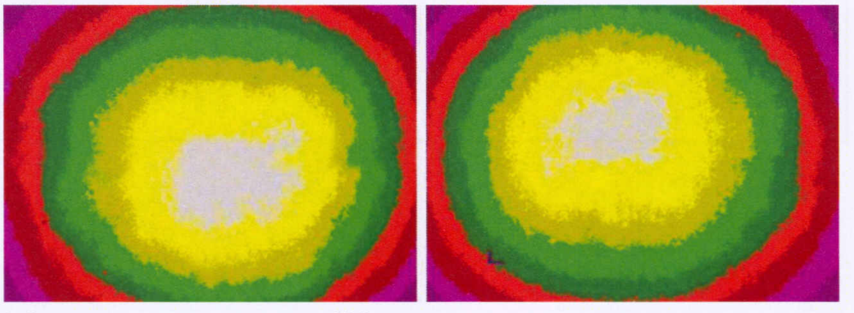
Then, lock the focus setting!

6.8 Adjust the Polarization Filters for the Lighting (Option)

Adjust the polarization filters according to 7.1.1.

6.9 Adjust the Aperture

If you want to use the lighting, switch it on now. Choose the shutter time according to the expected test speed and recording rate, the setting should be clearly below the recording rate. Settings below 100 ms at a frame rate of 4 images per second are usual. Now close the aperture until the video images are free of overexposure. Red areas in the video image indicate overexposure and therefore should not occur. Make sure, the aperture is closed as far possible (high aperture values) in order to achieve a best possible depth of field. The aperture of both cameras should be closed to approximately the same extent. You can check this by means of the false-color mode of the video image. You enable the false-color mode by clicking with the right mouse button onto the video image and selecting **Image Display ► False color**. The video images should show approximately the same color distribution.



Left camera Right camera

After you finished the setup of the sensor, select **Start/Stop Measurement Mode**.

7. Lighting (Option)

As lighting, two types of high-performance LED lamps are available:

- LED lamp with a beam angle of 10°
- LED lamp with a beam angle of 30°

This lighting is suitable for small measuring areas up to a maximum size of approx. 500 x 400 mm².

Sensor	Focal length of lens	Suitable LED lamp
4M	≥ 35 mm	Beam angle 30°
	≥ 65 mm	Beam angle 10°
5M	≥ 23 mm	Beam angle 30°
	≥ 35 mm	Beam angle 10°
HS	---	---

7.1 Adjust the Polarization Filters for the Lighting (Option)

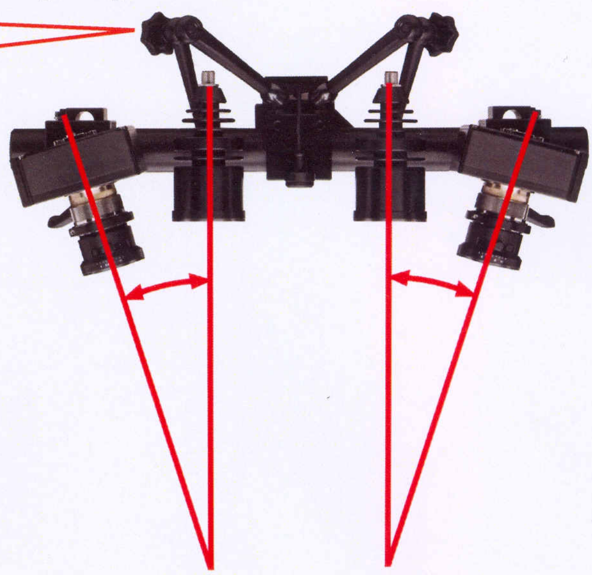
The polarization filters are used to avoid disturbing shiny points in the camera images.

All spotlights and cameras need to be equipped with a polarization filter.

Ensure that the angles between camera direction and spotlight direction are large enough in order to avoid disturbing reflections from the beginning.

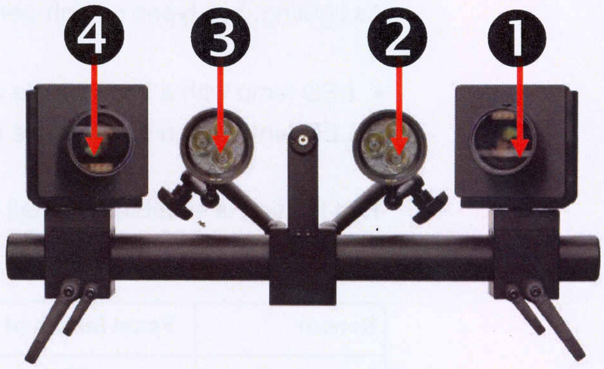
NOTICE

All joints of the lighting are locked or loosen by one common screw!



7.1.1 Adjustment Method for Polarization Filters

Switch on the LED lighting.



Step 1	The polarization filter ❶ of the left camera is not changed!
Step 2	Close down the spotlights ❸ (either turn the spotlight to the side or disconnect its power supply) and set the polarization filter ❷ to minimum intensity of shiny points in the left image of the live video.
Step 3	Activate the spotlight ❸ again (spotlight ❷ remains switched on) and set the polarization filter ❸ to minimum intensity of shiny points in the left image of the live video.
Step 4	Finally, in the right image of the live video, set the polarization filter ❹ to minimum intensity of shiny points.

Info Each time you change the camera or spotlight position, you need to readjust the polarization filters!

8. User Information About the PC

The computer is part of the measuring system.

Info

When connecting the computer with your local are network, please use the network port labeled as LAN0 on the rear side of the computer. This network port is being referred to as **eth0** in the YaST setup tool (system software).
Feel free to configure **eth0** but please leave all other network port settings as they are. An FAQ is available on our GOM support web page.

NOTICE

Please shut down the computer decently. Try to avoid using the reset button. A controlled shutdown of the computer is also possible by pressing the power on button on the front in the same way you would switch on the computer. A non-controlled shutdown may have an impact on the file system.

Only for 19" PCs:

In order to guarantee fewer problems using the computer, please remember to regularly clean the dust filters located in the front doors. We recommend cleaning them every four weeks or more often depending on the environment.

Removing filters:

9. The Sensor Controller

The sensor controller for the measuring system, serves to flexibly record images just-in-time and with analog value control for all applications (high-speed/low-speed).

In addition to the power supply unit for max. 2 cameras, the sensor controller includes a process computer for trigger signals, a DHCP server, as well as an A/D and D/A converter for analog force, distance and control signals. In connection with the different input interfaces and individual trigger lists, the sensor controller provides the trigger signals for the cameras and frame grabber boards of the PC. The camera images are intermediately stored in the evaluating computer.

The sensor controller has an own IP address (192.168.4.200). You may configure the sensor controller by means of the web interface. For more information see section 9.3.

9.1 Commissioning

After switching on the sensor controller (Power), the status LED lights up in orange for about 15 seconds. The sensor controller is ready for use if the LED changes to green. You may switch on and off the sensor controller in all operating states.

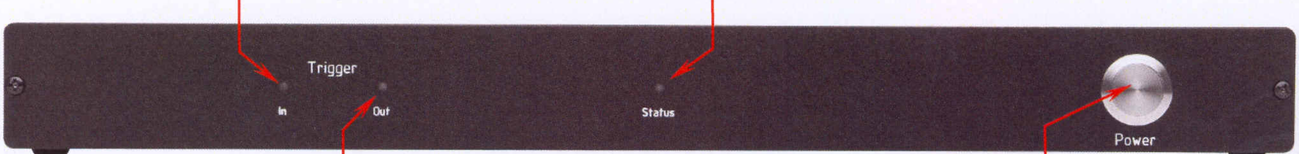
If the status LED is red, a hardware error occurred.

9.2 Brief Description

9.2.1 Sensor Controller Front Panel

Trigger In (LED) Illuminates in case of incoming trigger signals.

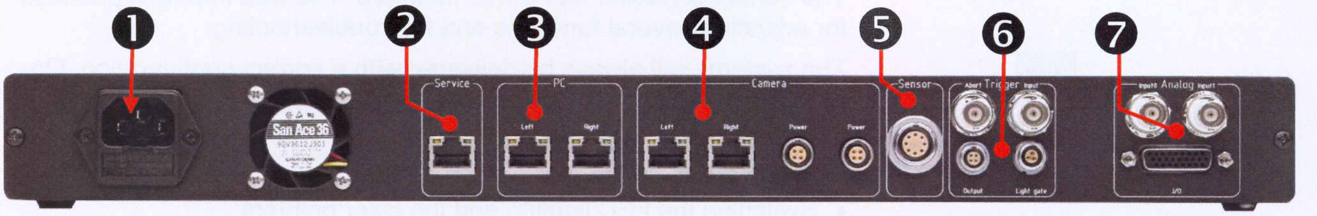
Status LED — **green**: Sensor controller is ready for operation. **orange/red**: Switching on or off phase **red** (permanent): Hardware error



Trigger Out (LED) Illuminates in case of image recording.

On/off switch of the sensor controller

9.2.2 Sensor Controller Rear Panel



1			AC power connection, 115 /230 V, 50 to 60 Hz.
2	Service		**Info** GOM internal service interface. Do not use this interface!
3	PC	Left	Gigabit-Ethernet interface for the connection with the PC. • PONTOS 5M: Image transfer from left camera to PC and communication between PONTOS software and sensor controller. • PONTOS 4M or HS: Communication between PONTOS software and sensor controller.
		Right	Gigabit-Ethernet interface for the connection with the PC. • PONTOS 5M: Image transfer from right camera to PC • PONTOS 4M or HS: Not used.
4	Camera	Left	Gigabit-Ethernet interface for the connection to the left camera.
		Right	Gigabit-Ethernet interface for the connection to the right camera.
		Power	Power supply of one camera (PONTOS 4M or HS).
		Power	Power supply of one camera (PONTOS 4M or HS).
5	Sensor		Connection to the PONTOS sensor hub • PONTOS 5M: Power supply of cameras, laser pointer, LED lighting and trigger. • PONTOS 4M: Laser pointer, LED lighting. • PONTOS HS: Laser pointer.
6	Trigger	Abort	Direct push button connection (normally open switch) to abort a measuring procedure.
		Input	TTL input for trigger signals. In order to activate a switching action, the available signal must jump from low (0V) to high (+5V). This behavior may be inverted via the web interface, see section 9.3 (option).
		Output	• The PONTOS systems having separate frame grabber boards in the measuring computer (4M and HS) receive the trigger signals via this interface. • Synchronization of several measuring systems (option) • Control of external flash units (option, see also section 9.3)
		Light Gate	• Connection for a photoelectric sensor to trigger image recording, or • Push button connection (normally open switch) via an adapter, to start a trigger signal.
7	Analog	Input 0	The analog inputs 0 to 1 are rated for recording analog signals during image recording between -10 V and +10 V, e.g. for force and distance signals of the test machine. These inputs can also be used to generate a trigger signal at a certain voltage value or at a gradient. The input signals are sampled with 16 bit.
		Input 1	
		I/O (6 inputs)	If additional analog inputs are required, this interface together with an optional adapter cable provides for adding 6 inputs (BNC connector). The adapter cable provides the analog inputs Analog Input 2 to Analog Input 7. The analog inputs are rated for recording analog signals (max. -10 V to max. +10 V) during image recording, e.g. for force and distance signals of the test machine. The input signals are sampled with 16 bit.
		I/O (4 outputs)	The interface provides 4 analog outputs (max. 0V to max. +10V) for real-time sensor applications, e.g. to control test machines. The output signals are sampled with 12 bit.

9.3 Web Interface

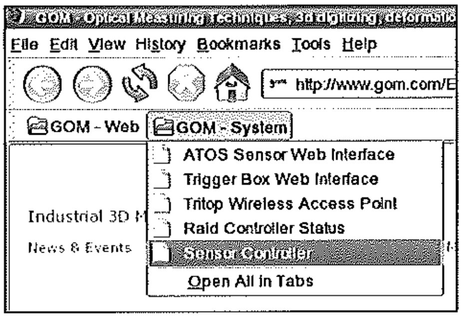
The sensor controller has a web interface. The web interface provides for adjusting several functions and for troubleshooting.

Info The systems will always be delivered with a correct configuration. Only use the web interface if it is absolutely required.

Possible applications:

- Switching the LED lighting and the laser pointers
- Adjusting the trigger behavior
- Checking trigger lists
- Testing the AD channels
- Setting the IP address of the sensor controller
- Network configuration of Gigabit-Ethernet cameras

You reach the web interface, by starting a browser (e.g. Firefox) and entering the address `http://192.168.4.200` into the address line. As an alternative, you may use the corresponding Firefox bookmark.

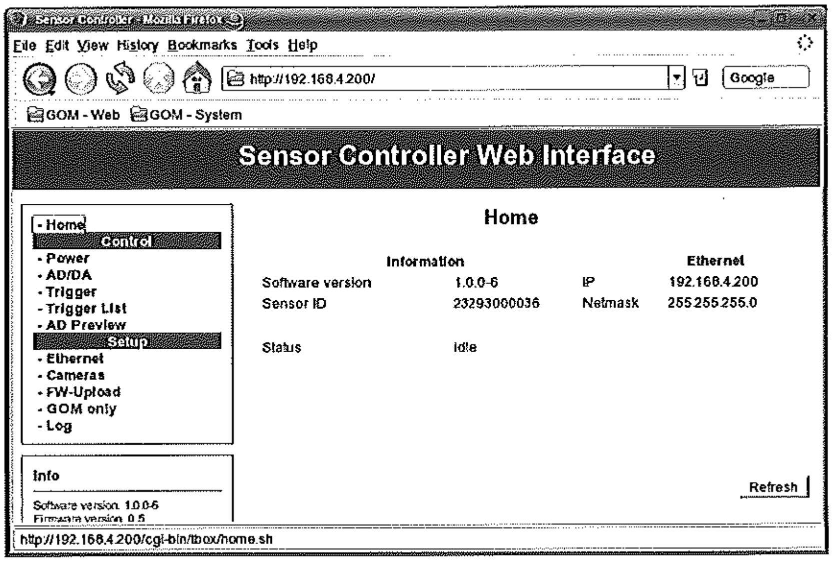


In the left frame, you may call different pages.

"Trigger" is a page important for special applications.

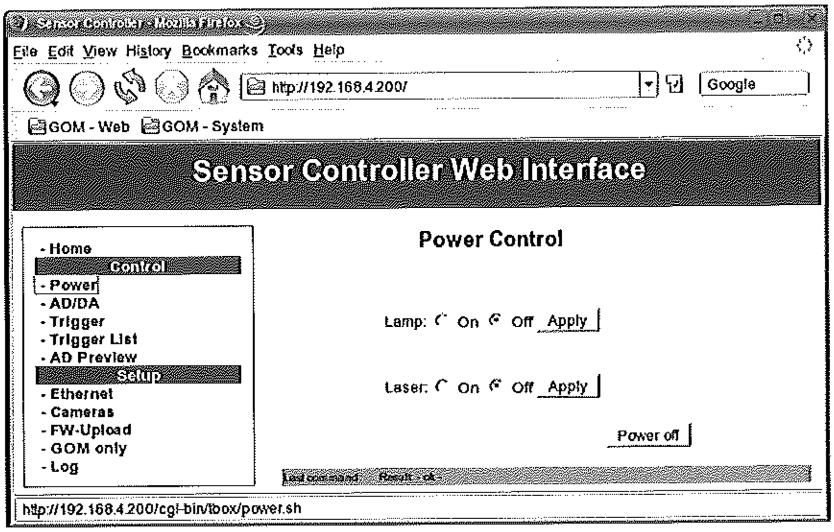
The pages "GOM only" and "Log" have no function for the user.

9.3.1 Home



Here you can see general information about the sensor controller.

9.3.2 Power



Here, you may switch the power supply.

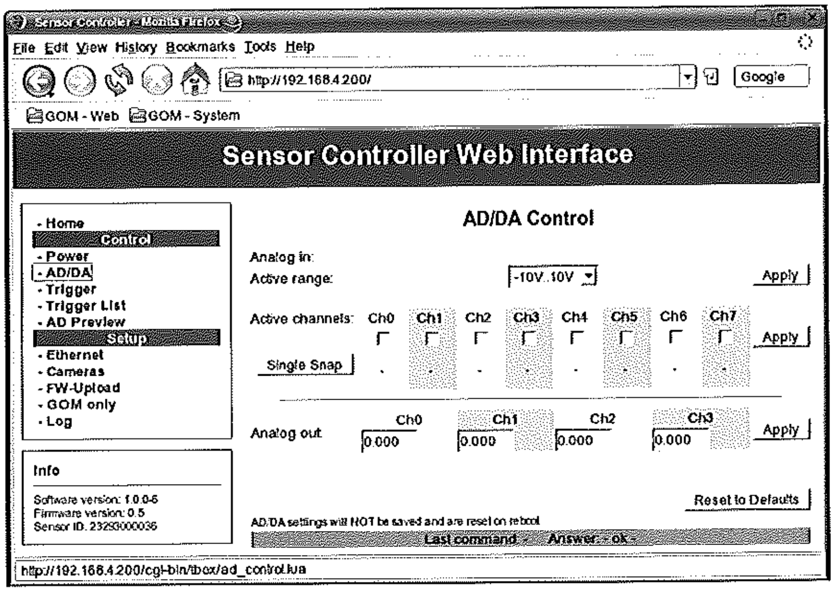
Lamp controls the LED illumination of the sensor.

Laser controls the laser pointers of the sensor.

Each setting has to be confirmed with **Apply**.

With **Power off** you switch off the sensor controller.

9.3.3 AD/DA



Here, you may test the functions of the A/D inputs and the D/A outputs.

Active range selects the range for the 16bit A/D conversion for the active A/D channels.

Active channels selects the channels to be measured.

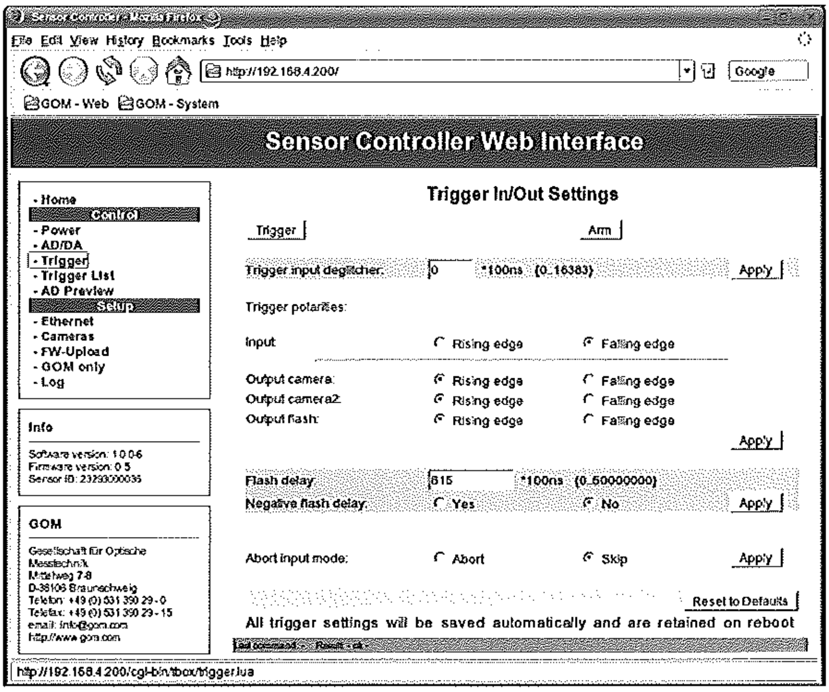
Single Snap starts a single measurement of the selected A/D channels in the selected range.

Analog out applies the specified voltage to the D/A outputs.

Each setting has to be confirmed with **Apply**.

Reset to Defaults restores the default settings.

9.3.4 Trigger



Trigger sends a trigger signal for test purposes (e.g. flashes). During a measurement (e.g. trigger list) a trigger is emitted. Depending on the trigger list element, this means triggering an internal event and/or an image.

Arm sets the ARM status active. During a trigger list measurement with an element for which "arm=true", only the next following trigger will be processed.

Trigger input deglitcher sets the deglitcher for the trigger input signal (e.g. for debouncing the pushbutton).

Input sets the polarity of the trigger input signal at the "Input" or "Light gate" connection of the sensor controller rear side.

Output camera sets the polarity of the camera trigger.

Info Depending on the camera used, the software sets this value and the user should not change it.

Output camera2 sets the polarity of the additional trigger output at the "Output" connection of the sensor controller rear side (for triggering, synchronizing of additional hardware).

Output flash sets the polarity of the delayed trigger output.

Flash delay sets the delay of the flash trigger with respect to the actual trigger signal.

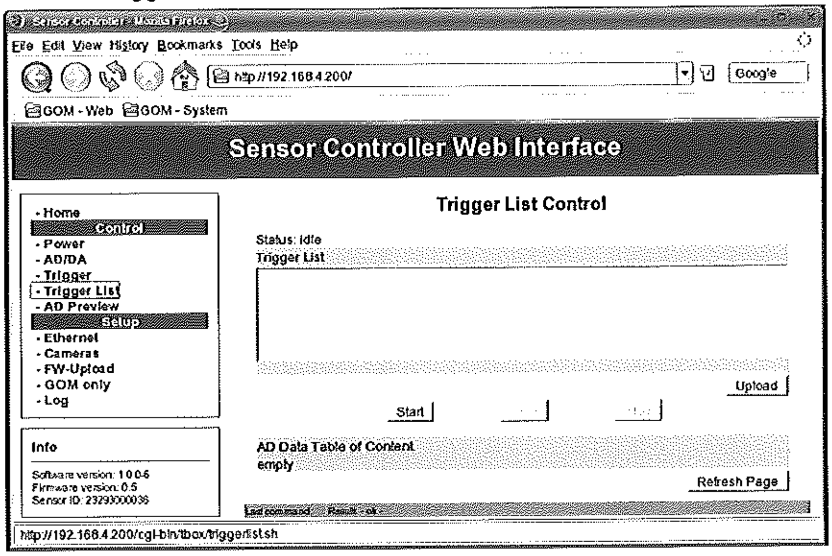
Negative flash delay inverts the trigger time of the flash trigger and the actual trigger.

Abort input mode sets the behavior of the abort button at the "Abort" connection of the sensor controller rear side. In case of **Abort** pressing a button aborts the entire trigger list, in case of **Skip** only the current element is aborted.

Each setting has to be confirmed with **Apply**.

Reset to Defaults restores the default settings.

9.3.5 Trigger List



Here, you may load manually created trigger lists into the sensor controller. Loaded trigger lists can be started, aborted or individual elements can be aborted.

Upload loads the trigger list in the **Trigger List** window into the sensor controller.

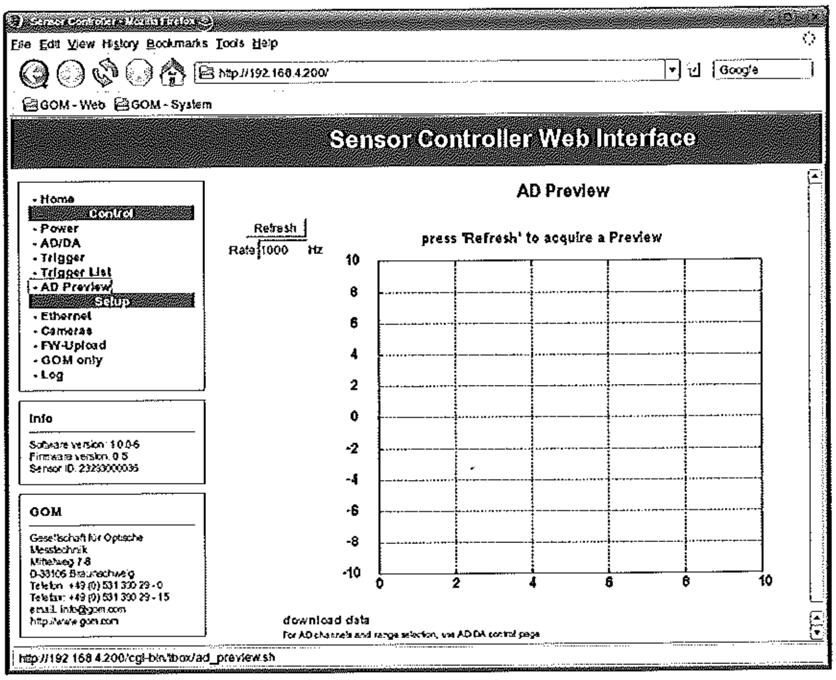
Start starts the trigger list in the sensor controller.

Skip aborts an individual element of the trigger list.

Stop aborts the trigger list.

Refresh Page loads the trigger list from the sensor controller into the **Trigger List** window.

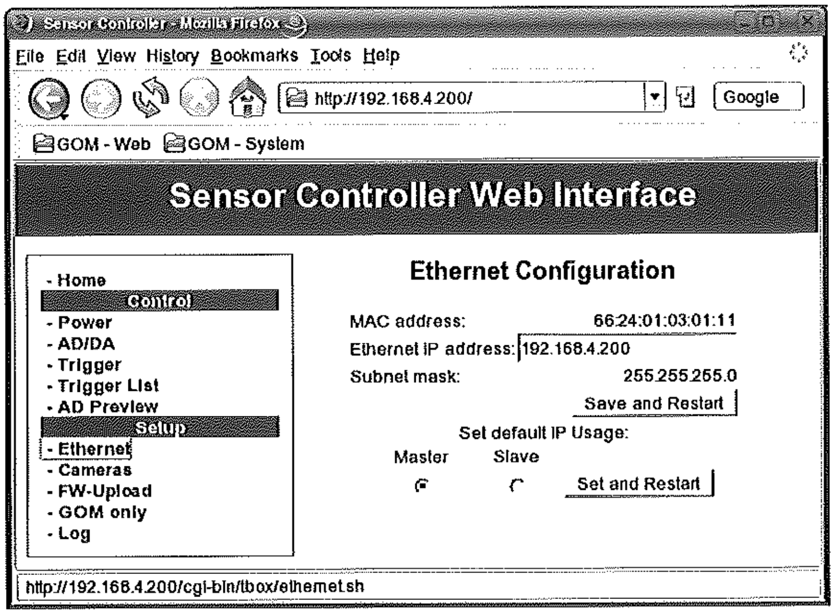
9.3.6 AD Preview



Here, you may measure the A/D channels activated in window "AD/DA" (see chapter 9.3.3) over a certain time period (e.g. in order to determine noise and offsets of the analog signals).

Refresh carries out a measurement with the specified measuring rate and plots the measured analog signals in a diagram.

9.3.7 Ethernet



Here, you can manage the network configuration of the sensor controller.

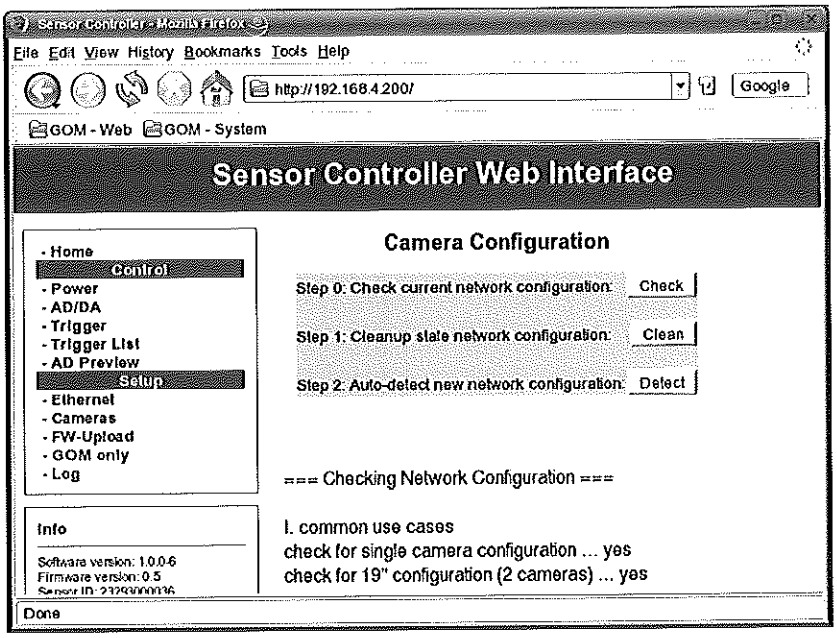
Ethernet IP address sets the IP address of the sensor controller. You need to confirm this setting with **Save and Restart**. Then, the web interface can only be reached via the new IP address.

Info

Only change the IP address of the sensor controller if the company network uses the same subnet mask and a computer with this IP already exists. The changed IP address must also be changed in the software (ARAMIS, PONTOS, IVIEW). In case of a support request, you need to announce this change.

Master / Slave sets the default settings of the sensor controller for a double sensor system. You need to confirm this setting with **Save and Restart**. In case of **Slave**, the web interface can only be reached via the IP address `192.168.14.200`.

9.3.8 Cameras



For Gigabit-Ethernet cameras, here the network configuration of the cameras is managed.

Info

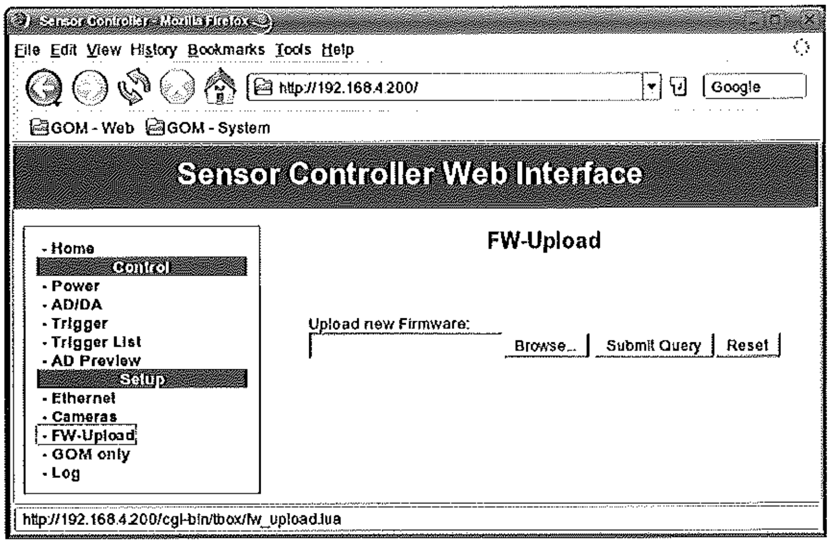
The systems will always be delivered with a correct configuration. Therefore, you should only adapt the configuration in case of an hardware exchange (**Clean / Detect**).

The sensor controller clearly identifies the cameras. Therefore, you have to repeat the configuration via **Clean / Detect** every time you change the cameras, this also includes interchanging the cameras or using cameras of a different sensor. The hardware configuration of the software (ARAMIS, PONTOS, IVIEW) is not affected.

Check verifies the existing camera configuration and returns information about this configuration (e.g. if the right and left camera were interchanged) in the web interface. **Clean** deletes the existing camera configuration. Then, you have to execute **Detect**.

Detect sets the IP address of the connected Gigabit-Ethernet cameras. Prior to that you need to execute **Clean**.

9.3.9 Firmware Upload



Here, you may update the firmware of the sensor controller.

Info

Normally, a firmware update here is not required. Only update the firmware via the web interface if the GOM support explicitly instruct you to do so!

10. Calibration

Calibration is a measuring process during which the measuring system with the help of calibration objects is adjusted such that the dimensional consistency of the measuring system is ensured.

The calibration object also contains the scale bar information. The scale bar information is the specified distance between two defined reference points.

During calibration, the sensor configuration is determined. This means that the distance of the cameras and the orientation of the cameras to each other are determined. In addition, the image characteristics of the cameras are determined (e.g. focus, lens distortions). Based on these settings, the software calculates from the reference points of the calibration object in the 2D camera image their 3D coordinates.

10.1 Calibration Objects

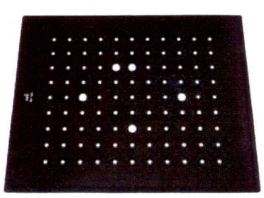
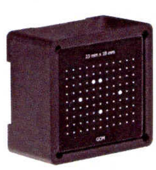
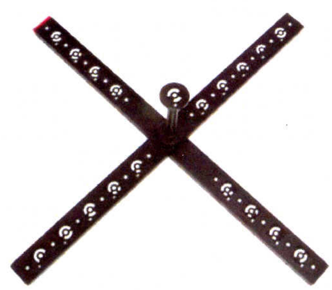
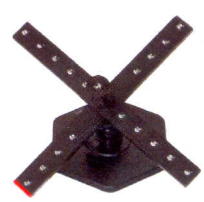
Two different calibration types (panel and cross) which are available in different sizes and versions are used. Depending on the version, a calibration panel has one or two scale bars. A calibration cross has two scale bars (on each cross section). For each standard measuring volume a corresponding calibration object is available. When registering a calibration object in the software, you need to select, in addition to the type (panel or cross), also the version of the calibration object (simple or coded).

How you can identify the versions is explained in the following tables.

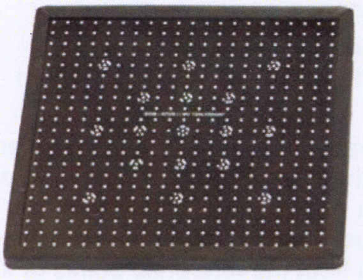
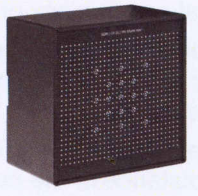
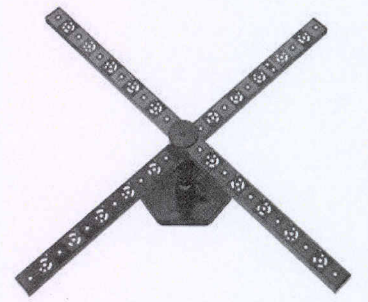
NOTICE

Treat the calibration objects with care. Avoid touching the surface of the calibration side with your hands. Some calibration objects (e.g. all cubes and some calibration panels) are made of ceramics. You cannot remove finger prints from ceramic surfaces without any remains.

10.1.1 Calibration Objects Simple (Version 1)

Icon in the software		Icon in the software	
			
Calibration panel with uncoded reference points and one scale bar value. <u>Distinguishing characteristic:</u> • No coded points	Calibration cube with uncoded reference points and one scale bar value. <u>Distinguishing characteristic:</u> • No coded points • Type label starts with **CQ**	Calibration cross with retro markers (uncoded points) and two scale bar values. <u>Distinguishing characteristic:</u> • On the rotation axis of the cross there is a coded reference point.	Calibration cross only with coded points and two scale bar values. <u>Distinguishing characteristic:</u> • On the rotation axis of the cross there is a coded reference point.

10.1.2 Calibration Objects Coded (Version 2)

Icon in the software		Icon in the software
		
Calibration panel with coded and uncoded reference points and two scale bar values. The coded reference point in the center of the plate identifies the object in the software. Distinguishing characteristic: • Type label starts with **CP** • Coded points	Calibration cube with coded and uncoded reference points and two scale bar values. The coded reference point in the center of the plate identifies the object in the software. Distinguishing characteristic: • Type label starts with **CQ** • Coded points	Calibration cross with coded and uncoded reference points and two scale bar values. One coded reference point close to the rotation point of the cross identifies the object in the software. Distinguishing characteristic: • On the rotation axis of the cross there is no reference point. • Type label starts with **CC**

10.2 Calibration Objects and Corresponding Measuring Volumes

Calibrate the system only with the calibration object valid for the respective measuring volume as you otherwise will get wrong measuring results!

For information about the calibration objects see also the sensor configuration tables in section 3.

10.3 Calibration of the PONTOS System

Before starting measurements for the first time, the system needs to be calibrated.

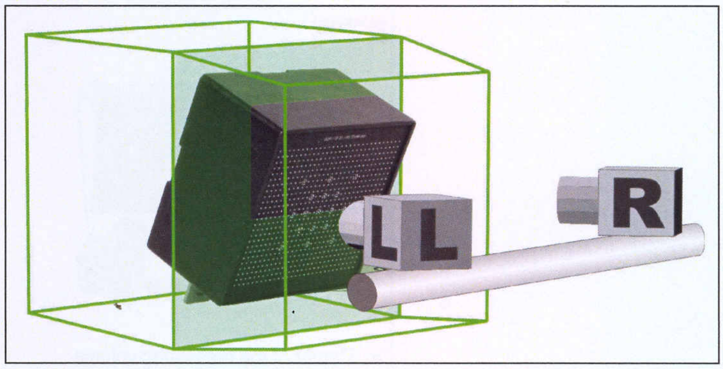
Also, if the adjustment of the camera lenses or the position of the cameras with respect to each other is changed, the system requires calibration.

A prerequisite for successful calibration is the correct setup of the sensor, see section 5 or 6. The measuring object defines the measuring volume and thus the set of lenses to be used. The measuring distance to the calibration object has to be adjusted according to the camera lenses used and according to the available camera support, see Sensor Configurations section 3.

A wizard in the application software leads you through the individual calibration steps.

For further information about the calibrating process, please refer to the PONTOS User Manual – Software and the Online Help.

Info If you carry out a panel calibration using a calibration cube, you need to perform the tilted position of the calibration object in calibration steps 4 and 5 opposite to the instructions (tilted 40°) of the application software.

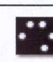
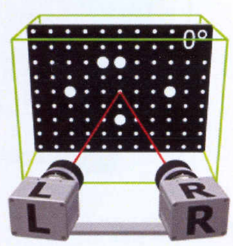
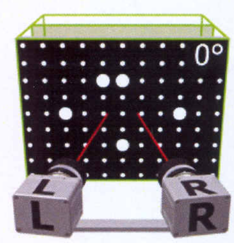
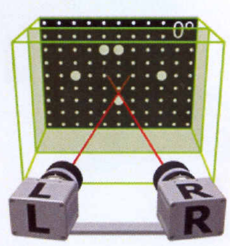
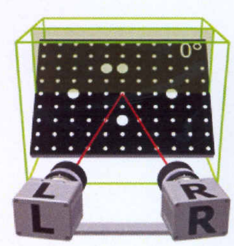


The opposite orientation of the cube is due to its design and does not affect the calibration result.

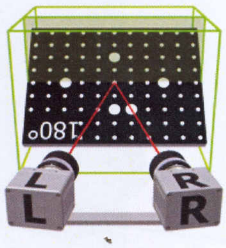
10.4 Calibration with External Image Series

For the special case you need to work with external image series which were not recorded with GOM standard sensor setups (e.g. for ultra high-speed applications), the necessary calibration steps are described in the following. In case of an external image series, the software cannot automatically guide you through the necessary calibration steps.

10.4.1 Steps for Calibration Object Panel – Simple

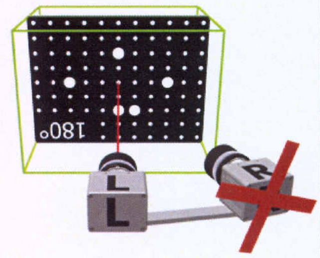
Calibration object panel - simple 	
Step 1:  • Center of the measuring volume • Panel position 0°	**Step 2:**  • Closer to the sensor • Panel position 0°
Step 3:  • Further away from the sensor • Panel position 0°	**Step 4:**  • Center of the measuring volume • Panel position 0° • Single point tilted 40°

Step 5:



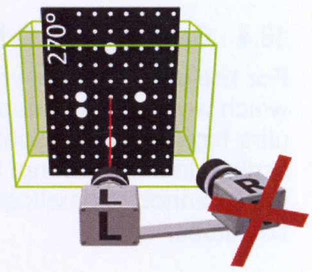
- Center of the measuring volume
- Panel position 180°
- Double points tilted 40°

Step 6:



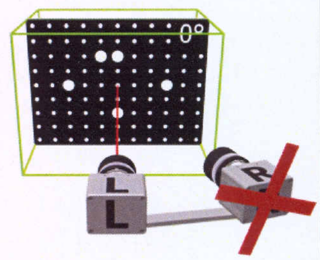
- Left camera only
- Panel position 180°

Step 7:



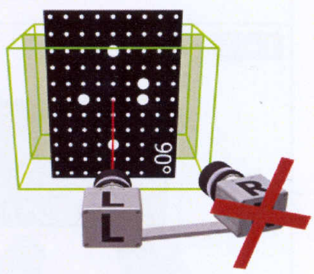
- Left camera only
- Panel position 270°

Step 8:



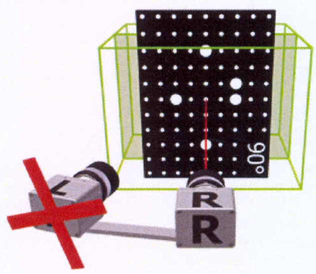
- Left camera only
- Panel position 0°

Step 9:



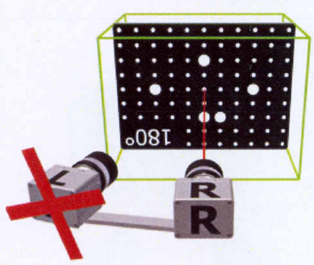
- Left camera only
- Panel position 90°

Step 10:



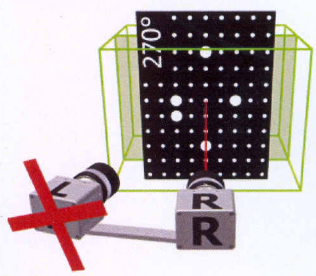
- Right camera only
- Panel position 90°

Step 11:

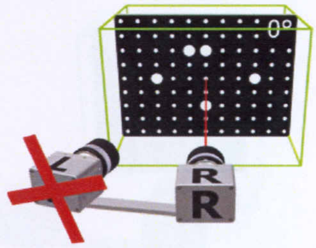


- Right camera only
- Panel position 180°

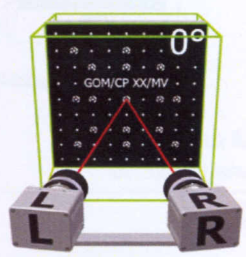
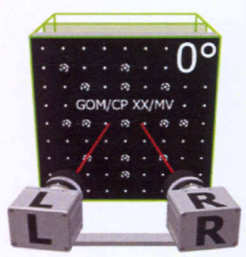
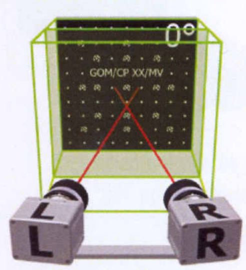
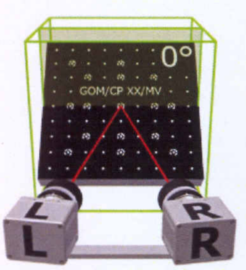
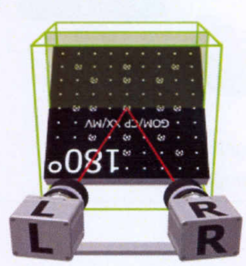
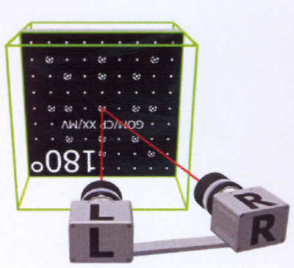
Step 12:



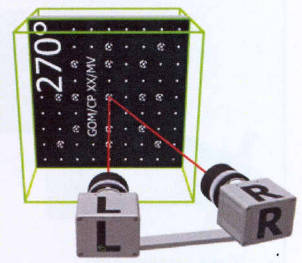
- Right camera only
- Panel position 270°

Step 13:  • Right camera only • Panel position 0°	

10.4.2 Steps for Calibration Object Panel – Coded

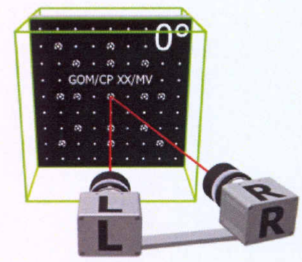
Calibration object panel - coded	
Step 1:  • Center of the measuring volume • Panel position 0°	**Step 2:**  • Closer to the sensor • Panel position 0°
Step 3:  • Further away from the sensor • Panel position 0°	**Step 4:**  • Center of the measuring volume • Panel position 0° • Tilted 40°
Step 5:  • Center of the measuring volume • Panel position 0° • Tilted 40°	**Step 6:**  • Left camera normal • Panel position 180°

Step 7:



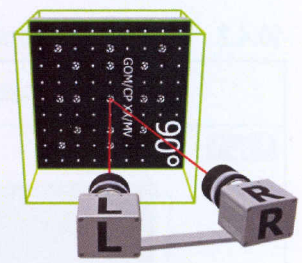
- Left camera normal
- Panel position 270°

Step 8:



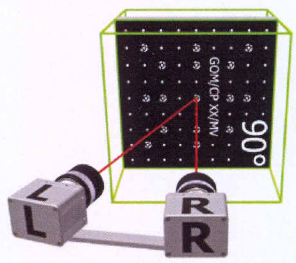
- Left camera normal
- Panel position 270°

Step 9:



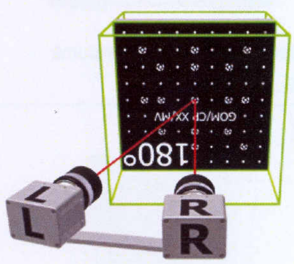
- Left camera normal
- Panel position 90°

Step 10:



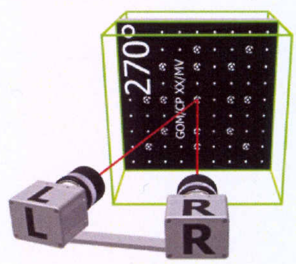
- Right camera normal
- Panel position 90°

Step 11:



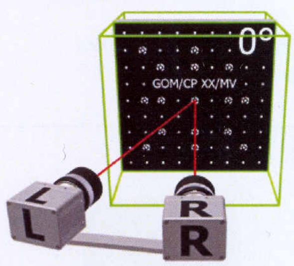
- Right camera normal
- Panel position 180°

Step 12:



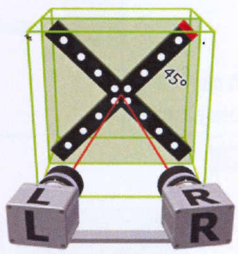
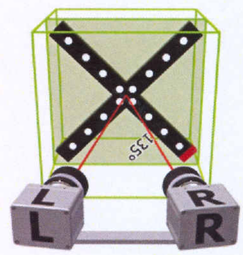
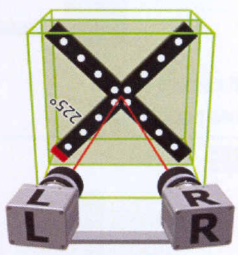
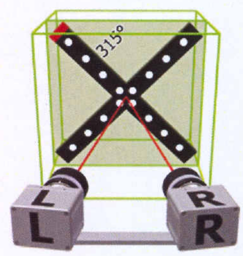
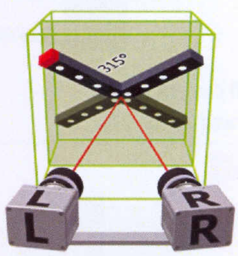
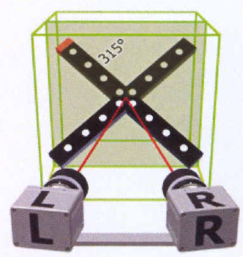
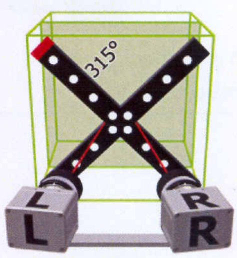
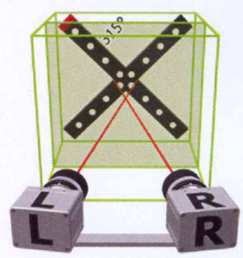
- Right camera normal
- Panel position 270°

Step 13:

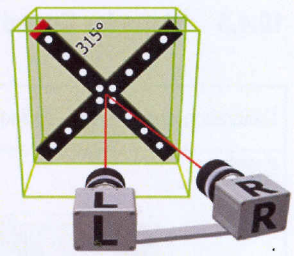


- Right camera normal
- Panel position 0°

10.4.3 Steps for Coded Calibration Object Cross – Coded

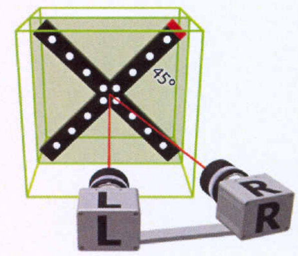
Calibration object cross - coded	
Step 1:  • Center of the measuring volume • Cross position 45°	**Step 2:**  • Center of the measuring volume • Cross position 135°
Step 3:  • Center of the measuring volume • Cross position 225°	**Step 4:**  • Center of the measuring volume • Cross position 315°
Step 5:  • Center of the measuring volume • Cross position 315° • Top tilted 40°	**Step 6:**  • Center of the measuring volume • Cross position 315° • Bottom tilted 40°
Step 7:  • Closer to the sensor • Cross position 315°	**Step 8:**  • Further away from the sensor • Cross position 315°

Step 9:



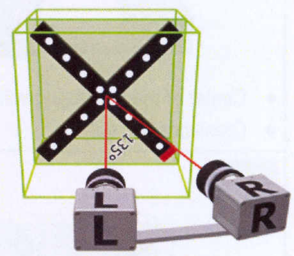
- Left camera normal
- Cross position 315°

Step 10:



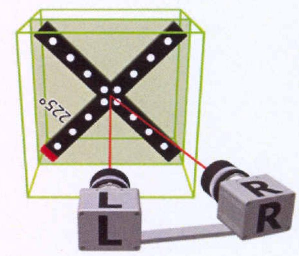
- Left camera normal
- Cross position 45°

Step 11:



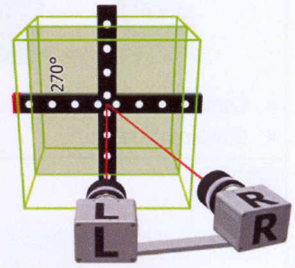
- Left camera normal
- Cross position 135°

Step 12:



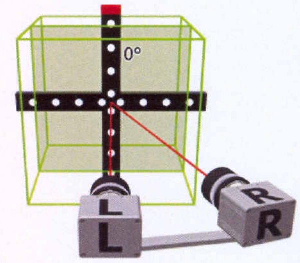
- Left camera normal
- Cross position 225°

Step 13:



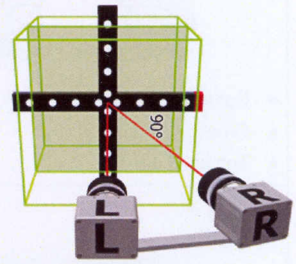
- Left camera normal
- Cross position 270°

Step 14:



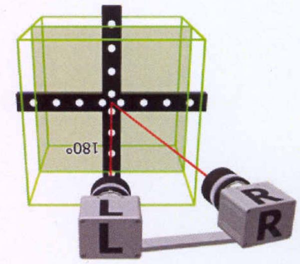
- Left camera normal
- Cross position 0°

Step 15:

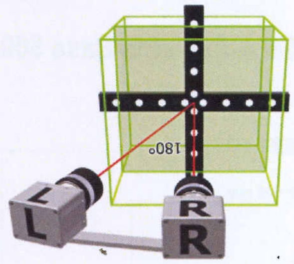
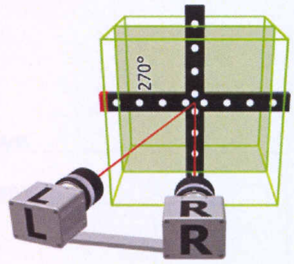
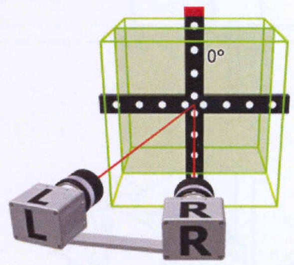
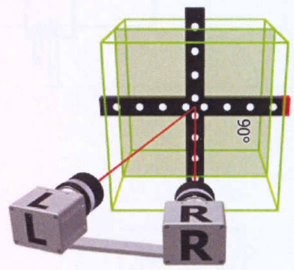
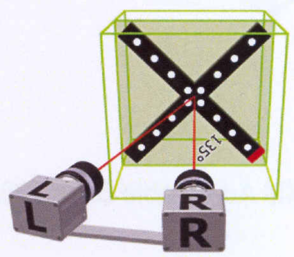
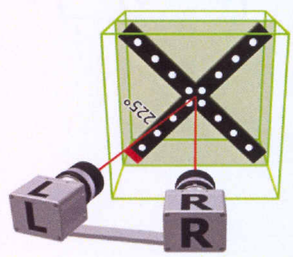
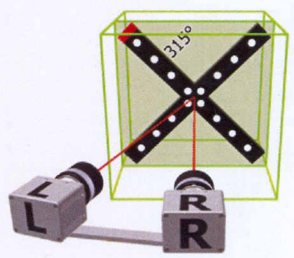
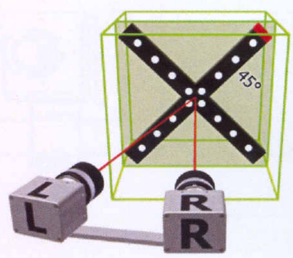


- Left camera normal
- Cross position 90°

Step 16:

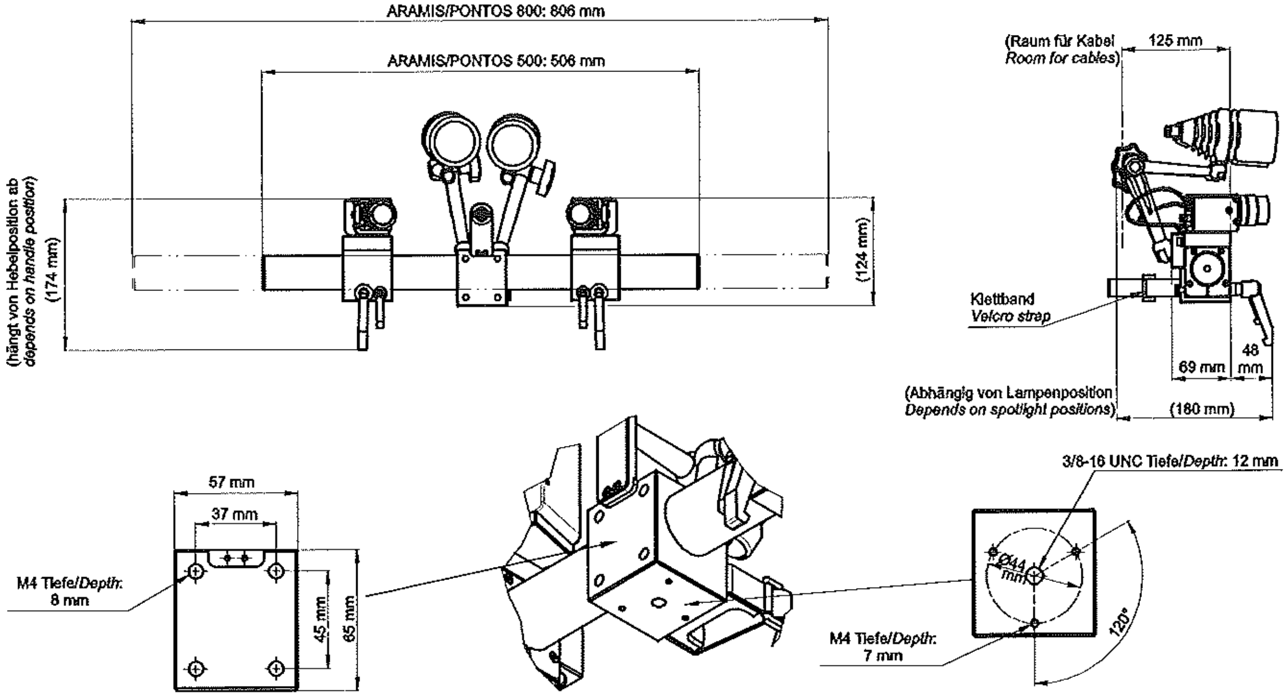


- Left camera normal
- Cross position 180°

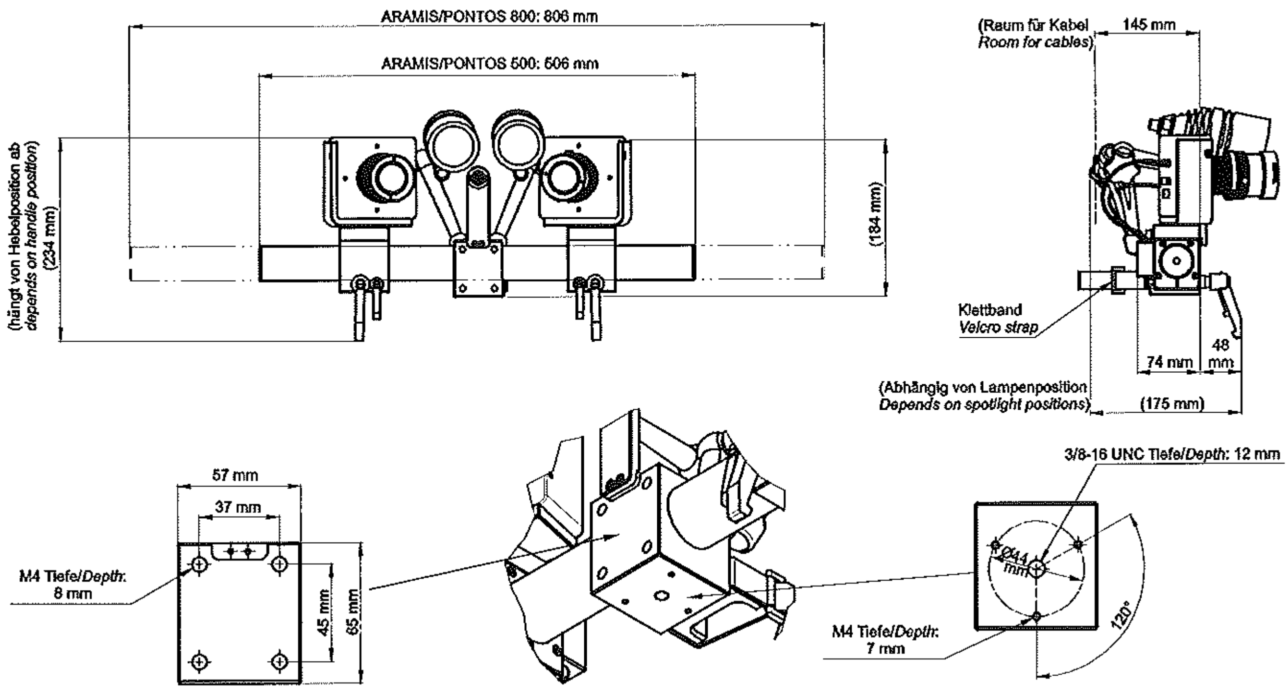
Step 17:  • Right camera normal • Cross position 180°	**Step 18:**  • Right camera normal • Cross position 270°
Step 19:  • Right camera normal • Cross position 0°	**Step 20:**  • Right camera normal • Cross position 90°
Step 21:  • Right camera normal • Cross position 135°	**Step 22:**  • Right camera normal • Cross position 225°
Step 23:  • Right camera normal • Cross position 315°	**Step 24:**  • Right camera normal • Cross position 45°

11. Sensor Dimensions

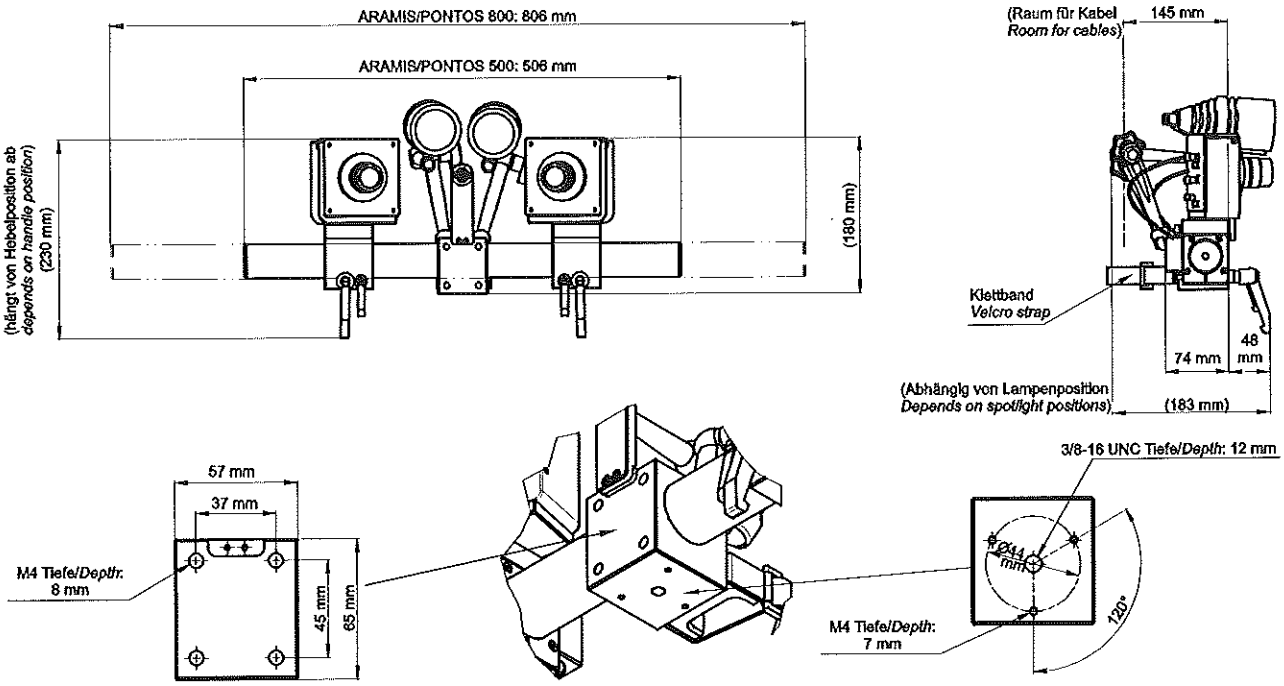
11.1 5M Adjustable Base 500/800



11.2 4M Adjustable Base 500/800



11.3 HS Adjustable Base 500/800

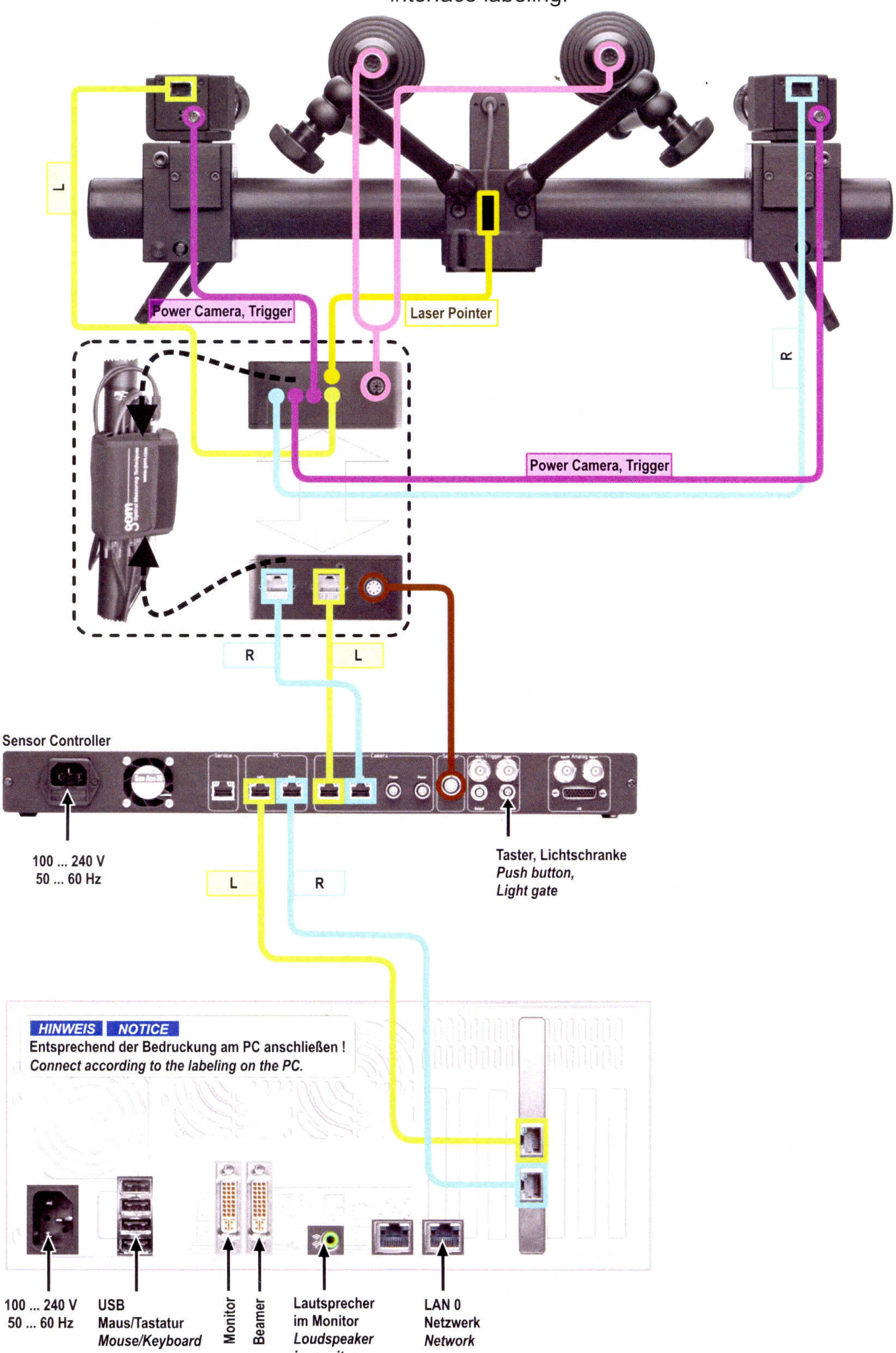


12. Cabling of the PONTOS Systems

12.1 5M Adjustable Base with 19" PC

Info

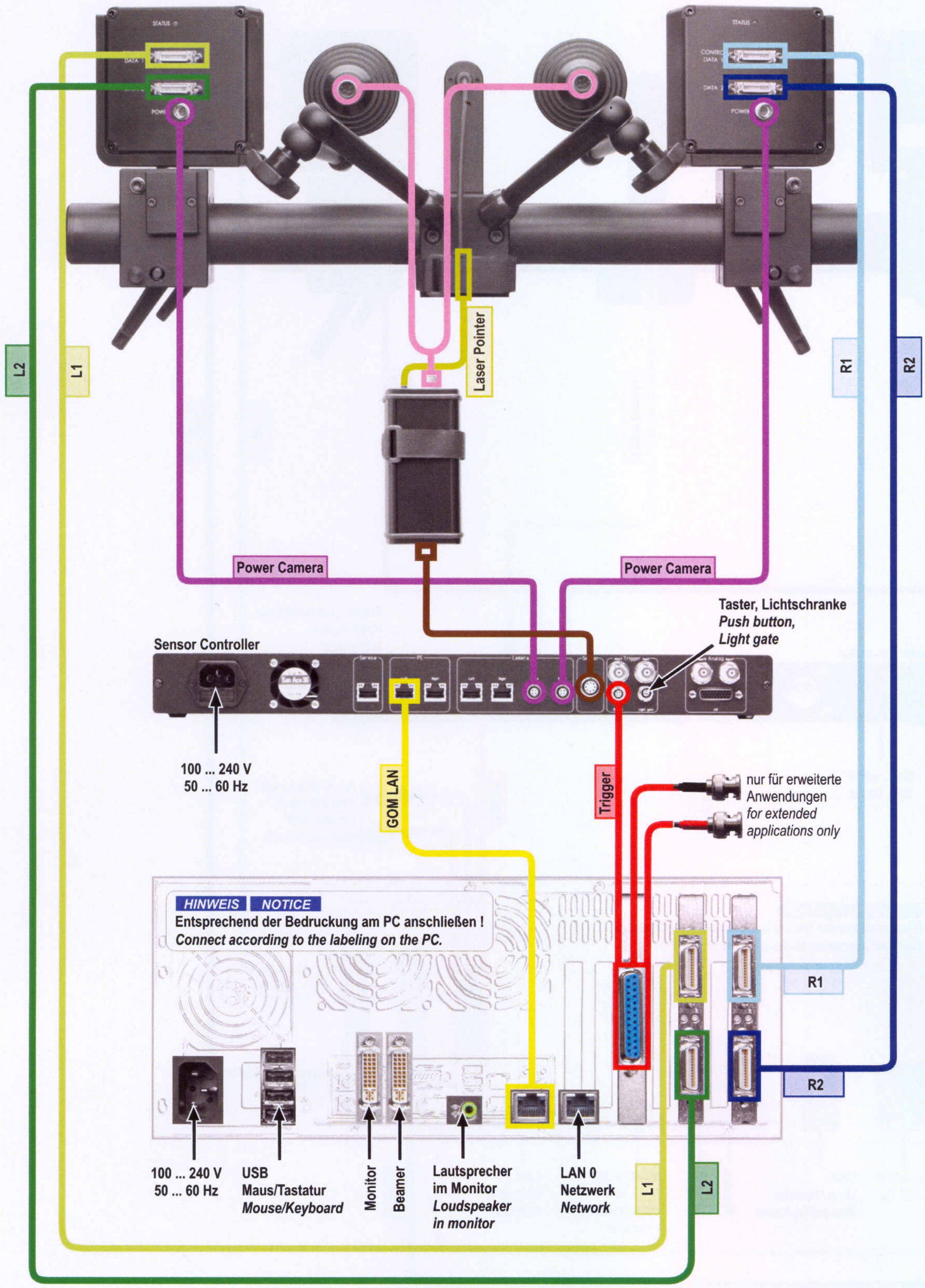
During cabling, the devices need to be switched off! The PC connectors may be different from the illustration here. In this case, follow the interface labeling.



pontos_hw-5m-4m-hs-adjustable_en_rev-c 22-Sep-2009

12.2 4M Adjustable Base with 19" PC

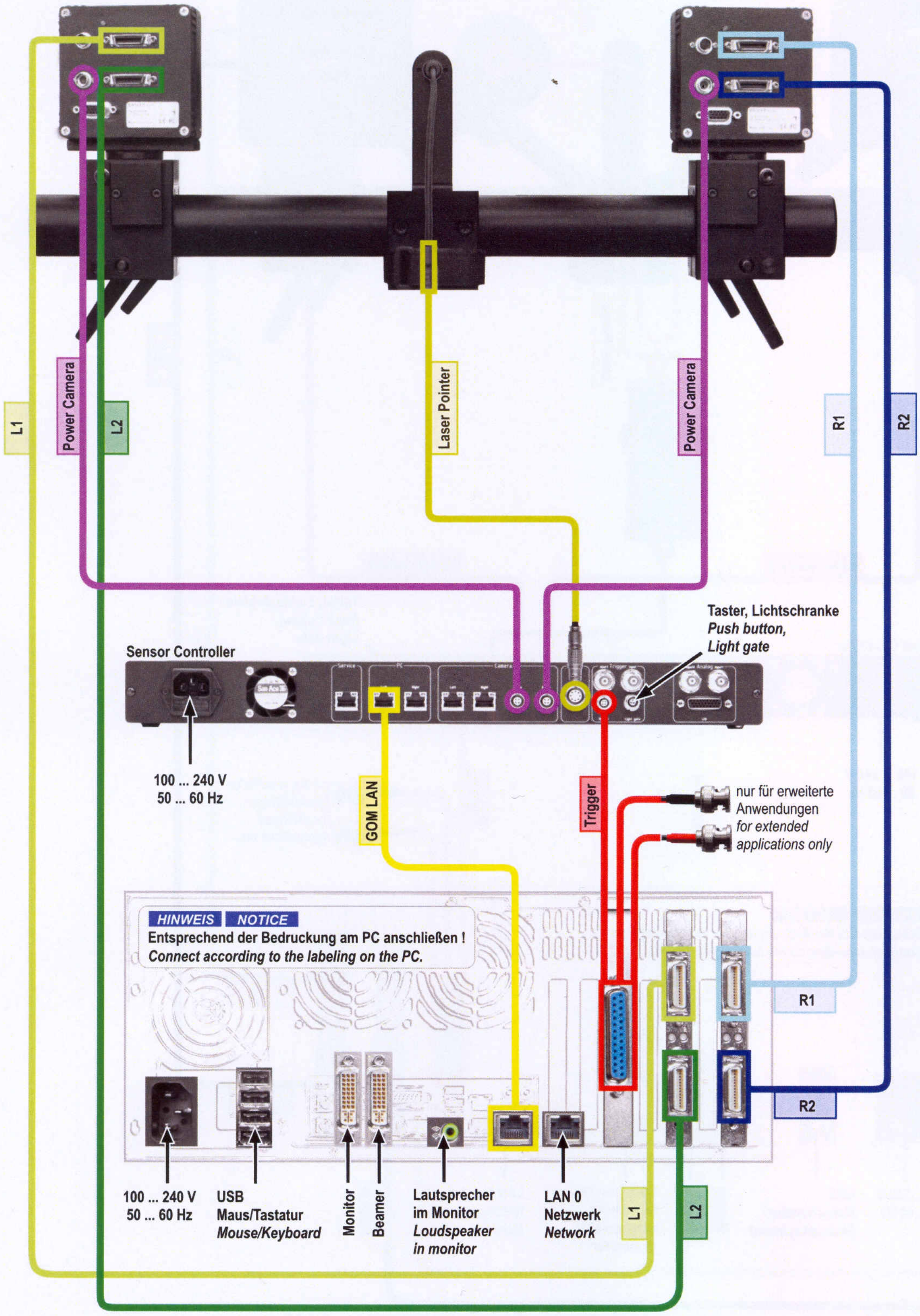
Info During cabling, the devices need to be switched off! The PC connectors may be different from the illustration here. In this case, follow the interface labeling.



12.3 HS Adjustable Base with 19" PC

Info

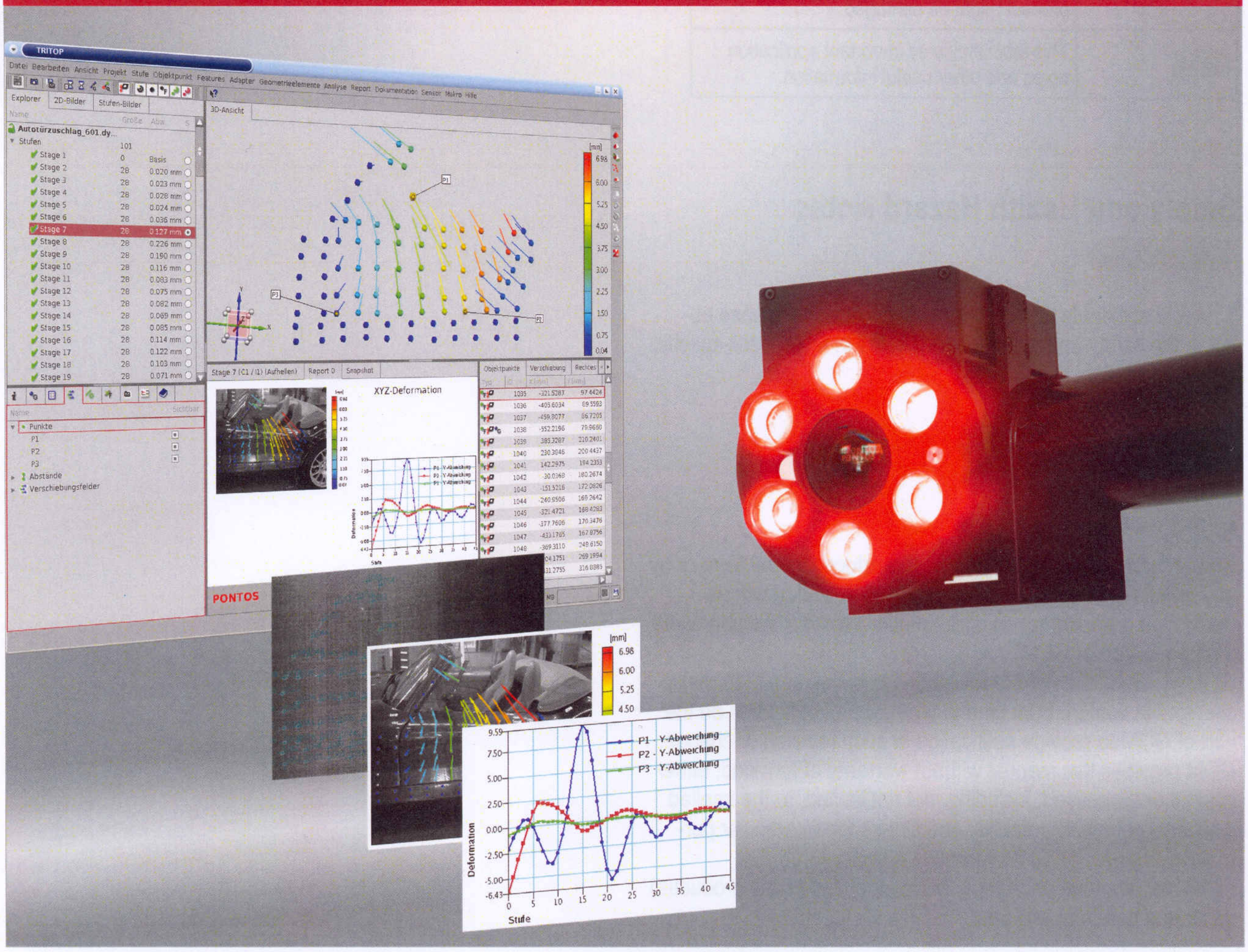
During cabling, the devices need to be switched off! The PC connectors may be different from the illustration here. In this case, follow the interface labeling.



pontos_hw-5m-4m-hs-adjustable_en_rev-c 22-Sep-2009

PONTOS

User Manual - Software



pontos_v62_1st_en_rev-b 7-Aug-2009

PONTOS v6.2

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gom Optical Measuring Techniques

Legal and Safety Notes

Symbols
In this user manual the following standard signal words may be used:

⚠WARNING	This label points to a situation that might be dangerous and could lead to serious bodily harm or to death.
⚠CAUTION	This label points to a situation that might be dangerous and could lead to light bodily harm.
NOTICE	This label points to a situation in which the product or an object in the vicinity of the product might be damaged.
Info	This label indicates important application notes and other useful information.

Safety and Health Hazard Notes

⚠WARNING

To avoid accidents and damages to the devices, please observe the safety and health hazard notes in the sensor-specific User Information!

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GOM may improve or change the manual and/or the product(s) described herein at any time.

pontos_v62_1st_en_rev-b 7-Aug-2009

About This User Manual

This user manual is intended for qualified personnel who has experience in handling measuring systems and basic PC knowledge (windows-based programs and operating systems).

In addition to this user manual, the software provides an Online Help. You may open the Online Help with the **?** icon or with the **F1** key.

While the Online Help for the most part describes the **How**, for example, how do I create a **New Deformation Project**, this user manual mainly informs about the **Why** and imparts basic strategic knowledge.

This user manual essentially is configured to the logical transfer of knowledge based on training concepts and standard measuring procedures.

Info

The scope of delivery of your software depends on the functions you bought according to your purchase contract. The user manuals and the Online Help describe the full scope of software functions. Therefore, it may happen that described functions are not included in your software package.

For being able to make optimum use of the system, we assume the ability to visualize in 3D and a color vision ability.

This user manual is divided into the following sections:

- Chapter A gives a brief introduction to the PONTOS system as well as basic knowledge about the Linux operating system and the PONTOS application software.
- Chapter B informs about the calibration of the measuring system and about adapting the sensor.
- Chapter C deals with the preparation of the measuring object and with carrying out a measurement.
- Chapter D informs about computation, components, stage transformation and identification.
- Chapter E informs about transformation methods and CAD import.
- Chapter F deals with result representation.
- Chapter G informs about report and documentation functions.
- Chapter H deals with automation and functional extensions.
- Chapter J informs about the support (troubleshooting).

PONTOS Software and Manuals for Measuring System or Evaluation Windows

Normally, the PONTOS software is used on Linux computers together with the measuring hardware. However, the same software is available as an option for Windows operating systems in order to be able to evaluate finished PONTOS measuring projects in this operating system environment as well. The scope of functions of the PONTOS software for Windows is restricted, e.g. no image recording is possible here.

This user manual describes the software for all operating systems. If sections or chapters of this manual are only valid for one operating system, they are marked with Measuring System or Evaluation Windows. If one section is marked, then this also applies to the respective subsections.

User Manual A-J

Chapter A - Table of Contents (rev-b)

A Basics

A 1 Brief Introduction to the PONTOS System

PONTOS is a non-contact optical 3D measuring system. It analyzes, computes and documents object deformations, rigid body movements and the dynamic behavior of a measuring object.

It is the task of the PONTOS software to precisely find ellipses (a perspective view of reference points) in all images and their 3D orientation.

With that, PONTOS provides a dynamic, precise and synchronous position detection for as many measuring markers (reference points) as you like which are applied to the object.

A digital stereo camera system records different load or movement states. The software assigns 3D coordinates to the image pixels, compares the digital images and computes the displacement of the reference points. Image recording is flexibly triggered and synchronized with the test setup, providing the possibility to additionally record and process analog values. The measuring results can be graphically represented in reports using colored deviation vectors and/or diagrams.

Most of the system functions are controlled by the software. Measuring, evaluation, display and print functions are available. All functions can be accessed via pull-down menus, hotkeys and dialog windows.

Info

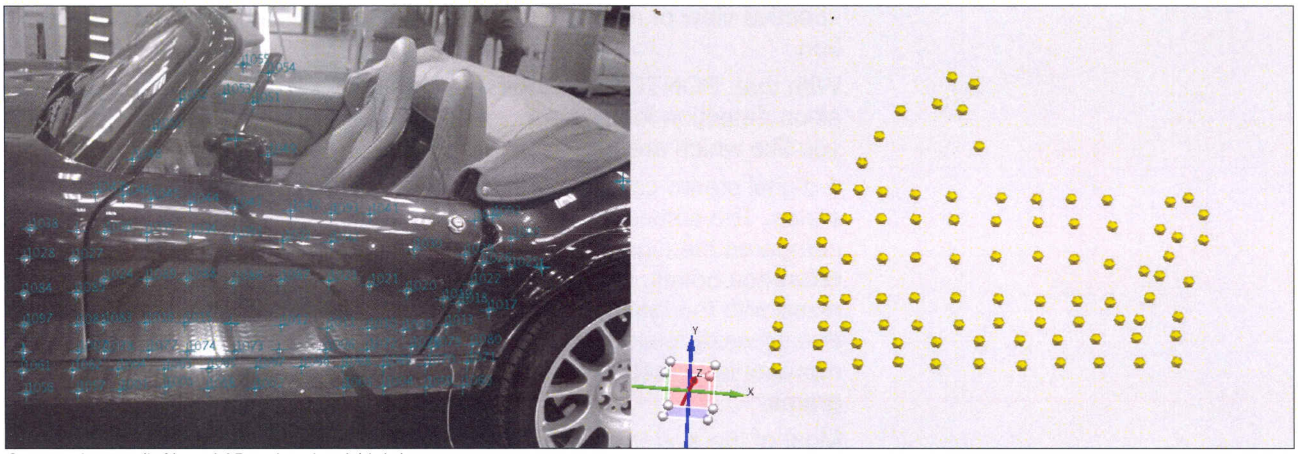
The PONTOS system is a measuring system that also addresses experts of digital optical measuring. Therefore, it is unavoidable that the PONTOS software contains menu items not intended for the standard user. Improper use of these menu items (expert parameters) may cause incorrect measurements.

A 1.1 Fields of Application

- 3D measurement of object movements, deformations and vibrations
- Verification of design concepts and simulation computations
- Checking the dynamic behavior, and the rise and fall of structural vibrations up to 250 Hz
- Load tests, creep tests and aging influences also for complex structures and viscoelastic elements
- Motion analysis
- Noise vibration harshness (NVH) tests in the automotive industry, also in a wind tunnel
- Recording of relative displacements
- Recording of gap size and flush changes
- Alternative for complex sensor technology like laser sensors, draw-wire sensors or accelerometers

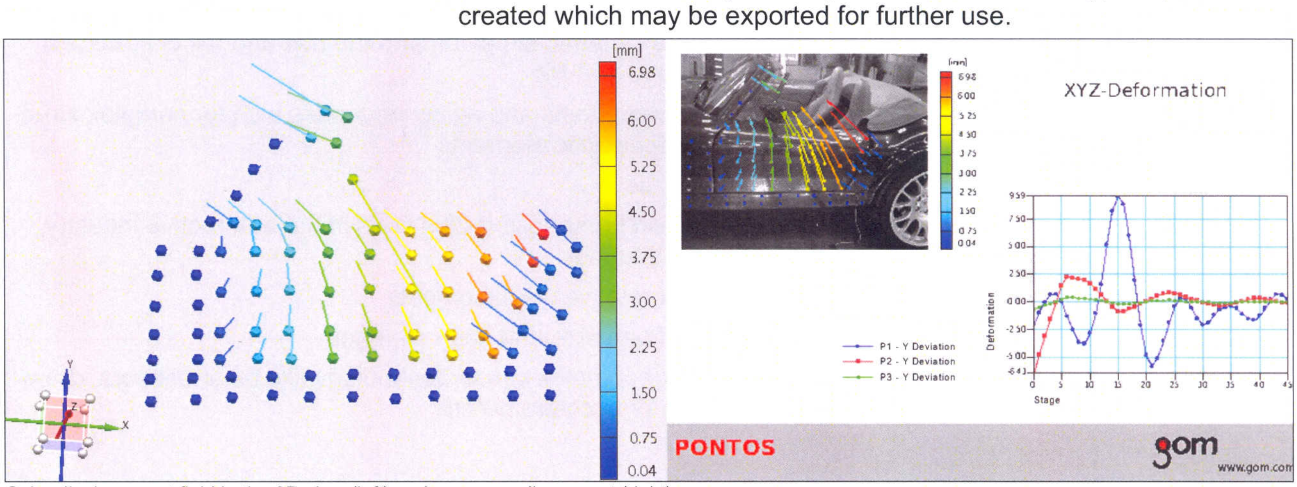
A 1.2 Typical Measuring Procedure Measuring System

Prepare the measuring object by applying the reference point markers and freely positioning the PONTOS sensor on a stand in front of the measuring object. After creating a new deformation project in the software, the system is calibrated and the desired images are recorded through a trigger during the deformation process. The software reads in these images as stages and automatically computes the 3D coordinates of the reference points and thus their position. They are displayed in the 3D view as a point cloud.



Camera image (left) and 3D point cloud (right)

In order to assess the deformation of the object, all stages are aligned to the reference stage based on components and fixed points which have to be specified. During the following identification, the IDs of the uncoded reference points which the system randomly assigns will be renumbered automatically so that the same points in all stages will have the same ID. A displacement field, to be defined by selecting an area of points, marks the area for which the software will display the computed deformation through all stages. The deformation is calculated automatically as soon as the stage is identified. Within the displacement field, the 3D view displays in color the deviation of the points from the stage selected as deformation reference. Measurements and further analyses may be carried out. Finally, a report is created which may be exported for further use.



Color displacement field in the 3D view (left) and corresponding report (right)

pontos_v62_a_en_rev-b 30-Jul-2009

A 1.2.1 General Steps to Carry Out a Standard Measuring Project

For carrying out a standard measuring project using a calibrated PONTOS system, the following steps are required:

Step 1:	Start the PC and the PONTOS software.
Step 2:	Switch on the sensor controller and, if required, the additional existing power supply unit.
Step 3:	Create a new deformation project in the PONTOS software.
Step 4:	Use **Start/Stop Measurement Mode** to record images of the required deformation stages.
Step 5:	Compute all stages.
Step 6:	Define components and identification points.
Step 7:	Choose the component for stage transformation and identify the stages.
Step 8:	Determine coordinate system (if required).
Step 9:	Create a displacement field and carry out analyses.
Step 10:	Report generation.

A 1.3 Features

These are some of the most important PONTOS features:

- Non-contact acquisition of the precise 3D position of any number of measuring points Measuring System.
- Computation, visualization and display of the measuring points' position and displacement in different object states (stages).
- Image recording frequency independent of the number of the recorded reference points Measuring System.
- Flexible triggering of image recording, synchronized with the test setup (including recording of analog signals) Measuring System.
- Mobility and flexibility due to an easy and compact measuring system Measuring System.
- Robust against environmental influences like vibrations, light changes Measuring System.
- Easy and quick adaptation to different measuring volumes and measuring tasks Measuring System.
- Also suitable to measure large deformations (e.g. crash) Measuring System.
- Project transformations according to the 3-2-1 or best-fit method.
- 6DoF analyses
- The graphical representation of the measuring results provides an optimum understanding of the component behavior.
- Report generation and export functions for measuring and result data.
- Automation due to macro functions.
- In combination with the photogrammetric system TRITOP, PONTOS can also be used for large objects Measuring System.

- Several PONTOS systems can be combined to analyze large structures Measuring System.
- Option: Creation of user profiles for customer-specific adaptation of the user interface.

A 1.4 Main Hardware and Software Components

For information about the main hardware and software components, please refer to the Hardware User Information.

A 1.4.1 Basic Requirements Measuring System

In order to achieve full functionality when working with the PONTOS software, the following is required:

- GOM Linux operating system as of version 10
- One of the following computers: Dual Core Opteron (64 bit), Dual Opteron (64 bit) or
  □one of the following notebooks: Dell Precision M65, Dell Precision M70, Dell Precision M4300.
- PONTOS sensor
- USB Dongle: As of software version v6.1, the GOM applications will be delivered with a USB dongle (CodeMeter). This dongle is either integrated into the computer or can be plugged in separately. Generally, the dongle contains a single license. However, server licenses are available on request.

A 1.4.2 Basic Requirements Evaluation

- Operating system:

  Recommended:
  Windows XP SP2, Windows XP 64Bit Edition for large, computation intensive projects

  Also useable for:
  VISTA 64Bit (only with graphics card NVIDIA Quadro FX570, FX1700)

- Computer:

  Recommended configuration:
  Processors: Intel Core2Duo or AMD Dual Core Opteron,
  RAM: 4GB RAM, NVIDIA Quadro
  Graphics card: NVIDIA Quadro FX1100, FX1500, 128 MB
  Info The software has been tested with NVIDIA Quadro graphics cards. Certified NVIDIA graphics cards: FX570, FX1100, FX1300, FX1500, FX1700

  Minimum requirements:
  Processors: Pentium IV, 2GHz,
  RAM: 2 GB,
  Graphics card: OpenGL graphics card. 64 MB

- Current graphics card drivers

- In case of other graphics cards the scope of functions and performance may possibly be restricted!

- USB Dongle: As of software version v6.1, the GOM applications will be delivered with a USB dongle (CodeMeter). Generally, the dongle contains a single license. However, server licenses are available on request.

Graphics Cards and Driver Software for Windows

In order to ensure optimum hardware acceleration when rendering the 3D view (Open GL), an NVIDIA Quadro graphics card with current graphics card drivers is required. Only an appropriate hardware acceleration allows for comfortable rotating and zooming in the 3D view.

If your computer has a different graphics card or if you do not have the current drivers, the PONTOS software probably works with a considerably slower software rendering.

If your application does not run stable, please start the PONTOS software in the **Safe Mode** (mode with software rendering). Start the **Safe Mode** in the **Windows start menu ▶ Programs ▶ PONTOS vx.xx.x ▶ PONTOS (Safe Mode)**.

Info

If you are not sure if your computer is equipped with a suitable graphics card, start the PONTOS software and choose **Help ▶ Graphics Board ▶ Reset**. A wizard leads you through the further steps. For further information, please refer to the Online Help.

A 2 The GOM Linux Operating System Measuring System

A 2.1 Starting the PC

When pressing the power switch, the Linux operating system starts automatically. If a second system like Windows is installed on the PC, first a menu appears to select the desired operating system.

The Linux operating system is factory-adjusted with the following default user and default password:

GOM Linux version	as of v10
Default user	user
Password	user

A default user has the rights for writing, reading and deleting data and directories he created.

This user manual does not deal with the Linux operating system in more detail. You only need superficial Linux knowledge to be able to work with the PONTOS software.

A 2.1.1 The KDE Start Menu

In the tool bar at the bottom of the Linux screen you may start different software, adapt system settings, etc. using the Linux KDE start menu, similar to operating systems based on Windows.

A 2.1.2 Home Directory

In your home directory, you will find all folders important for you.

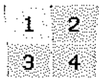
A 2.1.3 Text Console

In case you need support, it may happen that, on request, you need to enter a certain command syntax into the so-called text console. In that case, open the text console by clicking on the respective icon.

A 2.1.4 Internet

Using the Firefox web browser, you may establish a connection to the internet in order to, for example, download updates from the GOM web site.

A 2.1.5 Virtual Desktops

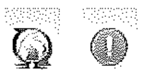


With Linux, you may use several equivalent desktops. The respective active desktop is displayed lighter than the others. Four virtual desktops are factory-preadjusted. Using the context menu of the right mouse button when clicking on the desktop icon, you may create more virtual desktops.

A 2.1.6 Loudspeakers

If loudspeakers are connected to your computer, this icon becomes active and you may adjust the volume here.

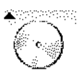
A 2.1.7 Linux Operating System Updates



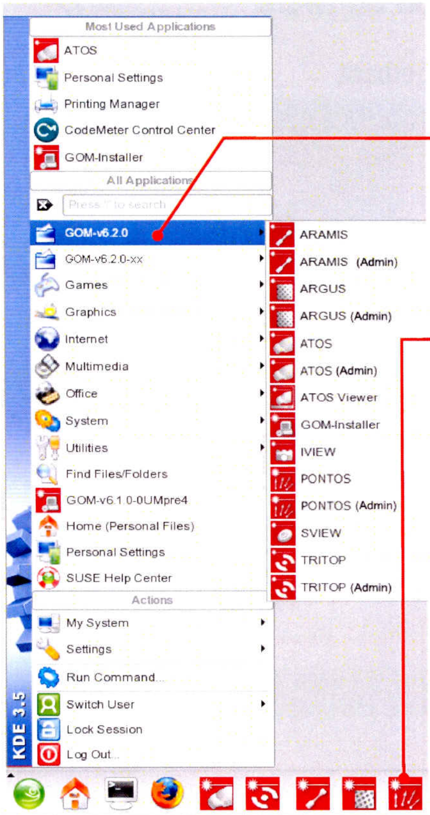
This icon indicates if new operating system updates are available. The blue icon means that there are no new updates. The orange icon indicates that new updates are available for the operating system. If you are connected to the GOM web site via the internet, you may start the update procedure by clicking on this icon.

A 2.1.8 Mounting and Unmounting CD/DVD and USB

When you insert a CD or another storage medium in your computer, the respective icon appears on the screen and the medium is automatically mounted. A little green arrow appears.



If you would like to remove the medium again, you need to unmount it by clicking with the right mouse button on the medium icon and selecting the respective entry from the context menu. For the CD, the little green arrow disappears, and in case of a USB stick the entire icon disappears.



A 2.1.9 Starting the PONTOS Software

You may start the software in two ways:

a) Using the KDE menu

Click on the KDE start icon and select the software from the directory **GOM-v6.2.x**. This directory is the master version and is automatically linked to the current software version (**GOM-v6.2.x-xx**) installed on your computer.

b) Using the software icon

Simply click on the respective icon in the KDE tool bar.
In case the icon is not available, click on the desired software in the master directory **GOM-v6.2.x**, keep the left mouse button (LMB) pressed and drag the icon in the tool bar.

Dongle with Administrator License:

If you have a dongle with administrator license (default as of software version v6.2), you can only administer the GOM software when starting it with **PONTOS (Admin)**. Only with this start routine you will reach the user profile management.

If you start **PONTOS** without the supplement **Admin**, you may test the user profile settings.

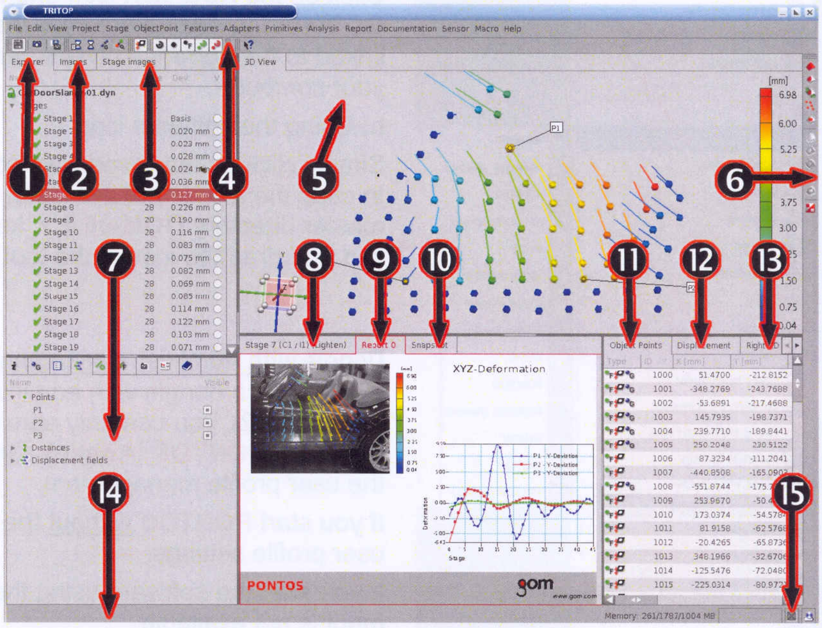
If you start the software using the icon, the user profile management is not available.

Dongle without Administrator License:

As in this case the user rights are restricted, it does not matter in which way you start the application (with or without the supplement **Admin**).

A 3 The PONTOS Application Software

A 3.1 The Default Screen Arrangement



Screen elements:

❶	Tab **Explorer**. Here, you will find all stages of a deformation project. You may select the stages and thus switch the 3D view, the 2D view or report to the respective stage. **Symbols in the explorer:** The stop sign indicates that the stage was not computed. The red cross and the letters NT inform that the stage is neither identified nor transformed. The yellow cross indicates that the stage is transformed but not all fixed points were used or found. The green cross shows that the stage is transformed but not identified and that all fixed points were used. The yellow check mark informs that a stage was transformed but not by all fixed points, that it was renumbered successfully and thus is identified. The green check mark means that a stage transformed by all fixed points was renumbered successfully and thus is identified.
❷	Tab **Images**. Here, for each stage, the first image of the first image group of the stage is displayed. If you click on the images, you change the stages like in the explorer itself.
❸	Tab **Stage Images**. Here, you will find all images of a stage.
❹	Icon bar to select functions (enabling/disabling point types, compute stage, etc.). The tool bar and its scope of functions depend on the operating modes. The icon bar can be adapted individually (right mouse button click in the bar).
❺	3D view
❻	Icon bar to choose selection and deselection tools.

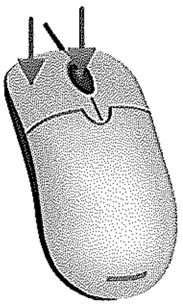
7	Sub-explorer with various tabs: Tab **Info**: Here, you will find information about the selected stage. Tab **Elements**. This tab shows an explorer view of different elements like analysis elements, primitives, adapters and features. Features are 3D objects that were created based on 2D images. You may select the elements, set them visible/invisible, and much more. Tab **Fixed Points**: This tab contains a list of all fixed points including their status for each stage. Tab **Stage Data**: This tab contains a list of all stage data for each stage. Tab **Image Series**: This tab contains a list of all image series that were created for the project. Tab **Reports**: This tab contains a list of all reports that were created for the project. Tab **Documentation**: This tab contains a list of all documentation data that were created for the project to be exported using **File ▶ Export ▶ Tables**.
8	Tab **Left 2D Image**. Displays the 2D camera image of the selected stage.
9	Tab for viewing and editing reports.
10	Tab for viewing and editing snapshots.
11	Display of the object point list for 3D points. Here, you get information about the 3D points and you may edit them (right mouse button click).
12	This tab displays the displacement for each object point for the selected stage.
13	Tab **Right 2D Image**. If, for defining a 3D point or a feature, a second image is required, you may select it here.
14	Status indicator line. Here, all important information about the project and the current commands are displayed.
15	Cancel button for computation-intensive operating steps.

A 3.2 Tool Bars

The software provides several tool bars (e.g. for the views, the selection or for snapshot editing etc.). You may enable or disable these tool bars using the context menu of the right mouse button (clicked on the tool bar area).

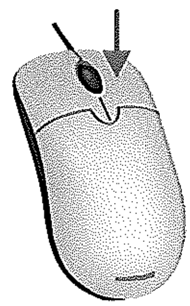
A 3.3 Mouse Functions

The software is mainly operated by using the mouse. The right, middle and left mouse button and the mouse wheel have functions assigned and are window-dependent. The middle mouse button and the mouse wheel are one common control element.



A 3.3.1 Functions of the Left and Middle Mouse Button

- When pressing the **left** mouse button (LMB) in the 3D view and dragging the mouse, you may rotate the object.
- When pressing the **Shift** key and the **left** mouse button (LMB) in the 3D view and dragging the mouse, you may rotate the object around the clicked point.
- A simple click with the **left** mouse button (LMB) on an element in the explorer, in the sub-explorer, in the 3D view or in a report selects this element.
- Clicking with the **left** mouse button (LMB) together with the **Shift** button on an element in the explorer or in the sub-explorer, selects several consecutive elements.
- Clicking with the **left** mouse button (LMB) together with the **Ctrl** button on elements in the explorer, in the sub-explorer, in the 3D view or in a report, selects several independent elements.
- Double clicking with the **left** mouse button (LMB) on an element in the explorer, in the sub-explorer, in the 3D view or in a report opens an element-specific dialog to edit the element properties.
- When pressing the **Ctrl** key and the **left** mouse button (LMB) in the 3D view or in a report and dragging the mouse, a selection frame becomes visible and all elements within this frame are selected.
- With **Ctrl** and **left** mouse button (LMB) you may make selections when dialog windows are open.
- When pressing the **middle** mouse button (mouse wheel) in the 3D view and dragging the mouse, you may move the object.
- When turning the **middle** mouse wheel, you may zoom the 3D object, the 2D image or the report.
- When pressing **Ctrl** and the **middle** mouse button in the 3D view, the 2D image or in a report and dragging the mouse, you may zoom the object to a specific detail.
- When turning the **mouse wheel** in a box of values [10.00 mm], you may change the values in steps of the default increment. The default increment depends on the parameters, is preset and cannot be changed.
- When turning the **mouse wheel** in a box of values [10.00 mm] and simultaneously press the **Shift** key, you may change the values in one tenth of a step of the default increment. The default increment depends on the parameters, is preset and cannot be changed.
- When turning the **mouse wheel** in a box of values [10.00 mm] and simultaneously press the **Ctrl** key, you may change the values in steps of ten of the default increment. The default increment depends on the parameters, is preset and cannot be changed.

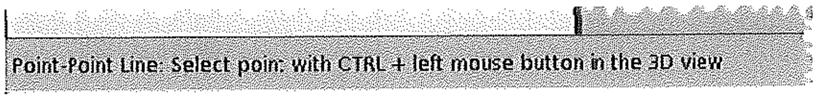


A 3.3.2 Functions of the Right Mouse Button (RMB)

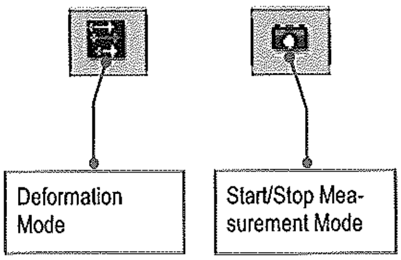
The context menu functions of the right mouse button (RMB) depend on the element on which or the window/dialog in which you press the button. For example, you may edit elements, insert keywords, and much more.

A 3.4 Status Indicator Line

The status indicator line at the bottom left on the screen gives interesting and helpful information regarding the current functions.



A 3.5 Operating Modes



PONTOS generally works in two operating modes, the **Deformation Mode** and the **Start/Stop Measurement Mode**.

A 3.5.1 Deformation Mode

The **Deformation Mode** is used for creating deformation projects, processing and analyzing the measuring data, creating measurements, visualizing deformations, generating reports, etc.

A 3.5.2 Start/Stop Measurement Mode

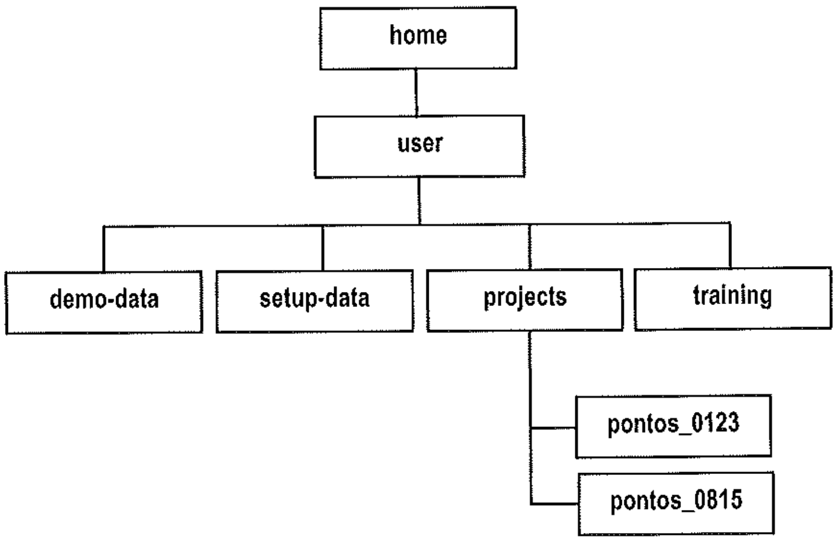
Change to the **Start/Stop Measurement Mode** by clicking on the corresponding button. Here, the 2D camera images are recorded. To quit the mode click on the icon again.

A 3.6 PONTOS Directory Structure Measuring System

As default user you are authorized to save and delete directories and files in the directory **user** (path: home/user).

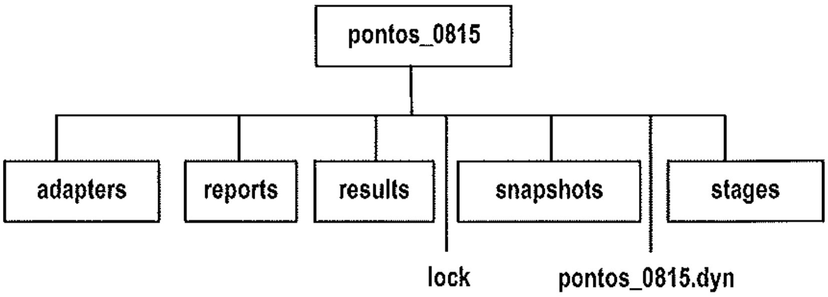
We recommend a structured filing of these data in order to be able to work with the measuring projects and the corresponding files and directories any time.

A 3.6.1 Recommended Directory Structure:



projects	Save your deformation projects here. For each measuring project, the software automatically creates a directory. The name of the directory is identical to the project name. A measuring project always consists of several files and directories (see A 3.6.2). The figure shows as an example the structure for two measuring projects (0815 and 0123).
setup-data	Here, save all setting files you would like to use additionally like calibration files from image series.
demo-data	Saved data for demonstration purposes only.
training	Saved data for training purposes only.

A 3.6.2 Automatically Created Project Directory



adapters	In this directory, adapter data, if available, is saved.
reports	Directory that contains all created reports.
results	Directory in which result data is stored. File export_elements.dat, for example, contains information about analysis elements or snapshots which you created in the software. In this directory, you may also save all files you export.
snapshots	Directory in which all image series created in the software are stored.
lock	Temporarily created file when a measuring project is open.
stages	Directory containing all stages and the corresponding images and files.
pontos_0815.dyn	Deformation project file. With this file, a deformation project is opened in PONTOS.

A 3.7 Save Data

The data from measuring projects are automatically stored in a directory Measuring System.

The name of the directory is the name of the project. The project data consist of several files and directories. The .dyn-file is the deformation project with which PONTOS is started when resuming the project. All primitives, distances and other measurements created in the deformation project, for example, are linked to this file.

NOTICE

Note that the software does not provide a possibility to undo operating steps!

A 3.7.1 Save Project Under a Different Name

Using function Save as you may save a copy of your project under a different name. This copy will immediately be opened and you can edit it.

A 3.7.2 Export Data-Reduced Project

The software offers the possibility to save a deformation project as a data-reduced version under a different name. Data-reduced here means that you may delete (stages and images) and/or compress (images) certain data. This is particularly suitable if you would like to pass on a project to be viewed with the PONTOS Viewer. You original project remains open and you may continue working with it.

NOTICE

Generally, a data-reduced project can no longer be recomputed as images either were deleted completely or compressed to a large extent so that the reference points can no longer be identified.

A 3.8 Record CD/DVD Measuring System

The CD/DVD drive allows for reading and recording CDs or DVDs. The system also supports re-writable CDs or DVDs. DVDs are recorded according to the DVD-R(W) standard. Each recording process generates at least a data block of approx. 1 GB on the DVD.

The recording program automatically finalizes all CDs and DVDs, i.e. additional recording of data at a later time is not possible.

If it is not possible to record the data on just one blank CD/DVD, the data is automatically recorded on several CD/DVDs.

Info

In case of 19" computers, make sure the door of the CD/DVD recorder is always open when recording data because the CD/DVD slide comes out for a short moment when checking the CD/DVD. If the CD/DVD slide is hindered when coming out, this might in rare cases cause a system crash!

A 3.9 Preferences

The software provides extensive settings for preferences to allow you adapting the software optimally to your needs. Most of the changes only take effect on new measuring projects!

The software also provides the possibility to save user-defined preferences in a file to optimally adapt to the measuring projects.

Info — You may restore the factory-adjusted settings any time.

A 4 User Profiles

User profiles are used to adapt the user interface of the GOM software to company-specific workflows. For this purpose, you can hide menu items of the software as well as GOM standard templates and add user-defined scripts to menus. Generally, a user profile is saved in a determined local directory. The configuration data of this directory are then available to the user. You need to set up this directory prior to creating a user profile.

You can define user profiles only in the Administration Mode of the GOM software. As of software version v6.2.0, the corresponding administrator license is integrated in your license dongle by default.

Info — A user profile is always fixed to a specific computer and not to the individual measuring projects or files!

For further information, please refer to the Online Help.

Features

- Special directory for user profiles
- Fixed to a specific computer
- Displaying and hiding menus and toolbars
- Inserting own scripts before or after menu items
- Including configuration files like templates and scripts
- Locking the editing of templates
- Hiding default GOM templates
- Special dongle for restricted user rights required

A 5 Summary

- Brief introduction
- Hardware and software components
- Linux operating system Measuring System
- Software operating structure
- Most important mouse functions
- Operating modes
- Directory structure
- Saving data
- Record CD/DVD
- User profiles

Chapter B - Table of Contents (rev-a)

B Sensor Measuring System

B 1 Calibration

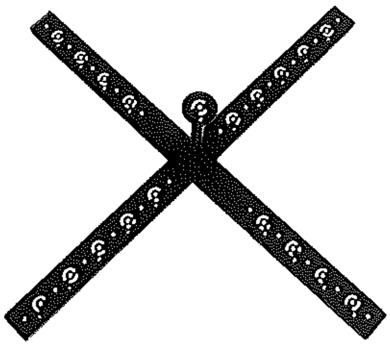
Calibration is a measuring process during which the measuring system with the help of calibration objects is adjusted such that the dimensional consistency of the measuring system is ensured.

B 1.1 Calibration Objects

For the PONTOS measuring system one calibration object (cross) is used. They are available in different sizes. Depending on the type of the system and the size they may differ slightly in their appearance. Calibration objects are equipped with so-called retro-reflective reference points.

Info

Prior to use the calibration cross, you need to screw it onto the supplied stand in camera height in order to easily rotate and tilt it.



Calibration cross

The calibration object contains the scale bar information. A calibration cross has two scale bars, that is the specified distance between two specific points on each cross axis.

B 1.1.1 Calibration Object Selection

Which calibration object you need to choose depends on the measuring volume you would like to use. The size of the calibration cross corresponds to the size of the measuring volume (see also the sensor configuration tables in the valid User Information – Hardware).

NOTICE

Calibrate the system only with the calibration object valid for the respective measuring volume as you otherwise will get wrong measuring results!

B 1.1.2 How to Handle Calibration Objects

NOTICE

Always handle the calibration objects with utmost care and prevent them from getting dirty and being scratched. Make sure you do not touch the surface of the calibration object if possible. After each use, accommodate the calibration objects at the places dedicated for that.

B 1.2 Calibration Conditions

B 1.2.1 When is Calibration Required?

- Before starting measurements for the first time, the respective PONTOS measuring volume needs to be calibrated.
- Also, if the adjustment of the camera lenses or the position of the cameras with respect to each other is changed (e.g. when changing the camera support to a different length), the system requires calibration again.

B 1.2.2 Prerequisites (e.g. Warm-Up)

A prerequisite for successful calibration is the correct setup of the sensor. For further information, please refer to the valid User Information – Hardware. The object to be measured defines the measuring volume and thus the set of lenses to be used.

Adjust the measuring distance to the calibration object accordingly, see also the sensor configuration tables in the valid User Information – Hardware.

B 1.3 Calibration Process

For the calibration process, you need to open the respective menu item in the software and select the correct calibration object from a list (see Online Help).

Info

Calibrate the system with the same lighting conditions as used for measuring.
Follow the instructions in the software.

B 1.3.1 Positioning of the Calibration Object (HS)

Place the calibration object in the center of the measuring volume such that the rays of the three laser pointers meet in the middle of the cross plane (not on the higher protruding point). Make sure the calibration cross fills the live video images of the cameras (see Online Help). Follow the instructions in the software.

In order to capture the entire measuring volume, you need to move the calibration cross during calibration. For this, the following general rule applies: You should move the calibration object by 1/3 of the measuring volume height closer to the sensor and by 1/2 of the measuring volume height further away – in each case starting from the center of the measuring volume.

Info

Make sure there is always enough space between the calibration object and the stand so that it cannot bump against the stand during the required movement.

B 1.4 Calibration Results

At the end of the calibration process, the software displays the calibration results.

Info

For a good calibration, the calibration deviation needs to be smaller or equal to 0.04 pixels.
In addition, for a calibration object (with the information of two scale bars), the deviation of the adjusted calibration scale bar must not be too high (less than 0.005% of the calibration scale bar). A high deviation indicates an incorrect calibration object or incorrect scale parameters.

B 2 Sensor Changes

B 2.1 Adapting the Sensor to Other Measuring Volumes

B 2.1.1 When is an Adaptation Required?

Ideally, the measuring object fits into the measuring volume. Depending on the size of your measuring object, you will find the correct measuring volume in the sensor configuration table in the Hardware User Information. Depending on what you would like to measure, you need to equip the sensor with the respective correct lenses.

For information about how to handle lenses, please refer to the User Information – Hardware.

B 2.2 Expert Calibration

B 2.2.1 Calibration Theory

During calibration, the sensor configuration is determined. This means that the distance of the cameras and the orientation of the cameras to each other are determined. In addition, the image characteristics of the cameras are determined (e.g. focus, lens distortions). Based on these settings, the software calculates from the reference points of the calibration object in the 2D camera image their 3D coordinates. The calculated 3D coordinates are then calculated back again into the 2D camera images. For the position of the reference points, this results in the so-called reference point deviation (intersection error).

B 2.2.2 Calibration Deviation

The calibration deviation is calculated from the average intersection error of all reference points recorded during the calibration process.

B 2.2.3 What Causes Decalibration of the System?

A decalibration occurs if the sensor configuration is changed. This might be, for example, changes of the camera angle to each other or changes in the image characteristics of the cameras (use of other lenses). If the sensor configuration changes, the calculated reference point deviation changes as well.

B 2.2.4 Quick Calibration

If during a measurement it is indicated that the system might be decalibrated (e.g. if you knocked against the cameras), you may perform a Quick Calibration.

During this process, the calibration object needs to be placed into three positions: in the center of the measuring volume. further away from the sensor, closer to the sensor. These three new images are combined with the original calibration and thus a new calibration is calculated for the following measurements.

This method is fast and can easily be used during recording a measuring project.

Info

However, the image characteristics of the cameras must not have changed! If, for example, you inserted new lenses, you need to perform a complete new calibration!

NOTICE

The calibration cross must not have been taken apart during the last calibration and the quick calibration!

B 3 Preparations for Expert Measuring Tasks

B 3.1 Lens Adjustment

B 3.1.1 Why do Lenses Need to be Adjusted?

Normally, the lenses are preadjusted for the respective measuring volumes and do not need to be changed. However, it might happen that you need to adjust the lenses under certain conditions, e.g.

- because the adjustment changed due to vibrations or
- because you would like to insert the lenses of one measuring volume for a different one.

For information about how to adjust lenses, please refer to the User Information – Hardware.

B 3.2 Changing the Camera Support

B 3.2.1 Why Should the Camera Support be Changed?

<u>Change to a Different Length</u>
If you would like to change your measuring system from a medium measuring volume to a large one, you need a longer camera support which allows for a larger distance between the two cameras. Therefore, you need to change the present camera support. The required steps are described in the User Information - Hardware.

B 3.3 Adjust Cameras

B 3.3.1 Why do Cameras Need to be Adjusted?

The correct angle between the cameras and the correct measuring distance are required to optimally capture the measuring object in the measuring volume.

If, for example, you adjusted your sensor to a new measuring volume or if you changed the camera support, the cameras need to be correctly adjusted again. The required steps are described in the User Information - Hardware.

B 4 Summary

- Calibration objects
- Calibration prerequisites
- Calibration process
- Calibration results
- Calibration theory
- Calibration deviation
- Quick calibration
- Adapting the sensor to other measuring volumes
- Lens adjustment
- Adjust cameras

Chapter C - Table of Contents (rev-b)

C Measuring Measuring System

C 1 Measuring Procedure

C 1.1 Selecting the Correct Measuring Volume

The measuring volume depends on the size of the measuring object or on the size of the area you would like to analyze. Choose a measuring volume in which the measuring object or the measuring area fills the entire image as best as possible.

Info

Ensure that the measuring object or the measuring area remains within the measuring volume in all deformation stages!

C 1.2 Preparing the Measuring Object

Prior to start the deformation measurement, you need to prepare the measuring object. For this purpose, apply reference points to those areas you are interested in.

C 1.2.1 Reference Points – General Information

Reference points are self-adhesive marks (measuring markers) which are applied to the measuring object. They have a defined geometry and a high contrast (white circle on a black background).

For the PONTOS HS system retro-reflective markers are used. These markers reflect the light back in that direction from which it came. Thus, optimum light conditions are achieved when using the flash LEDs.

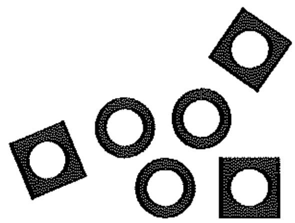
In a calibrated measuring setup, the PONTOS software computes the 3D coordinates of all reference points for each stage from the combination of both camera images.

You can analyze the displacement of a point by comparing its 3D coordinates through all stages.

We distinguish uncoded and coded reference points:

<u>Uncoded reference points</u>

PONTOS always works with uncoded reference points. Round and square measuring markers are available in different sizes. Select the corresponding reference point size according to the size of the measuring volume.



Uncoded reference points, square and round

Coded Reference Points

Coded reference points are mainly used in photogrammetry, i.e. for the TRITOP system. Around the circular point, they have a fixed defined bar code. Based on this bar code, the software can exactly identify the same reference point in the various camera images and thus is able to transform the individual 2D images into each other and determine the correct position of the measuring object and of the uncoded reference points which are also applied to the object.

For PONTOS, these markers are rarely used.

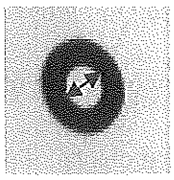
Coded reference points as used in the TRITOP system

C 1.2.2 Which is the Correct Reference Point Size?

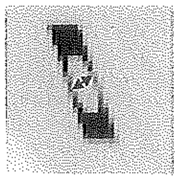
Choose a sufficient reference point diameter depending on the measuring volume used.

The size of the reference points (ellipses seen from a perspective view) recorded by the camera images should be at least 6 to 10 pixels such that the PONTOS system is able to identify them automatically in good quality.

The sensor configuration table of the valid User Information – Hardware contains an overview of the recommended measuring point sizes.



Ref. point automatically identifiable with a diameter of 10 pixels



Ref. point not identifiable with a diameter of 3 pixels

C 1.2.3 How are Reference Points Positioned Correctly?

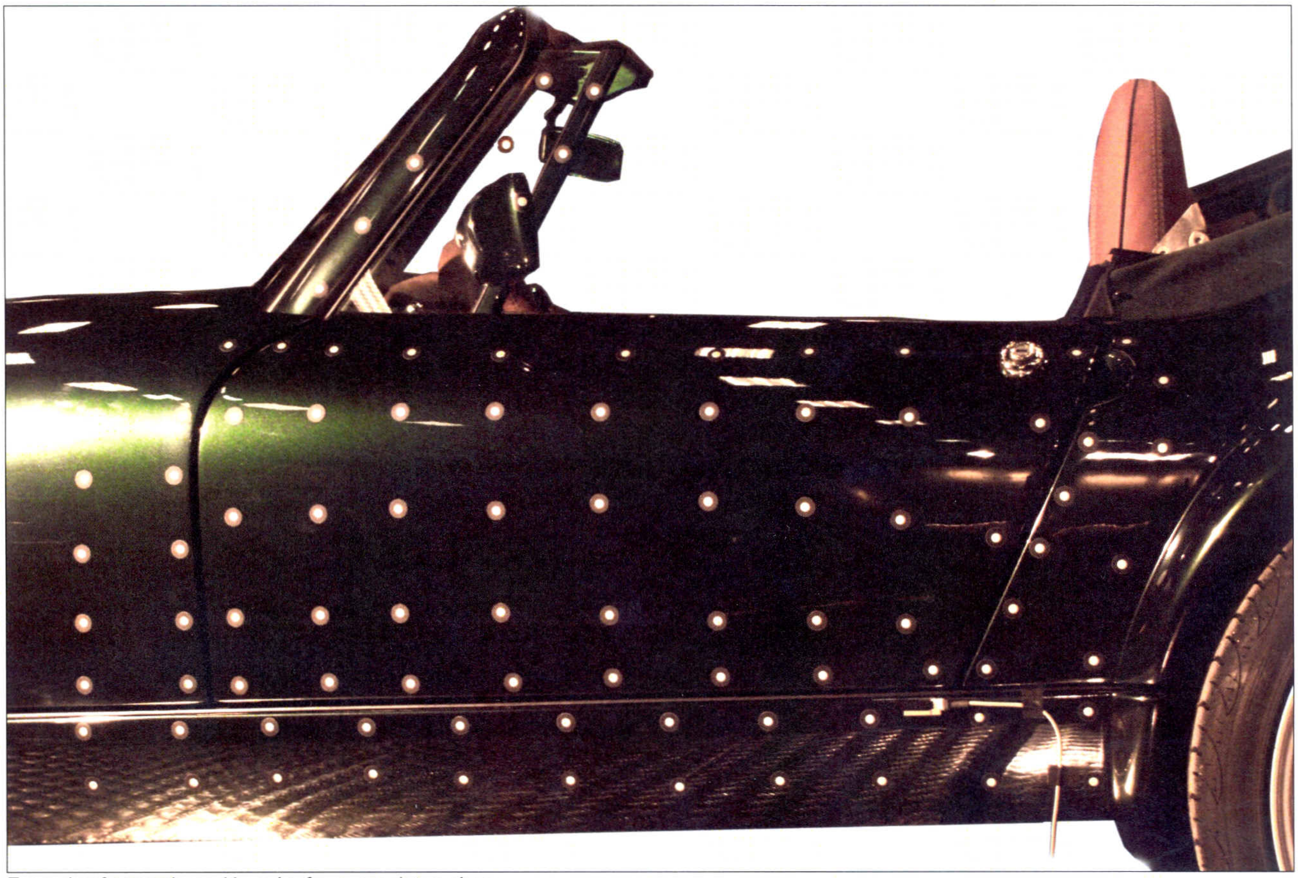
- Make sure the reference points are applied to plane or just slightly curved surfaces.
- Apply sufficient markers where you would like to measure deformations. Make sure you place the markers further away from each other than the expected deformation (at least double spacing). This ensures correct automatic renumbering through all stages later. In addition, these markers should not be applied in an exact horizontal line so that they can be identified correctly later. Avoid regular point patterns.
- Apply some markers in positions where you expect no or just insignificant deformations (relative deformation / relative movement,

compensation of rigid body movements). These points are later required as static points.

- In addition, apply the markers such that you may create components later (see Chapter D), if you would like to analyze certain parts of your measuring object separately. Make sure that within one component there are at least 3 reference points which move as little as possible with respect to each other and that form a clear pattern within the measuring project.
- You may apply some markers at points which you might need later e.g. for a 3-2-1 transformation in order to transform the entire project into a defined coordinate system.

Info

Make sure you apply the retro-reflective markers such that the angle of the incoming light is not larger that 45° as otherwise the reflected amount of light is too small for the software to identify the point.
We can just deal with this matter in a directive manner here.



Example of correctly positioned reference point markers

C 1.2.4 Using a Photoelectric Sensor

In order to precisely start a measurement in a certain moment, you may use a photoelectric sensor which releases the trigger signal for the measurement.

When using such a photoelectric sensor it needs to be positioned on the measuring object such that it activates the sensor controller at the required point in time. In our door slam example it is installed at the bottom of the door frame and activates the sensor controller just before the door hits the frame.

C 1.3 Creating a New Project

In order to analyze the deformation of an object, many camera images of the different deformation states are required. As all data collected during a measurement is automatically stored in a deformation project, you first need to create a **New Deformation Project** for your measuring task. A wizard in the software leads you through the individual steps.

The project name at the same time is the project directory (see also Chapter A, PONTOS directory structure). It is defined together with the project name.

How you create a project you will find in the Online Help.

C 1.3.1 What are Project Keywords?

When creating a new project, you have the opportunity to enter user-defined project information, so-called project keywords, which you may use later, for example, in reports to document your measuring results (e.g. inspector, date, part no. etc.). All information you enter there is automatically taken over into the preferences and thus is available for new projects later. For further information, please refer to the Online Help.

C 1.3.2 What are Project Parameters?

The project parameters contain all settings important for a project. They belong to the expert settings.

Info

Do not change the settings of these menus if you do not have any background knowledge!
For standard measuring projects, use the default settings of the project parameters.

Changed parameters only take effect on future measurements in the opened measuring project!

For further information, please refer to the Online Help.

C 1.4 How Do I Start the Measurement Mode?

Start the **Start/Stop Measurement Mode** using the respective icon in the tool bar.

Then, adjust all necessary settings (see C 1.5 and Online Help) and start the actual measurement using the start button.

C 1.5 Adjusting the Shutter Time

The shutter time is the time in which the camera chips in the sensor record image data. A wrong shutter time leads to underexposed (shutter time too short) or overexposed (shutter time too long) images.

In case of high-speed systems with flash LEDs, adjusting the shutter time is easy. Make sure both cameras can well record the measuring object by increasing the shutter time until you clearly see the object in the live camera images. Then, reduce the shutter time again.

Info

It must be below 10 ms and ideally should be below 5 ms. The typical flash duration of the flash LEDs is 100 μs (see User Information – Hardware).

In order to know whether you adjusted the shutter time correctly for systems without flash LEDs, you should display any overexposed areas in the live video image (context menu of the right mouse button). No overexposed areas should occur.

C 1.6 Standard Recording Modes

For a standard measuring project, the following two recording modes are sufficient:

C 1.6.1 Simple with AD

In this mode, only one image at a time is recorded and you always start measurement manually in the software by clicking on the respective icon. The image is immediately inserted into your project as a new stage. Via the sensor controller, existing analog voltage values will also be recorded.

Use this recording mode if, for example, you would like to carry out a static measurement and only need few images which you may compare later as stages. This mode is also suitable for adding individual images to an already recorded series of images.

For further information, please refer to the Online Help.

C 1.6.2 Fast Measurement (FG-Board Memory)

In case of a fast measurement, a sequence of many images is recorded the number of which you may define. As the images are first stored in the frame grabber boards, the maximum number of images to be recorded is limited by the maximum frame rate of the cameras.

Image recording is released via the sensor controller, i.e. a start pulse (a TTL pulse or a photoelectric sensor pulse) connected to the sensor controller or a trigger pulse from the measurement dialog releases the recording of one image sequence.

Info

Between the start of image recording and the first recorded image of the image series there might be delays of up to a few milliseconds.

The sensor controller releases the start pulse for image recording and also records existing analog voltage values.

After recording, you may load all or just selected images as stages into your measuring project.

Use this recording mode in a high-speed system if you would like to analyze dynamic processes.

For further information, please refer to the Online Help.

C 2 Advanced Measuring Methods

C 2.1 Sensor Controller

C 2.1.1 Tasks of the Sensor Controller

The sensor controller enables flexible starting of image recording for the measuring system at an exact time and controlled through analog values. In addition, it is the voltage source for the cameras.

To the sensor controller, you may connect simultaneously:

- External pushbutton trigger (manual start)
- Photoelectric sensor
- TTL signal
- Analog channels (require trigger lists)

For further information, please refer to the User Information - Hardware.

C 2.2 Analog Channels (AD Channels)

Analog channels are external analog voltage values (e.g. for force and distance signals of a test machine) which come from the test setup and are used as additional information to evaluate the deformation of the measuring object.

The GOM software reads these external analog values via the sensor controller and internally converts them into digital values. You may define a total of 7 different voltage values by means of the analog channels. For this purpose, a separate menu item is available in the software (see also Online Help).

In order to correctly interpret an analog channel and to enter it in diagrams, it is necessary to assign a correct unit to the voltage value and to transform it by a corresponding factor. You may define these parameters prior to measuring using menu item **AD Setup Mode** globally for all future stages or later for existing stages using tab **Stage Data** in the sub explorer.

C 2.3 Additional Recording Modes

C 2.3.1 External Trigger with AD

In this mode, whenever an external signal is received, an individual image is recorded. In addition to this image, the corresponding AD channels and a time signal are recorded. This mode is limited to one image per second.

Use this recording mode if you would like to record an image always at a certain point of time or in a certain situation (e.g. manually via a pushbutton trigger connected to the sensor controller or automatically via a determined signal from the test setup).

For further information, please refer to the Online Help.

C 2.3.2 Fast Measurement (Main Memory)

In this mode, a sequence of several images is recorded the number of which you may define. As the images are directly stored in the computer, the maximum number of images that can be recorded is limited to 40 images per second (40 Hz).

Image recording is released via the sensor controller, i.e. a start pulse (a TTL pulse or a photoelectric sensor pulse) connected to the sensor controller or a trigger pulse from the measurement dialog releases the recording of one image sequence.

Info

Between the start of image recording and the first recorded image of the image series there might be delays of up to a few milliseconds.

The sensor controller releases the start pulse for image recording and also records existing analog voltage values.

After recording, you may load all or just selected images as stages into your measuring project.

Use this recording mode if you need more images than can be stored in the frame grabber boards and no high-speed recording is required.

For further information, please refer to the Online Help.

C 3 Measuring For Experts

C 3.1 Trigger Lists

A trigger list is an automatically or manually created text file containing all commands to control the sensor controller and the measuring procedure. This means that after starting a measurement, the camera control etc. is entirely transferred to the sensor controller which then controls the complete measurement procedure.

The software contains some default trigger list macros and, in addition, provides the possibility to easily create an individual trigger list in the script editor.

For detailed information, please refer to the separate trigger list user information.

C 3.2 Slave Mode

In the special case that several measuring systems will be used simultaneously in order to record the deformation of a measuring object from different views, one computer is declared to be the master by selecting the required recording mode (e.g. Fast Measurement (FG Board Memory)). All additional computers are operated in the slave mode and exactly carry out the measurements of the master PC.

For further information, please refer to the Online Help.

C 4 Measuring with Adapters

C 4.1 What Are Adapters and What Are They Used For?

Adapters are auxiliary tools with an individual defined reference point constellation which is identified in a measuring project and which may create points, lines and other primitives throughout all stages.

With PONTOS, adapters are mainly used to measure areas which are difficult or impossible to access or to measure without the need to apply reference point markers to the measuring object at the spot of interest.

C 4.2 Adapter Types

There are preconstructed adapters available at GOM as an option such as edge, plane, cylinder or sphere adapters.

However, the software also provides the possibility for creating user-defined adapters.

Info

As for PONTOS projects in most cases very specific adapters are required for a special measuring task, mainly the user-defined adapters will be used.

C 4.3 Creating Adapters

C 4.3.1 Step 1 - Planning

Before you create an adapter, you need to know exactly the specific measuring task and consider how the adapter can be visible in all images and stages of the measuring project during the image recording process.

C 4.3.2 Step 2 - Adapter Preparation

Next, you need to apply reference point markers to the object you decided to be an adapter. Ensure that you apply a sufficient number of points which result in an unambiguous point constellation within the measuring project.

C 4.3.3 Step 3 - Measuring the Adapter

Measure the adapter with PONTOS so that you get a complete point cloud.

Info

Depending on the measuring task and the type of the adapter it might be necessary to record the adapter photogrammetrically using the TRITOP software.

C 4.3.4 Step 4 - Creating the Required Primitives

According to the measuring task, create the required primitives from the point cloud in order to get your real measuring point.

C 4.3.5 Step 5 - Creating the Adapter in the Software

Create the required adapter in the software using menu item **User-Defined Adapter**.

For further information, please refer to the Online Help.

C 4.3.6 Step 6 - Load Adapter Into Measuring Project and Identify It

Add the finished adapter to your measuring project using **Preferences** and identify it in the project.

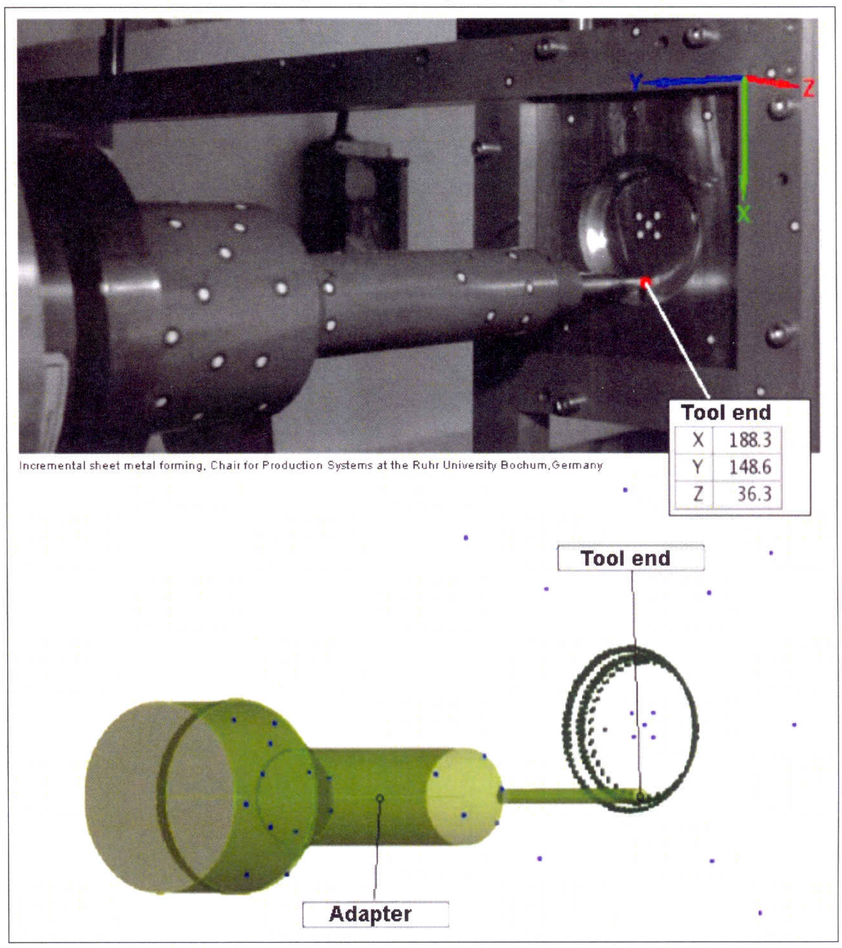
C 4.4 Application Examples

C 4.4.1 Flight Path of an Object

If, for example, you would like to measure the flight path of a ball in a room, apply reference point markers to the ball, measure it with the TRITOP software and create a best-fit sphere from the point cloud. Then, define an adapter which, based on the point constellation of the ball, calculates the center point of this sphere. If you then measure the flight of the ball with PONTOS, you may trace the center point identified by the adapter throughout all stages, and thus you may analyze the flight path.

C 4.4.2 Movement and Position of a Tool End

If, for example, you would like to determine the movement and position of a tool end but cannot apply reference point markers at this point, a user-defined adapter assists you during measurement.



Tool (top), constructed adapter in the 3D view (bottom)

C 5 Summary

- Selecting the measuring volume
- Preparation of the measuring object
- Positioning of the reference point markers
- Creating a new project
- Project keywords
- Project parameters
- Shutter times
- Standard recording modes – simple and fast measurement
- Sensor controller
- Analog channels
- Additional recording modes – external trigger and fast measurement
- Trigger lists
- Slave mode
- Adapters

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Chapter D - Table of Contents (rev-a)

D Computation

D 1 Project Computation

After you recorded all measurement images, they are available in your deformation project as stages that are not yet bundled. Each stage consists of a right and a left camera image. From these images, the software now has to compute for each stage the respective 3D coordinates to provide data for the deformation analysis later.

Open the function using the respective icon. Select the standard setting **Compute all image points** and start the computation for all stages. The software now computes the 3D coordinates and assigns a fixed ID to each 3D point.

In the 3D view, the resulting point cloud is displayed and in the list **Object Points** all points are listed with their IDs.

This first stage is the **Basis** of the project to which all further computations will refer. Generally, it is also the **transformation reference stage** to which all other stages will be aligned to.

D 2 Components

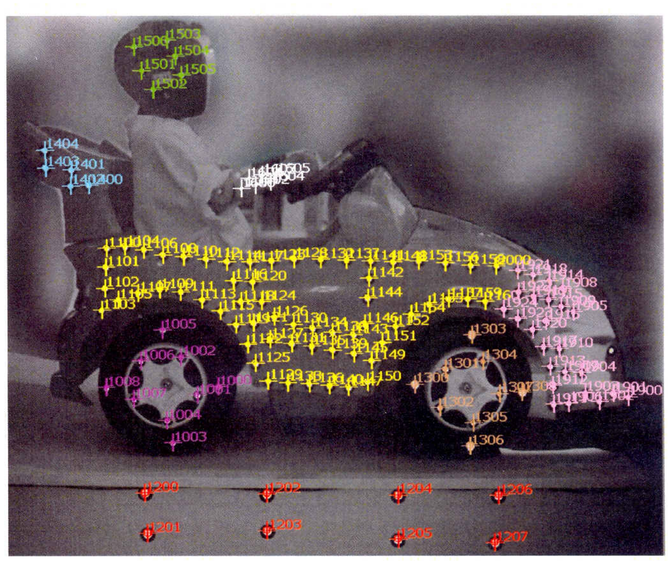
D 2.1 What are Components?

Typically, a deformation measuring project consists of different quasi rigid bodies. Each quasi rigid body might be of interest for the user. Therefore, it can be defined in a so-called **Component**.

A **Component** is a group of 3D points which, in a measuring project, represent such a quasi rigid body. The movement of the 3D points within a component is relatively small. However, the movement of different components with respect to each other can be quite large.

Info

Generally, define all components in the first stage of the project. Each component is automatically allocated a separate ID number range.



Measuring object with several components. For a better understanding, they are shown here in different colors.

D 2.1.1 Define Components

Info

All components and their respective parameters are always defined in menu item **Edit Components** or via the corresponding icon.

Defining a component includes the following steps:

- Create a new component.
- Select all points (at least three) which are supposed to form a component, and transfer these points into this component. Ensure that the points of a component are visible in all stages of the project, if possible.
- Select some of the component points (at least three) which clearly identify this component in the project.
- Adjust parameters (search radius, identification threshold)

For further information, please refer to the Online Help.

D 2.2 Standard Component "Static Points"

A standard deformation project should have at least one component so that the stages can be aligned to each other and identified, and the deformation can finally be computed. For this purpose, the software provides the standard component **Static Points**. At first, this component is empty and needs to be filled with points (identification points) which you select.

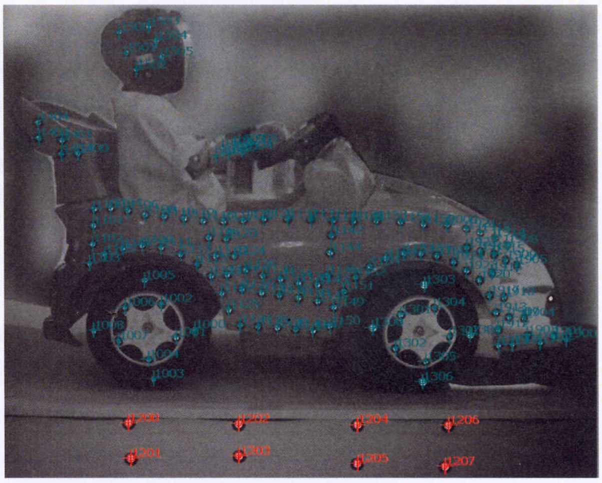
D 2.2.1 What are Static Points?

Static points are points in a measuring project which do not undergo any object deformations and which keep the distance between each other during the entire measuring process.

D 2.2.2 Selecting Static Points

Suitable static points are coded reference points (if available) and uncoded reference points which were not or just insignificantly displaced.

You need at least three static points for aligning the stages to each other correctly. These points must not lie on one line and should be steady with respect to each other. If more than three points are used, the software averages the values and thus the noise of individual points is less important. We therefore recommend defining about 5 to 10 points.



Example for reasonably selected static points (red)

D 2.3 Identification Points

D 2.3.1 What are Identification Points?

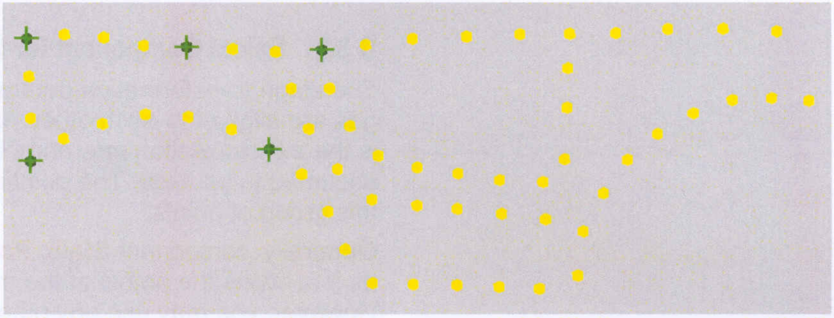
Identification points are points within a component with the help of which the software recognizes the component in all stages of the project. The software searches this point pattern in all stages and then tries to determine the remaining component points by means of a distance search. Thus, measuring points can be correctly assigned between the stages despite large object movements.

D 2.3.2 Choosing Identification Points

When defining a component, select points as identification points that move as little as possible with respect to each other and that form a clear pattern within the project.

At least three identification points are required to recognize a component. Identification points automatically are marked with a green cross.

For further information, please refer to the Online Help.



Example for reasonably selected identification points (green). For a better distinction, the remaining component points in this example were colored in yellow.

D 3 Identification

In order to assess the deformation of an object, all stages of a project need to be aligned, i.e. transformed, to a component of the transformation reference stage (the first stage of the project). Then, the respective component needs to be identified in each stage and its point IDs need to be assigned correctly. This is done by means of the defined identification points.

You start the entire computation process with menu item **Identify** or with the respective icon.

Identification is divided in three steps:

- Select components and determine identification order
- Select component for stage transformation
- Evaluate computation results

For further information, please refer to the Online Help.

D 3.1 Select Components and Determine Identification Order

All components and all adapters (if available) are automatically listed with information about type and number of reference points.

As a default, all elements available in this list are used for the identification process. You should disable components only if they do not exist in your current project.

Info

During identification, the software processes the list of components from top to bottom. Therefore, we recommend to move the component with the most points to the top. Thus, components with fewer points can be easily found in the remaining point cloud due to less ambiguities in the result.

Info

If adapters exist, they take precedence over the components in the identification process.

D 3.2 Select Component for Stage Transformation

The stage transformation determines in which way the individual stages are aligned to each other. As a default, the first stage of a project is the transformation reference stage. Certain points of this stage are assumed to be fixed. The points of all other stages are then aligned to this group of points.

Generally, component **Static Points** is used for stage transformation as it contains the points of the measuring project that do not move. However, you may use any other component for stage transformation if you would like to analyze the movement of the remaining points and components relative to this one.

Info

The identification points of the component selected for stage transformation in this case are called **Fixed Points**.

D 3.3 Evaluate Computation Results

As soon as you click on button **Compute**, the results of the component identification and the stage transformation are listed as preview.

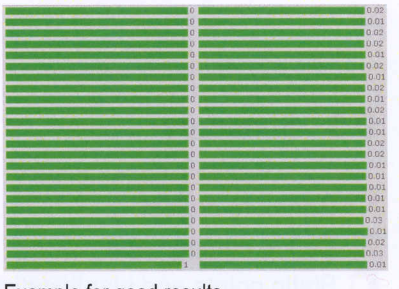
This list is created for each stage in each component and can be accessed via the individual tabs. In addition, there is the tab **Total**.

The list is divided into two columns and consists of color bars and numbers. One column informs about missing or not identified points while the second column contains information about the identification deviation or the transformation deviation. The color intensity and the length of the color bars combined with the respective values help you to assess these results. The color of all bars may continuously change from green (everything is ok) to red (bad).

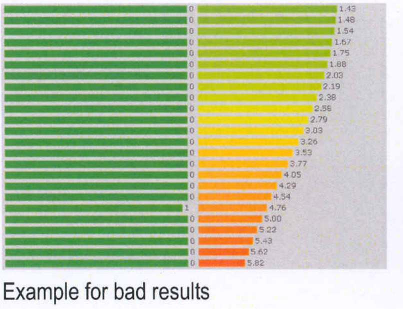
The meaning and interpretation of the color bars depend on whether you are in a component tab or in the tab **Total**.

In addition, icons in front of the stage and component names indicate the status of the components or stages.

For further information, please refer to the Online Help.



Example for good results



Example for bad results

If the preview results do not meet your expectations, you may here influence the values, for example, by changing the component parameters, before you confirm the results and accept them for your project.

D 4 Further Computation Parameters

D 4.1 Additional Stage Transformation Options

D 4.1.1 Stage Transformation Using Setting "Sensor"

If you do not have any chance to define static points (fixed points) in your measuring project because, for example, you would like to examine the movement or velocity of an object, you may choose setting **Sensor** for the stage transformation.

Info

For this type of transformation, the sensor must be fixed and must not be moved or just be moved in a defined manner!

In this case, the sensor represents a fixed point to which you measure relatively. No transformation is carried out, i.e. the stages will not be aligned to each other.

Info

If you select the sensor coordinate system as transformation basis, all previously made identifications and transformations are rejected and you will return to the original state of the project after image recording.

D 4.1.2 Manual Stage Transformation

Info

Only select this mode in really special cases!

In this case, you need to carry out the transformation manually for each stage by clicking transformation points in the transformation reference stage and in the current stage. If you already carried out a stage transformation with a component, the existing fixed points will be suggested for manual transformation.

Info

Manual stage transformation requires for the current and all following stages of the project a new identification. Make sure that for the identification in this case you select **No Transformation** as stage transformation.

For further information, please refer to the Online Help.

D 5 Summary

- Compute project
- Define components
- Static points and identification points
- Stage transformation and identification
- Transformation to the sensor coordinate system
- Manual stage transformation

Chapter E - Table of Contents (rev-a)

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E Transformations

E 1 Transform Project Data

Depending on the measurement task, the deformation data of a measuring project sometimes needs to be transformed into a defined coordinate system in order to be interpreted correctly.

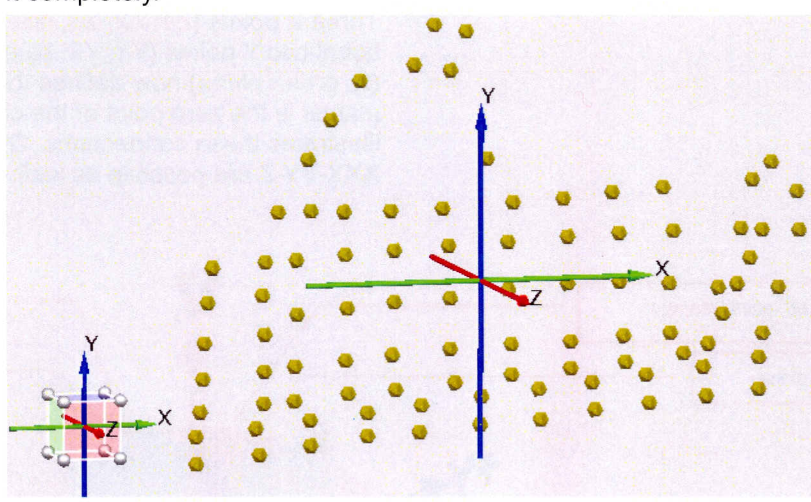
E 1.1 What is a Coordinate System?

A coordinate system is used to unambiguously describe the position of points in space by stating three numerical values (X, Y, Z coordinates). The point where all numerical values are 0 is called the origin of the coordinate system.

E 1.1.1 Visualization of the Coordinate System

PONTOS can show the coordinate system in the left bottom corner of the screen. It is displayed as a dice and serves as guide for easy rotating the measuring object. By clicking on the axes or the corner points you may rotate the measuring object into different views.

In addition, you may display the coordinate system in its origin or hide it completely.



Coordinate system in the left bottom corner and in the origin, without transformation

E 1.2 Views in the Software

The software offers several views. **View** shows the measuring object from top, bottom, left, right, front and back and **ISO View** displays the measuring object additionally in the respective diagonal views (see also Online Help).

E 1.3 Why is Transformation Required?

After calibration, the Z axis of the coordinate system in PONTOS points to the sensor. For a better understanding, or in order to be able to use the data, for example, for further processing by subsequent systems, they may be transformed into a defined coordinate system.

In order to put a coordinate system in a defined condition, the nominal coordinates of some reference points need to be known. This might be CAD data, data of other measuring projects or data determined by coordinate measuring machines.

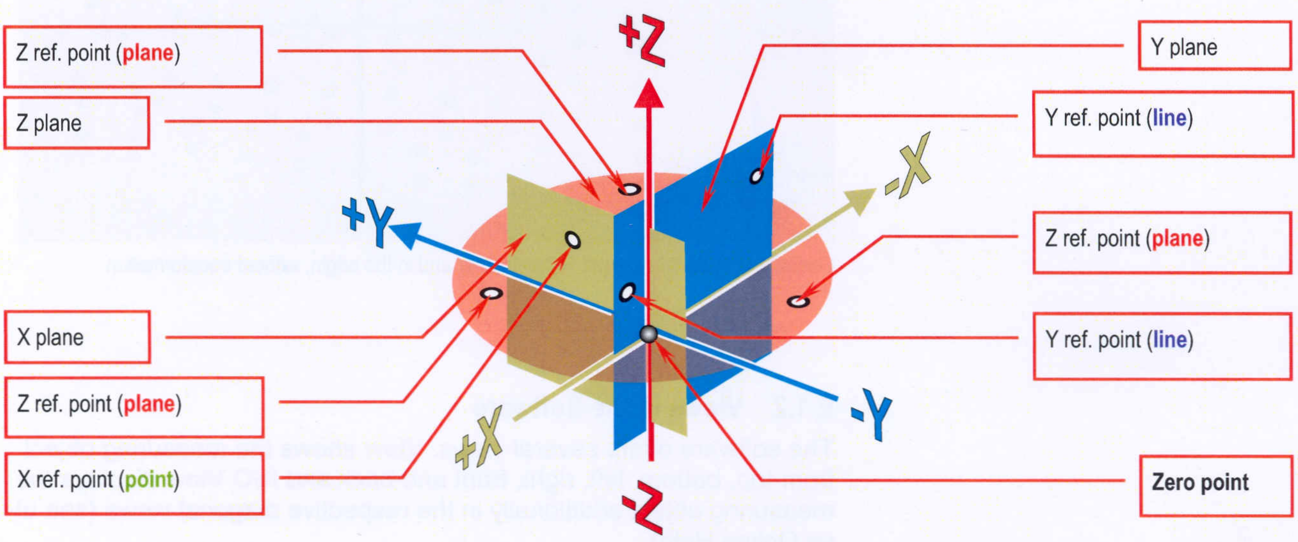
Depending on the measuring task, you need to define the coordinate system. Many manufacturers define, for example, the default coordinate system of a car in the middle of the front axle with the Z axis pointing towards the top, the X axis pointing to the back and the Y axis pointing to the right.

There are different transformation methods (e.g. 3-2-1 transformation, best-fit by reference points). Which method is preferred depends on the measuring project and the data available.

E 1.4 Principle of the 3-2-1 Transformation

The **3-2-1 Transformation** is the mostly used method in PONTOS. Therefore, we introduce the basics here.

3-2-1 means that three 3D points (Z1, Z2, Z3, located as far as possible from each other and not in a line) describe a plane, two additional 3D points describe a line (Y1, Y2, located as far as possible from each other in the X-axis) and one 3D point describes a point (X). For the transformation method ZZZ-YY-X means the following:
Three Z points (Z1, Z2, Z3, red plane) define the Z plane. The additional two Y points (Y1, Y2, blue plane) define the Y plane. The X point (X, green plane) now defines the X plane. At the intersection of the planes is the zero point of the coordinate system. The following figure illustrates these connections. Of course, other transformations like XXX-YY-Z are possible as well.

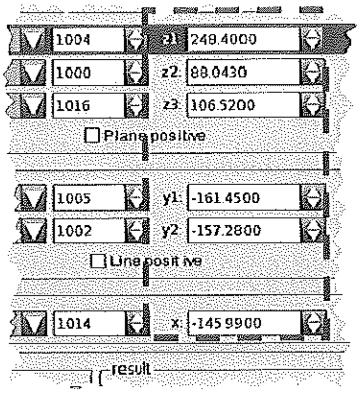


The above example shows the factual relations using the minimum number of points required fort his transformation method. You may use reference points or self-defined 3D points. In this case, the points define the coordinate system directly. It is important that the points reliably describe the required coordinate system.

E 1.4.1 Direction of the Coordinate Axes

The direction of the Z axes (positive or negative) depends on the order in which the three reference points are defined. It results from the sequence of the points and the resulting "sense of rotation" of the plane (points 1 to 3). The direction of the Z plane can be defined, independently of the "sense of rotation", by toggling menu item **Plane positive**.

The direction of the Y axis (positive or negative) depends on the order in which the two Y reference points are defined and results when defining the points 1 and 2 of the line. The direction of the Y plane can be defined, independently of the sequence of the points, by toggling menu item **Line positive**.



E 1.4.2 Indirect Determination of the Coordinate System

It is not always possible that points determine a coordinate system directly. Therefore, in case of the transformation method **ZZZ-YY-X**, you may enter alignment coordinates for each point with **z1**, **z2**, **z3**, **y1**, **y2**, **x**, which now define the respective plane, line or point.

E 1.4.3 Additional Points

You may define **additional points** in the software which will also be taken into account for the 3-2-1 transformation. The additional points may increase the accuracy of the coordinate system, for example, if you use four instead of three 3D points to define a plane. The plane now is overdetermined. However, as four or more 3D points in practice never lie on one ideal plane, the software determines the average value of the resulting differences.

E 1.4.4 3-2-1 Transformation in PONTOS

For typical PONTOS measurements, a defined component coordinate system is not necessarily required because mainly relative values (displacements) are measured. Here, only the correct direction but not the origin is important.

However, for further processing of the data e.g. in a simulation software, the data needs to be transformed into a defined coordinate system. This is typically done by measuring the points with a TRITOP system or with a coordinate measuring machine. Then, the transformation is made by entering the values into the 3-2-1 transformation menu.

E 2 Registration

In order to be able to use measuring data for a comparison to the nominal data (CAD data), they need to be transformed into the coordinate system of the CAD data. This is done by registration. There are different registration methods (pre-registration, best-fit registration). The import of CAD data is a prerequisite for all methods.

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E 2.1 CAD Import

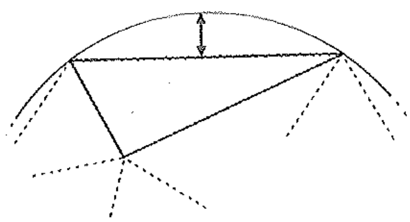
E 2.1.1 What Are CAD Data Needed For?

CAD data are the ideal design data according to which a component is manufactured. They contain all nominal elements and nominal values which are important for a component. However, PONTOS measures a really existing object. If you now would like to know how much the real object deviates from its nominal dimensions, you need the CAD data as reference data in order to carry our a respective analysis.

E 2.1.2 What do the Parameters Mean?

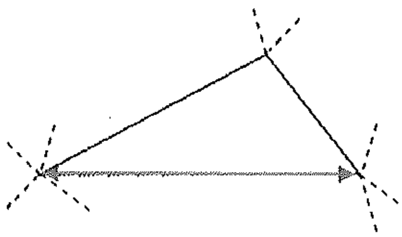
When importing the CAD data, they are converted into mesh polygons. In order to achieve an optimum result, several parameters need to be specified.

<u>**Surface Tolerance**</u>



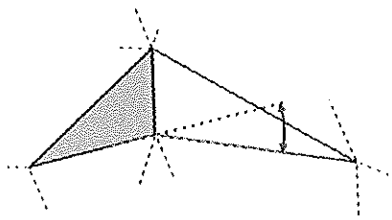
The surface tolerance describes the max. admissible chord error of triangles for freeform surfaces.

<u>**Maximum Edge Length**</u>



The maximum edge length describes the max. permissible length of a side of a triangle.

<u>**Maximum Angle**</u>



The maximum angle describes the max. admissible tilt angle of triangles for freeform surfaces.

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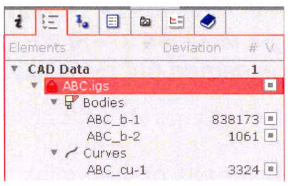
Structure Repair Mode

This mode defines how the CAD data will be processed during the import. We recommend using **Mode 1 (default)**.

E 2.1.3 After the Import



After the import, the data are available in the sub-explorer and are split into so-called **Bodies** and **Curves**.

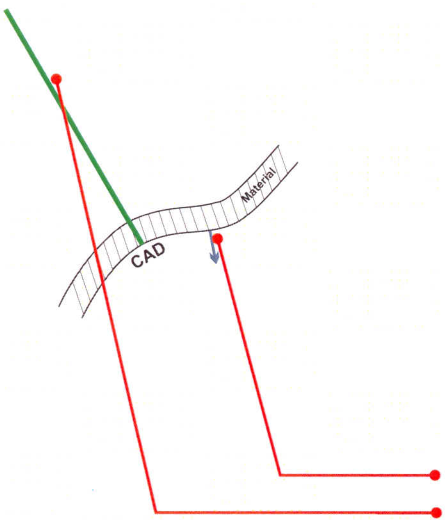
A **Body** is a single, coherent mesh. Depending on the original CAD data and on which structure repair mode you chose for the import, several bodies may be displayed. A body, again, may consist of several patches. A patch is a partial area of a body but adheres to it. The patches may have different colors.

Under **Curves**, auxiliary CAD lines are displayed which are mainly important for the design. Usually, these lines also contain the material thickness vector which is really important for a deviation analysis.

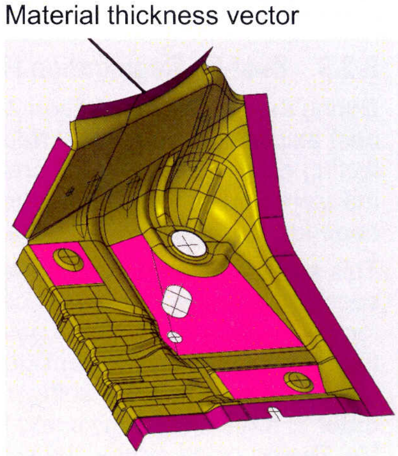
Material Thickness Vector / Surface Normal

The material thickness vector states in which direction the material builds up. In most CAD applications, its direction in the CAD data is defined such that it points from the surface to the material. Its length is normally 100 times the material thickness. It runs opposite to the surface normal. The surface normal is a vector which is perpendicular on the surface and thus defines the front side of the mesh.

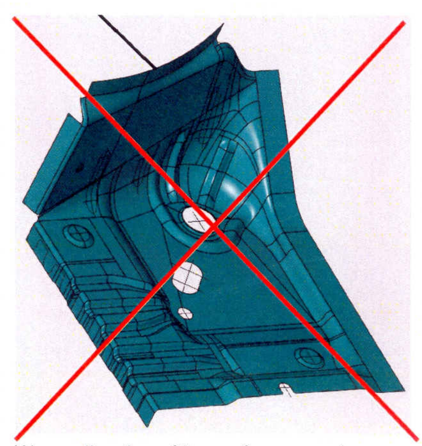
Check to which direction the material thickness vector in the CAD data points and whether the surface normal is opposite to this direction so that the front side is defined correctly. In the GOM software, the rear side of the mesh generally has a uniform color which is defined in the preferences.



- Surface normal
- Material thickness vector



Correct direction of the surface normal



Wrong direction of the surface normal

Now, you may decide if you measured the correct side or which side you would like to measure. Generally, you should measure the CAD front side. If, in special cases, you would like to measure the opposite side, you may do it by clicking with the right mouse button onto a body of the CAD data in the **Sub-Explorer** and select ▶ **Edit Properties** ▶

tab **General** ▶ **Measure opposite side**. For this purpose, the CAD data are corrected by the material thickness of the sheet metal in normal direction by entering the correct value for the material thickness.

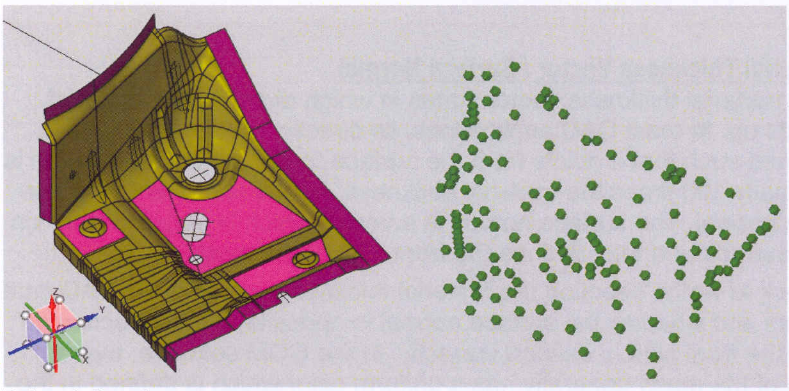
E 2.2 Pre-Registration

A pre-registration is the prerequisite for the best-fit registration. During the pre-registration, the measured data is brought as close to the coordinate system of the CAD data as possible It is carried out manually.

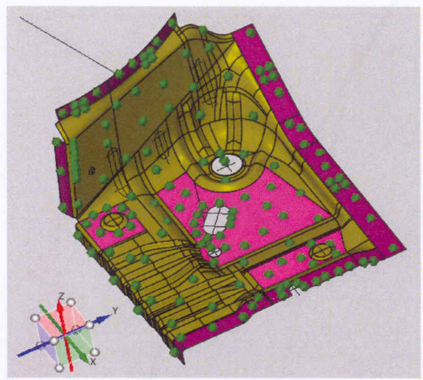
E 2.2.1 Pre-Registration Project

Using this function, you register two data sets by means of manually determined points. You define these points in the measuring data and in the CAD data. The points must not lie on one line and should be far away from each other in order to achieve a good pre-registration. As soon as at least three points are marked, the transformation is calculated and the deviation is displayed.

For further information, please refer to the Online Help.



Data not aligned

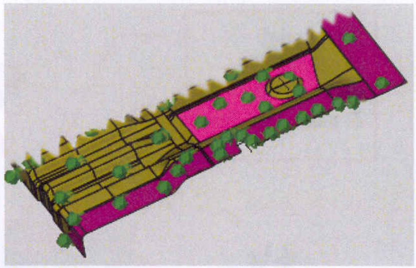


Pre-registered data

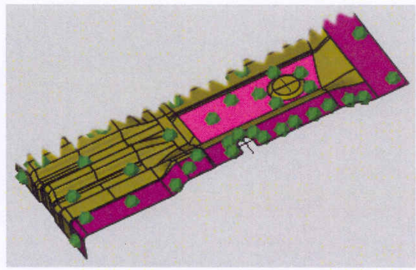
E 2.3 Best-Fit Registration Project

During the best-fit registration, the measured points are dragged as best as possible onto the surfaces of the CAD data. This requires selecting either certain best-fit areas on the measuring data or the entire measured points. Therefore, the best-fit registration leads to a user-dependent registration because the user may influence the selection.

This surface registration is based on a defined **Search radius** which specifies, how far in the CAD data corresponding points are searched for, i.e. in order to register a point of the measured data, all points of the reference mesh are considered that are within this given search radius. As a default, the software carries out several best-fit cycles in order to reduce this radius and to register the data as best as possible. During these cycles, the software adapts the number of used points automatically.



Detail view, pre-registration



Detail view, best-fit registration

E 3 Other Transformation Methods

E 3.1 Best-Fit by Reference Points

E 3.1.1 Prerequisite

For this method, the complete 3D coordinates of at least 3 arbitrary reference points need to be known. The function automatically identifies these points in the measuring project if the coordinates entered describe a reference point constellation that can be found in the measuring project as well. The measuring project then is transformed into the coordinate system of these points.

E 3.1.2 Procedure in PONTOS

If, for example, you have captured your measuring project in a complete TRITOP project prior to the deformation measurements, you may export defined points that shall be used to transform the project into the component coordinate system in a reference point file. Load this file into PONTOS using menu item **Best-Fit by Ref. Points** and thus transform your deformation project into the correct coordinate system.

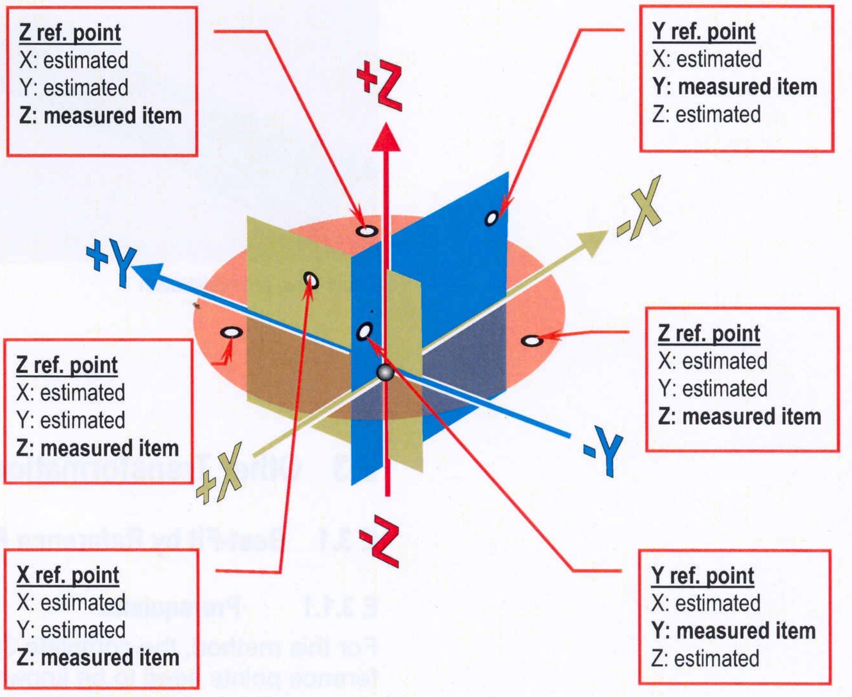
E 3.2 Weighted Points

Defining a coordinate system by means of weighted points is very similar to the 3-2-1 method.

Whereas for the 3-2-1- method you need, for example, three Z coordinates for the Z plane, two Y coordinates for the Y plane and one X coordinate for the X plane, the **Weighted Points** method requires all XYZ coordinates of at least 3 reference points, six of which must be measured precisely according to the 3-2-1 definition and the others are estimated. The estimated values should be in the range of approx. +-10 % of the maximum length of the measuring volume.

The direction of the coordinate system results from entering the complete coordinates.

For further information, please refer to the Online Help.



E 3.3 Transform Plane-Line-Point

With this function, you may carry out a transformation using the primitives plane, line and point that were derived from the measuring data and the reference data (CAD, ...). Equivalent primitives of the measuring data and the reference data are hierarchically assigned to each other (e.g. plane to reference plane, line to reference line and point to reference point). First, all elements need to be created in suitable areas according to the 3-2-1 rule.

This function allows aligning objects where the reference plane is not located in the planes of the reference coordinate system.

E 3.4 Transformation of Meshes

When you included polygonized meshes into your project (e.g. by converting CAD data into such meshes), you may align these meshes to your measured points such that they move together with the points in the stages according to the deformation.

Here as well, the pre-registration is the prerequisite for the best-fit registration.

E 3.4.1 Pre-Registration Mesh

The procedure is the same as for the **Pre-Registration Project** but you align an existing mesh to the measured points (see also **Fehler! Verweisquelle konnte nicht gefunden werden.**).

E 3.4.2 Best-Fit Registration Mesh

The procedure is the same as for the **Best-Fit Registration Project** but you align an existing mesh to the measured points (see also **Fehler! Verweisquelle konnte nicht gefunden werden.**).

E 4 Summary

- Transform project data
- Coordinate system
- Transformation
- Basics of 3-2-1 transformation
- CAD import
- Pre-registration
- Best-fit registration
- Method best-fit by reference points
- Method weighted points
- Method transform plane-line-point
- Transformation of meshes

Chapter F - Table of Contents (rev-a)

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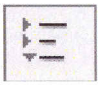
F Result Creation

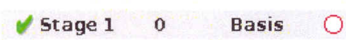
F 1 Analysis



In order to analyze the deformation of a measuring object with respect to a reference state, the software needs to display the deformation which was computed through all stage in color in the 3D view. For this purpose, you need to define an area which you are interested in. You may also obtain additional analysis data, for example, by examining the position of a point closer, by measuring the distance between a point and a line, and much more. All analysis data you create appear in the sub explorer under tab **Elements**.

F 1.1 Deformation Reference Stage

In order to define the reference state to which the deformation analysis shall refer, you may select a stage as deformation reference stage any time.



In the explorer, the deformation reference stage is always displayed in bold letters and with a filled (stage is currently visible) or with an empty (stage is currently not visible) red circle. Generally, the basic stage is also the deformation reference stage.

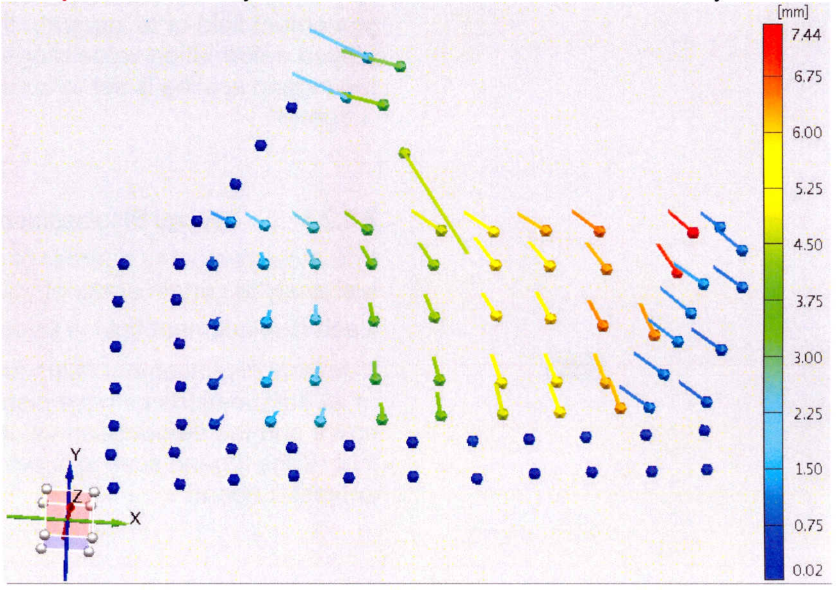
F 1.2 Displacement Fields

F 1.2.1 Defining a Displacement Field

A displacement field is a user-selected area of points, for which the deformation – i.e. the position offset of the points in the current stage compared to their position in the reference stage – is to be displayed in color in the 3D view. This means, a displacement field is a way to visualize deformations.

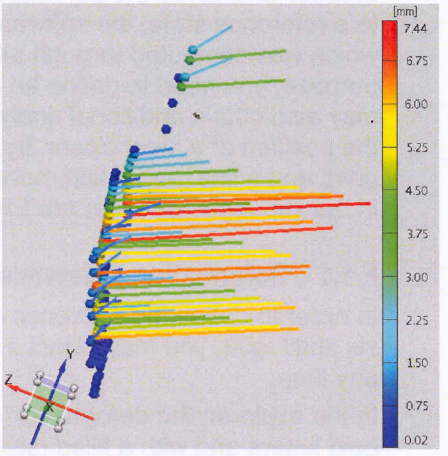
Info

If you use components, you may use the selection command **Select Component** to easily select the area which is of interest for you.



Displacement field over the entire measuring object

The color, direction and length of the vectors informs about the deformation of the object at individual measuring points. The stronger the deformation is the longer is the respective vector. You may adapt the length and scaling of the vectors in a displacement field individually but the length ratio of the vectors with respect to each other remains the same.



Side view of a displacement field

How you create a displacement field you will find in the Online Help.

F 1.2.2 Legend in a Displacement Field

Generally, the legend is set to **Automatic scaling**, i.e. the range of values for the deformation in the displacement fields is calculated over the entire color scale. Thus, a displacement field has an individual legend in each stage.

F 1.2.3 Editing a Displacement Field

Any time, you have the possibility to exclude certain points from a displacement field or to integrate the excluded points again. The displayed deformation value range of the legend changes accordingly if the legend scaling is set to automatic. See also Online Help, subject “Legend”.

F 1.2.4 Several Displacement Fields

You may create any number of displacement fields, for example, to just analyze certain areas of your measuring object.

Each displacement field is listed separately in the sub explorer.

Info

If several displacement fields are visible at the same time, the values of all deformations in these displacement fields will be taken into account and the deformation value range of the legend changes accordingly if the legend scaling is set to automatic. See also Online Help, subject “Legend”.

F 2 Extended Analysis

In addition to the displacement fields, you may evaluate the deformation at or between certain points. Menu item **Analysis** provides for various functions for distance and angle analyses.

Info

All analyses may also display the deviations of the measured points to CAD data. You may choose whether the CAD data is to be compared with the deformation reference stage or with the currently visible stage.

In addition, the software provides the possibility to analyze movements in space. For this purpose, menu items **6DoF** and **Relative 6DoF** are available.

You may use menu item **Primitives** to create auxiliary elements for analysis tasks.

F 2.1 Measure Point Positions, Distances and Angles

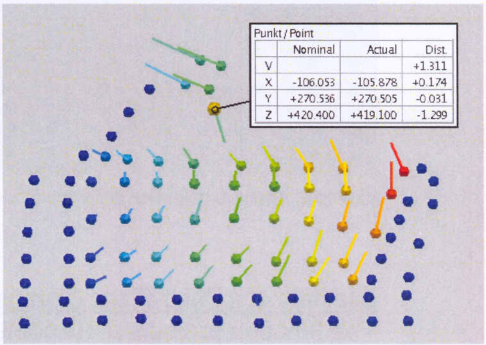
F 2.1.1 Measure Point Positions

Using the corresponding menu item, you may display the displacement of individual points with respect to the reference stage and document it with labels.

Info

If the text label in the 3D view does not display the desired parameters, you may change it with a right mouse button click on the label.

For further information, please refer to the Online Help.



Example: Point position analysis

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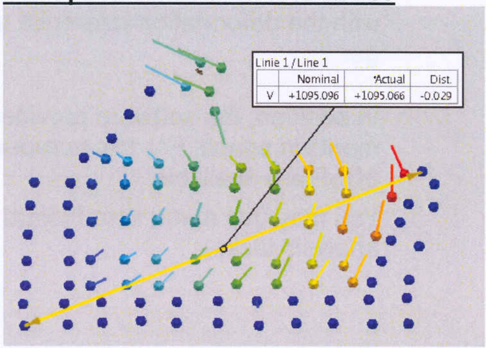
F 2.1.2 Measure Distances

Using the corresponding menu item you may carry out distance measurements and document them with labels.

Info If the text label in the 3D view does not display the desired parameters, you may change it with a right mouse button click on the label.

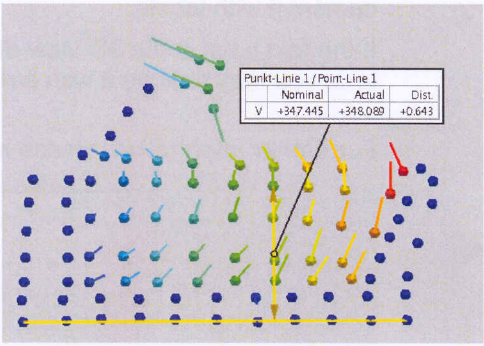
Example of a Point-Point Distance



Example: Analysis point-point distance

Example of a Point-Line Distance

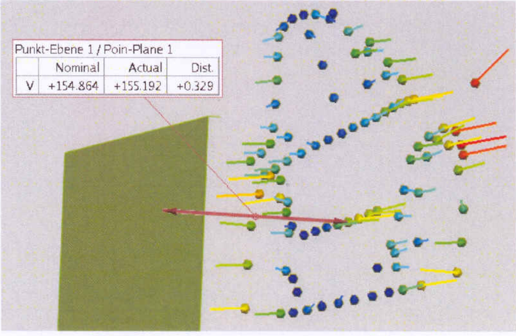
The function determines the perpendicular distance of a 3D point to a line.



Example: Analysis point-line distance

Example of a Point-Plane Distance

The function projects a 3D point perpendicularly onto a plane and determines the distance between these points.



Example: Analysis point-plane distance

F 2.1.3 Measure Angles

Using the corresponding menu item you may carry out angle measurements and document them with labels.

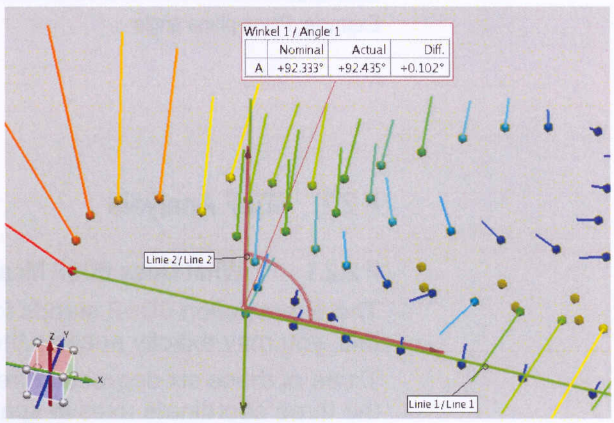
You may determine angles between the elements **Planes** and **Lines**.

Info

Angles in the 3D space are limited to 0° to 180°. Therefore, angle variances around zero are ambiguous. In order to prevent wrong analyses, you should not define angles close to 0° or 180° in the deformation reference stage.

Example of a Line-Line Angle

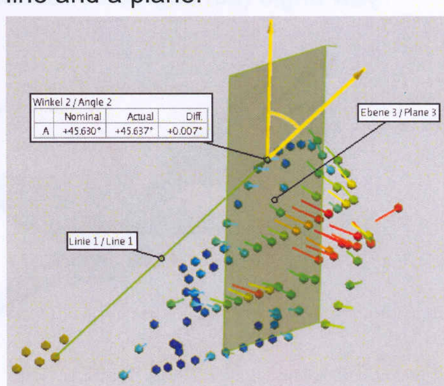
Using this menu item, you may measure angle variances between two lines.



Example: Line-line angel

Example of a Line-Plane Angle

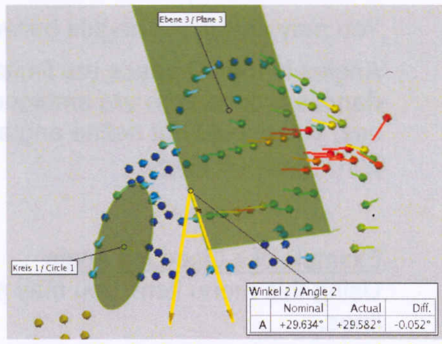
Using this menu item, you may measure angle variances between a line and a plane.



Example: Line-plane angle

Example of a Plane-Plane Angle

Using this menu item, you may measure angle variances between two planes.



Example: Plane-plane angle

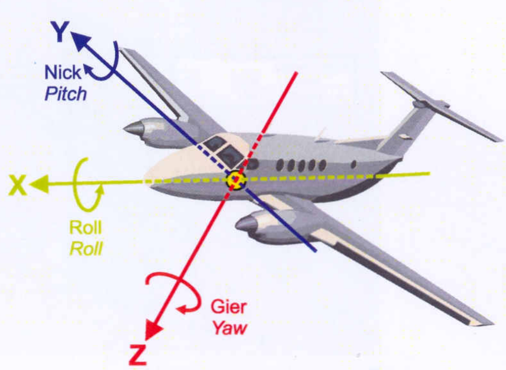
F 2.2 6DoF Analysis

F 2.2.1 What Does 6DoF Mean?

The abbreviation **6DoF** stands for "Six Degrees of Freedom". With this, you may exactly analyze the movement of an object in space.

Three of these six degrees of freedom refer to the **translation along** the three coordinate axes in space, i.e. an object may move back and forth (1st degree of freedom), up and down (2nd degree of freedom) and left or right (3rd degree of freedom).

The remaining three degrees of freedom refer to the **rotation around** the three coordinate axes. The resulting angles are also called roll angle (4th degree of freedom), pitch angle (5th degree of freedom) and yaw angle (6th degree of freedom).



Example for roll, pitch and yaw angle of an airplane coordinate system.

F 2.2.2 Determine Origin for Local Coordinate System

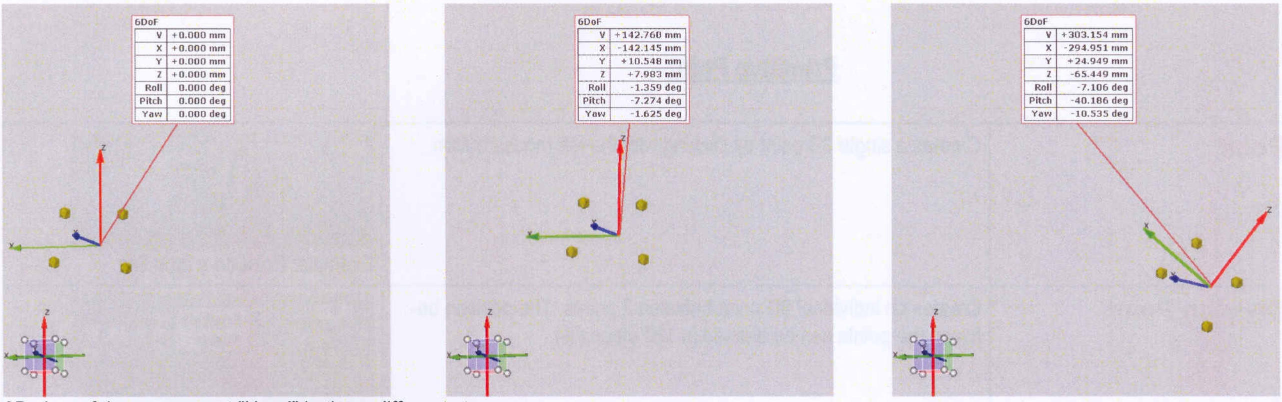
In order to create a 6DoF analysis for a component in PONTOS, you need to determine the origin of the local coordinate system. For this purpose, you may select individual points or, with the help of primitives, you may create the origin at a position which is of interest for you.

F 2.2.3 Define Direction of Local Coordinate System

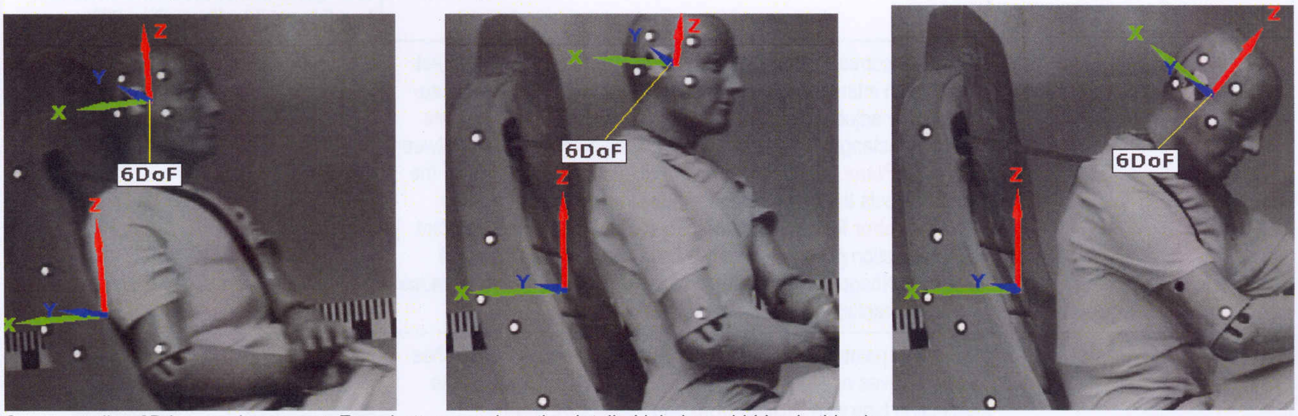
In order to evaluate your 6DoF analysis according to your measuring task, you need to decide if the local coordinate system shall correspond to the global coordinate system of your measuring project or if the direction of the coordinate axes need to be different. You may define the direction of the coordinate axes manually.

F 2.2.4 Example of a 6DoF Analysis

In this example, the movement of the dummy head in a crash test was examined. The origin of the local coordinate system is in the head's center of gravity. Its direction corresponds to the global coordinate system of the project. You may clearly see a displacement and rotation of the head.



3D view of the component "Head" in three different stages.



Corresponding 2D images in a report. For a better overview, the detailed label was hidden in this view.

F 2.2.5 Relative 6DoF Analysis

The software also offers the possibility to examine two 6DoF analyses relative to each other. Thus, you may analyze the relative movement of two different components with respect to each other.

F 2.3 Primitives

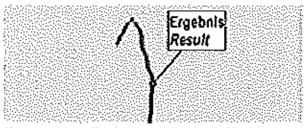
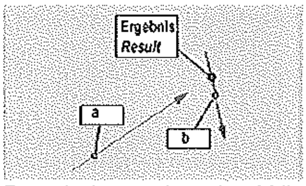
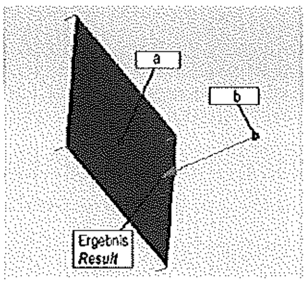
Primitives (points, lines, circles, planes, spheres, ...) are user-defined objects in the 3D view. You need primitives, for example, for transformation or inspection (documentation of measuring results) of a measuring object.

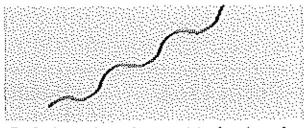
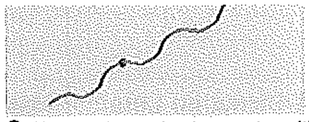
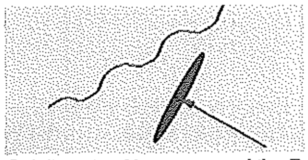
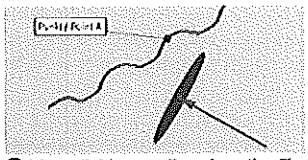
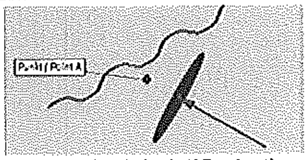
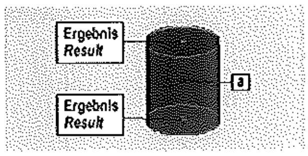
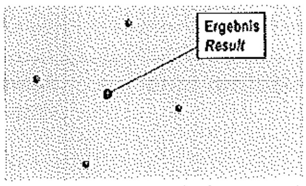
When clicking with the right mouse button on the defined primitive, you may edit the element. The following functions are available:

- Set or unset the primitive as reference
- Change the appearance of the primitive or the label
- Defining the normal direction

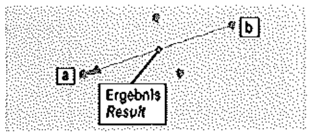
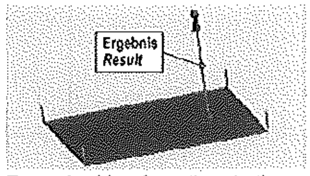
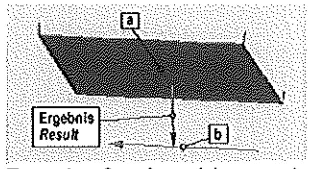
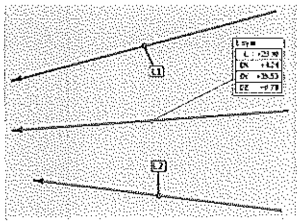
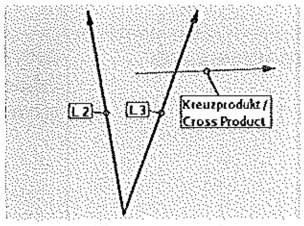
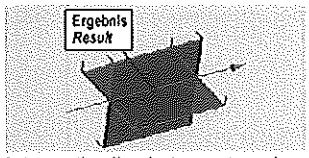
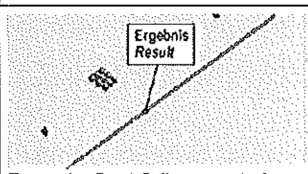
The following table informs you in extracts about possible primitives and particularities when creating them. All primitives are generated based on 3D points or 3D polygon meshes or other primitives (e.g. planes and lines). Use Ctrl and left mouse button in the 3D view to select points, planes, lines, etc. to create primitives or by directly clicking on the primitive's label with Ctrl and left mouse button. You may also select the elements directly from the explorer list.

Primitive Point

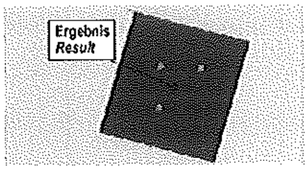
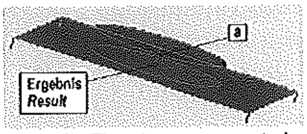
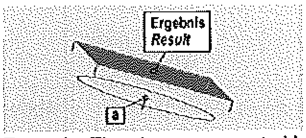
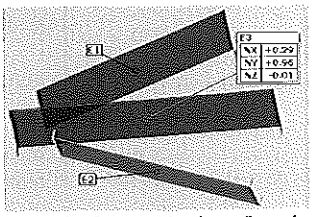
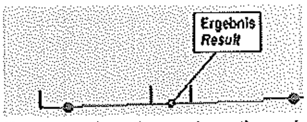
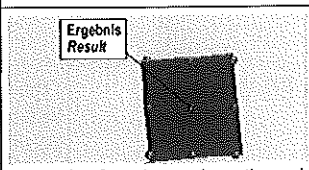
Point	Creates a single 3D point by clicking with the left mouse button.	 Example: Point on a tape line
Division Point	Creates an individual 3D point between 2 points. The position between the points can be defined in 100 steps (%).	 Example: Point between two circle centers (a) and (b) with position 50%.
Intersection Point	**Active if** corresponding primitives exist in the measuring project. Creates an intersection point between primitives. The system automatically adjusts the **Intersection type** under **Base elements.** Only for rectangular holes or slotted holes you can choose between **Line** and **Plane.** If under **Element** you select the mesh, and if the line intersects the mesh several times, choose the point under **Point number** for which you wish to create the intersection point. As intersection point between two lines, the center point of the shortest orthogonal distance between these lines is given because the lines practically never intersect each other.	 Example: Intersection point of 2 lines (a) and (b)
Projection Point	Projects a point of 3D meshes and primitives to other 3D meshes and primitives on the shortest possible way. You can adjust the projection type with **Project onto** and **Projection mode.** Projection modes: **Surface** creates a point on the surface of 3D meshes and bodies. **Point** only uses the junction points of the 3D meshes or the centers of circles and spheres. **Curve** uses the border lines. **Plane** uses the planes of circles or planes. **Line** uses the rotation axis of cones or cylinders.	 Example: Projection of point (b) onto plane (a).

Touch Point (Disc)	Projects a circular plane onto primitives, point clouds, sections, 3D meshes, ... and creates a point at the location of the initial touch. The function is similar to the **Disc Caliper** with the difference that here the result is a point instead of a distance.	 ❶ Select the element to be touched in the 3D view.  ❷ Choose the projection center with **Center** and determine the touch direction with **Direction**.  ❸ Adjust the **Clearance** and the **Radius** of the circular plane.  ❹After clicking on **Preview** the **Touch Point (Disc)** is displayed.  **Touch Point (Disc)**, if **Projection on direction vector** is enabled.
Points from Line	**Active if** corresponding primitives exist in the measuring project. Extracts the start or end points of lines, intersection lines and rotation axes of cylinders (a) and cones.	 Example: Extraction of start and end points of a cylinder rotation axis (a).
Best-Fit Point	Creates a geometrical average value from selected 3D points and/or 3D meshes.	 Example: The result is the geometrical average value.

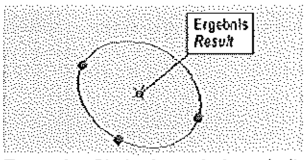
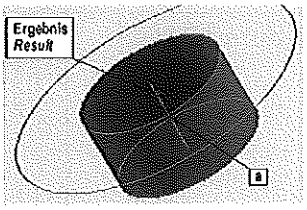
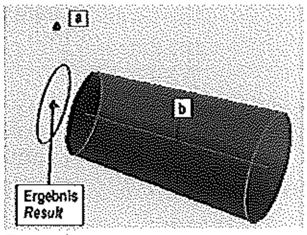
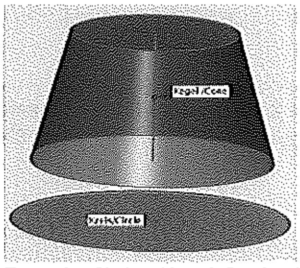
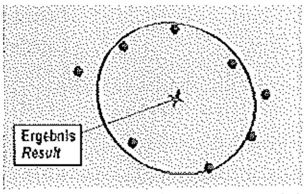
Primitive Line

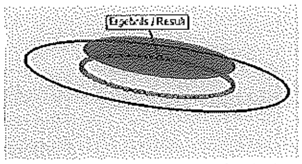
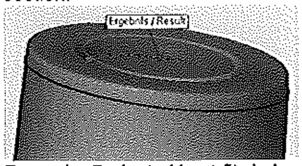
Point-Point Line	Creates a line between two points.	 Example: Line between two individual points
Point-Direction Line	Creates a line from the start point in a **Direction** to be defined. The length of the line in arrow direction can be defined with **Length**.	 Example: Line from the starting point on the plane in normal direction of the plane.
Perpendicular Line	**Active if** corresponding primitives exist in the measuring project. Creates a line from the start point (plane a) orthogonal to another line (b).	 Example: On plane (a), we selected a start point for the perpendicular line which runs perpendicular to line (b).
Symmetric Line	Creates a line symmetrically to two other elements which contain a line (e.g. line, cylinder, cone, etc.).	 Example: Symmetric line (here in red)
Line by Cross Product	Creates a line that is perpendicular to two other lines or direction vectors and has its origin in the point you clicked.	 Example: The cross product was created from lines 2 and 3. The new line is perpendicular to both other lines.
Intersection Line	**Active if** corresponding primitives exist in the measuring project. Creates intersection lines between surfaces of primitives.	 Intersection line between two planes.
Best-Fit Line	Creates a line according to the best-fit principle based on selected 3D meshes, sections and features. Based on the selected points, the line can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points. Using the statistical methods, measuring point outliers can be eliminated during the best-fit process.	 Example: Best-fit line, created on previously selected (red) points of a border line.

Primitive Plane

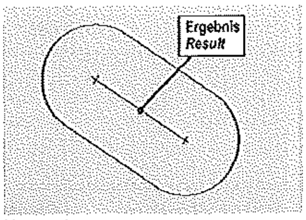
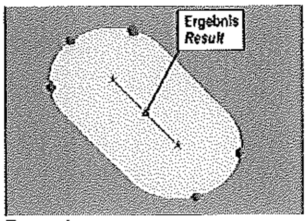
Point-Point-Point Plane	Creating a plane through 3 points.	 Example: The plane was created by selecting three points.
Point-Normal Plane	Creates a plane through one point in the direction of other objects like lines, cylinders, etc.	 Example: The plane was created using a point on the rotation axis of cylinder (a) and the normal direction of cylinder (a).
Parallel Plane	**Active if** corresponding primitives exist in the measuring project. Creates a plane parallel to a circle, a rectangular hole, a slotted hole or another plane. Use "Offset" to adjust the distance to the element you created the plane from.	 Example: The plane was created in parallel to circle (a), stating an offset value.
Symmetric Plane	Creates a plane symmetrically to two other elements which contain a plane (e.g. plane, circle, section, etc.).	 Example: Symmetric plane (here in red)
Plane in Viewing Direction	Creates a plane through two points or a temporary defined line (using the selection tool of the menu) in the current viewing direction.	 Example: Creating a plane through 2 points.
Best-Fit Plane	Creates a plane according to the best-fit principle based on selected 3D meshes, sections or features. Based on the selected points, the plane can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points. Using the statistical methods, measuring point outliers can be eliminated during the best-fit process.	 Example: Creating a plane through previously selected points.

Primitive Circle

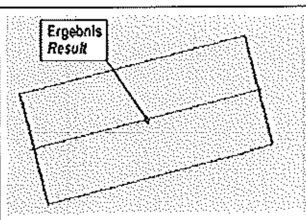
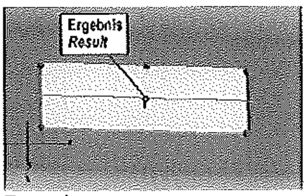
Point-Point-Point Circle	Creates a circle through three points.	 Example: Circle through three individual and selected points.
Point-Normal-Radius Circle	Creates a circle by defining the circle center and stating the rotation axis. The radius can be defined by selecting the points or by entering the radius value directly.	 Example: The circle was created using a point on the rotation axis of cylinder (a) and the normal direction of cylinder (a). The radius was directly entered as value.
Cylinder/Cone Intersection Circle	**Active if** corresponding primitives exist in the measuring project. Creates a circle on the rotation axis of cylinders or cones (b) by projecting a point (a) orthogonally onto this axis. This point is the center of the new circle. The radius of the circle is calculated from the radius of the cylinder or cone at the point of projection.	 Example
Cone-Radius Circle	Creates a circle with a defined radius based on a cone.	 Example: Circle with a defined radius (here in red).
Best-Fit Circle	Creates a circle according to the best-fit principle based on selected 3D meshes, sections or features. Based on the selected points, the circle can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points. Using the statistical methods, measuring point outliers can be eliminated during the best-fit process.	 Example: The circle was created through several selected points by means of the best-fit principle.

Projected Best-Fit Circle	Creates a circle according to the best-fit principle based on selected 3D meshes, sections or features and projects it onto a plane chosen by the user. Based on the selected points, the circle can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points. Using the statistical methods, measuring point outliers can be eliminated during the best-fit process.	 Example: Projected best-fit circle, created from the selected points (red) of a section.  Example: Projected best-fit circle with mesh data.

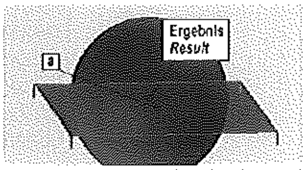
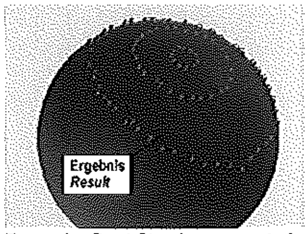
Primitive Slotted Hole

Point-Normal-Direction Slotted Hole	Creates a slotted hole based on externally entered values or derived from other primitives or feature elements. This function is mainly used for the nominal/actual comparison of a slotted hole if the nominal element is created manually by entering data. The function requires the following information: **Point** (center point coordinates), **Normal**, **Direction**, **Length**, **Width**.	 Example
5-Points Slotted Hole	Creates a slotted hole by clicking on five points on the edge (circular area) of a slotted hole in the CAD data. This function is used for the nominal/actual comparison of slotted holes.	 Example

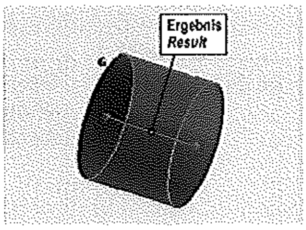
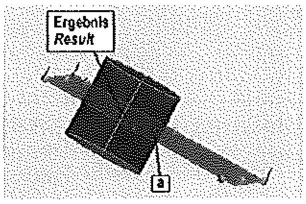
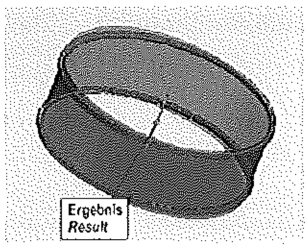
Primitive Rectangular Hole

Point-Normal-Direction Rectangular Hole	Creates a rectangular hole based on externally entered values or derived from other primitives or feature elements. This function is mainly used for the nominal/actual comparison of a rectangular hole if the nominal element is created manually by entering data. The function requires the following information: **Point** (center point coordinates), **Normal**, **Direction**, **Length**, **Width**.	 Example
5-Points Rectangular Hole	Creates a rectangular hole by clicking on five points on the edge of a rectangular hole in the CAD data. This function is used for the nominal/actual comparison of rectangular holes.	 Example

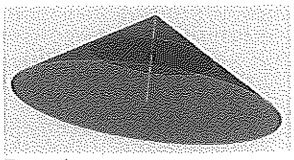
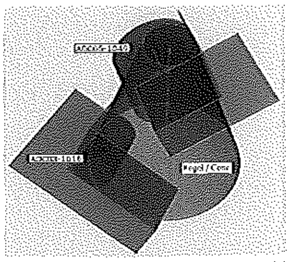
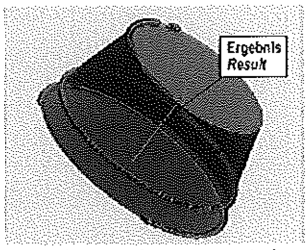
Primitive Sphere

Point-Radius Sphere	Creates a sphere by means of stating the center of the sphere and the radius. The radius can be defined by selecting the points or by entering the radius value directly.	 Example: Freely defined sphere with the center on plane (a). The center of the sphere was determined by selecting a point with Ctrl and left mouse button.
Best-Fit Sphere	Creates a sphere according to the best-fit principle based on selected 3D points or sections that can determine a sphere. If the radius of the sphere is known, you may enter it to support the best-fit function by means of **Radius**. Based on the selected points, the sphere can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points. Using the statistical methods, measuring point outliers can be eliminated during the best-fit process.	 Example: Best-fit sphere, created on a previously selected spherical point cloud.

Primitive Cylinder

Point-Point-Radius Cylinder	Creates a cylinder through two points. **Point 1** determines the beginning of the cylinder's rotation axis. **Point 2** determines the end point of the rotation axis. Use **Radius** to adjust the circumference of the cylinder.	 Example: The cylinder was created based on a line. The end points of the line were created with Ctrl and left mouse button. The radius was entered as value.
Point-Direction-Radius Cylinder	Creates an aligned cylinder by means of a point and a direction. **Point** determines the center of the cylinder. **Direction** determines the direction of the rotation axis. You can adjust the cylinder by means of **Radius** and **Length**.	 Example: Cylinder perpendicular to plane (a). The center of the cylinder is a point that was selected on the plane. This plane is also used to determine the direction.
Best-Fit Cylinder	Creates a cylinder according to the best-fit principle based on selected 3D points or sections that can determine a cylinder. Based on the selected points, the cylinder can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points. Using the statistical methods, measuring point outliers can be eliminated during the best-fit process. If the radius of the cylinder or/and the direction of the cylinder is known, you may enter these values to support the best-fit function by means Radius or Direction.	 Example: Best-fit cylinder, created on previously selected (red) points.

Primitive Cone

Point-Direction-Angle Cone	Creates a directed cone based on a **Point**, a **Direction** and an **Angle**. Under Construction conditions you can select the condition you would like to use. You define the circle radius of the cone around the defined point by using **Radius by point** or **Radius by value**. The **Length** of the cone can be manually adjusted as you like.	 Example
2-Cylinder-Adapter Cone	Creates a cone based on two cylinder adapters.	 Example: Cone (here displayed in red) which was created from 2 cylinder adapters.
Best-Fit Cone	Creates a cone according to the best-fit principle based on selected 3D points or sections that can determine a cone. Based on the selected points, the cone can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points. Using the statistical methods, measuring point outliers can be eliminated during the best-fit process. If the direction of the cone is known, you may enter it to support the best-fit function by means of Direction.	 Example: Best-fit cone, created on previously selected (red) points.

More Primitives

Best-Fit Paraboloid	Creates a paraboloid. Based on the selected points, the paraboloid can be calculated for **All points** or with the help of statistical methods with **1 Sigma** to **5 Sigma**. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points.	no figure

F 3 Export Documentation as Tables

Menu item **File ▶ Export ▶ Tables** provides for exporting all or selected data as complete result documentation or as data lists. For this purpose, different templates are available in ASCII, HTML and OpenOffice (open source software) format.

The export process is set up as a wizard.

You also have the possibility to create a user-defined export template with the data you are interested in. Hierarchy levels provide for structuring the data and for filling headers and footers for the individual paragraphs and/or for the entire export file in addition to their respective contents. The context menu of the right mouse button is used to insert the data available for the respective paragraph by means of keywords. In addition, you may insert control characters and other special characters.

The exported data then is available for further applications (e.g. Excel).

You will find additional information and an example of creating a simple user-defined ASCII export template in the Online Help.

F 4 Summary

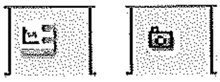
- Deformation reference stage
- Displacement fields
- Measure point positions
- Measure distances
- Measure angles
- 6DoF and relative 6DoF analysis
- Primitives
- Export tables

Chapter G - Table of Contents (rev-a)

G Reports and Documentation

G 1 Standard Reports

Deformation results can clearly be illustrated in reports. Several report templates are available. Based on these standard report templates you may easily present your measuring results. However, you may design reports individually and save them as user-defined templates.



All reports you create are available in the sub explorer under tab **Reports** and tab **Image Series**.

PONTOS standard reports may contain images and/or diagrams.

As image, automatically the selected image for each stage is inserted but the standard diagrams are empty and need to be filled with the data you are interested in. You may automatically include all analyses you made in your measuring projects into a report when creating the report or you may add them later.

For further information, please refer to the Online Help.

G 2 Extended Report Functions

G 2.1 Create and Edit User-Defined Reports

Using report template **Report (blank)**, you create a blank sheet of paper on which you may design your own report.

For designing a report, several elements are available. The software distinguishes between the following element types:

- Drawn elements (like lines, ellipses, etc.)
- Images
- Diagrams
- Legends
- Text labels
- Logos

You may modify each of these elements in position, appearance and shape. Double clicking on an element opens a dialog window with the editing options available for the selected element which are distributed to the respective tabs.

To certain elements (images or diagrams) you need to assign the data you are interested in so that they can be displayed accordingly in your report. This assignment is also done using the specific tabs.

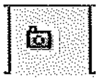
Legends always have to be connected with the element to which they refer.

You may use text labels to insert text information into a report. You may write free text or insert certain keywords using the context menu of the right mouse button.

For further information, please refer to the Online Help.

G 2.2 Image Series and Movies

An image series is a sequence of individual images (one file per image, file name is numbered consecutively) which is created, for example, from camera images, 2D images, the 3D view or from the images of a report. An image series may also contain images of an external camera which can be imported.



All image series are listed in the sub explorer under the respective tab. Camera image series and the image series from all created reports are available by default and do not need to be created separately.

You may integrate image series in reports. Thus, for example, it is possible to display 3D views interesting for you through all stages or the image series of an external camera for documentation purposes. In this case, however, the number of the external images must be identical to the number of stages in your project.

An internal image player provides for playing the image series and checking them prior to e.g. export them.

When exporting an image series, you may decide if you would like to export the series as individual images or as a movie (video). A video combines the images in the .avi or .mpeg format in one file which you may play also using an external player. You may define the format in the preferences.

For further information, please refer to the Online Help.

G 2.3 Snapshots

With the snapshot function you may save a screenshot of the 3D view or of the 2D images as an image in order to use it, for example, as reports and result representations. A snapshot is a static image that does not change through the stages. If you want to, you may also print a snapshot directly from the software. Several predefined default templates provide for easy editing of a snapshot for report purposes.

All snapshots are displayed in the sub-explorer under tab **Documentation**.

G 2.3.1 Advanced Snapshot Functions

<u>Creating Snapshot Templates</u>

In addition to the default snapshot templates supplied, you may create own templates any time. First, the software creates an empty snapshot that you may design individually by using the functions for editing snapshot elements. You may edit snapshot elements in the same way as report elements (see also G 2.1). If the template is ready, you may save it as template.

G 3 Documentation

When you have finished your measuring task including all the required steps, you may prepare a documentation from the available data which may contain image elements, text elements and value tables. Using such a documentation, you may present your measuring results demonstratively.

G 3.1 Documentation Preparation

Menu item **Documentation** offers different possibilities to prepare report documentation. The elements created here appear in the sub-explorer under **Documentation** with a corresponding headline. All elements that are listed may later be exported as tables in the order in which they appear in the explorer (see also Chapter F). You may change the order in the explorer using the right mouse button menu.

Info Except for the snapshots, all elements listed in the documentation container are virtual export data and cannot be looked at in PONTOS.

G 3.1.1 Chapter Titles

The software provides for defining a chapter headline under which data selected later is to be listed in the documentation template.

G 3.1.2 Compiling Documentation Data

Using menu item **New Documentation Data**, you define which elements you would like to integrate into the documentation. For this purpose, select the respective elements in the explorer. They will then be added to the documentation container in the explorer.

G 4 Deformation Results on TRITOP Images

For very small deformations which can well be illustrated by means of a static image, you may display your PONTOS deformation results on a TRITOP camera image, provided you carried out a complete TRITOP measuring project prior to your deformation project. For this purpose, load the TRITOP project as new stage into your deformation project, transform it to the basic stage and identify it. Then, in your report, select the image of the TRITOP stage.

Info For this function, you need a TRITOP license.

G 5 Summary

- Standard reports
- Create and edit reports
- Use image series and movies
- Creating snapshots
- Creating snapshot templates
- Preparing documentation data
- Display deformation results on TRITOP images

Chapter H - Table of Contents (rev-a)

H Automation and Functional Extensions

H 1 Macros

H 1.1 Automation

For recurrent deformation projects with very complex analysis elements, the PONTOS software provides for recording macro scripts based on Python. Thus, automation of individual processing steps is possible.

You may easily generate a new macro by creating a new, empty macro, start recording, carry out the desired operating steps, stop recording and save the macro.

You may modify macro commands in the editor any time using the context menu of the right mouse button on the respective command. If you have the necessary knowledge, you may also change the script directly in the syntax.

In addition, you may include a macro into another macro.

For more detailed information about scripts and programming, please refer to the expert manual "GOM Scripting Language".

H 1.2 Functional Extensions

For very exceptional and special measuring tasks, you may have user-specific macros created by GOM which extend the functions of the PONTOS software.

H 2 Summary

- Automation due to macros
- Functional extensions by macros

Chapter J - Table of Contents (rev-a)

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J Support

J 1 Where Do You Find Help?

If you face a problem, you will find help at several places.

J 1.1 Manuals / Online Help

In the software, you will find in menu item Help not only the Online Help but also a document overview of all available manuals. If you do not have them as paper version, you may look at the texts here in pdf format.

J 1.2 FAQs

If you have the corresponding access information, you may reach the English FAQ area (Frequently Asked Questions) via the internet (http://support.gom.com/) and find responses to frequently asked questions.

J 1.3 Distributor

If you cannot solve a problem yourself and do not find answers in the other help sources, please contact your responsible distributor or your contact partner in your country first.

J 1.4 Support Form

If your problem cannot be solved using the above mentioned methods, you may send your support request to GOM using the request form available in the internet (http://support.gom.com/). This form is also available without login.

J 1.5 Direct Support

You also reach the GOM support by
email address: support@gom.com
or
phone number: +49 531 39029 0

J 2 Useful Support Data

J 2.1 Creating Support Data

If you have a technical problem (e.g. hardware or software crash) you may create a compressed analysis file using menu item **Help ▶ Collect Support Data** and entering the root password, and send this file to the GOM support.

J 2.2 Snapshots in Linux Measuring System

It might also be helpful to include in your support request a snapshot of your current screen.

Open the KDE start menu (see Chapter A) and navigate to **Utilities ▶ Desktop ▶ KSnapshot**. Create a snapshot and add it to your support request.

J 2.3 Movies of Screen Actions in Linux Measuring System

In some cases it might be useful for handling your support request to document the order of certain screen action by means of a little movie.

Click on the respective icon on your desktop. This starts recording. Now, carry out the required actions and finally stop the recording. Send the resulting two files to the GOM support.

J 3 Troubleshooting Measuring System

Problem:	Remedy:
The Linux PC is "frozen" but the mouse pointer can still be moved.	Press Ctrl and Alt and Backspace ← and log in again.
The Linux PC is "frozen" and the mouse pointer cannot be moved, or the mouse pointer can be moved but the keyboard does not respond.	Switch the PC off and on again.
The PONTOS software is "frozen" and other applications work.	Click with the mouse pointer on the open windows and press Escape. If necessary, repeat several times. If you do not succeed, press Ctrl and Alt and ← and log in again or use Ctrl, Alt, Esc and left mouse button to quit the application.
How can I change the language of the PONTOS application software?	For this purpose, open menu item **Edit** ▶ **Preferences** ▶ **Preferences** ▶ **General** and select the desired language in the selection list under **Language**. Confirm the selection with **OK**. When starting the program again, the application software appears in the newly selected language.
How can I change the language of the Project Keywords?	In the project keyword window click on button **Edit**, then click with the right mouse button onto the list and select **Add Defaults**. Select the required language and confirm with **OK**.
What shall I do if I cannot achieve the desired calibration values?	Check if the sensor is configured correctly. In addition, verify if the calibration object is screwed tight correctly and has not been moved.
How do I know if I need to calibrate the system again?	If in tab **Object Points** you move the horizontal scroll bar totally to the right, you may see the values of the **Intersection error**. If the value is too high, you should calibrate the system again.
I cannot work with the PONTOS project. The stages in the explorer are highlighted in gray.	The project is already open in a PONTOS application. This effect may occur after the computer crashed and thus, temporary lock files were not correctly deleted.
Loading CAD data is not possible with the CAD converter.	The CAD converter identifies the CAD data only by the file extension. Therefore, correct spelling of the file extension is absolutely required.
The best-fit function does not work correctly in connection with primitives.	The reason could be a wrong selection in the 3D view. Deselect all, then select again and repeat the best-fit function.
May I select an area for a displacement field in the 2D camera image as well?	Yes. You then select those points that were seen by the camera.
I cannot play the image series I saved in .mpeg format with external players, why?	You created an image series from the original camera images. You should not use the .mpeg format for that, as during the export, the original image size of the camera is used but the mpeg specification requires a lower resolution. For image series created from reports, the mpeg format does not cause any problems!
PONTOS cannot overwrite CD or DVD-RW media.	Delete the media completely by means of an external program.