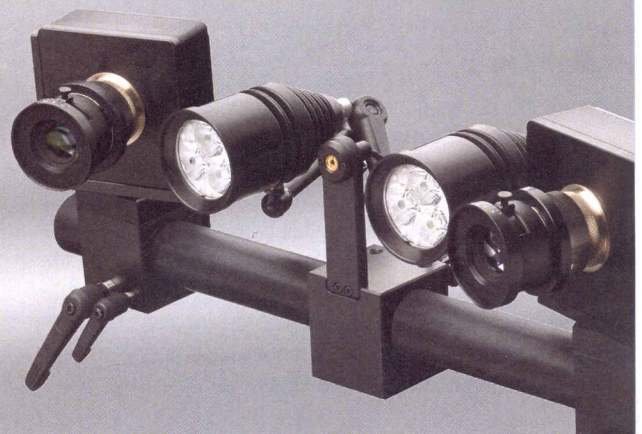
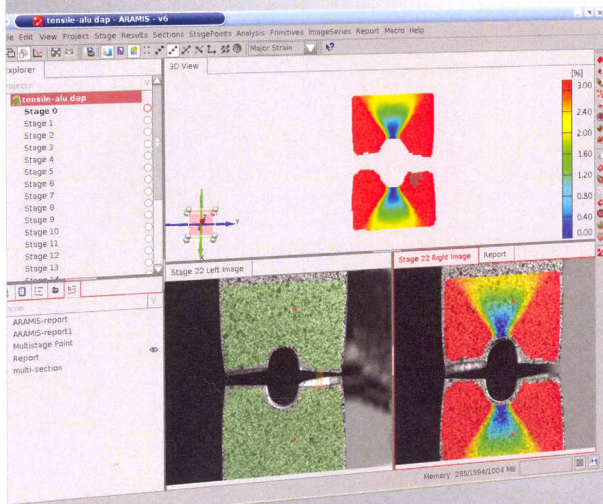


# ARAMIS

## User Manual - Software



**ARAMIS v6.1 and higher**

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**gom**  
Optical Measuring Techniques

## Symbols, Legal and Safety Notes

### Symbols

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

<b>⚠ WARNING</b>	This label points to a situation that might be dangerous and could lead to serious bodily harm or to death.
<b>⚠ CAUTION</b>	This label points to a situation that might be dangerous and could lead to light bodily harm.
<b>NOTICE</b>	This label points to a situation in which the product or an object in the vicinity of the product might be damaged.
<b>Info</b>	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 User Information - Hardware!

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

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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 Project, this user manual mainly informs about the **Why** and imparts basic strategic knowledge.

For the ARAMIS hardware or special software functions, additional manuals are available.

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 ARAMIS system as well as basic knowledge about the Linux operating system and the application software.
- **Chapter B** informs about the calibration of the measuring system and about adapting the sensor.
- **Chapter C** contains a typical ARAMIS measuring procedure (choosing the measuring volume, preparing the specimen, creating a project, recording images, ...)
- **Chapter D** informs about the computation of the images (definition of facets, computation masks, creation of start points, strain computation).
- **Chapter E** informs about transformation methods for the measuring project and about eliminating rigid body movements.
- **Chapter F** deals with methods and functions to create or edit measuring results (result representations, filtering, interpolation, legends, primitives, analysis elements).
- **Chapter G** deals with methods to document measuring results (creating reports, snapshots, movies, image series, printing documentations).

- **Chapter H** informs about how to export measuring results and automate procedures in the software.
- **Chapter J** explains the theory of the basics of strain.
- **Chapter K** describes the support concepts and troubleshooting.

## ARAMIS with Linux and Windows

**Info**

This manual describes the software functionalities under Linux. Please note that when operating the software under Windows, operating steps may be slightly different, e.g. the starting of the software or file structures. However, the general system functionalities are identical except for the differences listed in the table.

**Info**

For directly operating the sensor with the ARAMIS application software, a Linux operating system is required. As of software version v6.0.2, the ARAMIS software is also available with limited functions on Windows systems.

### Functional Differences in the ARAMIS Application Software Depending on the Operating System

Function:	Linux	Windows
Direct image recording with camera	yes	no (Images can only be integrated into the software as external image series.)
Operation with the sensor controller	yes	no
Laser pointer function	yes	no
Software-supported calibration	yes	yes, but limited. (Calibration is only possible using external image series.)
Record CDs/DVDs directly in the application software	yes	no (CDs/DVDs can only be recorded using external software.)



## Main Hardware and Software Components

### Basic Requirements Under Linux

In order to achieve full functionality with the ARAMIS 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.
- Sensor controller
- 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.

### Basic Requirements Under Windows

- 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: 2GB 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: 1 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 ARAMIS software probably works with a considerably slower software rendering.

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

**Info**

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

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## A Basics

### A 1 Brief Introduction to the ARAMIS System

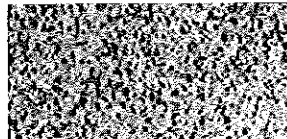
ARAMIS is a non-contact optical 3D deformation measuring system. ARAMIS analyzes, calculates and documents deformations. The graphical representation of the measuring results provides an optimum understanding of the behavior of the measuring object.

ARAMIS recognizes the surface structure of the measuring object in digital camera images and allocates coordinates to the image pixels. The first image in the measuring project represents the undeformed state of the object.

After or during the deformation of the measuring object, further images are recorded. Then, ARAMIS compares the digital images and calculates the displacement and deformation of the object characteristics.

**Info**

If the measuring object has only a few object characteristics, like it is the case with homogeneous surfaces, you need to prepare such surfaces by means of suitable methods, for example apply a stochastic color spray pattern.



Stochastic pattern

ARAMIS is particularly suitable for three-dimensional deformation measurements under static and dynamic load in order to analyze deformations and strain of real components.

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 or dialog windows.

### A 2 Fields of Application

- Material testing
- Strength assessment
- Component dimensioning
- Examination of non-linear behavior
- Characterization of creep and aging processes
- Determination of **Forming Limit Curves (FLC)**
- Verification of FE models
- Determination of material characteristics
- Analysis of the behavior of homogeneous and inhomogeneous materials during deformation
- Strain computation

### A 3 Features of the ARAMIS System

- Used as 2D or 3D measuring system.
- ARAMIS assigns square or rectangular image details, so-called facets (e.g. 15 x 15 pixels), in different images to each other.
- Varying lighting conditions of different images are automatically compensated.
- Simple preparation of the specimen as the raster method used only requires the application of a stochastic or regular pattern in case the surface of the specimen is not structured sufficiently.
- Large measuring area: Both, small and large objects (from 1 mm to 2000 mm) can be measured with the same sensor. Deformations can be measured in a range of 0,01% up to several 100%.
- Full-field and graphical 3D representation of the measuring results with high data point density.
- The graphical representation of the measuring results provides an optimum understanding of the component behavior.
- High mobility as the system can easily be accommodated in the transport cases included in the delivery. Thus, it can be transported by car or plane without any problems.  
For more mobility, the ARAMIS FireWire system is available with a powerful notebook PC.
- Transformations e.g. according to the 3-2-1 method.
- Quality control: Calculation and display of the measuring results with default or customer-specific color representations.
- Report generation and export functions for measuring and result data.
- Automation due to macro functions. Recurring command sequences can easily be automated.
- Option: Creation of user profiles for customer-specific adaptation of the user interface.

### A 4 Main Hardware and Software Components

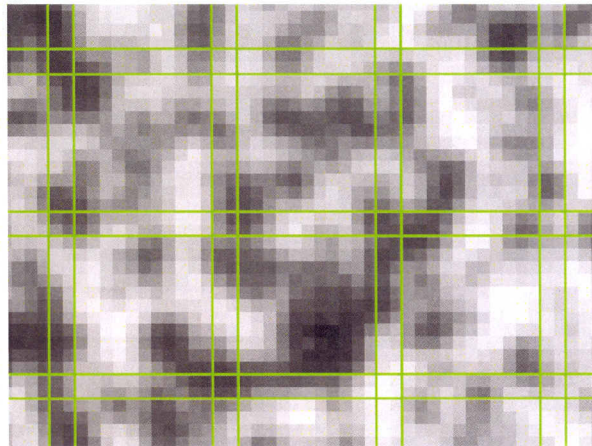
- Sensor with two cameras (only for 3D setup)
- Stand for secure and steady hold of the sensor
- Sensor controller for power supply of the cameras and to control image recording
- High-performance PC system
- ARAMIS application software v6.1 and GOM Linux 10 system software or higher

## A 5 Principle of Deviation Measurements

In general, the ARAMIS sensor unit is operated on a stand in order to optimally position the sensor with respect to the specimen. For a 3D measurement setup, two cameras are used (stereo setup) that are calibrated prior to measuring. The specimen needs to be within the resulting measuring volume (calibrated 3D space). After creating the measuring project in the software, images are recorded (monochrome, right camera, left camera) in various load stages of the specimen.

After the area to be evaluated is defined (computation mask) and a start point is determined, the measuring project is computed.

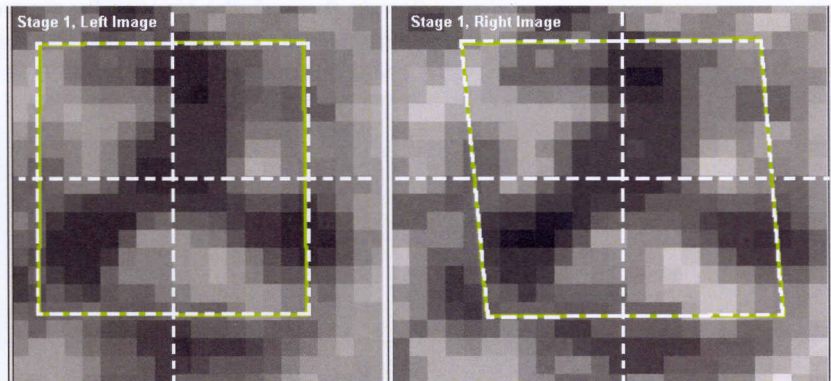
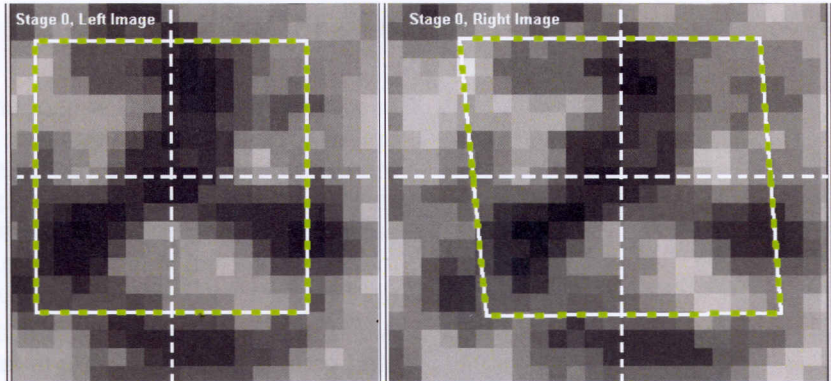
During computation, ARAMIS observes the deformation of the specimen through the images by means of various square or rectangular image details (facets). The following figure shows 15 x 15 pixel facets with a 2 pixel overlapping area in stage 0.



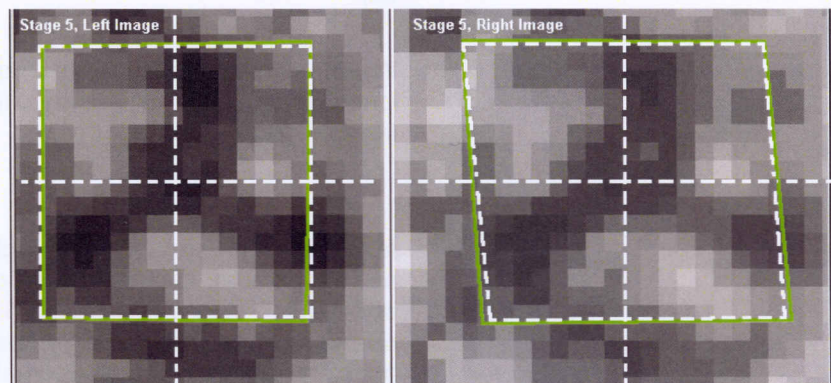
15x15 facets with 2 pixels overlapping (made visible in the 2D image via the right mouse button)

You may adjust the facet size in pixels in the software. In the different load stages, the facets are identified and followed by means of the individual gray level structures.

In the following, we show a pair of facets (15 x 15 pixels) of the right and left camera, the gray values of which were observed through six deformation stages (**Stage 0** to **Stage 5**). **Stage 0** is the undeformed reference state and **Stage 5** is the final deformation state. In these images, the white dashed line visualizes the undeformed state in order to make clear the factual relation between facets and deformation.



Stage 2, Left Image	Stage 2, Right Image
Stage 3, Left Image	Stage 3, Right Image
Stage 4, Left Image	Stage 4, Right Image



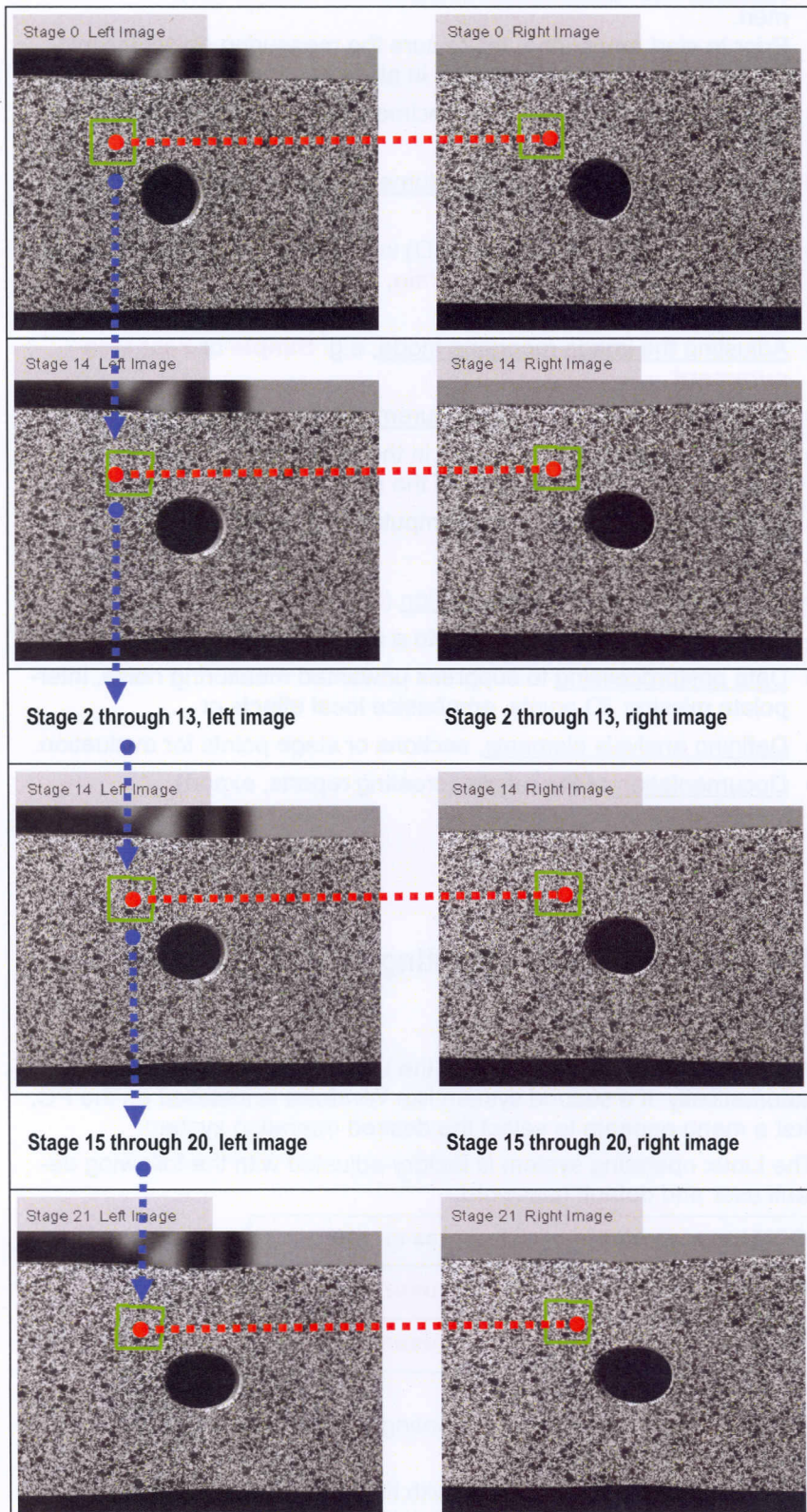
The system determines the 2D coordinates of the facets from the corner points of the green facets and the resulting centers. Using photogrammetric methods, the 2D coordinates of a facet, observed from the left camera and the 2D coordinates of the same facet, observed from the right camera, lead to a common 3D coordinate.

After successful computation, the data may undergo a post-processing procedure in order to e.g. reduce measuring noise or suppress other local perturbations.

The measuring result is now available as 3D view. All further result representations like statistical data, sections, reports, etc. are derived thereof.

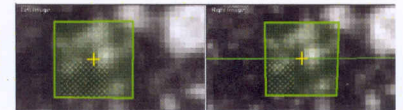


A 5.1 Facet Computation




Using a single facet (enlarged representation) as example, we explain the computation principle for a 3D point through several deformation stages.


- The facet computation requires start points in all stages.



Start point definition (automatically or manually)

- The size of the green facet results from the facet field definition when creating the project.
- Computation is started in **Stage 0, Left Image**.

-  Due to the start point definition, the software in principle knows the position of the facets and their adjacent facets in the 2D image. By identifying the individual spray pattern of a facet in the right and left image, the facet quadrangle is optimized. From the resulting 2D image coordinates of the facet (central point of the facet) in the right and left camera image, the software now calculates the 3D position of the facet.

-  After the computation of the 3D positions of one stage, the software automatically continues with the next stage. Here as well, in principle the position of the facet is known because of the start point definition. Now, computation of the 3D position of the facet starts again.

- The strain computation results from the displacements of the 3D points.

**A 5.2 Steps to Carry Out a Typical Measuring Procedure**

- Determination of Measuring Volume and Preparation of the Specimen.  
Prior to start measuring, make sure the measuring object fits into the selected measuring volume in all its deformation stages.
- Specimen preparation if the specimen has only little surface structure.
- Calibration of the measuring volume in case of a 3D measuring project.
- Creating a new project (2D or 3D) in the software and defining the project parameters (Facets, Strain, Keywords, Stage Parameter ...).
- Adjusting the image recording mode, e.g. Simple or Fast Measurement.
- Recording images during measurement (e. g. tensile test)
- Defining the computation mask in the measuring images, so that only deviation relevant areas of the specimen will be computed.
- Defining a start point for the computation process.
- Compute project
- Selecting the result representation (Major Strain, Minor Strain, ...).
- Transformation of the project into a defined coordinate system.
- Data postprocessing to suppress unwanted measuring noise, interpolate missing 3D points, emphasize local effects or ... .
- Defining analysis elements, sections or stage points for evaluation.
- Documentation of the results (creating reports, export).

**A 6 The GOM Linux Operating System**

**A 6.1 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:

<b>GOM Linux version</b>	<b>as of v10</b>
<b>Default user</b>	<b>user</b>
<b>Password</b>	<b>user</b>

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 ARAMIS software.

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**A 6.1.1 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 6.1.2 Home Directory**

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

**A 6.1.3 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 6.1.4 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 6.1.5 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 6.1.6 Loudspeakers**

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

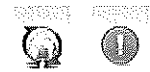
**A 6.1.7 Linux Operating System Updates**

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 6.1.8 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 6.1.9 Starting the ARAMIS Software**

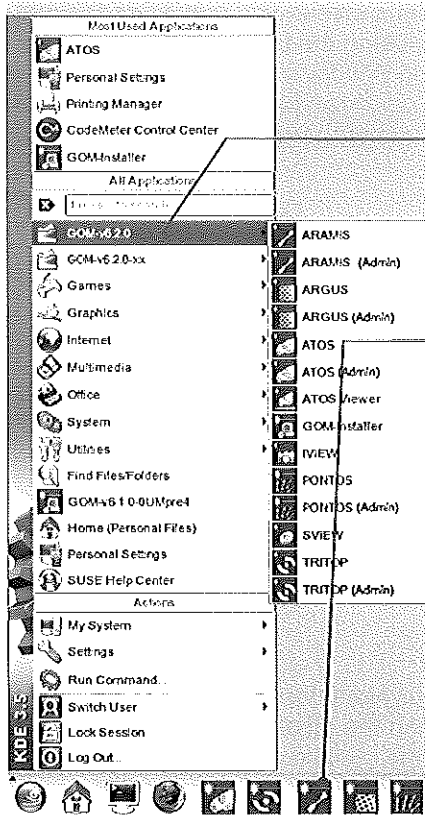
You may start the software in two ways:

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 **ARAMIS (Admin)**. Only with this start routine you will reach the user profile management.

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

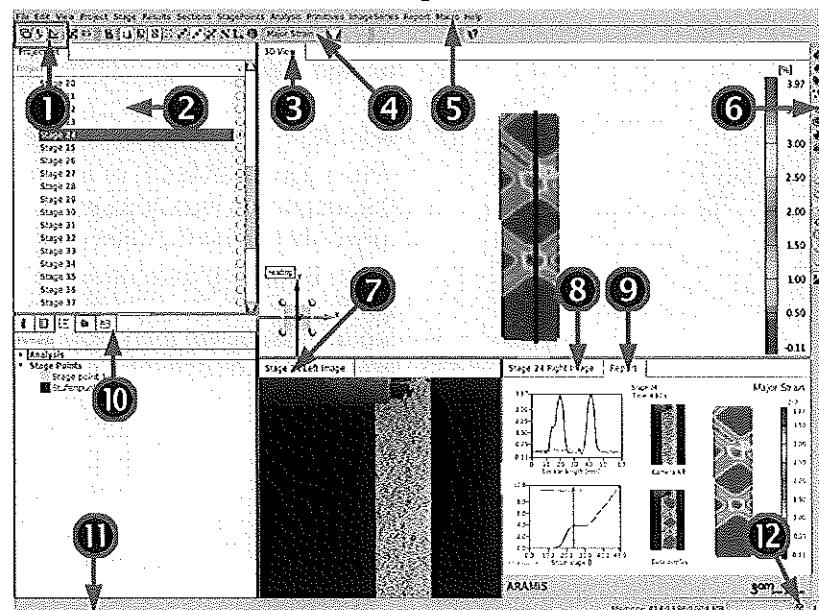
If you start the software using the icon , the user profile management is not available.

**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 7 The ARAMIS Application Software**

**A 7.1 The Default Screen Arrangement**



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**A 7.1.1 Screen elements:**

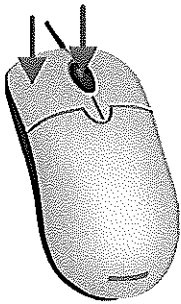
<b>1</b>	Selection between the operating modes (from left to right: project mode, evaluation mode, FLC mode)								
<b>2</b>	<p>Tab Explorer. Here, you will find all open projects and all stages of each project. Using the arrow keys of the keyboard you may navigate forward and backward. Of the selected stage (  ) you will see the 3D strain data of the surface on the right, the camera image on the bottom left and the report for this stage on the bottom right.</p> <p>Symbols in the project list:</p> <table border="1"> <tr> <td><input type="radio"/></td> <td>Strain reference stage not selected.</td> </tr> <tr> <td><input checked="" type="radio"/></td> <td>Strain reference stage selected.</td> </tr> <tr> <td><input type="radio"/></td> <td>Strain stage not selected.</td> </tr> <tr> <td><input checked="" type="radio"/></td> <td>Strain stage selected.</td> </tr> </table>	<input type="radio"/>	Strain reference stage not selected.	<input checked="" type="radio"/>	Strain reference stage selected.	<input type="radio"/>	Strain stage not selected.	<input checked="" type="radio"/>	Strain stage selected.
<input type="radio"/>	Strain reference stage not selected.								
<input checked="" type="radio"/>	Strain reference stage selected.								
<input type="radio"/>	Strain stage not selected.								
<input checked="" type="radio"/>	Strain stage selected.								
<b>3</b>	3D view								
<b>4</b>	Selecting the result representations.								
<b>5</b>	Icon bar to select the functions (strain directions, visualizations, 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).								
<b>6</b>	Icon bar to choose selection and deselection tools.								
<b>7</b>	Tab to display the left 2D camera image of the selected stage.								
<b>8</b>	Tab to display the right 2D camera image of the selected stage.								
<b>9</b>	Tab for viewing and editing reports.								
<b>10</b>	Sub-explorer with various tabs:								
	 Tab Info: Here, you will find information about the selected stage and about the project.								
	 Tab Stage Data: This tab contains a list of all stage data for each stage.								
	 Tab Stage Elements: Here, you will find Sections, Stage Points, Analysis and Primitives. This tab contains a list of all elements that were created for the project.								
	 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.									
<b>11</b>	Status indicator line. Here, all important information about the project and the current commands are displayed.								
<b>12</b>	Cancel button for computation-intensive operating steps.								

**A 7.2 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).

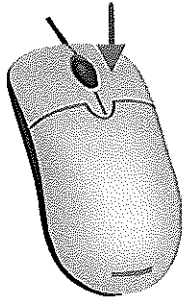
### A 7.3 Mouse Functions

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 7.3.1 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.
- When pressing the **Shift** key and clicking with the **left** mouse button (LMB) in the 3D view, the software arranges the view of the object such that the normal direction of the point clicked points to you.
- 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, and select stage points in the 3D view.
- 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 (on the position of the mouse pointer).
- 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 , 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  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  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 7.3.2 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 7.4 Status Indicator Line

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

Point-Point Line: Select point with CTRL + left mouse button in the 3D view

### A 7.5 Operating Modes

	<p><b>Project Mode</b> After creating a new project and defining the project parameters, the ARAMIS software automatically is in the project mode.</p> <p>In this mode, you calibrate the system and record the images.</p> <p>After image recording, the images need to be prepared for computation. For this purpose, you define a mask in the left image of the undeformed stage (0) which limits the area (green area) of the specimen to be computed (stochastic pattern). Here as well, a start point is defined (automatically or manually). This start point is identified by means of the gray level distribution typical for this point in the right image (for creation of 3D data) and in each other stage (for creation of strain data). It is used as basis for the entire computation of the specimen.</p> <p>The image information outside the green area (blue area) will not be used for computation.</p> <p>Then, the specimen is computed and the evaluation mode starts automatically. If required, you may edit stages (delete, add, disable) or change stage or project parameters in this mode.</p>
	<p><b>Start/Stop Measurement Mode</b> This mode can only be opened from the project mode In this mode, you record the images.</p>
	<p><b>Evaluation Mode</b> In the evaluation mode, all computed results, e.g. strain, displacements, are visualized on the entire surface of the specimen.</p> <p>Various visualizations may be displayed and edited. To understand the behavior of the specimen to be examined, numerous functions like sections, stage points, measurements, primitives, etc. are available and may be displayed in diagrams or in the 3D view.</p> <p>To present the results, you may create and edit own or preadjusted reports in this mode.</p> <p>Using the export functions, you may make available the computed data for subsequent systems. This is just a small overview of the functionalities in the evaluation mode.</p>

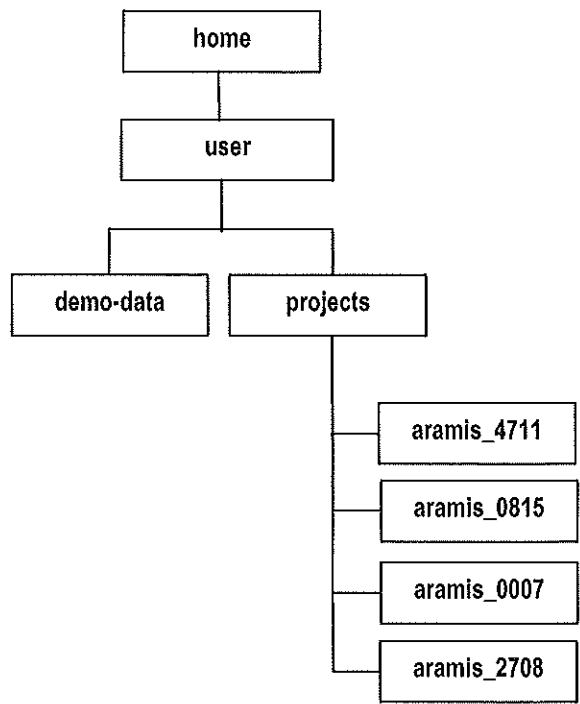
	<p><b>FLC Mode</b> (optional)</p> <p>In the FLC mode (FLC = Forming Limit Curve), section data gained from a series of Nakajima tests is evaluated and a forming limit curve is calculated. In this mode, you may create a material file which you may use in ARAMIS. For more information see the special documentation ARAMIS FLC Computation.</p> <p>When forming components, generally there are very different states of deformation. Failure when forming a single material is not a constant but depends on the local forming state. Therefore, in addition to the local deformation conditions, information about the respective limits is required. This is given by the forming limit curve (FLC). It assigns a critical value of the major strain to each value of the minor strain and is to be considered as material characteristic. The results of a forming analysis (major and minor strain) are represented together with the forming limit curve (FLC) in the so-called forming limit diagram (FLD). They allow an easy evaluation of the forming state.</p>
---	---

**A 7.6 ARAMIS Directory Structure**

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.

Recommended Directory Structure:

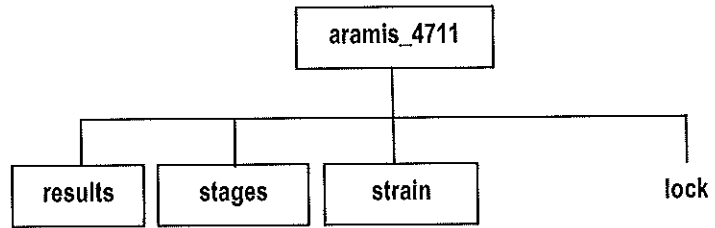


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<b>projects</b>	Save your deformation projects here. For each measuring project, the software automatically creates a directory. The name of the directory is identical to the project name. A measuring project always consists of several files and directories (see A 7.7). The figure shows as an example the structure for two measuring projects (4711 and 0815). Save your export data according to the project name.
<b>demo-data</b>	Saved data for demonstration purposes only.

**Automatically Created Project Directory**



<b>aramis4711.dap</b> (example)	Deformation project file. With this file, a deformation project is opened in ARAMIS.
<b>results</b>	Recommended directory in which you may save your result data (snapshots, images, exported data, movies, ...).
<b>stages</b>	Directory containing all stages and the corresponding images and files together with your project settings. <b>NOTICE</b> Do not remove any files or directories here! Your measuring project might be destroyed!
<b>strain</b>	Directory containing all strain data and the corresponding images and files. <b>NOTICE</b> Do not remove any files or directories here! Your measuring project might be destroyed!
<b>lock</b>	Temporarily created file when a measuring project is open.

**A 7.7 Save Data**

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

**NOTICE**

Remember that most of the operating steps cannot be undone!

### A 7.8 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 8 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 9 Summary

- Brief introduction
- Hardware and software components
- Linux operating system
- Software operating structure
- Most important mouse functions
- Operating modes
- Directory structure
- Saving data
- User profiles

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## B Sensor

### B 1 Sensor Setup

#### B 1.1 Adapting the Sensor to Other Measuring Volumes

##### B 1.1.1 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 [ARAMIS User Information – Hardware](#). 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 [ARAMIS User Information – Hardware](#).

#### B 1.2 Adjust Lenses

##### B 1.2.1 Why do Lenses Need to be Adjusted?

You need to adjust the lenses again, if, for example,

- the adjustment changed due to vibrations or
- 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 [ARAMIS User Information – Hardware](#).

#### B 1.3 Changing the Camera Support

##### B 1.3.1 Why Should the Camera Support be Changed?

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 [ARAMIS User Information - Hardware](#).

#### B 1.4 Adjust Cameras

##### B 1.4.1 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.

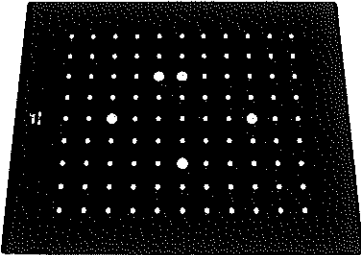
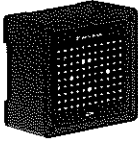
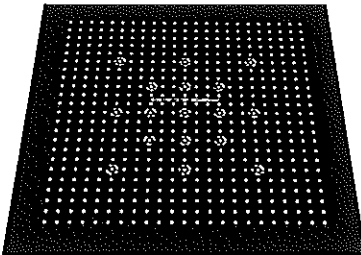
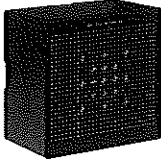
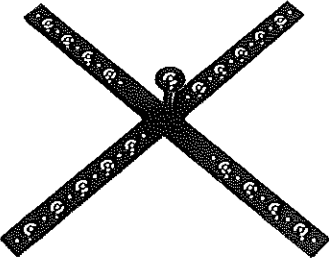
If, for example, you adjusted your sensor to a new measuring volume or if you changed the camera support, the cameras need to be correctly adjusted again. The required steps are described in the [ARAMIS User Information - Hardware](#).

## B 2 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 2.1 Calibration Objects**

For the ARAMIS measuring system, two different calibration objects are used, calibration panels for small measuring volumes and calibration crosses for large measuring volumes. Calibration panels are also available cube-shaped in order to calibrate particularly small measuring volumes (10x8 to 66x44 mm). 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 reference points.

Calibration panel with one scale bar	Calibration panel with two scale bars	Calibration cross with two scale bars
 <p>Cubic calibration panel:</p> 	 <p>Cubic calibration panel:</p> 	

The calibration object contains the scale bar information. Depending on the type, a calibration panel has one or two scale bars. A scale bar is the specified distance between two specific points. A calibration cross always has two scale bars (one scale bar on each cross section).

**B 2.1.1 Calibration Object Selection**

Which calibration object you need to choose depends on the measuring volume you would like to use. In the [ARAMIS User Information – Hardware](#) ► [Sensor Configurations](#) the corresponding measuring volumes for each calibration object are listed.

**NOTICE**

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

## B 2.1.2 How to Handle Calibration Objects

### Calibration Panel, Calibration Cross

#### 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 panels object if possible. After each use, accommodate the calibration panels at the places dedicated for that.

### Calibration Cube

#### NOTICE

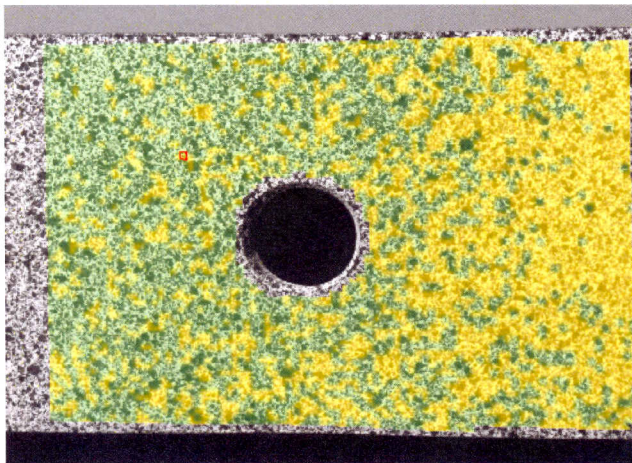
The surface of the calibration panel is made of ceramic and is therefore very susceptible to touch. Finger prints or any other kind of dirt can probably not be removed any more. Therefore, avoid contact of the surface!

Please wear gloves during the calibration to protect the ceramic panel!

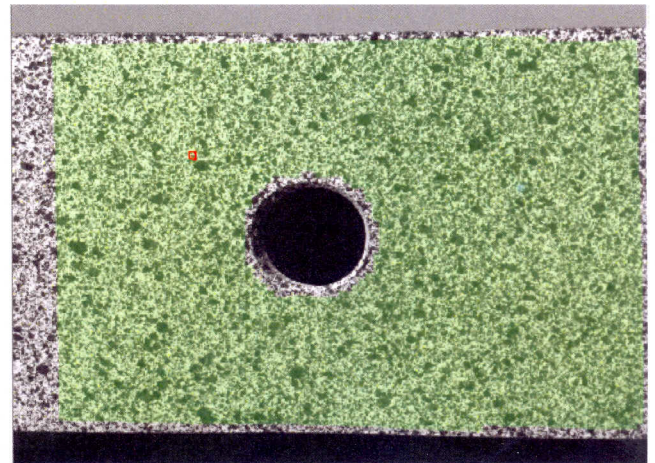
## B 2.2 Calibration Conditions

### B 2.2.1 When is Calibration Required?

- Before starting measurements for the first time, the respective 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.
- If the ARAMIS system shows many yellow facets in the camera images after computation, the system might be decalibrated.



Camera image of a stage in a decalibrated state



Camera image of the same stage in a calibrated state

The system automatically creates yellow image areas (yellow facets) if the intersection error of a 3D point (facet) is larger than 0.3 pixels (factory-adjusted setting). The average intersection error of all 3D points should not be larger than 0.1 pixel (see tab **Info** in the **Project Mode**).

### B 2.2.2 Prerequisites

We recommend calibrating the sensor under operating conditions.

**Info**

Do not expose the sensor to unnecessary temperature variations. Avoid that a possible specimen lighting strongly heats up the sensor.

A prerequisite for successful calibration is the correct setup of the sensor. For further information, please refer to the [ARAMIS User Information – Hardware](#). The measuring object defines the measuring volume and thus the set of lenses to be used. Depending on the measuring volume, you either need to use a calibration panel or a calibration cross for calibrating the system.

The measuring distance to the calibration object has to be adjusted according to the sensor head used, see [ARAMIS User Information – Hardware](#) ► [Sensor Configuration](#).

### B 2.3 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). Follow the instructions in the software.

**Info**

Calibrate the system with the same lighting conditions as used for measuring.

#### B 2.3.1 Positioning of the Calibration Object

First, position the calibration object in the center of the measuring volume such that the laser pointer hits the center of the calibration object. Now, move the calibration object in parallel such that the vertical red line of the cross hairs approximately coincides with the laser point in the right and left camera image. After that, follow the instructions in the software.

In order to extend the measuring volume in the viewing direction of the sensor, you need to move the calibration object relatively to the sensor during calibration. For this, the following general rule applies: Move the calibration object (in the viewing direction of the sensor) 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.

**NOTICE**

When using a calibration cross: Make sure that the calibration cross does not touch the floor when being tilted as otherwise deformation effects may lead to wrong results during the calibration.

#### B 2.3.2 Calibration Results

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

**Info**

For a correct calibration, the calibration deviation may be between 0.01 and 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 a wrong or damaged calibration object or also incorrect scale parameters.



## B 2.4 Calibration Using 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), calibration images are also required. As in this case the ARAMIS software cannot automatically guide you through the necessary calibration steps, you need to simulate the corresponding calibration steps. Make sure you move the calibration object within the measuring volume according to the instructions (see the [ARAMIS User Information – Hardware](#)) and record the respective images. It is not necessary to record the images in the order of the calibration steps.

### Info

After you loaded your calibration images into the ARAMIS software, you need to disable the function Instructions so that a calibration with a any order of images is possible.

## B 2.5 Background Information About Calibration

### B 2.5.1 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 lenses 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 2.5.2 Calibration Deviation

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

### B 2.5.3 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 (wrong adjustment of lenses). If the sensor configuration changes, the calculated reference point deviation changes as well, see B 2.2. You might notice a beginning decalibration of the system if, for example, the Avg. intersection deviation of all 3D points (Project Mode ► tab Info ► Facet field) is larger than 0.1 pixels.

## B 2.6 Quick Calibration

If it is indicated that the system might be decalibrated (e.g. if you slightly 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 and
- 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.

**Info**

However, the image characteristics of the cameras must not have changed! If, for example, you inserted new or incorrectly adjusted 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 Summary

- Calibration objects
- Calibration conditions
- Calibration process
- Calibration results, calibration deviation
- Calibration using external image series
- Calibration theory
- Average intersection deviation of all 3D points
- Quick calibration
- Adapting the sensor to other measuring volumes
- Lens adjustment
- Changing the camera support
- Adjust cameras

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## C Measuring

This chapter describes the typical measuring procedure with the ARAMIS system, the preparation of the specimen, the creation of a new measuring project in the ARAMIS software up to recording a series of images. The sensor is already adjusted and calibrated (see [ARAMIS User Information – Hardware](#) and [Chapter B](#) of this User Manual).

### C 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!

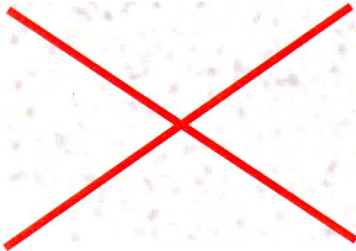
If it is necessary to adapt the measuring volume, you need to readjust and calibrate the sensor again (see [ARAMIS User Information – Hardware](#) and [Chapter B](#) of this User Manual).

### C 2 Preparing a Specimen

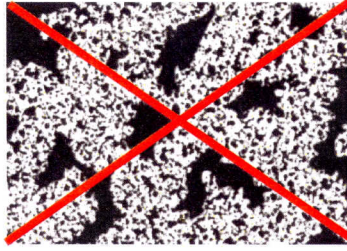
The surface structure is important for carrying out a measurement. The specimen's surface must meet the following requirements:

- The surface of the measuring object must have a pattern in order to clearly allocate the pixels in the camera images (facets). Thus, a pixel area in the reference image can be allocated to the corresponding pixel area in the target image.
- The surface pattern must be able to follow the deformation of the specimen. The surface pattern must not break early.
- The optimum specimen surface is smooth. Highly structured surfaces may cause problems in facet identification and 3D point computation.
- The pattern on the object should show a good contrast because otherwise such an allocation (matching) does not work.
- The surface pattern must be dull. Reflections cause a bad contrast and brightness differences between the right and left camera which prevent the facet computation in the areas of reflection.
- On one hand, the size of the surface characteristics should be small enough to allow a fine raster of calculation facets during evaluation. On the other hand, the pattern should be large enough to be completely resolved by the camera.
- Best suitable are stochastic patterns which are adapted to the measuring volume, camera resolution and facet size. In addition, for calculation, it is advantageous if the patterns do not have larger areas of constant brightness, e.g. large spots. Structures with changing gray values as they occur with random patterns are more

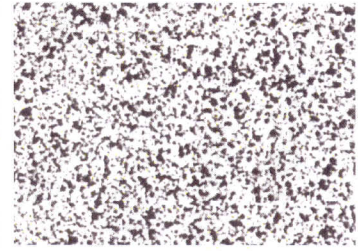
appropriate. The left figure shows a pattern that is not really suitable. The right figure shows a good and clearly better pattern.



Unsuitable low contrast stochastic pattern



High contrast stochastic pattern with disturbing large spots



Good high contrast stochastic pattern

In most cases, the specimens are pretreated with suitable lacquers or powder sprays.

### Info

## C 2.1 Spraying a Stochastic Pattern

Before you start spraying, make sure the surface of the specimen is free of grease and oil!

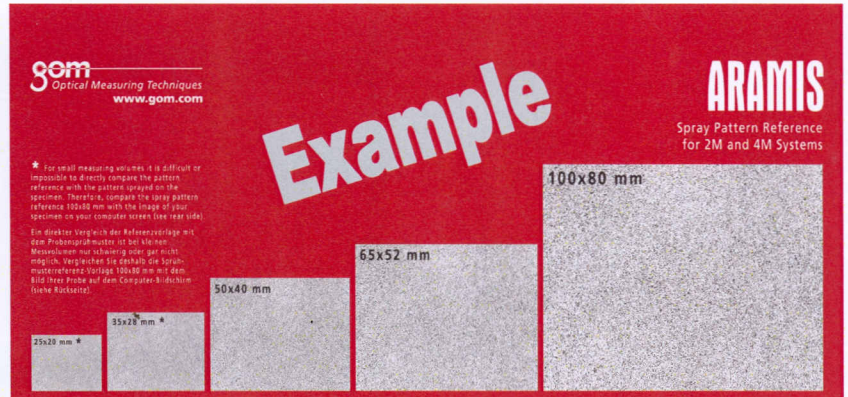
What lacquers or powder sprays you may use for your specimens largely depends on the measuring task and on the ambient conditions during the measuring process. Please contact the GOM support for more information.

GOM may give you spray recommendations for tests up to 300% strain and for high-speed tests up to 1500 °C.

In a first step, if required, you need to apply a white and dull base layer. In a second step, spray a black stochastic pattern.

Press the spray button of the black spray very softly so that the spray can “spit” and a high contrast, stochastic pattern results. Smaller measuring volumes require a finer pattern than large measuring volumes.

In order to check if your spray pattern is suitable for your measuring volume, specific reference patterns are available for the measuring volumes.

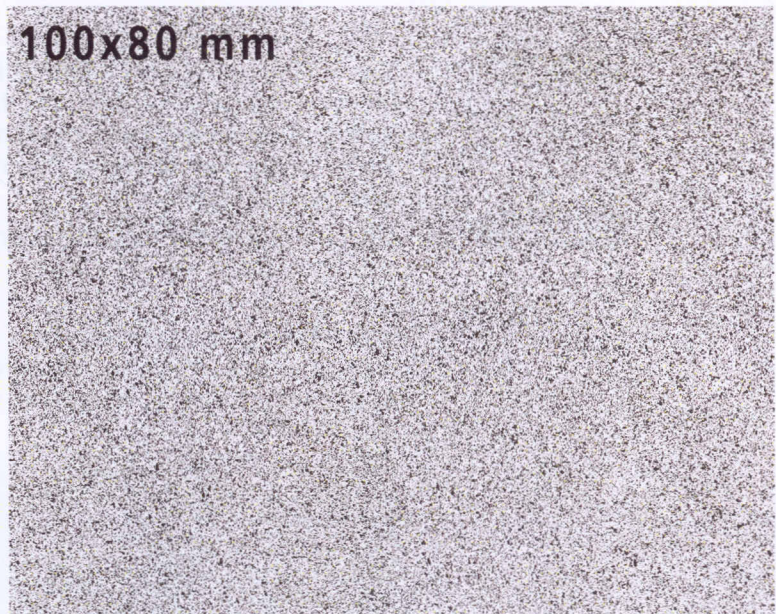


Info

For comparison, only use the original ARAMIS spray pattern reference!

However, you may judge your spray pattern on your computer screen as well. The advantage of this procedure is that independent of your measuring volume you just need one reference pattern (100 x 80 mm).

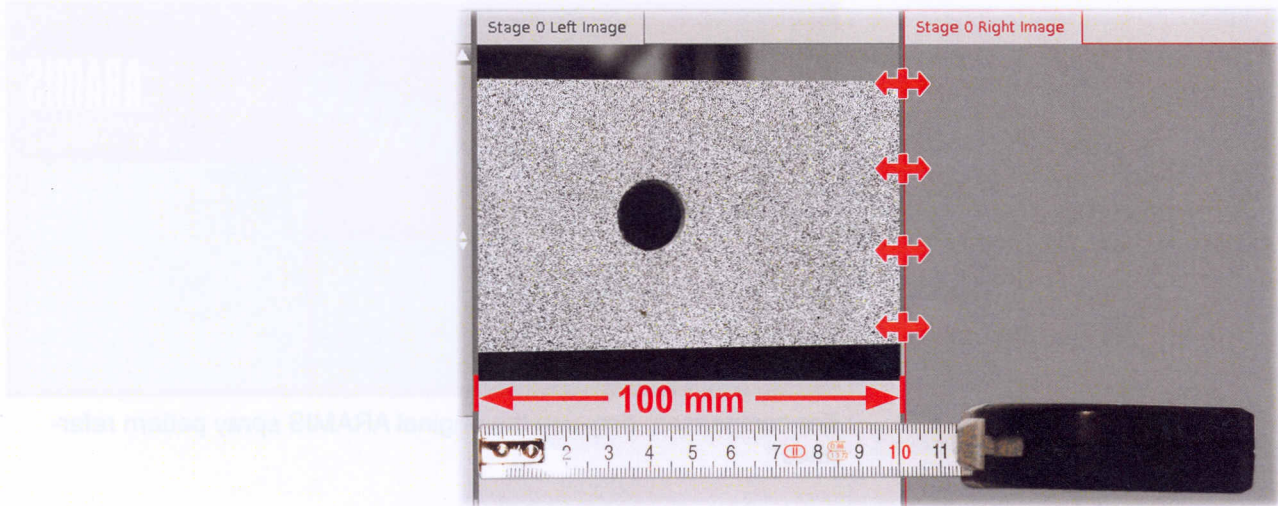
### C 2.2 ARAMIS Spray Pattern Reference



Spray pattern reference

To compare the spray patterns, please use your computer screen and the spray pattern reference for the volume 100x80 mm, regardless of the real measuring area. If you do not have an original spray pattern reference, you may also use this page of the user manual. Only use original pages of the user manual. Other printouts may probably have an insufficient display quality.

- Position your specimen with the spray pattern in the measuring distance in front of the camera.
- On your computer screen, adjust the window of the camera image to the same dimensions as the spray pattern reference 100x80 mm (see figure).



Window set to 100 mm

- Reset the zoom (left mouse button click on the image and key R).
- Compare the pattern of the camera image with the spray pattern reference for volume 100x80 mm.

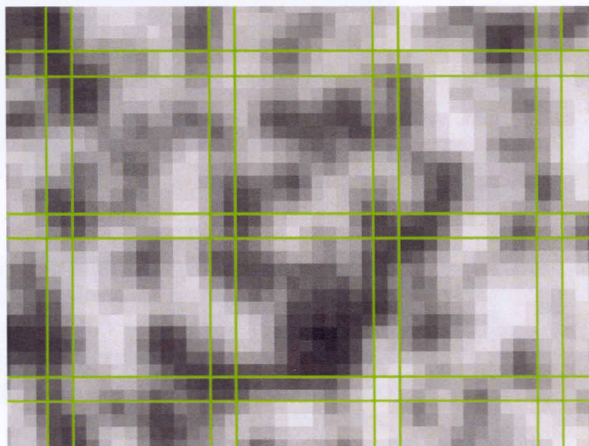
**CAUTION**

The spray may contain solvents! Please observe the warnings printed on the spray can. Do not inhale the fumes, only use the spray with the sufficient ventilation. Avoid contact with your skin and your eyes. Spray fumes may be highly inflammable - do not smoke! Keep away from ignition source.

**NOTICE**

Check the suitability of plastics and other non-metallic surfaces before you spray them.

The following figure shows some 15 pixel facets with a 2 pixel overlapping area and a good gray level distribution. With these settings, an unproblematic facet computation and a precise strain measurement are possible.



15x15 facets with 2 pixels overlapping made visible in the 2D image via the right mouse button

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### C 2.3 Spraying Patterns For Large Measuring Volumes

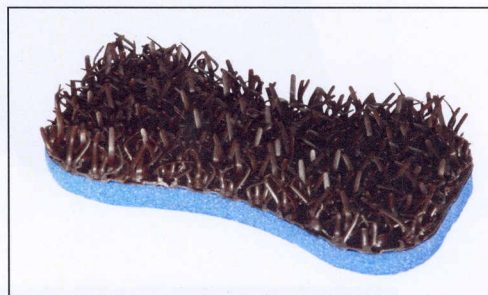
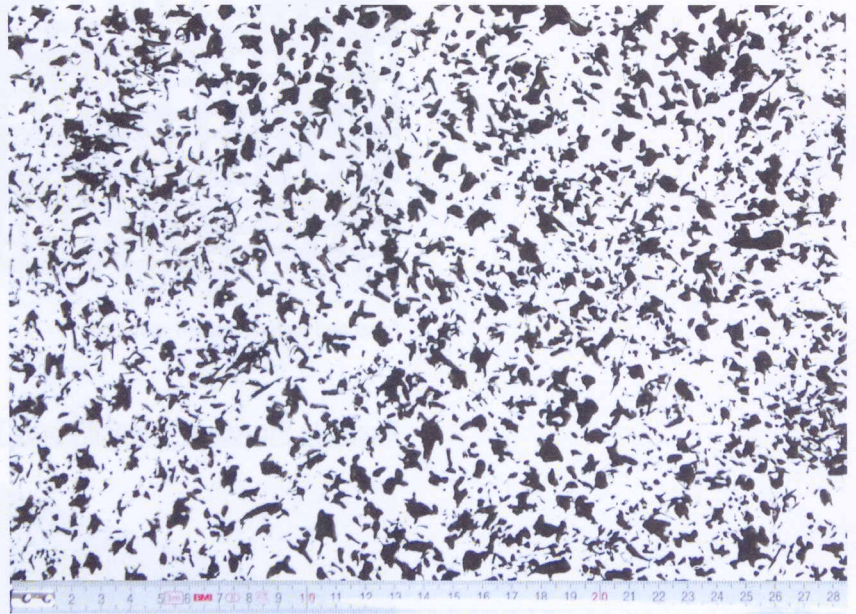
For large measuring volumes (e.g. 1m x 1m) the spray method described in section C 2.1 reaches its limits.

In this case, GOM recommends working with structural patterns that were applied to the surface of the specimen either with a pattern brush, a felt-tip pen or by means of the stencil/spray technique.

**Info**

When applying these structural patterns, make sure the pattern in the camera image is smaller than the selected facet size.

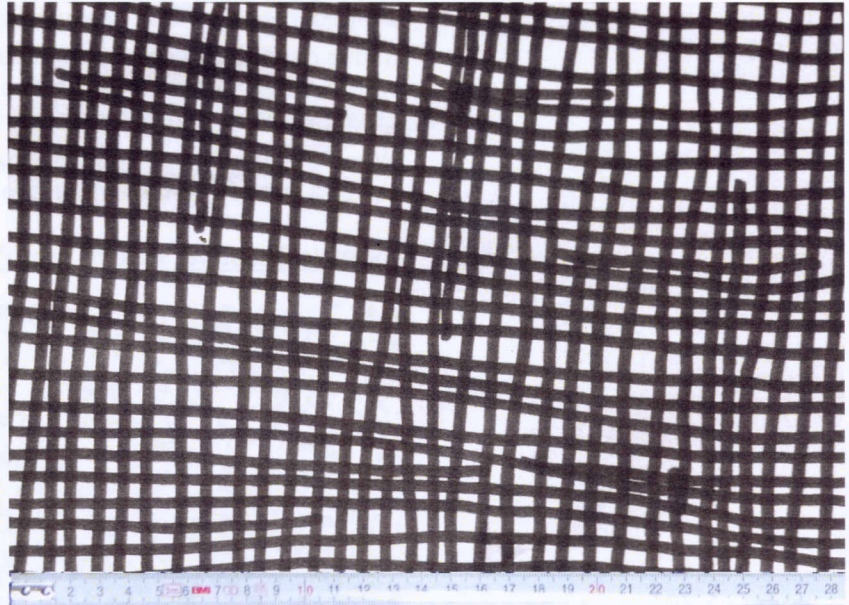
#### Example Structure "Pattern Brush"



Pattern brush

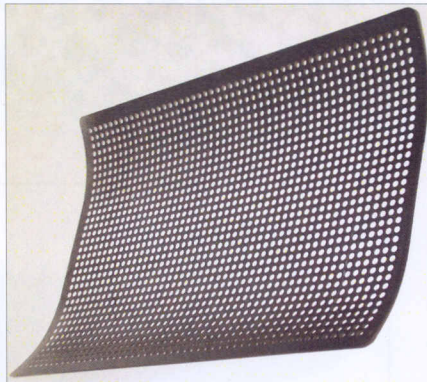
The pattern was created with a pattern brush using black paint on a white background. A slightly overlapping dabbing technique was used. Depending on the pressure you apply to the brush, you may create fine to rough patterns.

Example Structure "Felt-Tip Pen"



Freehand pattern created with a pen

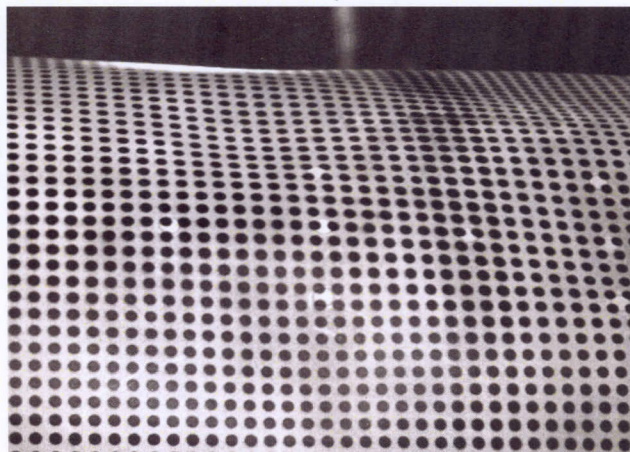
Example Structure "Stencil/Spray Technique"



Spray stencil



Spray stencil in practical use



Point pattern created with the stencil/spray technique

### C 3 Creating a New Project

In order to analyze the material deformations of an object, many camera images of various deformation stages are required. As all data collected during a measurement is automatically stored in a measurement project, you first need to create a **New 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**, ARAMIS directory structure). It is defined together with the project name.

How you create a project you will find in the Online Help (key F1).

#### C 3.1 2D, 3D Project

ARAMIS distinguishes between 2D and 3D measuring projects.

If you have a sensor unit with two cameras, normally only a 3D project is reasonable.

For the special case you have very small specimens (< 3 mm), perhaps a 2D measuring project may be suitable.

In this case, these specimen dimensions may result in large camera angles. A 3D point based on image data can only be computed if this point is visible for both cameras! This is not always the case for distinct specimen geometries.

In order to get information about displacements in a 2D project, it is necessary to define in the 2D parameters the 2D scaling (line distance) as substitute for the scale bar information.

#### C 3.2 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 (key F1).

#### C 3.3 Project Parameters

The project parameters define important parameters of a project. Normally, the default settings are sufficient but may be changed depending on the task. Parameters that are changed using **Project ► Project Parameter** only take effect on the current project.

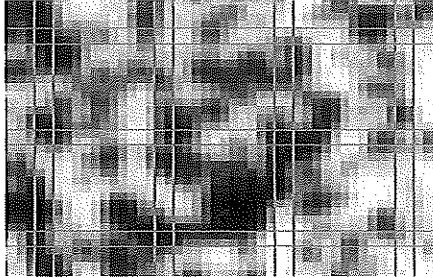
Do not change the settings of these menus if you do not have any background knowledge!

For standard measuring projects, use the default settings of the project parameters.

**Info**

### C 3.3.1 Facet Parameters

ARAMIS observes the deformation of the specimen through the images by means of various square or rectangular facets. The following figure shows the ARAMIS default settings, 15x15 pixel facets with a facet step of 13 pixels (corresponds to a 2 pixel overlapping area).



From each valid facet, a measuring point results after computation. For further information, please refer to **Chapter D**.

### C 3.3.2 Strain

For strain computation, ARAMIS distinguishes between two methods, **Linear strain** and **Spline strain** computation.

In ARAMIS measuring projects, normally only **Linear strain** computation is used. The default parameters of linear strain are **Computation size 3** and **Validity quote 55%**.

For the exception you would like to analyze your specimen in areas of small curvature radii, the **Spline strain** computation method is available (expert function!).

For further information, please refer to **Chapter D**.

### C 3.3.3 Stage Data

If required, you may define here additional stage information (like information about time and force) which will then be displayed in the explorer under stage data or are included in a report.

### C 3.3.4 Automatic Start Point

A start point is the facet with which the computation process is started. The function **Auto Start Point** is used for a project running automatically. Normally, the start point is defined later (e.g. after the measuring images are recorded).

## C 3.4 Stage Parameters

In the stage parameters, you determine a template containing the parameter constellation for processing your project. The factory pre-adjusted default templates are **Standard**, **Fast** and **High Accuracy**.

You also may determine the parameters yourself:

- Computation method
- Accuracy
- Iteration limit
- Pixel thinning
- Graylevel check

For more information see the Online Help (key F1).



### C 3.5 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 3.6 and Online Help) and start the actual measurement using the start button.

### C 3.6 Adjusting the Shutter Time, Specimen Lighting

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

ARAMIS does not have any special requirements for the ambient light. The light source (specimen lighting or daylight) should illuminate the specimen equally, and the available light intensity should be sufficient for overexposing the camera images with a longer shutter time. Specimen lighting with polarization filters should be set to minimum intensity of shiny points.

The maximum and minimum possible shutter time depends on the cameras connected and on the speed with which the specimen to be measured moves.

### C 3.7 Standard Recording Modes

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

#### C 3.7.1 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 (e.g. for force and distance information) can also be recorded.

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

This mode is limited to one image per second.

For further information, please refer to the Online Help (key F1).

#### C 3.7.2 Fast Measurement (Main Memory)

In this mode, a temporal equidistant sequence of images is recorded the maximum number of which you may define. The images are saved directly in the PC.

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 maximum possible frame rate depends on the ARAMIS sensor (cameras) and the PC:

ARAMIS 4M (max. image resolution)	max. 55 image/s (19" PC)
ARAMIS 5M (max. image resolution)	max. 15 image/s (19" PC) max. 7 image/s (laptop)
ARAMIS HS (max. image resolution)	max. 40 image/s (19" PC)

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. For further information, please refer to the Online Help (key F1).

## C 4 Advanced Measuring Methods

### C 4.1 Sensor Controller

#### C 4.1.1 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, laser pointers and specimen lighting.

#### C 4.1.2 Function

Depending on the signal which should start image recording, the sensor controller provides different trigger inputs (e.g. for TTL signals, analog signals, pushbutton, photoelectric sensor).

According to the selected mode, a switching operation which is coupled to image recording is released in the sensor controller, e.g. in case a certain voltage is exceeded.

For further information, please refer to the [ARAMIS User Information – Hardware](#).

### C 4.2 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 8 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 4.3 Additional Recording Modes

#### C 4.3.1 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 (key F1).

### C 4.3.2 Fast Measurement FG-Board Memory (For ARAMIS HS Systems Only)

In case of a fast measurement, a sequence of many images is recorded the number of which you may define. In this mode, you achieve the highest possible frame rate.

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.

As the images are first stored in the frame grabber boards (FG-Board Memory), the maximum recording speed is limited by the maximum frame rate of the cameras, and the max. number of images is limited by the RAM range of the frame grabber boards.

In this mode, frame rates of 500 full frames/s are possible and with reduced camera resolution (1/4, 1/8, 1/16) up to max. 8000 images/s.

The sensor controller releases the start pulse for image recording equidistant in time 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 (key F1).

## C 5 Measuring For Experts

### C 5.1 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 [User Manual – Trigger Lists](#).

### C 5.2 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 (key F1).

## C 6 Summary

- Selecting the measuring volume
- Preparing the specimen
- Spraying stochastic patterns
- Creating a new project
- Project keywords
- Project parameters
- Facet parameters
- Strain computation
- 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



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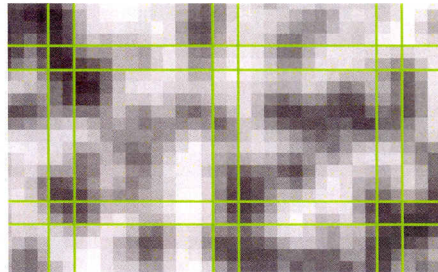
## D Computation

In the previous chapters, we already described the typical measuring procedure for an ARAMIS project (preparation of the specimen, creating a measuring project with default project parameters up to recording the series of images).

This chapter now extends the basic knowledge with respect to the most important project parameters which you also may adapt in the project mode of the software after having recorded an image series, explains the strain computation, and shows corresponding 3D representations.

### D 1 Facets (Project Parameter)

ARAMIS observes the deformation of the specimen through the images by means of various square or rectangular facets. The following figure shows 15x15 pixel facets with a facet step of 13 pixels (corresponds to a 2 pixel overlapping area, default setting).



**Info**

From each valid facet, a measuring point results after computation. Therefore, the adjustment parameters of the facets are important for strain computation and visualization.

#### D 1.1 Facet Size, Facet Step

The default facet (15 x 15 pixels) is a compromise between accuracy and computation time. For normal deformation projects, you should aim for this size and, if possible, adapt the surface pattern accordingly. This means, the typical stochastic pattern structure should clearly result within the facet.

You may of course deviate from the default settings if, for example, your surface pattern or the measuring test requires it. For facet dimensioning, the following factual relations apply:

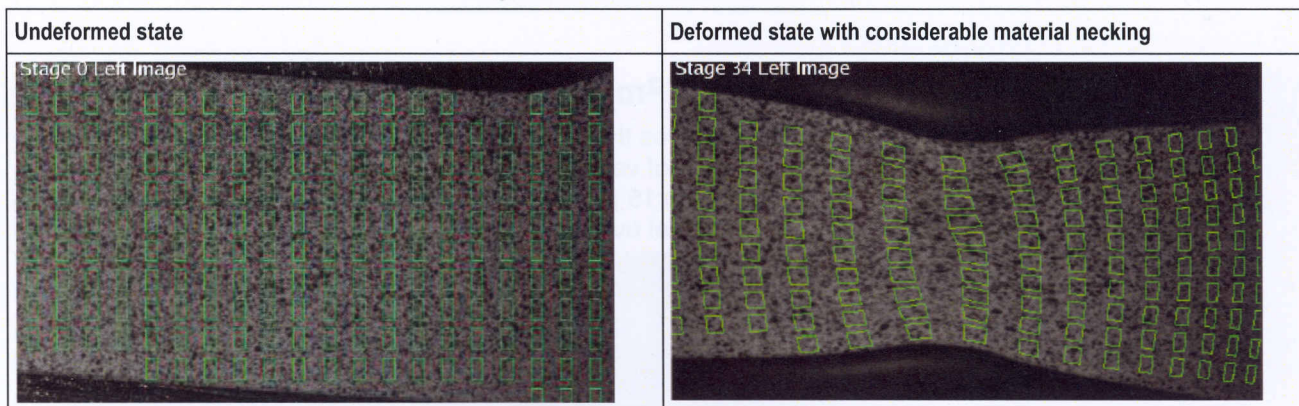
<b>The facet size is larger than the default value</b>	<ul style="list-style-type: none"> <li>▪ The accuracy of the resulting measuring point improves.</li> <li>▪ The computation requires more time.</li> <li>▪ Local effects within the facet size cannot be captured.</li> </ul>
<b>The facet size is smaller than the default value</b>	<ul style="list-style-type: none"> <li>▪ The accuracy of the resulting measuring point decreases.</li> <li>▪ The computation requires less time.</li> <li>▪ Local effects can be captured better.</li> </ul>
<b>The facet step is smaller than the default value</b>	<ul style="list-style-type: none"> <li>▪ The measuring point density increases.</li> <li>▪ The computation requires more time.</li> <li>▪ Overlapping areas up to 50% are still suitable for representing the measuring results.</li> </ul>
<b>The facet step is larger than the default value</b>	<ul style="list-style-type: none"> <li>▪ The measuring point density decreases.</li> <li>▪ The computation requires less time.</li> </ul>

### D 1.2 Facet Shapes

The facet shape (square, rectangular, quadrangular) influences the computability of the measuring project. Square and rectangular facets in the reference stage are always aligned according to the x-y orientation of the 2D image.

#### D 1.2.1 Rectangular Facets

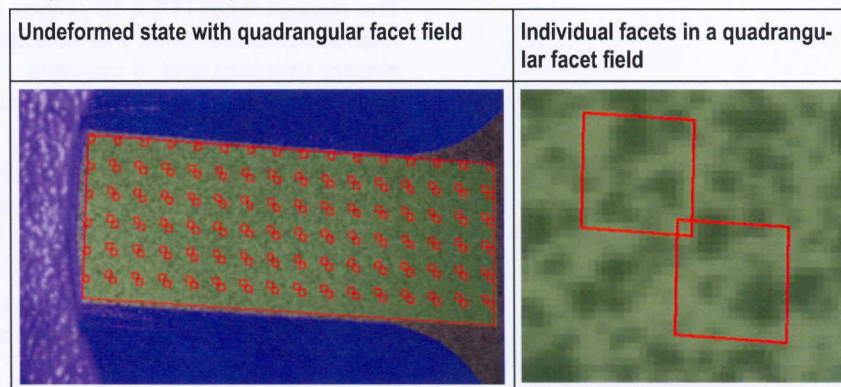
For strain measurements where the specimen is subject to high levels of strain, use rectangular facets according to the figure below in order to get evaluable facet fields.



#### D 1.2.2 Quadrangular Facets

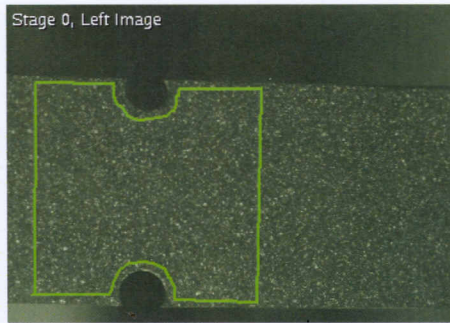
If, in case of quadrangular specimens you would like to create valid facets up to the edge, you may create a facet field manually which follows the specimen's geometry. The individual facets result within this field. The x-y orientation is based on this field as well.

As computation here is only done within the facet field, it is not necessary to mask the specimen.

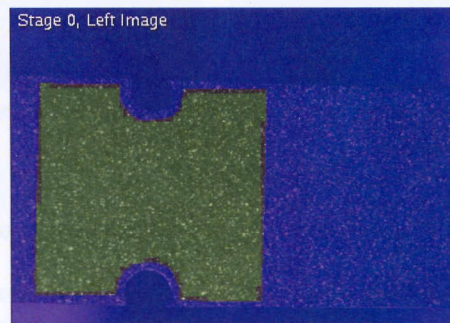


## D 2 Computation Masks

Computation masks allow the software to carry out facet computations in defined areas of the 2D camera images only. To define computation masks, the software provides extensive tools.



Computation mask during definition



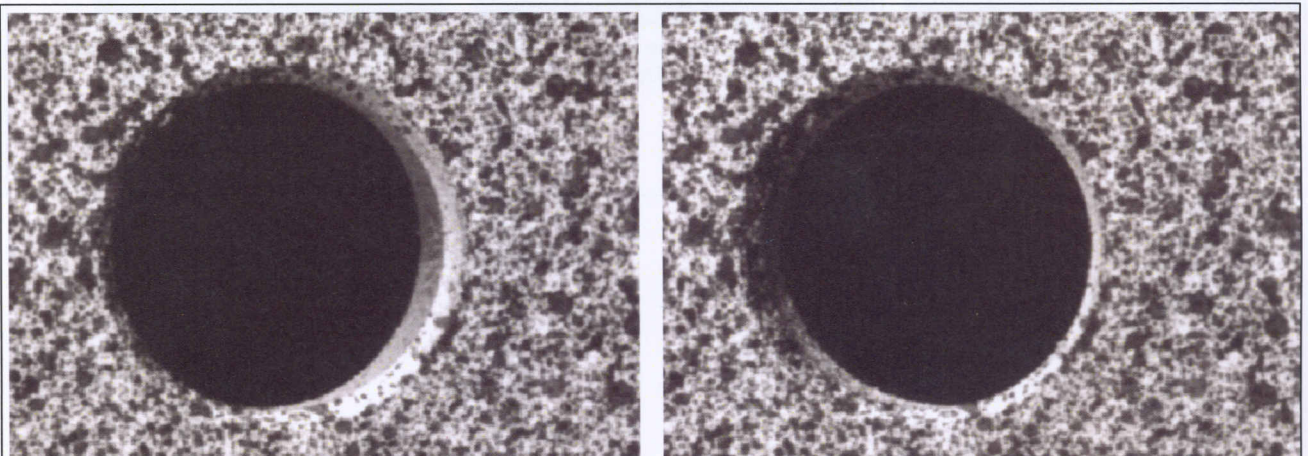
Finished computation mask (only the green area will be computed)

**Info**

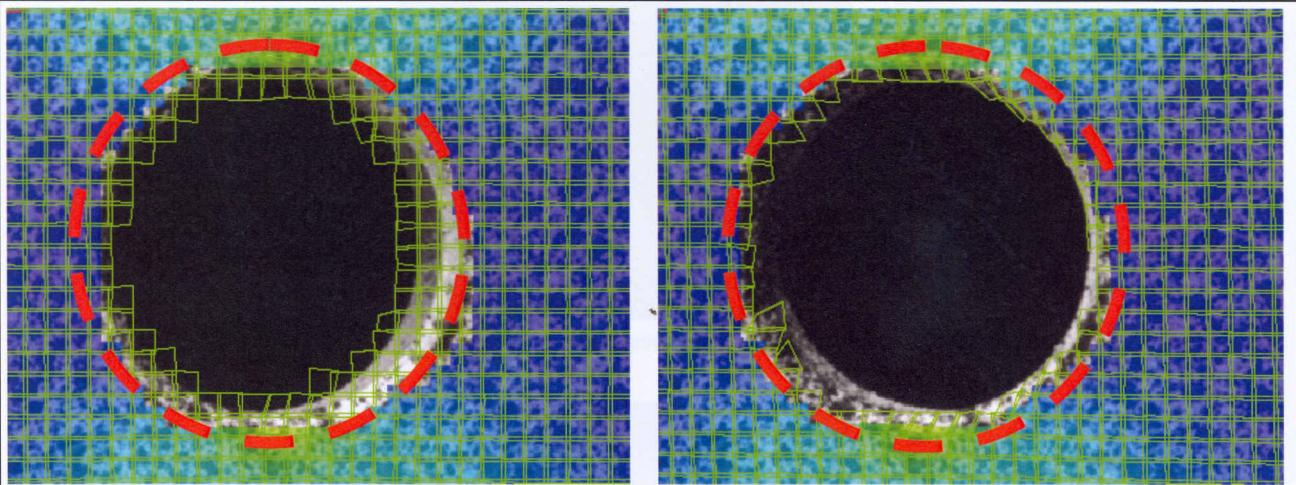
Only areas on a specimen that are relevant for deformation shall be calculated. Thus, for example, fixtures, backgrounds, specimen edges and contour jumps are not included in the computation.

As the 3D computation of the measuring points is based on facets that need to be seen from the right and left camera with the individual facet pattern, a correct 3D computation and strain computation is not possible for specimen edges and contour jumps in specimens!

The following measuring images explain this fact (tensile test specimen with circular hole):



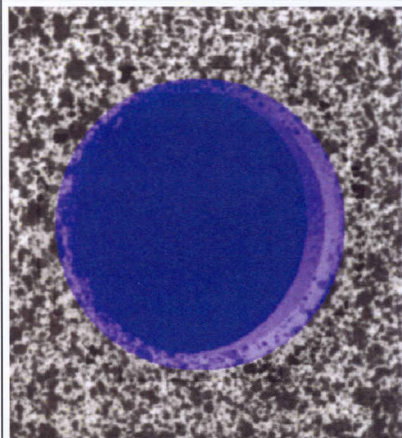
The images show a tensile test specimen with a hole in stage 1 of a strain measuring project, seen from the left and right camera. While the surface pattern almost looks the same, considerable differences result at the hole edges due to the different camera locations.



The image shows the same example as above but in an already computed state. 3D overlapping and facets are set visible, and no computation mask was defined.

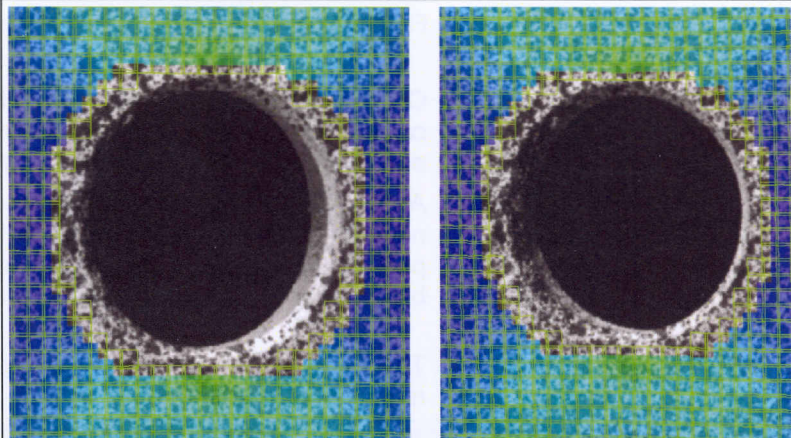
The example shows the facet problem in the edge region of the hole. Although measures are already effective that only permit facets with the same information content of the right and left image, it is impossible for the software to decide between strain and perspective view of the cameras (facets with homogeneous content, e.g. only white or black, are generally not used).

The red framed area shows strain which cannot be computed correctly because of the mentioned problems.



The image shows a tensile test specimen with hole and a computation mask.

In the blue area, facets will not be computed.



The image shows the same specimen but prior to computation a computation mask was defined. This excludes the facet problems in the edge region.

### D 3 Define Start Point (Project Mode)

For facet computation, all stages require the definition of a start point. Generally, the start point refers to the same facet in all stages. However, it is possible to work with different start points in one measuring project, for example, if after computation it turns out that for some stages ARAMIS could not calculate any facets.

If a specimen breaks apart and if you want to record the deformation in the fragments as well, you need to define another start point in the area of the fragments.

A start point is nothing else than a calculated facet.

ARAMIS allows three different methods to create start points:

#### Manual or Semi-Automatic Start Point Creation

With **Add Start Point ► Simple**, you define the start point semi-automatically or manually. With this method, the first start point is always defined manually, then you may decide if for the remaining stages the start point shall be created manually or automatically.

This method is particularly recommendable, because you may control the start point definition in all stages.

Define start points only in those areas of a specimen that are subject to the least relative movement within the ARAMIS measuring volume. Thus, you ensure that the semi-automatic start point creation works through all stages.

#### Fully Automatic Start Point Creation

**Auto Start Point** is a fully automatic start point definition process which searches for a start point in the middle of the area to be calculated.

Info

**Auto Start Point** only works correctly if the pattern of the specimen is good and if the stages were recorded without too large deformation steps.

Only use this function in automated measuring processes, e.g. for series measurements of similar specimens.

#### Complex Start Point Creation

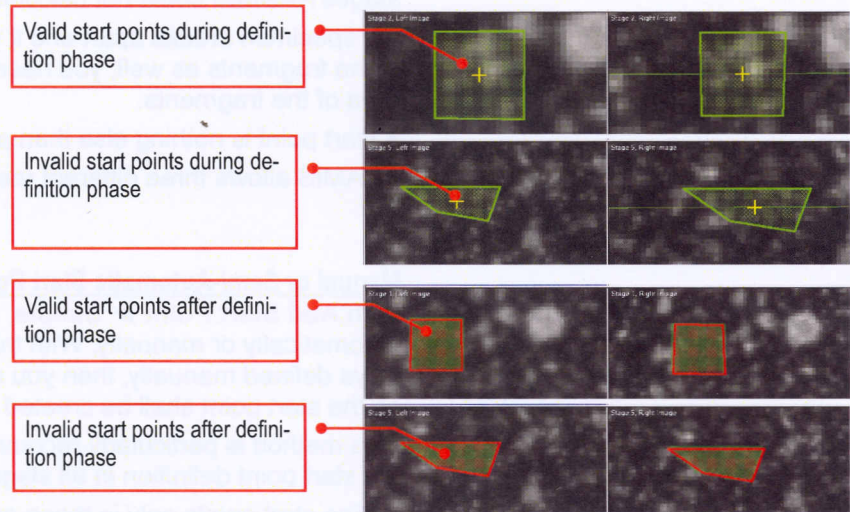
With **Add Start Point ► Complex**, you need to create the start points manually in all images.

For rotating specimens, for example, this is the only possibility to create start points.

### D 3.1 Checking the Start Points

Independent of the definition method you choose, you should check the start points in the images.

The figure shows valid and invalid start points of a project.



### D 3.2 Clicking Start Points

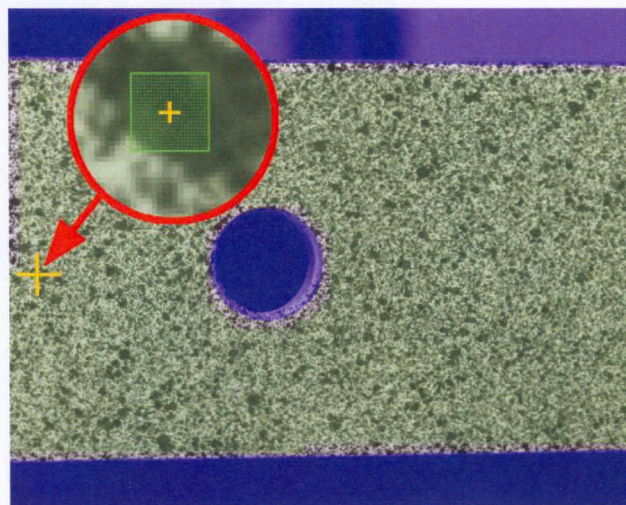
Click the start points in the 2D images with Ctrl and left mouse button.

**Info**

Always click a start point in the left image first and then in the right image!

The following examples are from a tensile test. With this test setup, the smallest relative movement is in the left image area.

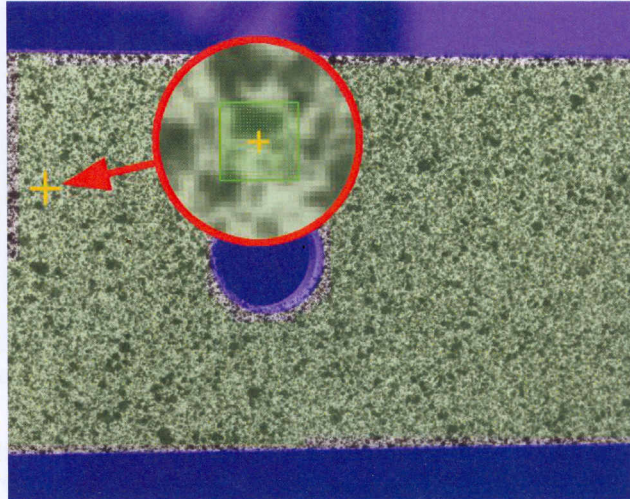
#### Example of a Poor Start Point



The semi-automatic start point creation may fail in the following stages because the facet content shows only little stochastic pattern structure.

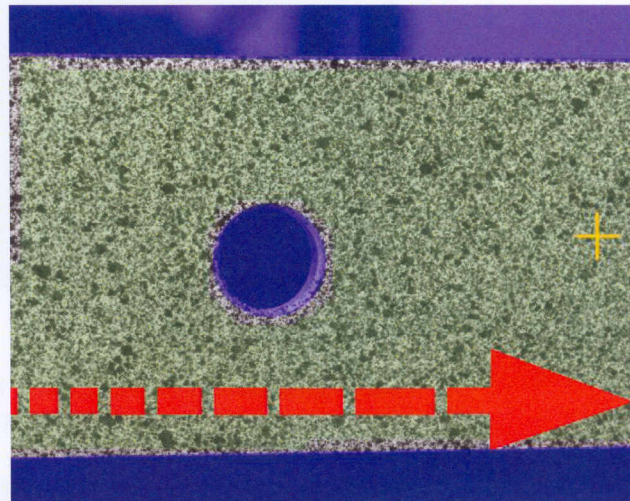


**Example of a Good Start Point**



In the following stages, the semi-automatic start point creation can fall back on a well perceptible stochastic pattern structure.

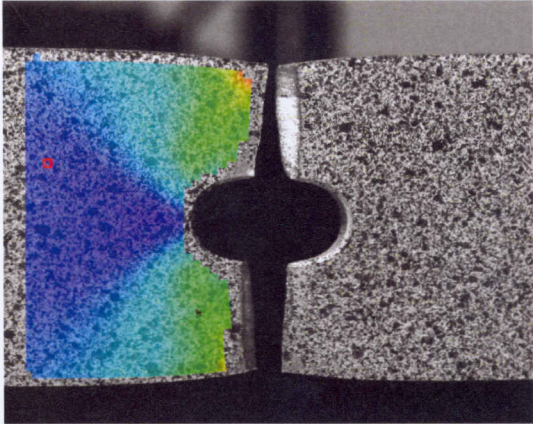
**Example of a Poor Start Point**



As the start point is located in the right-hand image and the relative movement here is the highest, there is a chance that the point will move out of the cameras' view during subsequent images.

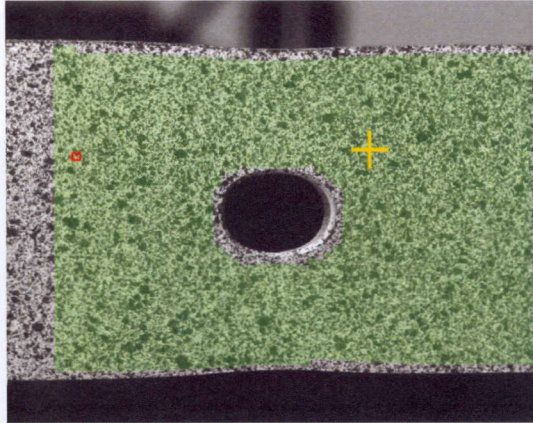
**D 3.3 Start Point Creation For Torn Specimens**

If a specimen tears apart during the test, strain will only be computed on that part of the specimen where the start point is located.



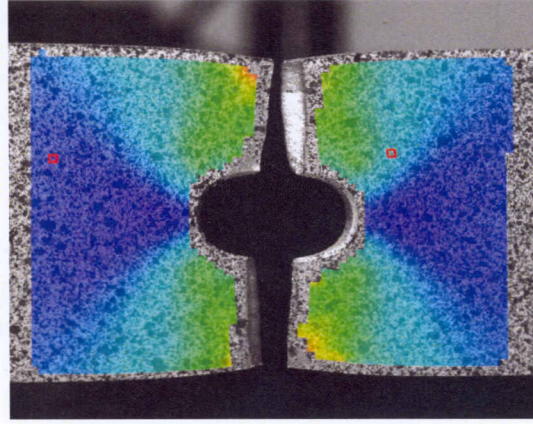
Torn specimen with one-sided strain computation

In order to compute the strain in the torn apart area of the specimen as well, define a second start point (project mode) as of the stage preceding the crack. This procedure optimizes the computation time.



Definition of the second start point

After calculating the project with the second start point, now strain data are also available in the torn apart area.



Torn specimen now with complete strain computation

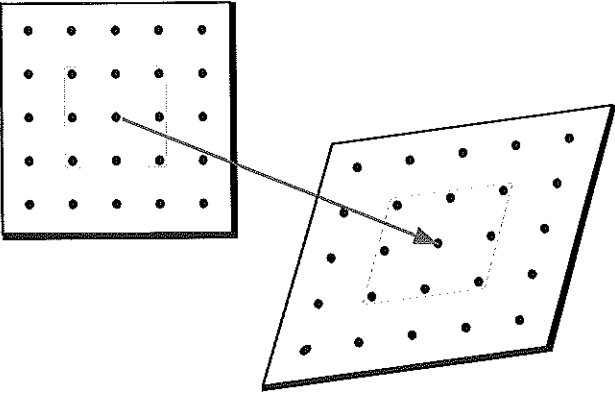
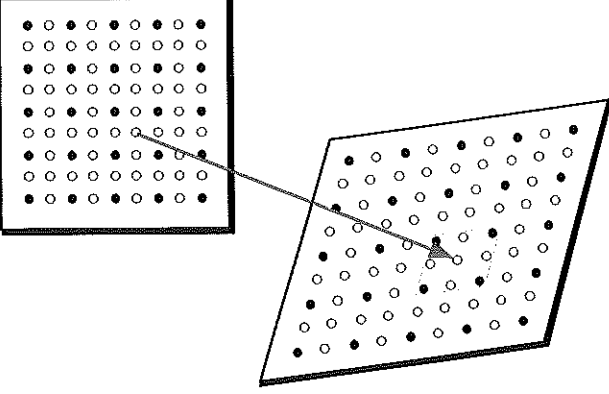
aramis-v6-1\_d\_en\_rev-c 7-Aug-2009

## D 4 Strain Computation

For strain computation, ARAMIS distinguishes between two methods, Linear strain and Spline strain computation. In ARAMIS measuring projects, normally only Linear strain computation is used. For the exception you would like to analyze your specimen in areas of small curvature radii, the Spline strain computation method is available (expert function!).

### D 4.1 Comparison Linear Strain and Spline Strain

The following table shows the practical differences between the computation methods.

Linear strain	Spline strain (expert function)
 <p>Principle of a specimen in the undeformed (left) and deformed (right) state. In this example, we consider the strain for a measuring point (red arrow) together with the surrounding measuring points (blue quadrangle). The strain is computed in connection with the surrounding measuring points which are directly derived from the facets.</p>	 <p>Principle of a specimen in the undeformed (left) and deformed (right) state. The black points are measuring points which are directly derived from the facets. The white points were interpolated from the black points using the spline function. Here, strain computation also considers the interpolated (white) points.</p>
<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>• Fast strain computation</li> <li>• Low measuring noise</li> <li>• Real points are the reference location for the strain</li> <li>• Small deviations of the measuring points from the local plane are compensated.</li> </ul>	<p><b>Advantages:</b></p> <p>Valid strain computation also in case of clear curvature (radii) in the blue quadrangle.</p>
<p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>• No strain computation for curvature radii of the specimen that are smaller or equal to a facet.</li> <li>• <b>Info</b> The surface of the blue quadrangle may only be curved slightly as otherwise the surface strain is falsified (narrow radii → spline strain is required).</li> </ul>	<p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>• Longer computation time (fourfold point amount)</li> <li>• More measuring noise</li> <li>• Interpolated points are the reference location for the strain.</li> </ul>

Linear strain	Spline strain (expert function)
<p><b>Computation parameters</b></p> <p><b>Size:</b> Computation size includes the adjacent points around a point in the strain calculation. The default setting is the lowest possible value 3. This means that a 3x3 field of 3D points is used to calculate the strain value of the center point. This setting is particularly suitable for the assessment of local strain. If you increase this value, the noise decreases and in the marginal area less strain can be calculated.</p> <p><b>Validity quote:</b> If not all adjacent points exist for a calculation, the strain for the center point can be calculated nevertheless. The Validity quote determines how many points have to exist for calculation. A quote of 100% means that all 9 points (for a field of 3x3) must exist. As default setting, use a Validity quote of 55%.</p>	<p><b>Computation parameters</b></p> <p><b>Computation location:</b> Due to the system, the 3D point calculation of ARAMIS is always carried out on the surface of the specimen. However, as e.g. in case of material bendings the strain on the surface, in the middle and on the rear side of the specimen are different, this effect may be compensated if strain values for the middle of the specimen are required.</p> <p><b>Material thickness:</b> Enter the original material thickness for the definition of the computation location.</p>

## D 4.2 Strain Reference

### Info

Please do not confuse the strain reference with the reference stages in the project mode. Reference stages in the project mode only influence start point and facet computation!

Normally (Project Parameter ► Strain ► Strain method ► Total), the strain reference always refers to Stage 0. However, you may set any other stage as strain reference (Evaluation Mode ► Stage ► Set as Strain Reference).

For the special case you only need strain from one stage to the next, e.g. in order to achieve acceleration from strain (only for image series with a defined temporal image sequence), function Project Parameter ► Strain ► Strain method ► Step by step is available.

## D 5 Summary

- Facet size
- Facet step
- Facet shapes
- Computation masks
- Defining start points
- Start points for torn specimens
- Strain computation linear
- Strain computation spline
- Strain reference

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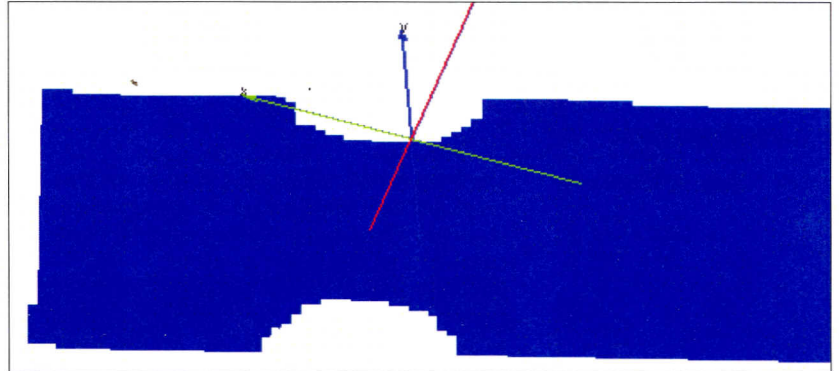
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## E Transformations

### E 1 Why are Transformations Required?

The position of the coordinate system depends on the calibration of the cameras and usually has no logical relation to the specimen.



Specimen in stage 0 with undefined coordinate system

The coordinate system allows for unambiguously describing the position of points in the 3D space by stating three numerical values (X, Y, Z coordinates). The point where all numerical values are 0 is also called the origin of the coordinate system.

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

#### Transform ARAMIS Projects According to Specimen Geometry

Often it is necessary to define the coordinate system based on the geometry of the specimen. So, for example, edges of the specimen or drilled holes are important to define axes or the origin.

#### Transformations of Several ARAMIS Projects

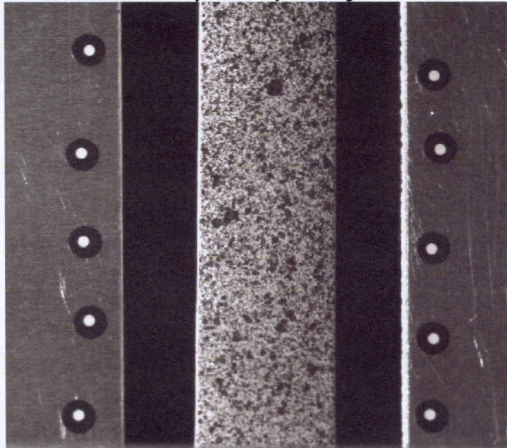
For ARAMIS projects which observe a 3D deformation simultaneously by several ARAMIS sensor units, a transformation by reference points (circular markers) is required. The 3D coordinates of these reference points were previously recorded by the photogrammetric system TRITOP. The ARAMIS sensor units partly recorded the same reference points. In a last step, the measuring data from the different views of the ARAMIS sensor units are transformed into the coordinate system of the TRITOP reference points by means of the best-fit method.

This method is also suitable for static deformation projects in which the static deformations are captured with just one ARAMIS sensor from different positions and are then transformed into the same coordinate system using the common reference points.

#### Transformations of Individual Stages in a Project

If the ARAMIS sensor or the entire test setup moves, a transformation of individual stages by reference points may be useful.

## E 2 Overview of the Transformation Methods

<b>Project transformations:</b>	
<b>3-2-1 Transformation</b>	At least 6 coordinates of 3D points according to the 3-2-1 definition need to be known, e.g. three Z, two Y coordinates and one X coordinate. The direction of the coordinate system can be adjusted as you like.
<b>Best-Fit by Reference Points</b>	If the measuring project contains photogrammetrically recorded reference points (e.g. points recorded by TRITOP), and in the images of the ARAMIS reference stage sufficient (at least 3) reference points were seen, the entire ARAMIS project can be transformed into the coordinate system of the reference points. During measurements, the reference points must not change their position.
<b>Stage transformations:</b>	
<b>Transform Stage by Reference</b>	<p>This is the same function as described above (<b>Best-Fit by Reference Points</b>), with the difference that the transformation refers to a stage. <b>Transform Stage by Reference</b> is only used in special cases. If the specimen has a fixed relation to reference points (frames, bars), all the stages can be transformed into a common coordinate system any time again even if the ARAMIS sensor or the entire test setup moved.</p>  <p>Camera image of a tensile test with reference points</p>
<b>Movement Correction</b>	The movement correction is a stage transformation which is able to eliminate rigid body movements through all project stages without influencing the global coordinate system. If you would like to analyze displacements of a specimen, <b>Movement Correction</b> is useful.

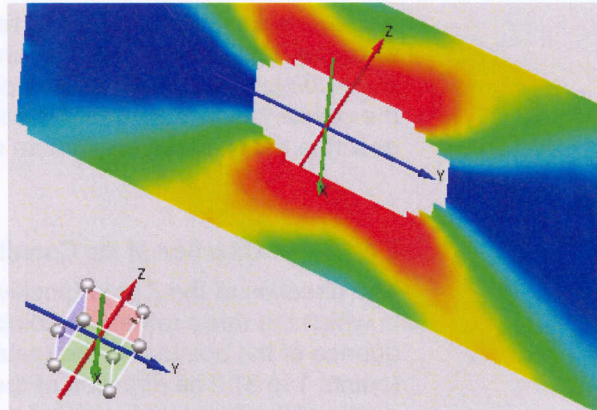
For further information, please refer to the Online Help (key F1).

## E 3 Visualization of the Coordinate System

ARAMIS 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.





Possibilities to display the coordinate system in the 3D view (bottom left corner or in the origin)

### E 3.1 Views in the Software

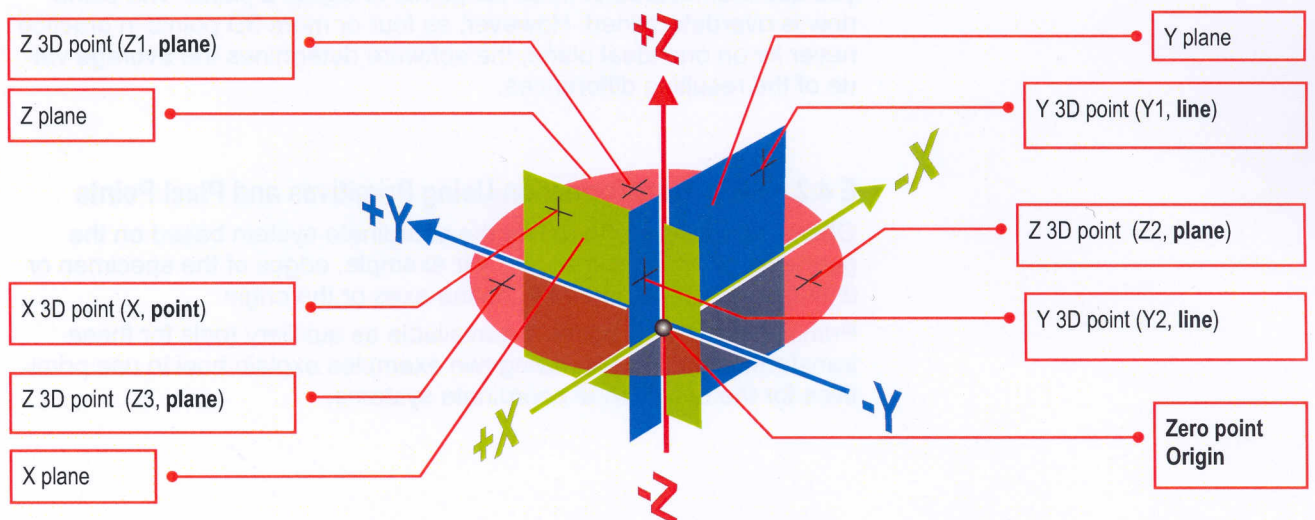
The software offers several views. **View** shows the measuring object from top, bottom, left, right, front and back and **ISO View** displays the measuring object additionally in the respective diagonal views (see also Online Help).

## E 4 Principle of the 3-2-1 Transformation

**3-2-1 Transformation** is one of the mostly used methods. Therefore, we introduce the basics here.

3-2-1 means that three 3D points ( $Z_1, Z_2, Z_3$ , located as far as possible from each other and not in a line) describe a plane, two additional 3D points describe a line ( $Y_1, Y_2$ , 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 ( $Z_1, Z_2, Z_3$ , red plane) define the Z plane. The additional two Y points ( $Y_1, Y_2$ , 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 example shows the factual relations using the minimum number of points required for this transformation method. You may use reference points, pixel points or 3D points. In this case, the points define the coordinate system directly. It is important that the points reliably describe the required coordinate system.

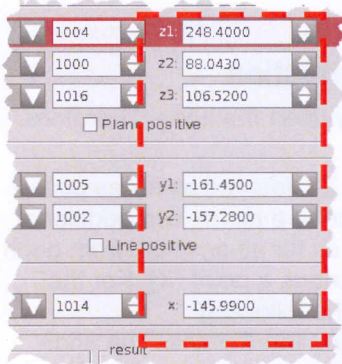
#### E 4.1.1 Direction of the Coordinate Axes

The direction of the Z axis (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 4.1.2 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 4.1.3 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.

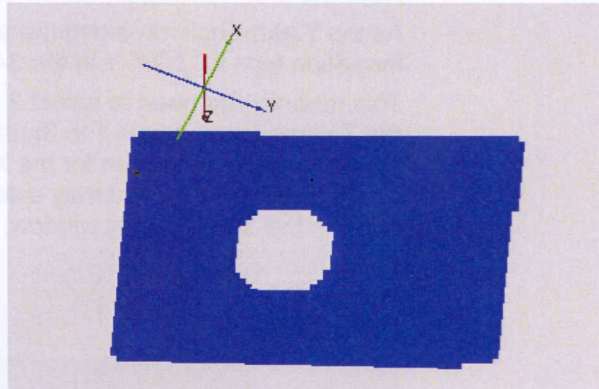
### E 4.2 3-2-1 Transformation Using Primitives and Pixel Points

Often it is necessary to define the coordinate system based on the geometry of the specimen. So, for example, edges of the specimen or drilled holes are important to define axes or the origin.

Primitives and pixel points are available as auxiliary tools for these transformations. The following two examples explain how to use primitives for the definition of coordinate systems.

**E 4.2.1 Transformation Using the Edge of the Specimen**

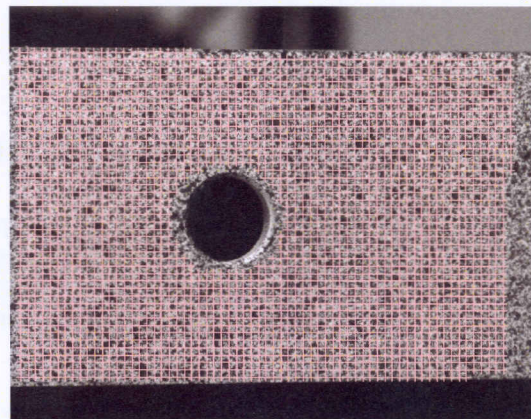
For this specimen, the Y axis shall follow the edge of the specimen.



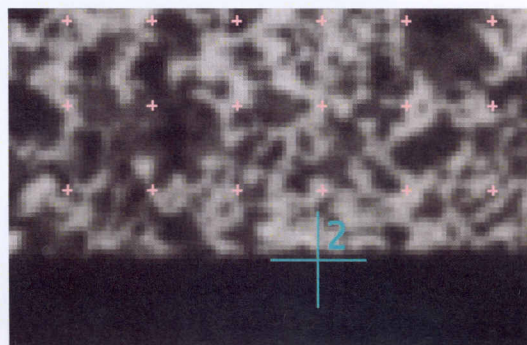
3D view with undefined coordinate system

Before you carry out the actual 3-2-1 transformation, you need to create pixel points in the 2D images based on the specimen edges.

**Pixel points** are 3D points that were created based on image pixels in the 2D images. **Pixel points** can be created in the entire 2D image range. Here, the computation mask has no effect. For creating **Pixel points**, information about the reference plane is required in order to get the 3D positions. You may define the reference plane when creating these points. A reference plane can only be created in areas where facets have been computed. You may create a reference plane automatically or manually. In case of flat specimens, you should define all facets as reference plane (manual creation).



2D camera view with selected reference plane

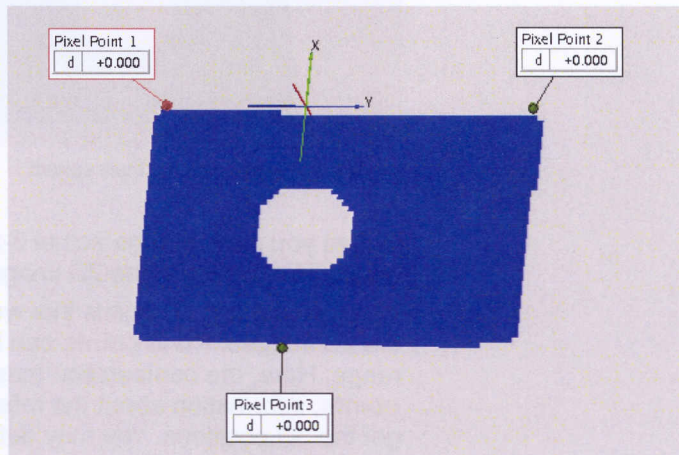


Pixel point at the edge of the specimen during definition

Now, the **3-2-1 Transformation** can be started.

As the Y axis shall run along the edge of the specimen, select transformation type **ZZZ-XX-Y** in the 3-2-1 dialog.

This means, you need to select 3 points on the specimen's surface for the Z plane (pixel points 1 to 3), the two points (pixel points 1 and 2) of the edge of the specimen for the X line and any point for Y (in this example pixel point 3). You may select the corresponding pixel points directly in the 3-2-1- dialog window.



Y axis along the edge of the specimen

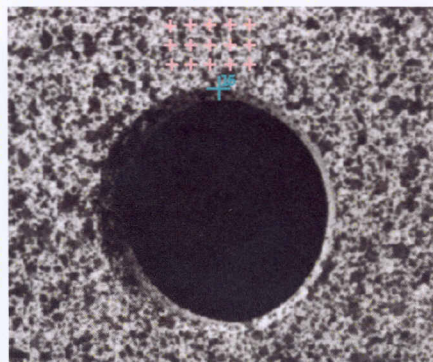
At the end, the coordinate system is positioned along the edge of the specimen.

#### E 4.2.2 Transformation Using the Edge of the Specimen and Circular Hole

If, in addition to the edge of the specimen, a circular hole is available, the coordinate system may be aligned along the edge and at the same time with respect to the circular hole. Using this example, we will show how you may create primitives for transformation.

##### Step 1:

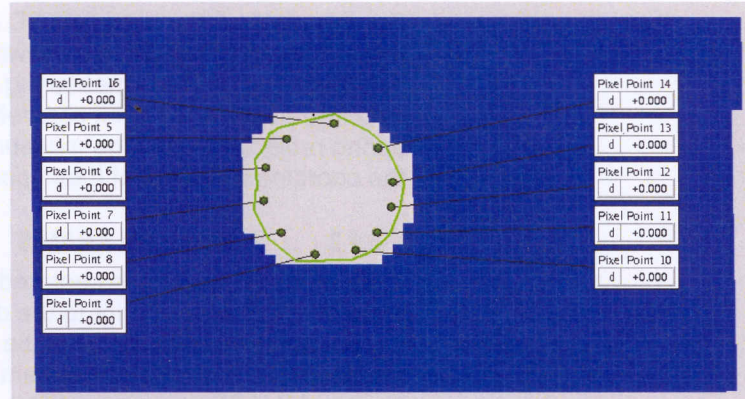
Click the pixel points on the edge of the hole and select the reference plane (**Manual plane** or **Best-fit plane**).



Pixel point with support plane during definition

**Step 2:**

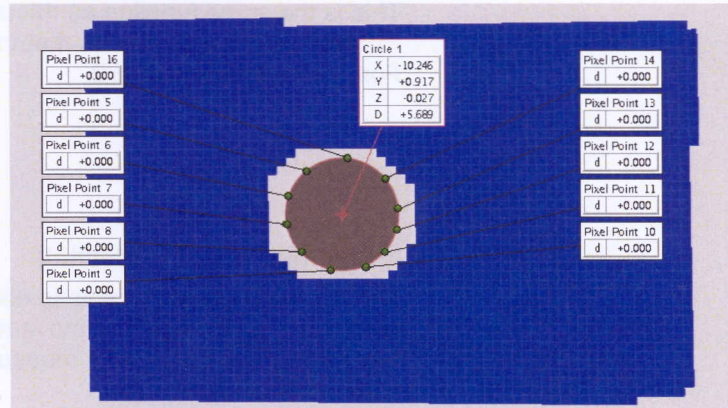
Select the corresponding points in the 3D view with the selection tool **Select on Surface** (Ctrl and space key).



Pixel points with selection lasso in the 3D view

**Step 3:**

Now, you can create a circle through the selected pixel points using **Primitives** ► **Circle** ► **Best-Fit Circle**.



Best-fit view in the 3D view

You may use the **Best-Fit Circle** now for 3-2-1 transformation.

## E 5 Other Transformation Methods

### E 5.1 Best-Fit by Reference Points

#### E 5.1.1 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 5.1.2 Procedure in ARAMIS

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 specimen's coordinate system in a reference point file. Load this file into ARAMIS using menu item **Best-Fit by Ref. Points** and thus transform your project into the correct TRITOP coordinate system.

### E 5.2 Transform Stage by Reference

This is the same function as described above (**Best-Fit by Reference Points**), with the difference that the transformation refers to a stage. For practical hints see E 2.

### E 5.3 Movement Correction

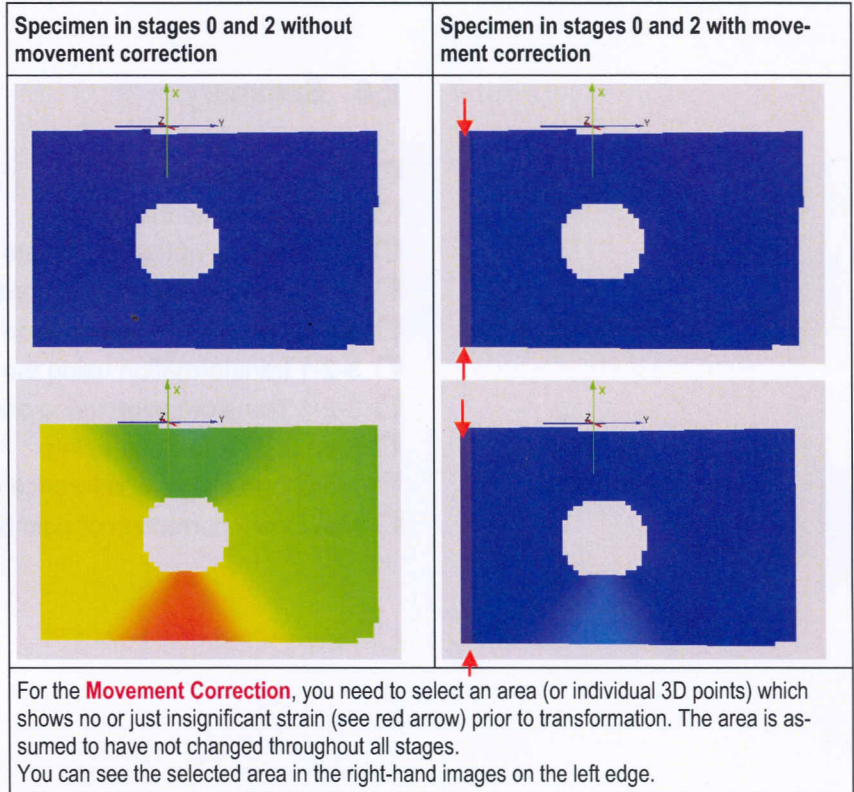
The ARAMIS system is able to eliminate unwanted rigid body movements in a specimen. The movement correction is a stage transformation through all stages of a measuring project without influencing the global coordinate system.

If, for example, you would like to analyze displacements in a specimen, **Movement Correction** is useful.

If you would like to record a movie without the specimen jumping back and forth, then **Movement Correction** can also be useful.

You may reset the movement correction any time (**Reset Stage Transformation**).

The following example shows the X displacement of a specimen in stages 0 (reference) and 2 with and without **Movement Correction**.



## E 6 Summary

- Why transformations
- Transformation methods
- Visualization of the coordinate system
- Principle of the 3-2-1 transformation
- Basics of 3-2-1 transformation
- 3-2-1 transformation using the specimen edge
- 3-2-1 Transformation using primitives
- Best-fit by reference points
- Transform stage by reference
- Movement correction of rigid body movements



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## F Creating and Editing Results

After strain computation, the data are available as color 2D or 3D view in each stage.

Before you edit the results, you need to select the correct 3D result representation. You may select from a variety of visualizations and compile the most important in a pull-down menu.

### F 1 Overview of the 3D Result Representations


Visualization:	Category:	Visualization:	Category:
Distance FLC	Strain	Yield Stress	Stress
Mises Strain	Strain	Major Strain	Strain
Tresca Strain	Strain	Minor Strain	Strain
Thickness Reduction	Strain	Surface	Surface
diff. Mises Strain	diff. Strain	Difference Radial	Displacement
diff. Tresca Strain	diff. Strain	Difference Radial Angle	Angle
diff. Thickness Reduction	diff. Strain	Radius	Displacement
diff. Epsilon X	diff. Strain	Shear Angle	Angle
diff. Epsilon XY	diff. Angle	Sigma 1	Stress
diff. Epsilon Y	diff. Strain	Sigma 2	Stress
diff. Major Strain	diff. Strain	Sigma X	Stress
diff. Minor Strain	diff. Strain	Sigma Y	Stress
diff. Difference Radial	diff. Displacement	Sigma Z	Stress
diff. Difference Radial Angle	diff. Angle	Displacement E	Displacement
diff. Shear Angle	diff. Angle	Displacement X	Displacement
diff. Displacement E	diff. Displacement	Displacement Y	Displacement
diff. Displacement X	diff. Displacement	Displacement Z	Displacement
diff. Displacement Y	diff. Displacement	Visualization 0	User-Defined
diff. Displacement Z	diff. Displacement	...	User-Defined
Epsilon X	Strain	Visualization 9	User-Defined
Epsilon XY	Angle	Z on XYZ	Displacement
Epsilon Y	Strain		

The result representations of strain can be visualized as Technical, Logarithm or according to Green.

Software tools for post processing allow for filtering or interpolating these result data, if required.


For the result representation in diagrams or as labels in the 3D view, you may create stage points, sections (plane sections, circular sections, spline sections) or primitives. The created elements follow the 3D points in each stage. For additional considerations, analysis elements are available for distances and angles.

## F 2 Info Points, Stage Points

**Info points**  are individually definable points in the 3D view of the specimen. The info point is used for getting fast and temporary information. Clicking with Ctrl and left mouse button in the 2D camera image or in the 3D view creates an **info point**. **Info Points** may be defined on the surface of the specimen (facet center points) or on sections.

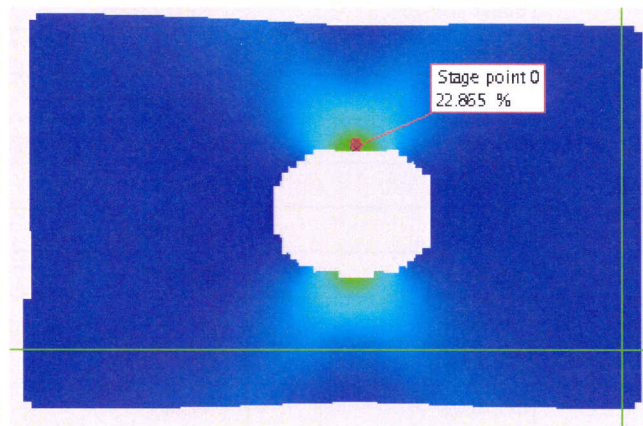
### Info

You may create just one **Info Point** in a measuring project. Only one info point is shown in the 3D view and in the 2D camera image.

You may set an **Info Point**  as a **Stage Point** any time, the coordinates and computation results of which may now be evaluated. Thus, it is possible to create e.g. a point behavior diagram over all stages.

Defined **Stage Points** and the **Info Point**  will be highlighted by color and listed in tab **Stage Points**  in the **sub-explorer**.

The following figure shows a stage point in a tensile test.



Stage point with visible text label and display of the major strain

The text label was set visible with **Edit Properties** and the default label template **Value** was chosen.

## F 3 Sections

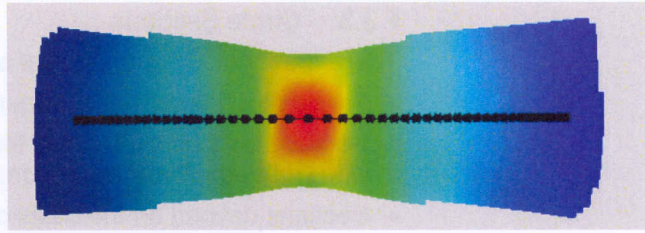
ARAMIS provides for cutting the computed 3D data. This function allows for creating plane sections, circular sections and spline sections in all stages of the specimen.

You may create several parallel sections in one process.

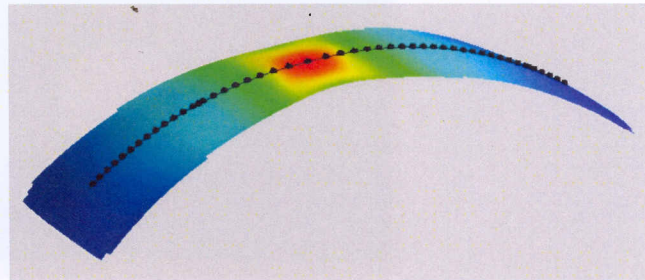
Defined sections will be highlighted by color and listed in tab **Sections**  in the **sub-explorer**.

### F 3.1 Plane Sections

There are two types of plane sections, free defined ones and sections according to the XYZ planes of the coordinate system.



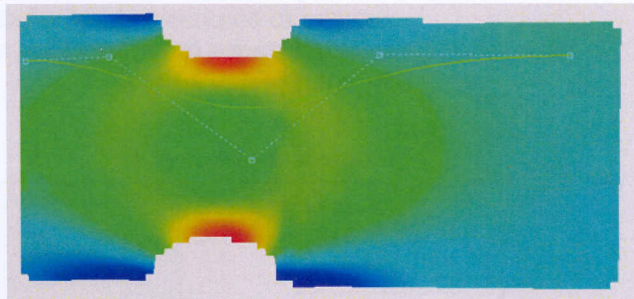
Direct view of a specimen's section



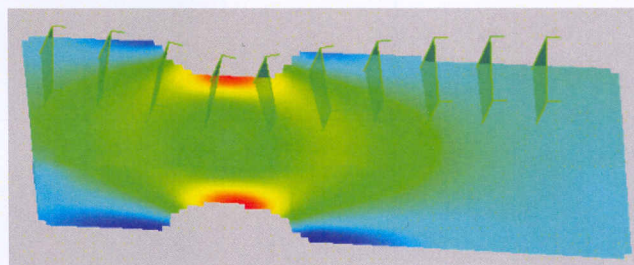
Perspective view of a section

### F 3.2 Spline Sections

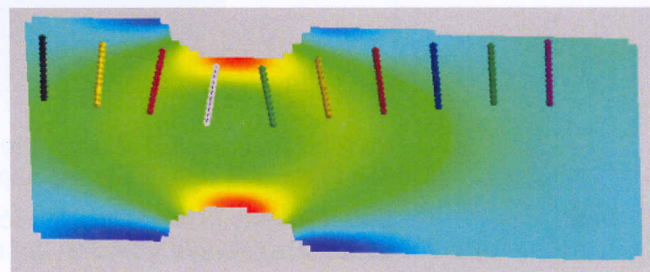
The section planes based on the spline curve always result perpendicular to the screen view.



Selected points in the 3D object and the resulting curve during definition



Cutting planes along the curve during definition

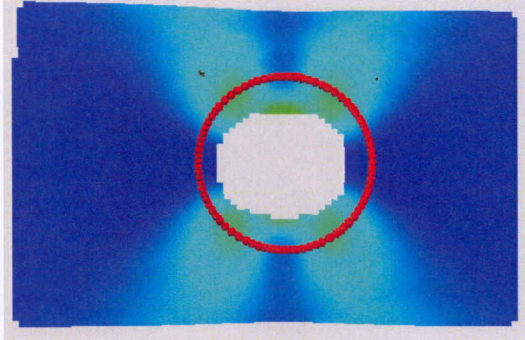


Final sections

### F 3.3 Circle Sections

There are three types of circular sections:

- Free defined ones in the screen view.
- Sections defined by 3 points that are directly clicked in the 3D view with Ctrl and left mouse button.
- Sections defined on the basis of primitives.

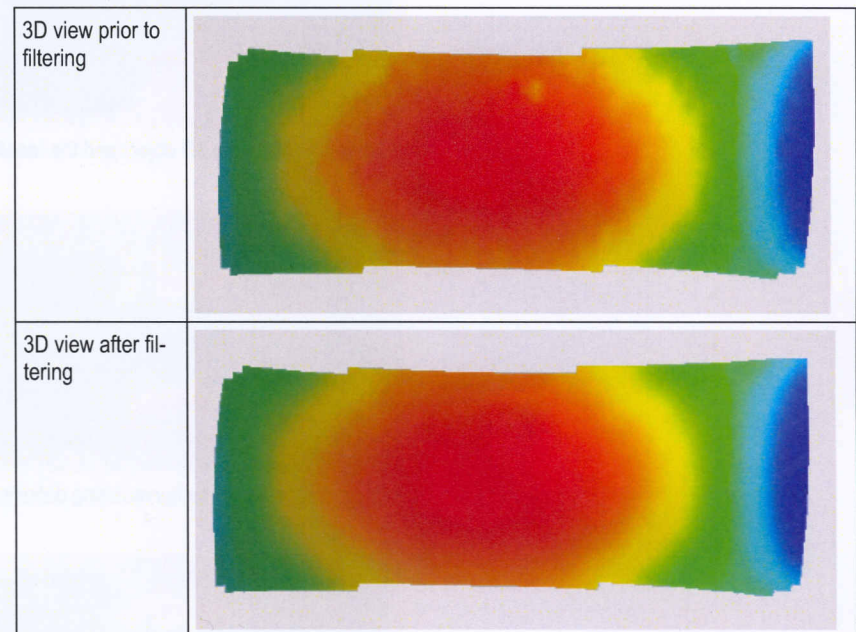


Circular section

### F 4 Filtering

You may filter result data in order, for example, to suppress possible noise or to emphasize local effects. The filter function may be used for selected stages or for all stages and additionally for selected areas or for not selected areas.

Example for filtering:

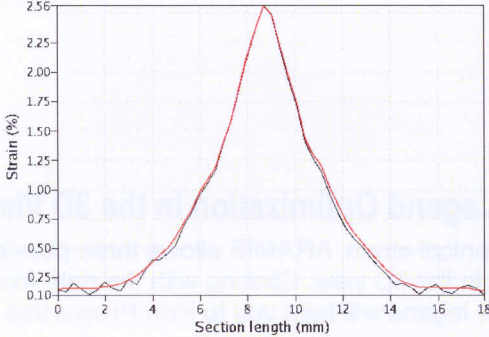
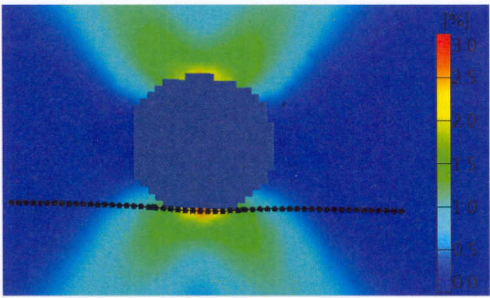


No filter function will change the coordinates of the 3D points. Function **Filter** only influences the result data.

**Info**

**Filtering** may deteriorate the accuracy of an individual point as the filter function always works on the entire surface.

### F 4.1 Filter Parameters

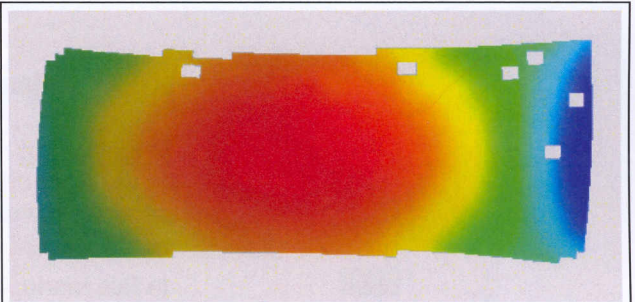
Parameters:		Brief Description:
Filter type	<b>Average</b>	The statistic average is calculated.
	<b>Median</b>	The central value is calculated (the values are sorted by size and the value in the middle is used).
	<b>Gradient</b>	<p>This filter type corresponds to the filter type <b>Average</b> as long as no point in the amount of points is outside the adjusted gradient value. The gradient value determines the max. admissible slope between two grid points at which filtering still is allowed.</p> <p>As the function of the filter is not always clearly visible in the 3D view, the following example shows a section. The black line in the diagram is the non-filtered state, the red line is the filtered one. Here, you clearly see that areas above the max. gradient were not filtered.</p>  
<b>Runs</b>	Number of runs for the adjusted filter parameters. If the value is 0, no filtering is performed.	
<b>Size</b>	Number of grid points for filter computation, e.g. <b>3</b> means that the center point of a 3x3 grid is filtered. The filter function is based on the adjacent grid points.	
<b>Max. gradient</b>	Only active with filter type <b>Gradient</b> , see filter type <b>Gradient</b> . The required value depends on the specimen. If the value is 0, no filtering is performed.	
<b>Filter quote</b>	Input of the validity quota of grid points in %. If, for example, <b>Size 3</b> and <b>Filter quote 50%</b> is adjusted, at least 50% of the grid points must be present in the 3x3 grid in order to be filtered.	
<b>Behavior</b>	Depending on the selected <b>Filter quote</b> , a grid point is deleted or not filtered. Accordingly, select <b>Remove</b> or <b>No filter</b> .	

### F 5 Interpolating 3D Points

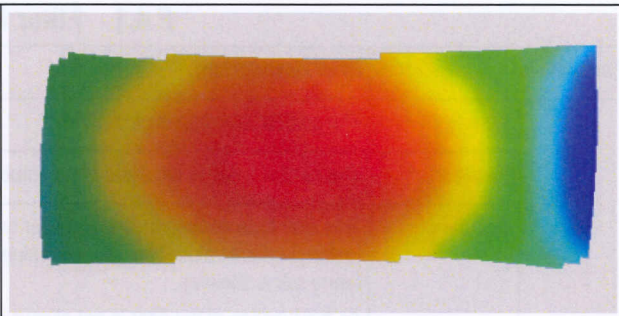
If your result representation has holes because, for example, the spray pattern failed at a point, you may fill these holes by means of interpolation.

In the interpolation parameters, you may adjust the maximum size of the hole to be filled.

3D view prior to interpolation:



3D view after interpolation:



## F 6 Legend Optimization in the 3D View

For technical strain, ARAMIS allows three possibilities for the legend scaling in the 3D view. Clicking with the right mouse button (RMB) onto the legend will lead you to **Edit Properties**.

### F 6.1 Fixed Legends With Manual Maximum and Minimum

**Prerequisite:**

**Scaling** ► **Min/Max.** ► **Manually** is selected in the **Properties!**

**Advantages/Disadvantages:**

In case of fixed limits and high strain, small strain cannot be made visible.

### F 6.2 Automatic Scaling Without Constraints

**Prerequisite:**

In the **Properties** for legends **Scaling** ► **Min/Max.** ► **Automatic** is selected!

**Advantages/Disadvantages:**

If no strain or just small strain amounts occur, the very small measuring noise of the system is displayed in the 3D view and in the diagrams although these values are very low.

### F 6.3 Automatic Scaling With Constraints

**Prerequisite:**

In the **Properties** for legends **Scaling** ► **Min/Max.** ► **Constraints** is selected! When clicking on **Constraints on** or **Constraints off** you reach menu **Legend Constraints**.

**Info**

In this menu **Automatic** must not be selected for both, minimum and maximum!



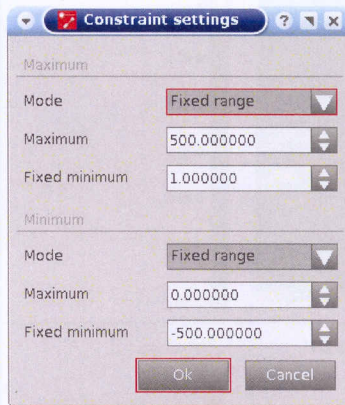
**Advantages/Disadvantages:**

Using this function, you may restrict the automatic scaling. The individual functions can be adjusted independently for the upper and lower part of the legend (**Maximum**, **Minimum**).

For example, it is possible to set the lower legend range to a fixed value (mode **Fixed value**), while the upper range is scaled automatically (mode **Auto scaling**).

The mode **Fixed range** only allows automatic scaling within a fixed range.

In the following example, automatic scaling will be carried out in the lower range from 0 to -500 and in the upper range from 1 to 500 (strain in %).



Info

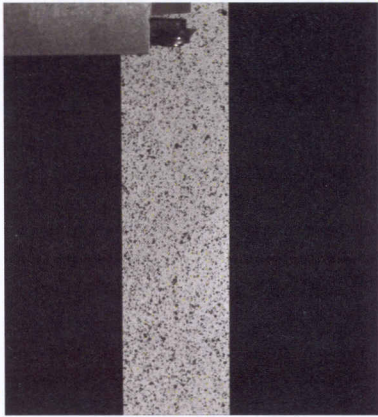
That is, if the value range is between 0 and 1%, the scaling always is from 0 to 1%. If, however, the strain values exceed 1%, the upper limit is scaled automatically based on the largest measuring value. If the smallest value falls below 0%, the lower limit as well is scaled automatically.

These settings were taken as ARAMIS default settings for strain and proved successful for technical strain.

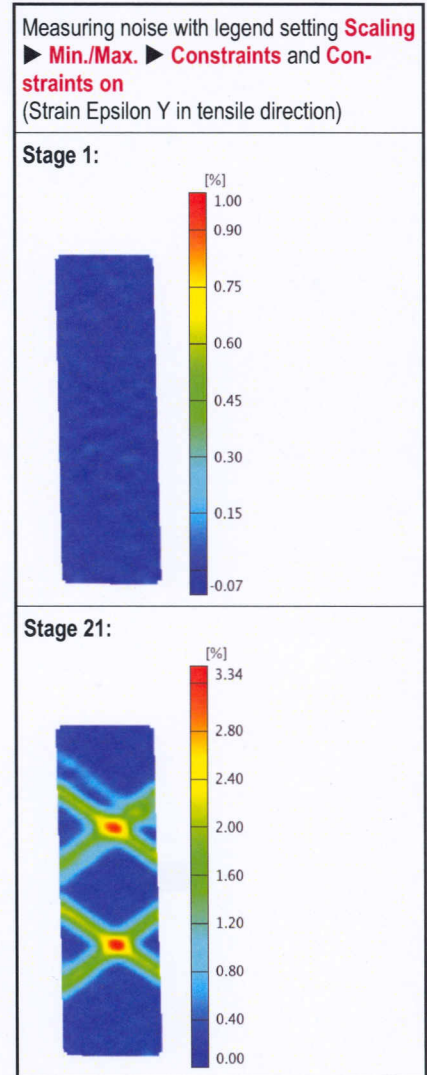
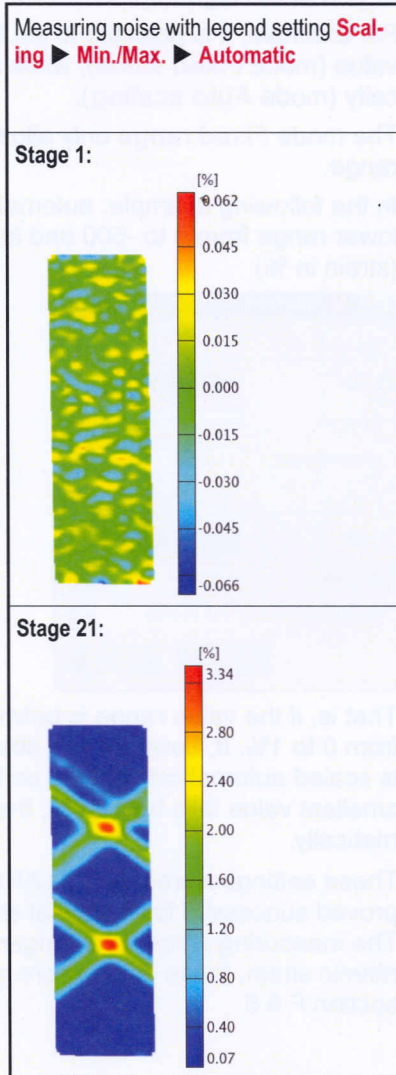
The measuring noise is no longer displayed in detail. In case of logarithmic strain, these settings are not useful. For more information see section F 6.5.

### F 6.4 Comparison Constraint On With Constraint Off

The following example of a tensile test specimen clearly shows the differences between automatic and restricted (with constraints) **Scaling**.



Stage 0: Left camera image of the specimen



While for strain around 3% no differences occur in the settings, stage 1 shows a considerably improved image as the measuring noise is completely suppressed.

Thus, expressive images can be obtained quickly without the need to edit them.

### F 6.5 Optimizing the Legend for Logarithmic Strain

The settings described in sections F 6.1 and F 6.4 are valid for technical strain. For the technical strain, the settings are factory-preadjusted.

If you work with logarithmic strain, you need to define the default setting again. According to the settings for technical strain (**Scaling** ► **Min./Max.** ► **Constraints** with **Constraints on** or **off** and **Fixed value**) we recommend the following settings for logarithmic strain:

<b>Maximum:</b>	<b>Fixed range</b>	<b>Fixed minimum</b> 0.01	<b>Maximum</b> 1
<b>Minimum:</b>	<b>Fixed range</b>	<b>Fixed minimum</b> -1	<b>Maximum</b> 0

Change the settings as follows:

If not done already, switch the ARAMIS software globally to logarithmic strain:

In the preferences (Edit ► Preferences ► Preferences), item Evaluation Mode ► Strain semantics you need to change every value of interest for you to Logarithm.



Confirm the changes with Apply and OK. The settings are now automatically taken over for the next project that is opened.

In the same way, you may change the values for the constraints settings (Edit ► Preferences ► Preferences) item Evaluation Mode ► Legend ► Scaling ► Min./Max. ► Constraints with Constraints on or off).

### F 7 Primitives


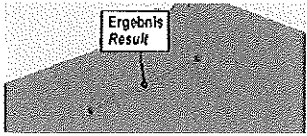
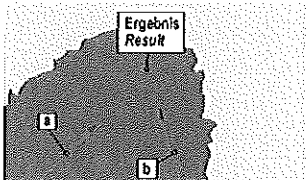
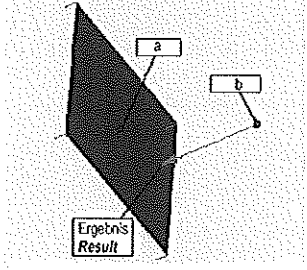
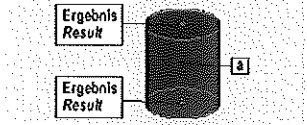
Primitives (points, lines, circles, planes, spheres, ...) are user-defined objects in the 3D view. You need primitives, for example, for transformation, for analysis or for the documentation of measuring results.

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

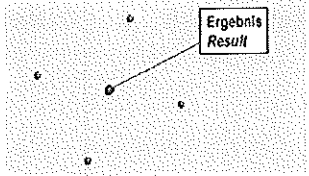
- Editing labels, label visibility
- Changing the appearance of the primitive

The following table informs you in extracts about possible primitives and particularities when creating them. All primitives are generated based on 3D points 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.

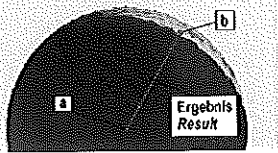
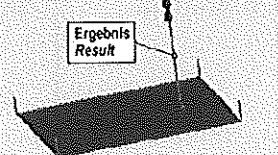
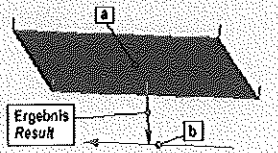
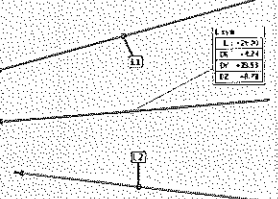
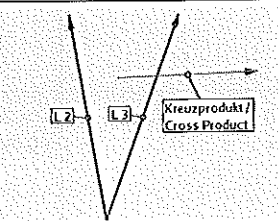
#### F 7.1 Primitive Point

Element	Description	Example
Point	Creates a single 3D point by clicking with the left mouse button.	 Point on 3D mesh
Division Point	Creates an individual 3D point between 2 points. The position between the points can be defined in 100 steps (%).	 Point between two points on 3D mesh with center value 50%.
Intersection Point	Active if corresponding primitives exist in the measuring project. Creates an intersection point between primitives. 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.	 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. Here, you may choose the 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.	 Projection of point (b) onto plane (a).
Points from Line	Extracts the start or end points of lines, intersection lines and rotation axes of cylinders (a) and cones.	 Ergebnis Result

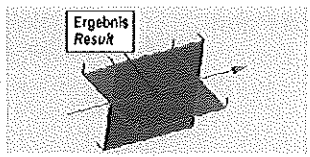
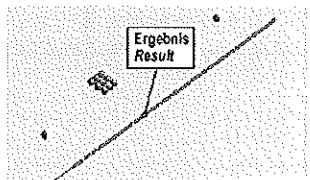
aramis-v6-1\_f\_en\_rev-c 7-Aug-2009

<b>Best-Fit Point</b>	Creates a geometrical average value from selected 3D points and/or 3D meshes.	 <p>The result is the geometrical average value.</p>
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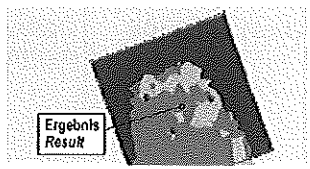
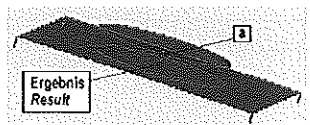
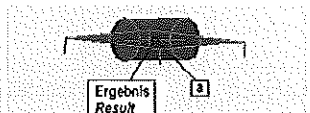

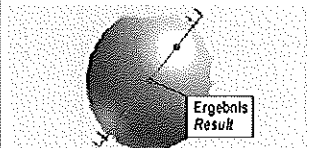
### F 7.2 Primitive Line

Element	Description	Example
<b>Point-Point Line</b>	Creates a line between two points.	 <p>Line between two individual points</p>
<b>Point-Direction Line</b>	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.	 <p>Line from the starting point on the plane in normal direction of the plane.</p>
<b>Perpendicular Line</b>	Creates a line from the start point (plane a) orthogonal to another line (b).	 <p>On plane (a), we selected a start point for the perpendicular line which runs perpendicular to line (b).</p>
<b>Symmetric Line</b>	Creates a line symmetrically to two other elements which contain a line (e.g. line, cylinder, cone, etc.).	 <p>Symmetric line (here in red)</p>
<b>Line by Cross Product</b>	Creates a line that is perpendicular to two other lines or direction vectors and has its origin in the point you clicked.	 <p>The cross product was created from lines 2 and 3. The new line is perpendicular to both other lines.</p>

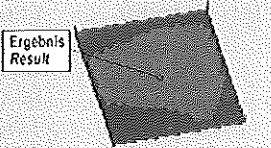
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<p><b>Intersection Line</b></p>	<p>Creates intersection lines between surfaces of primitives.</p>	 <p>Ergebnis Result</p> <p>Intersection line between two planes.</p>
<p><b>Best-Fit Line</b></p>	<p>Creates a line according to the best-fit principle 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.</p>	 <p>Ergebnis Result</p> <p>Best-fit line, created on previously selected (red) 3D points.</p>

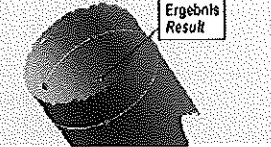
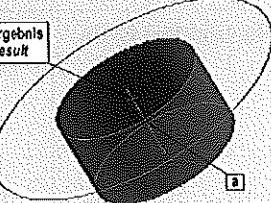
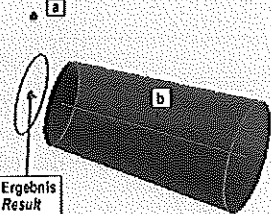

**F 7.3 Primitive Plane**

Element	Description	Example
<p><b>Point-Point-Point Plane</b></p>	<p>Creating a plane through 3 points.</p>	 <p>Ergebnis Result</p> <p>The plane was created by selecting three 3D points.</p>
<p><b>Point-Normal Plane</b></p>	<p>Creates a plane through one point in the direction of other objects like lines, cylinders, etc.</p>	 <p>Ergebnis Result</p> <p>The plane was created using a point on the rotation axis of cylinder (a) and the normal direction of cylinder (a).</p>
<p><b>Axis Parallel Plane</b></p>	<p>Creates a plane through a point (a) and parallel to the axis of the current coordinate system.</p>	 <p>Ergebnis Result</p> <p>A point on the rotation axis of cylinder (a) was selected, and the Z axis was selected as axially parallel plane.</p>
<p><b>Parallel Plane</b></p>	<p>Creates a plane parallel to a circle, a rectangular hole, a slotted hole or another plane.</p>	 <p>Ergebnis Result</p> <p>The plane was created in parallel to circle (a), stating an offset value.</p>
<p><b>Plane in Viewing Direction</b></p>	<p>Creates a plane through two points or a temporary defined line (using the selection tool of the menu) in the current viewing direction.</p>	 <p>Ergebnis Result</p> <p>Plane through two points on a sphere-shaped 3D mesh in viewing direction of the screen.</p>

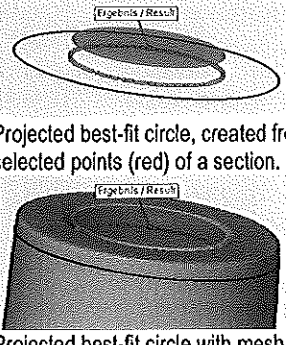
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<p><b>Best-Fit Plane</b></p>	<p>Creates a plane according to the best-fit principle based on selected 3D mesh or sections. Based on the selected points, the plane can be calculated for All points or with the help of statistical methods with 1 Sigma 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.</p>	 <p>Best-fit plane, created on previously selected 3D points.</p>
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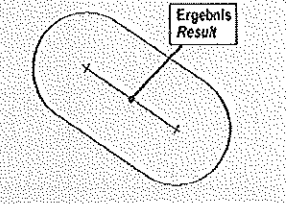
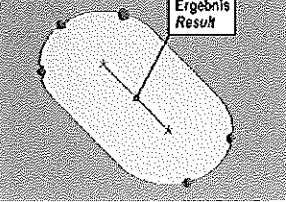
**F 7.4 Primitive Circle**

Element	Description	Example
<p><b>Point-Point-Point Circle</b></p>	<p>Creates a circle through three points.</p>	 <p>On a cylinder-shaped 3D mesh a 3D mesh section was created. By selecting three points on the 3D mesh section, the circle was created. The white 3D mesh section is superimposed by the green primitive circle.</p>
<p><b>Point-Normal-Radius Circle</b></p>	<p>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.</p>	 <p>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.</p>
<p><b>Cylinder/Cone Intersection Circle</b></p>	<p>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.</p>	
<p><b>Best-Fit Circle</b></p>	<p>Creates a circle according to the best-fit principle based on selected 3D mesh or sections. 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.</p>	 <p>On a cylinder-shaped 3D mesh a 3D mesh section was created. By selecting this 3D mesh section, the circle was created by means of the best-fit principle. The selected 3D mesh section is superimposed by the green primitive circle.</p>

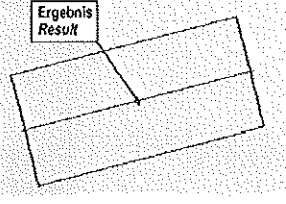
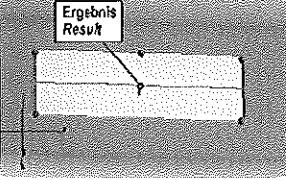
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<p><b>Projected Best-Fit Circle</b></p>	<p>Creates a circle according to the best-fit principle based on selected 3D meshes, sections or features and projects it onto a plane chosen by the user. Based on the selected points, the circle can be calculated 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.</p>	 <p>Projected best-fit circle, created from the selected points (red) of a section.</p> <p>Projected best-fit circle with mesh data.</p>
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**F 7.5 Primitive Slotted Hole**

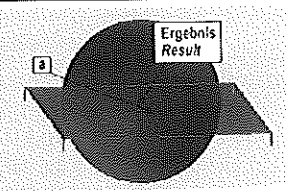
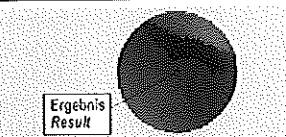
Element	Description	Example
<p><b>Point-Normal-Direction Slotted Hole</b></p>	<p>Creates a slotted hole based on externally entered values or derived from other primitives or feature elements. The function requires the following information: Point (center point coordinates), Normal, Direction, Length, Width.</p>	
<p><b>5-Points Slotted Hole</b></p>	<p>Creates a slotted hole by clicking on five points on the edge (circular area) of a slotted hole in the CAD data.</p>	

**F 7.6 Primitive Rectangular Hole**

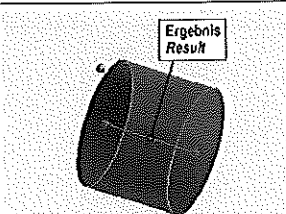
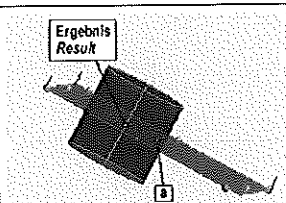
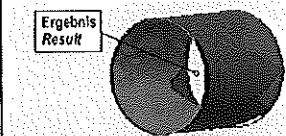
Element	Description	Example
<p><b>Point-Normal-Direction Rectangular Hole</b></p>	<p>Creates a rectangular hole based on externally entered values or derived from other primitives or feature elements. The function requires the following information: Point (center point coordinates), Normal, Direction, Length, Width.</p>	
<p><b>5-Points Rectangular Hole</b></p>	<p>Creates a rectangular hole by clicking on five points on the edge of a rectangular hole in the CAD data.</p>	



F 7.7 Primitive Sphere

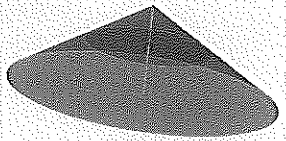
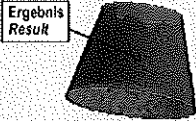
Element	Description	Example
<b>Point-Radius Sphere</b>	Creates a sphere by means of stating the center of the sphere and the radius. The radius can be defined by selecting the points or by entering the radius value directly.	 <p>Freely defined sphere with the center on plane (a). The center of the sphere was determined by selecting a point with Ctrl and left mouse button.</p>
<b>Best-Fit Sphere</b>	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.	 <p>Best-fit sphere, created on a selected spherical 3D mesh.</p>

F 7.8 Primitive Cylinder

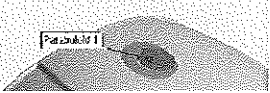
Element	Description	Example
<b>Point-Point-Radius Cylinder</b>	Creates a cylinder through two points. Point 1 determines the beginning of the cylinder's rotation axis. Point 2 determines the end point of the rotation axis. Use Radius to adjust the circumference of the cylinder.	 <p>The cylinder was created based on a line. The end points of the line were created with Ctrl and left mouse button. The radius was entered as value.</p>
<b>Point-Direction-Radius Cylinder</b>	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.	 <p>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.</p>
<b>Best-Fit Cylinder</b>	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.	 <p>Example: Best-fit cylinder, created on a selected cylindrical 3D mesh.</p>

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F 7.9 Primitive Cone

Element	Description	Example
<p><b>Point-Direction-Angle Cone</b></p>	<p>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.</p>	
<p><b>Best-Fit Cone</b></p>	<p>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.</p>	 <p>Best-fit cone, created on previously selected cone-shaped 3D points.</p>

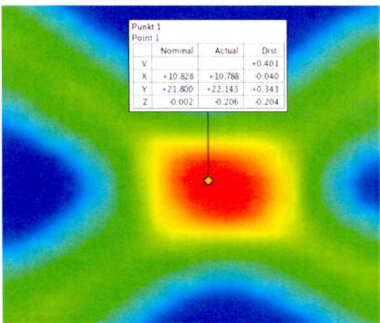
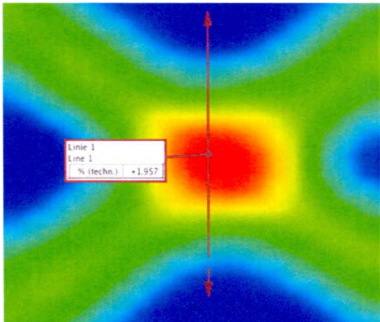
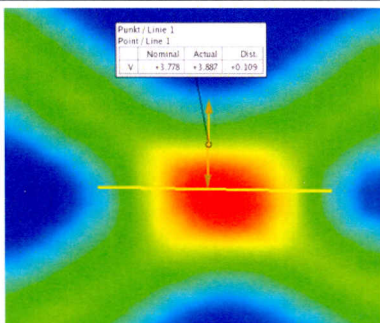
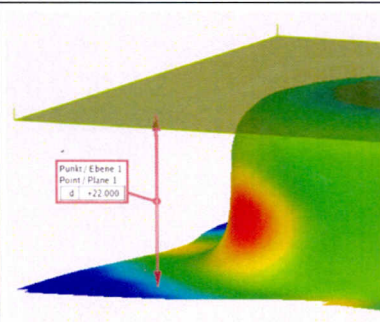
F 7.10 More Primitives

Element	Description	Example
<p><b>Best-Fit Paraboloid</b></p>	<p>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.</p>	 <p>Paraboloid created on a selected area of 3D points.</p>

## F 8 Analysis Elements

Using the analysis elements, you may evaluate the deformation at or between certain points. These evaluations may be visualized in form of a report and may also be exported. Using text labels, you may display information interesting for you in the 3D view either automatically by means of a template or you may create your own template manually.

There are various functions available for distance and angle analyses.

Element	Description	Example
<b>Point Position</b>	Using this function, you may display the displacement of individual points with respect to the basic stage. When changing the stages, the respective valid value is shown for the respective current stage.	
<b>Point-Point Distance</b>	This function provides for measuring changes in the distance between object points and/or primitives. You may create the respective reference element either directly by clicking points or you may select primitives. The distance is shown with an arrow. The corresponding label shows the deviation. When changing the stages, the calculated deformation value changes and displays the valid measure for the current stage.	
<b>Point-Line Distance</b>	This function provides for measuring changes in the distance between a point and a line (object points and primitives). You may create the respective reference element either directly by clicking points or you may select primitives. The software always calculates the shortest perpendicular distance from the point to the line. The distance is shown with an arrow. The corresponding label shows the deviation. When changing the stages, the calculated deformation value changes and displays the valid measure for the current stage.	
<b>Point-Plane Distance</b>	This menu item provides for measuring changes in the distance between a point and a plane (object points and primitives). You may create the respective reference element either directly by clicking points or you may select primitives. The software always calculates the shortest perpendicular distance from the point to the plane. The distance is shown with an arrow. The corresponding label shows the deviation. When changing the stages, the calculated deformation value changes and displays the valid measure for the current stage. First, select the point for which you would like to display the deviation. Then, define the reference element.	

Element	Description	Example
<p><b>Line-Line Angle</b></p>	<p>Using this menu item, you may measure angle variances between two lines. You may create the respective reference element either directly by clicking points or you may select primitives.</p> <p>The angle is shown with two arrows. The corresponding label shows the angle variance. You may adapt labels individually. For this purpose, there are also keywords available with the help of which you may analyze the measured angle projected on the planes of the coordinate system.</p> <p>The length of the angle sides and the origin of the angle may later be changed with <b>Edit Properties</b>.</p> <p>When changing the stages, the calculated deformation value changes and displays the valid measure for the current stage.</p> <p><b>Info</b> Angles in the 3D view 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°.</p>	
<p><b>Line-Plane Angle</b></p>	<p>Using this menu item, you may measure angle variances between a line and a plane. You may create the respective reference element either directly by clicking points or you may select primitives.</p> <p>The angle is shown with two arrows. The corresponding label shows the angle variance. You may adapt labels individually. For this purpose, there are also keywords available with the help of which you may analyze the measured angle projected on the planes of the coordinate system.</p> <p>The length of the angle sides and the origin of the angle may later be changed with <b>Edit Properties</b>.</p> <p>When changing the stages, the calculated deformation value changes and displays the valid measure for the current stage.</p> <p><b>Info</b> Angles in the 3D view 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°.</p>	
<p><b>Plane-Plane Angle</b></p>	<p>Using this menu item, you may measure angle variances between two planes. The angle is shown with two arrows. The corresponding label shows the angle variance. You may adapt labels individually. For this purpose, there are also keywords available with the help of which you may analyze the measured angle projected on the planes of the coordinate system.</p> <p>The length of the angle sides and the origin of the angle may later be changed with <b>Edit Properties</b>.</p> <p>When changing the stages, the calculated deformation value changes and displays the valid measure for the current stage.</p> <p><b>Info</b> Angles in the 3D view 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°.</p>	

### F 9 Evaluate Results Statistically

ARAMIS offers the possibility to evaluate results statistically.

For this purpose, you need to select the respective areas in the 3D view.

The parameters Points, Maximum, Minimum, Average and Sigma are available for evaluation.

The results are shown in the result window and are automatically updated for all changes of the visualization made in the 3D view.

Current data							
0->12	Visualization	Value	Points	Minimum	Maximum	Average	Sigma
Selection	Major Strain (Technical) [%]	-	596	2.266	16.557	5.662	2.028
Statistic data							
0->6	Visualization	Points	Minimum	Maximum	Average	Sigma	
Statistic Data	Major Strain (Technical) [%]	596	1.315	8.757	3.289	1.107	
0->7	Visualization	Points	Minimum	Maximum	Average	Sigma	
Statistic Data	Major Strain (Technical) [%]	596	1.468	9.891	3.657	1.238	
0->8	Visualization	Points	Minimum	Maximum	Average	Sigma	
Statistic Data	Major Strain (Technical) [%]	596	1.629	11.034	4.029	1.373	

Result window with current data and multistage data

For comparative evaluations you may define statistic data sets. For this data set, the data type is not changed, i.e. any changes made in display and selection of the 3D View have no effect on these results. Thus, the statistical information e.g. of Major Strain and Minor Strain of selected areas can be looked at simultaneously.

These data will be saved such that you may access this information e.g. by means of a statistics diagram (report function). In addition, you may create a Point Statistic from an info point. Multistage data shows the data of all stages selected in the explorer.

Statistic data can be exported.

## F 10 Summary

- Creating results
- Info points
- Stage points
- Plane section, spline section, circular section
- Filtering, using filter parameters
- Interpolating 3D Points
- Primitives
- Analysis elements
- Evaluate results statistically

**Chapter G** - Table of Contents (rev-c)

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## G Documentation

ARAMIS allows for presenting result data in various ways. The results in the 3D view with sections, primitives and analysis elements always are the basis for the different documentation possibilities. So, for example, image series may be created as movies or you may document your results using default report templates.

If you wish to document your results in external applications, you may also export your result data.

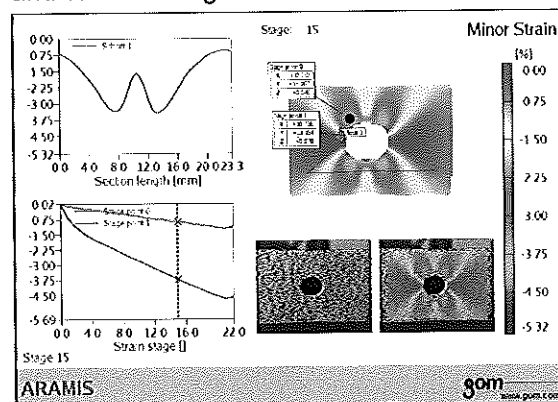
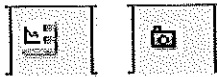
### G 1 Reports

#### G 1.1 Standard Reports

Deformation results can clearly be illustrated in reports. Different 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.

The standard reports Report-ARAMIS contain result images, diagrams and camera images.



#### Info

If the images or diagrams are empty or do not contain the required data, you may edit the corresponding connections by double clicking on the element in the report.

The standard reports contain the result images as project image strain overlay or as user-defined image series, see G 1.2.

In case of a modification, the project images in a report are automatically updated. For user-defined Image Series you need to create a new Image Series in case of a modification.

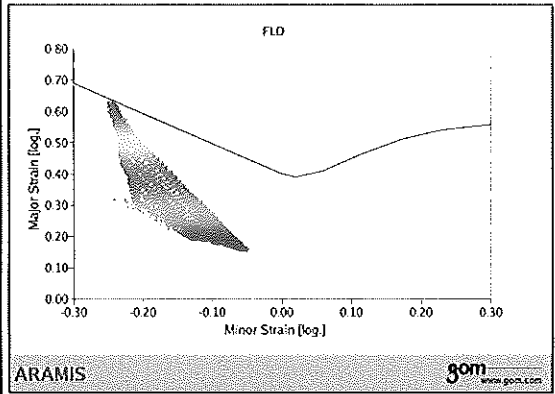
#### Info

Primitives may only be included into reports by means of image series.

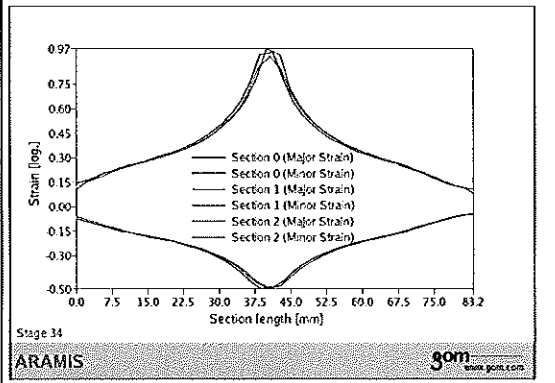
For further information, please refer to the Online Help (key F1).

G 1.2 Overview of Default Report Templates

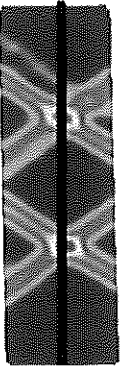
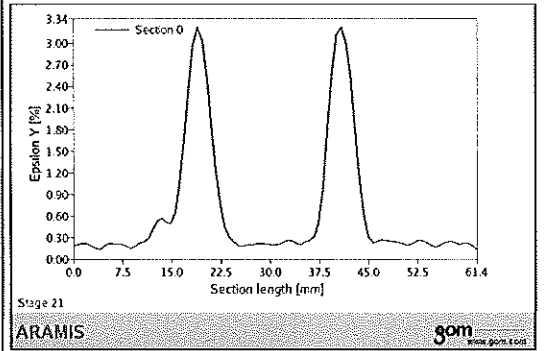
**FLD**  
**(Forming Limit Diagram)**  
 This diagram shows the major strain with respect to the minor strain. The color is displayed according to the current visualization.  
 Together with the known material data (FLC = Forming Limit Curve), the failure of the specimen can be determined.  
 How to change to logarithmic strain see chapter F, section "Optimizing the Legend for Logarithmic Strain".



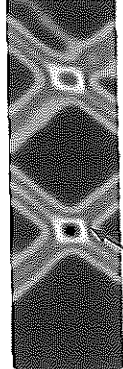
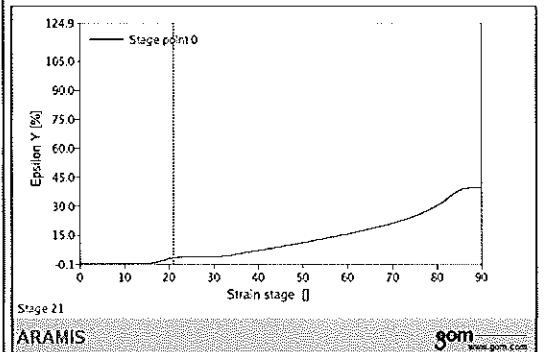
**Multi-Section FLC**  
**(Forming Limit Curve)**  
 Representation of the data used for FLC computation. For further information, please refer to the User Manual – Software FLC Computation.



**Multi-Section**  
 Diagram representation of one or more sections of the current load stage.  
 This diagram shows the selected visualization (here Epsilon Y) with respect to the length of a section per stage. Several sections are displayed in different colors. The current stage is shown on the bottom left. This way, values can be examined over the entire specimen.



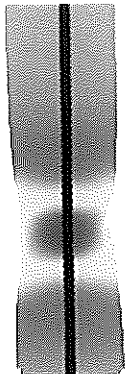
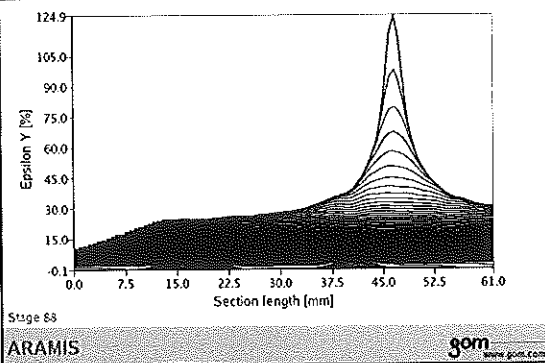
**Multi-Stage-Point**  
 Diagram representation of one or several stage points through all load stages.  
 Analysis of the point curve. Here, all values of the selected visualization and of one point are displayed through all computed stages. The current stage is displayed on the bottom left as well as in the diagram as a bar. This function provides for analyzing the behavior at critical points of a specimen.



**Multi-Stage-Section**

Diagram representation of a section through all load stages.

Here, one section of all stages is displayed with respect to the length of the section. The current section is colored.



**Project-Keyword-ARAMIS**

Shows the project keywords to be used in other report templates. You may transfer the keywords with copy (Ctrl and C) and paste (Ctrl and V).

You may also change the language of the keywords, see troubleshooting in **Chapter K**.

Project Keywords + Stage Data / Stufen-daten

Inspector:	Peter	Length:	mm	Comment 1:
Company:	GOM mbH	Width:	mm	Comment 2:
Department:	TechWills	Thickness:	mm	Comment 3:
Location:	Braunschweig			
Date:	15.03.2005			

Project:	Stain Abl
Change Nr.:	012345678
Part No.:	587654321
Test method:	
Material:	
Temperature:	°C
Test Speed:	

For Copy and Paste

ARAMIS

**Report-ARAMIS**

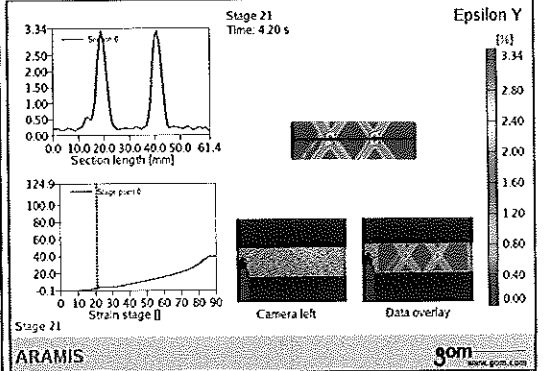
Example reports with the most important report elements for standard ARAMIS applications.

- Section diagram (Multi-Section)
- Stage point diagram (Multi-Stage-Point)
- Camera images (project images)
- Visualization of the deformation with an image of Strain overlay (project image)

Report-ARAMIS is the most used report. This report contains the most important data of a measurement and displays it clearly.

This report is particularly suitable for flat specimens, e.g. tensile test specimens.

The result image of the specimen's surface is displayed live and does not need to be integrated separately.



**Statistics**

Statistic diagram for extensive evaluations.

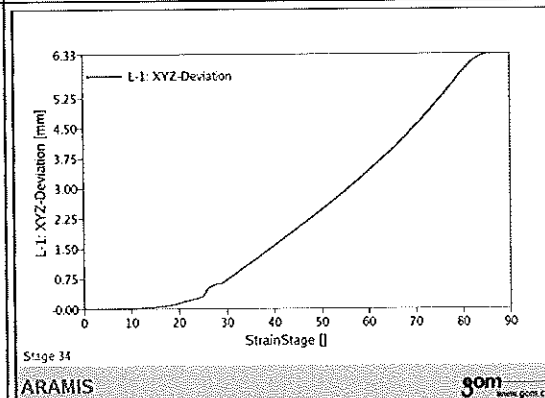
This diagram is the most versatile of all report diagrams. On the one hand, you may display the data of a measurement and on the other hand it provides many combination possibilities between:

**X axis**

- Number of stages
- Stage data (A/D values, time, calculated values from this)
- Statistics

**Y axis**

- Measurements
- Stage data
- Statistics



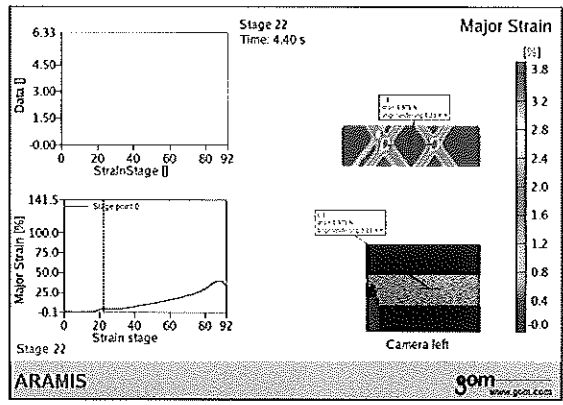
### G 1.3 Analysis Elements in a Report

You may integrate analysis elements in reports. If the result images are project images, e.g. Strain overlay, the analysis elements may appear automatically in the report image if the function Add to report is enabled.

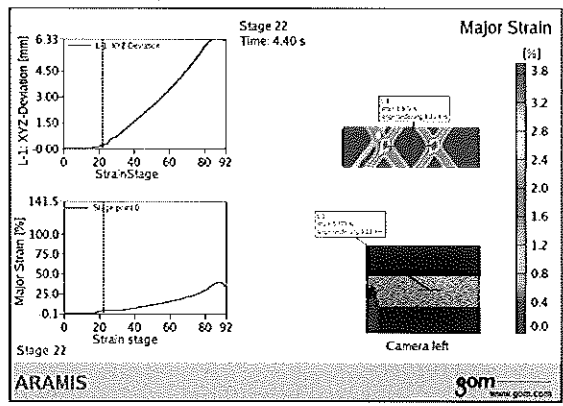
In the following, we show an example report (based on Report-ARAMIS).

Here, the analysis element Point-Point Distance was included.

The upper diagram still is empty because the connection to the analysis element has not yet been established.



A finished report could look like this:



When double clicking on the diagram, you may establish the connections. In this example, we chose for the X axis Visualization ► Project ► Point stage and for the Y axis Data ► Measurements ► L1 ► Line differences ► XYZ-Deviation.

## G 1.4 Special Settings in the Report Diagrams

### G 1.4.1 Legend Setting 3D

As default, legend setting 3D is preadjusted for the Y axis in each diagram (double clicking in the diagram ► tab Axis ► Y axis ► Maximum or Minimum).

#### Info

The advantage of this setting is the link to the legend in the 3D view. If you change the scaling or the visualization (e.g. Major Strain, Minor Strain, etc.) in the 3D view, this new setting is directly transferred to the report diagram.

Setting 3D enables the definition of an "own" axis setting (= value range) for each visualization which is displayed accordingly in the diagram by optimally adapting the legend of the 3D view.

Thus, you may quickly create report and diagram series which match the 3D image series without the need to permanently adapt the scaling of the diagram to the 3D legend manually.

If several visualizations are displayed in one diagram, the setting 3D automatically scales the value range of the diagram to the maximum and minimum value.

Example: Section data in a common major/minor diagram (Multi-Section Diagram)

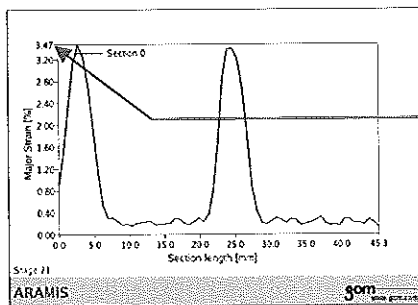


Diagram Major Strain

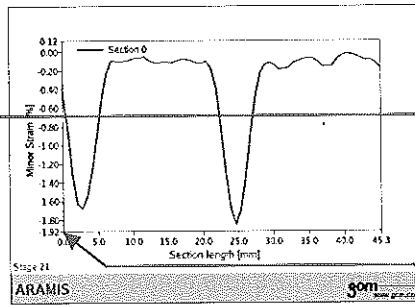


Diagram Minor Strain

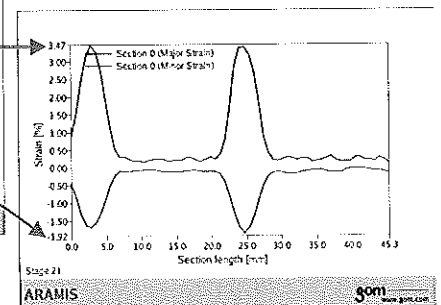


Diagram Major/Minor Strain

To load two data sets into one diagram proceed as follows:

Change the diagram parameter of the Y axis to Strain and of the X axis to Section length (double click on the diagram ► Visualization ► Main ► ...).

In tab Visualization ► Visualization select the desired visualization parameters, in this example Major Strain and Minor Strain.

If several sections exist, you may adjust here how they should be distinguished in the diagram.

When choosing Different colors, the sections keep the color you assigned them in the section explorer.

If, in the section explorer you assigned 2D symbols to a section (double clicking on the section ► Rendering ► ...), then, you may include these symbols into the diagram.

You take over the symbols into the diagram with the setting Different symbols (double clicking on the diagram ► Visualization ► Main ► Section mode).

### G 1.4.2 Legend Settings Fixed and Auto

If you wish to scale the individual axis of a diagram manually or automatically, i.e. independent of the 3D legend, you need to disable the 3D setting.

For effectively creating diagrams, we recommend setting 3D.

### G 1.5 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 Image Series and Movies

An image series is a sequence of individual images.

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.



3D view	With a right mouse button (RMB) click, you may select areas in the 3D view and select the alternate color for the background.
Left image	
Right image	
Project images	<ul style="list-style-type: none"> <li>• Source undeformed camera left</li> <li>• Source undeformed camera right</li> <li>• Source deformed camera left</li> <li>• Source deformed camera right</li> <li>• Facet overlay camera left</li> <li>• Facet overlay camera right</li> <li>• Strain overlay camera left</li> <li>• Strain overlay camera right</li> </ul>
Reports	Image series of existing reports.

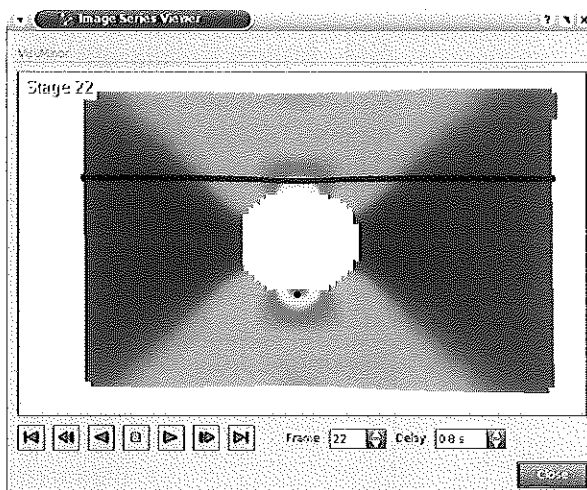
You may integrate image series in reports. Thus, for example, it is possible to display 3D views interesting for you through all stages.

If you created several user-defined result image series (major strain, minor strain, Mises strain, ...) with the function **Use result selection**, the images will change in the report if you change the result selection.

An image series may also contain images of an external camera which can be imported. Thus, for example, it is possible to display images 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!

### G 2.1 Play Image Series

In the explorer, click with the right mouse button (RMB) on the image series you want to play and select **View Image Series**.



### G 2.2 Export Image Series as Individual Images

You may export an image series as individual images in PNG, TIFF or JPEG format. You may define the export format in the Preferences.

For further information, please refer to the Online Help.

### G 2.3 Export Image Series as Movie

You may also export image series as movie. The individual images will be combined in a movie and saved in the AVI or MPEG format. You may define the export format in the Preferences.

For further information, please refer to the Online Help.

## G 3 Snapshots

Using the snapshot function, you may save the screen representation of the 3D view, of the left or right 2D camera image or of reports as an image and print or copy this image to the clipboard.

A snapshot is a static image that does not change through the stages. Using the right mouse button (RMB) you may limit the snapshot function to defined areas.

## G 4 Printing Documentations

Printing in ARAMIS is only possible using the snapshot function (see G 3).



## G 5 Summary

- ☐ Standard reports
- ☐ Analysis elements in a report
- ☐ Special report diagram settings
- ☐ Individual reports
- ☐ Image series and movies
- ☐ Snapshots
- ☐ Printing documentations



**Chapter H** - Table of Contents (rev-c)

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## H Export, Automation

### H 1 Export

ARAMIS provides extensive export functions to make your measuring results available for subsequent systems or applications in defined formats.

#### H 1.1 Overview of the Export Options

Export functions:	Comment:	Format:
Export Tables	<ul style="list-style-type: none"> <li>For analysis elements and primitives</li> <li>Configurable export using export templates (default export templates or user-defined templates).</li> <li><b>Info</b> For more information, please refer to the Online Help.</li> </ul>	ASCII, HTML and OpenOffice format.
Export 3D Data	<ul style="list-style-type: none"> <li>Export of all 3D points of the current 3D view (just of one stage)</li> </ul>	One ASCII file.
Export All Points	<ul style="list-style-type: none"> <li>Exports all data of a 3D point.</li> <li>Export using a configuration file (default configurations or user-defined configurations).</li> <li><b>Info</b> For more information, please refer to the Online Help.</li> <li>Exports all or selected stages.</li> </ul>	One ASCII file for each stage.
Export Stage Points	<ul style="list-style-type: none"> <li>Exports the data of one or several stage points (selected in the explorer).</li> <li>Export using a configuration file (default configurations or user-defined configurations).</li> <li><b>Info</b> For more information, please refer to the Online Help.</li> <li>Exports all or selected stages.</li> </ul>	One ASCII file for each point.
Export Section 3D	<ul style="list-style-type: none"> <li>Exports the data of one or several sections (selected in the explorer).</li> <li>Export using a configuration file (default configurations or user-defined configurations).</li> <li><b>Info</b> For more information, please refer to the Online Help.</li> <li>Exports all or selected stages.</li> </ul>	One ASCII file for each section and each stage.
Export Section FLC	<ul style="list-style-type: none"> <li>Exports the data of one or several sections (selected in the explorer) for FLC applications (Forming Limit Curve).</li> <li>Exports sections of one defined stage (selected in the explorer)</li> <li>Enter the crack width for further computations</li> </ul>	One ASCII file for each section and a defined stage.
Export Diagram Data	<ul style="list-style-type: none"> <li>Exports the data of one diagram (selected in the explorer ► Report).</li> </ul>	One or several ASCII files (depends on the diagram type and the stage selection).
Export Statistics	<ul style="list-style-type: none"> <li>Export of statistic data</li> <li>Configurable export</li> </ul>	ASCII
Export Image Series	<ul style="list-style-type: none"> <li>Exports result images</li> <li>Exports user-defined image series, project images or reports (selected in the explorer ► Image Series)</li> <li>Configurable export</li> </ul>	One image for each stage in PNG, JPEG or TIFF format (selectable in the Preferences).
Export Movie	<ul style="list-style-type: none"> <li>Function as for Export Image Series</li> <li>Individual images are combined in a movie</li> </ul>	MPEG or AVI (selectable in the Preferences).

Export functions:	Comment:	Format:
Export Linear Strain	<ul style="list-style-type: none"> <li>• Special format for ARAMIS applications with multi sensor systems</li> </ul>	
Export Spline Strain		
Export Session	<ul style="list-style-type: none"> <li>• Exports the 3D result data in order to use them in other GOM applications, e.g. TRITOP, ATOS, ATOS Viewer.</li> <li>• 3D data are available again as stages in other GOM applications if they were selected for the export in the explorer.</li> <li>• Export as monochrome mesh</li> <li>• Export as colored mesh</li> <li>• Export as surface deviation with legend</li> </ul>	.session (GOM format)
Export STL	<ul style="list-style-type: none"> <li>• Exports all 3D result data in one common file or in separate files (one file for each stage).</li> <li>• In case of a common file, the 3D representations of the individual stages are merged</li> </ul>	One or several STL files.
Export Ref. Points	<ul style="list-style-type: none"> <li>• Exports the reference points of a stage (selected in the explorer)</li> </ul>	One ASCII file.
Export Stage Images	<ul style="list-style-type: none"> <li>• Exports the right and left camera image of selected stages or of all stages.</li> </ul>	Each image in one TIFF file.

## H 2 Macros

### H 2.1 Automation

For recurrent measurements with very complex analysis elements, the ARAMIS 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 2.2 Functional Extensions

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

## H 3 Summary

- Export functions
- Automation due to macros
- Functional extensions by macros

**Chapter J - Table of Contents (rev-c)**

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## J The Basics of Strain

In this section, we explain the basics of strain and strain calculation. This description follows closely the following books: [Hib], [BB75], [Mal69] and [Hah84].

Note:

- In the GOM software, the German conventions (letters) are used for the strain values:

Technical strain:  $\varepsilon$

Logarithmic (true) strain:  $\varphi$

In the legends, log. is used as abbreviation for logarithm. Mathematically however, the natural logarithm (ln) is meant (see J 1.1).

- With optical measurement techniques (e.g. ARAMIS, ARGUS) coordinates, displacements and strains will be determined only on the surface of objects. This means that the calculation is limited to local strains, which are tangential to the surface. As additional information perpendicular to the surface is missing, it is not possible to calculate a complete 3D strain tensor (strain values). In this case, the calculation of the thickness change is based on the assumption of volume constancy of the material during loading. Should the thickness reduction be used for the complete material thickness, a constant strain distribution in the thickness direction (orthogonal to the surface) has to be valid. If this is not valid, bending influences of thin metal sheets can be compensated by the material thickness compensation (available for the spline strain model). In all other cases, the calculated thickness change belongs to a thin area of the material close to the surface only.

### J 1 Basics of 2D Strain Computation

#### J 1.1 The Term "Strain"

Strain is the measure for the deformation of a line element and can be defined as follows:

$$\lambda = \lim_{l \rightarrow 0} \left( \frac{l + \Delta l}{l} \right)$$

The stretch ratio  $\lambda$  is the relative elongation of an infinitesimal line element. A strain value  $\varepsilon$  can be defined as the function of the stretch ratio  $\lambda$ :

The following known functions are frequently used strain measures:

- Technical strain:

$$\varepsilon^T = f(\lambda) = \lambda - 1$$

- Logarithmic or true strain:

$$\varepsilon^L = \varphi = f(\lambda) = \ln(\lambda)$$

- Green's strain:

$$\varepsilon^G = f(\lambda) = \frac{1}{2}(\lambda^2 - 1)$$

**J 1.2 The Deformation Gradient Tensor**

The previous section defined the stretch ratio in the one-dimensional case and the general description of a strain measure. This will now be extended to the two-dimensional case.

**J 1.2.1 Deformation Gradient Tensor Definition**

In order to quantitatively display the deformation of a surface element, the deformation gradient tensor  $F$  is introduced. The deformation gradient tensor transforms a line element  $dX$  into the line element  $dx$ . In both cases, the line element connects the same material coordinates. Theoretically, it must be an infinitesimal line element. The following figure illustrates this case.

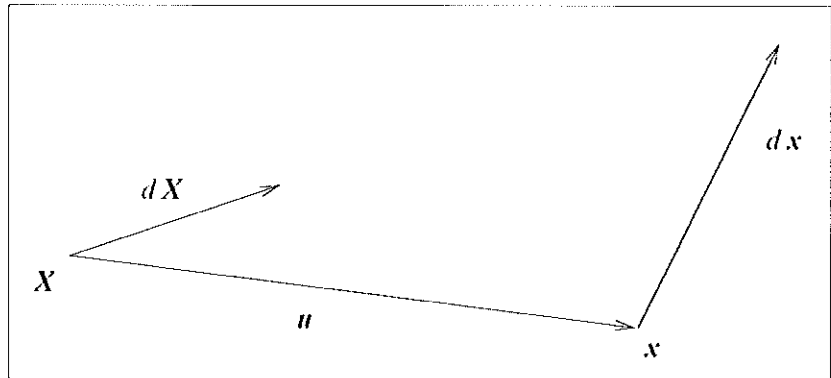


Figure a: Translation (u) and strain of a line element

Thus, the deformation gradient tensor is defined as:

$$dx = F \cdot dX$$

**J 1.2.2 Decomposing the Deformation Gradient Tensor**

A disadvantage of the deformation gradient tensor is that rotation and stretch are modeled using one matrix only. This can be compensated by splitting the deformation gradient into two tensors: purely rotation matrix and pure stretch tensor. The matrix can be decomposed in two different ways:

- Decomposition into rotation  $R$  and right stretch tensor  $U$ . Mathematically, the deformation gradient tensor is decomposed as follows:

$$F = R \cdot U$$

- Decomposition into left stretch tensor and rotation. Mathematically, the deformation gradient tensor is decomposed as follows:

$$F = V \cdot R$$

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**J 1.3 Definition of the x-y Strain Values in 2D**

Values  $\epsilon_x$ ,  $\epsilon_y$ , and  $\epsilon_{xy}$  can directly be read from the symmetric stretch tensor  $U$  with the following form:

$$U = \begin{pmatrix} U_{11} & U_{12} \\ U_{21} & U_{22} \end{pmatrix} = \begin{pmatrix} 1 + \epsilon_x & \epsilon_{xy} \\ \epsilon_{xy} & 1 + \epsilon_y \end{pmatrix}$$

The strain values  $\epsilon_x$ ,  $\epsilon_y$ , and  $\epsilon_{xy}$  have the disadvantage of being defined as dependent on the coordinate system. The geometrical interpretation of strain values is described with the following example values:

$$\begin{aligned} \epsilon_x &= 40\% \\ \epsilon_y &= 0\% \\ \epsilon_{xy} &= 0.2 \end{aligned}$$

So the stretch tensor is given by:

$$U = \begin{pmatrix} u_{11} & u_{12} \\ u_{21} & u_{22} \end{pmatrix} = \begin{pmatrix} 1.4 & 0.2 \\ 0.2 & 1 \end{pmatrix}$$

Regarding a unit square in the 2D space (points (0/0), (0/1), (1/0), (1/1)) the deformation introduced by this stretch tensor is shown in figure b.

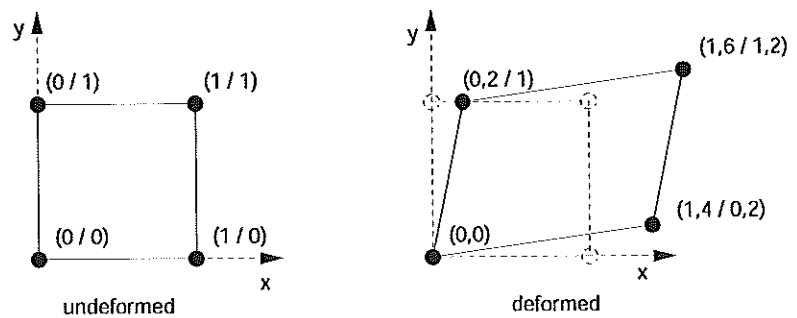


Figure b: Example for the deformation of a unit square

For the geometrical interpretation of the values  $\epsilon_{xy}$  the shear angle  $\gamma_{xy}$  is used. This angle describes the change of an angle of 90° in the undeformed state to a new angle in the deformed state.

For large strain values and angles as used in this example, the assumption for small strains from the elastic strain theories must NOT be used:

$$\gamma_{xy} \neq 2 \epsilon_{xy}$$

**Info**

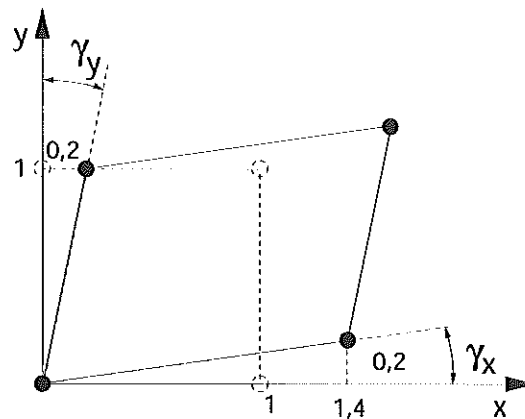


Figure c: Shear angle definition

Based on the example values used, the definition of the shear angle can be generally separated from figure c as follows:

$$\begin{aligned} \gamma_{xy} &= \gamma_x + \gamma_y \\ \gamma_x &= \arctan(\epsilon_{xy} / (1 + \epsilon_x)) = \arctan(0.2 / (1.4)) \\ \gamma_y &= \arctan(\epsilon_{xy} / (1 + \epsilon_y)) = \arctan(0.2 / (1)) \end{aligned}$$

Notes:

- As given by this example, the values for  $\gamma_x$  and  $\gamma_y$  can be different.
- With a symmetric stretch tensor only a parallelogram can be realized for the local deformation field.
- The fixed values for  $\gamma_x$  and  $\gamma_y$  show that the orientation of the parallelogram to the coordinate system is fixed. The stretch tensor cannot describe rotations. The coordinate system is defined as "x"-y" system.

### J 1.4 Definition of the 2D Coordinate System and Strain Directions

The deformation gradient tensor  $F$  creates a functional connection of the coordinates of the deformed points  $P_{v,i}$  with the coordinates of the undeformed points  $P_{u,i}$  ( $i$  being the index for the different points). The functional connection for each local point is as follows:

$$P_{v,i} = u_i + F \cdot P_{u,i} \tag{1}$$

With:

- $P_{v,i}$  Coordinates of the deformed point
- $P_{u,i}$  Coordinates of the undeformed point
- $u_i$  Rigid body translation

The deformation gradient tensor  $F=R U$  can be split to the rotation matrix  $R$  and the stretch tensor  $U$ . The rotation matrix  $R$  describes the rotation of the points and the directions only.

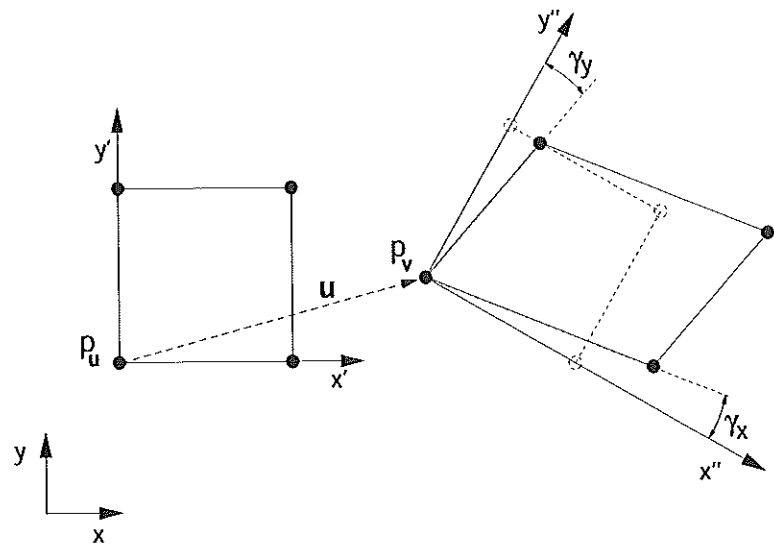


Figure d: Definition of the coordinate system (based on the deformation of a unit square)

This context is shown in figure d. Different coordinate systems are used.

- x-y: global coordinate system
- x'-y': local undeformed coordinate system
- x''-y'': local deformed coordinate system  
= directions of strain

The coordinates of the point (e.g.  $p_u$  and  $p_v$ ) are calculated in the global x-y coordinate system. For the 2D discussion, the coordinate system x'-y' is parallel to x-y, but is placed in the undeformed position of the point of interest  $P_{u,i}$ .

The rotation matrix  $R$  defines the rotation from the x'-y' to the x''-y'' system. The coordinate system x''-y'' for the strain calculation is independent from rigid body movement and rotation. It shows the deformation introduced by the stretch tensor  $U$  and defines the direction of the strain values similar to figure c. This leads to:

- X'' direction == direction of strain x
- Y'' direction == direction of strain y

The coordinate system can be visualized, e.g. in ARAMIS-v6 in the 3D result window.

### J 1.5 Major and Minor Strain Derived From the Deformation Gradient Tensor

The strain measures  $\epsilon_x$  and  $\epsilon_y$  have the disadvantage of being defined as dependent on the coordinate system. This disadvantage can be eliminated by calculating major and minor strain values. The symmetrical matrix  $U$  can be transformed to the main diagonal form. The two eigenvalues  $\lambda_1$  and  $\lambda_2$  can be calculated as follows:

$$\lambda_{1,2} = 1 + \frac{\epsilon_x + \epsilon_y}{2} \pm \sqrt{\left(\frac{\epsilon_x + \epsilon_y}{2}\right)^2 - (\epsilon_x \cdot \epsilon_y - \epsilon_{xy}^2)}$$

Depending on the choice of the strain measure, the stretch ratios  $\lambda_1$  and  $\lambda_2$  can be transformed into corresponding strain values. Based on the larger eigenvalue, the major strain is determined ( $\epsilon_1$  or  $\varphi_1$ ), and based on the smaller eigenvalue the minor strain ( $\epsilon_2$  or  $\varphi_2$ ). The corresponding eigenvectors determine the two directions of major and minor strain. The strain values thus determined are independent of the coordinate system and are universally applicable.

If the material thickness with respect to the entire surface is small, it is frequently necessary to deduce the remaining material thickness from the deformation of the surface. As the optical measuring techniques used cannot obtain any data in this dimension, the third principle strain  $\epsilon_3$  can be calculated from major and minor strain  $\epsilon_1$  and  $\epsilon_2$ , assuming a constant volume. Without determining a strain value, the relationship between the stretch ratios can be expressed more generally. The volume constancy can be defined as follows:

$$\lambda_1 \cdot \lambda_2 \cdot \lambda_3 = 1$$

Frequently, the effective strains are needed. The effective strains according to von Mises and von Tresca are available. The effective strain according to von Mises results from the following formula:

$$\varphi_V = \sqrt{\frac{2}{3}(\varphi_1^2 + \varphi_2^2 + \varphi_3^2)}$$

As  $\varphi_3$  is included in the formula, the effective strain is only valid if the volume constancy is valid.

The effective strain according to von Tresca results from the following formula:

$$\varphi_V = |\varphi|_{max}$$

#### Info

The technical values for the effective strain according to von Mises and von Tresca are calculated based on the logarithmic values  $\varphi_i = f(\varphi)$  with subsequent conversion  $\epsilon = e^{\varphi}$  (new for Tresca as of v6.2.0).

#### Example:

$\varphi_1 = 0.2$ ;  $\varphi_2 = -0.3$ ;  $\varphi_3 = 0.1$ ;

are converted to  $\epsilon_1 = 22\%$ ;  $\epsilon_2 = -26\%$ ;  $\epsilon_3 = 10\%$ ;

which results in  $|\varphi|_{max} = 0.3 \rightarrow \epsilon_V = 35\% \neq |-26\%$

## J 2 Calculation of the Deformation Gradient Tensor From a 2D Displacement Field

This section explains the calculation of the deformation gradient tensor  $F$  from a given 2D displacement field of points. For this purpose, the 2D coordinates of each point must be known both, in its undeformed and in its deformed state. The definition of the deformation gradient tensor  $F$  explains how an undeformed line element is transformed into a deformed one. In order to calculate the deformation gradient tensor for a point, a number of points in the neighborhood is needed. For this model of calculation, a homogeneous state of strain must be assumed for this set of adjacent points.

Formula (1) describes a linear system of equations and the unknown variables are the four parameters of the deformation gradient tensor  $F$ . The deformation gradient tensor  $F$  can be interpreted as an affine transformation which transforms a unit square into a parallelogram.

If more than three points are chosen for the calculation, the result is overdetermined and an adjustment is used.

For calculating the deformation gradient tensor for a point  $p$ , the used number of neighboring points can be adjusted. The width of the field is the strain reference length. In figure e for example, the neighborhood of  $3 \times 3$  points is shown.

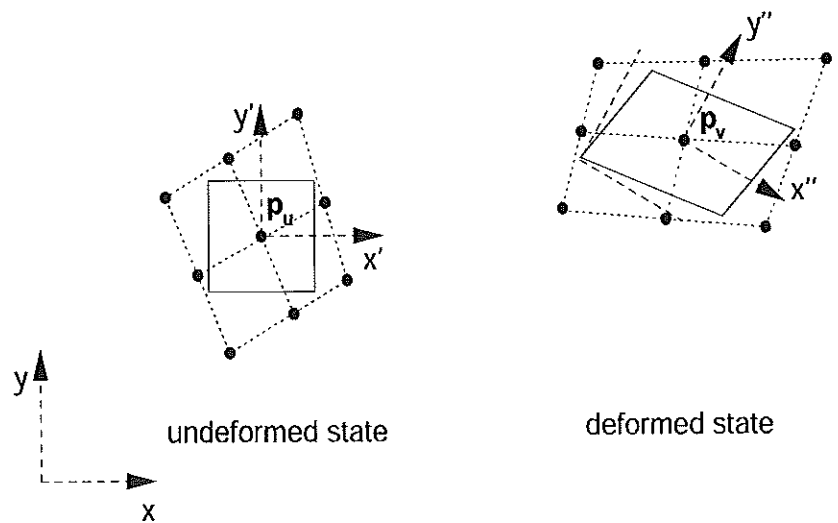


Figure e:  $3 \times 3$  neighborhood for 2D strain calculation

For this figure, the following definition is valid:

- Dashed lines = coordinate systems
  - x-y: global
  - x'-y': locally undeformed
  - x''-y'': locally deformed
- Dotted lines: logical grid of measurement points ( $3 \times 3$ )
- Solid lines: unit square and deformed quadrangle

In general, the logic grid of the undeformed points has not to be oriented in the global x-y coordinate system. In a 2D displacement field, the global and local undeformed coordinate system are equally oriented.

For calculation of  $F$  the  $x'$ - $y'$  coordinate system is used, and the coordinates of the complete neighborhood of the deformed  $3 \times 3$  points must be translated so that the point  $P_v$  is shifted to the origin of the  $x'$ - $y'$  system (= to the position of  $P_u$ ).

For a better understanding of figure f, a unit square is shown in the undeformed state. Based on  $F$  this square will be deformed to the quadrangle field in the deformed state. This field visualizes the shear strain  $\varepsilon_{xy}$  and the shear angle  $\gamma_{xy}$ . The coordinate system  $x''$ - $y''$  represents the strain directions from section J 1.4.

### J 3 Definition of the x-y Strain Values and the Strain Directions in 3D

The description so far showed in detail the calculation of strain in 2D. However, the measurement data in general consists of 3D points of the specimen's surface.

To be able to use the above defined 2D models of calculation, an extended definition for the local directions is needed. The local strain coordinate systems must be tangential to the local surface, and for the strain calculation the 3D data must be transformed into the 2D space.

#### J 3.1 Definition of Strain Directions in 3D

In figure g, the definition of the local strain directions is shown. The global coordinate system x-y-z cannot be used in general for the local strain values. The x-y-z coordinate system in general is not parallel to the local tangential directions. For the local strain calculation in ARAMIS and ARGUS an  $x'$ - $y'$  coordinate system is defined for the undeformed state as follows:

For each point (e.g. point  $P_i$  in figure g)

- the local strain direction  $x'$  is:
  - tangential to the surface of the local point
  - parallel to the x-z plane
- the local strain direction  $y'$  is:
  - tangential to the surface of the local point
  - perpendicular to the local  $x'$



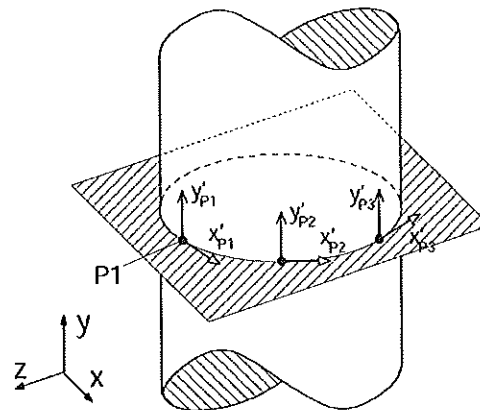


Figure f: Definition of the undeformed local surface strain coordinate system in 3D based on a plane parallel to x-z

In figure f, the local coordinate system ( $x'_{p1} - y'_{p1}$ ;  $x'_{p2} - y'_{p2}$ ;  $x'_{p3} - y'_{p3}$ ) is shown for a cylindrical specimen for three different points ( $P_1, P_2, P_3$ ). In this case, the global y direction is parallel to the axis of the cylinder. For this special case, the y' directions for all surface points are parallel to the global y direction.

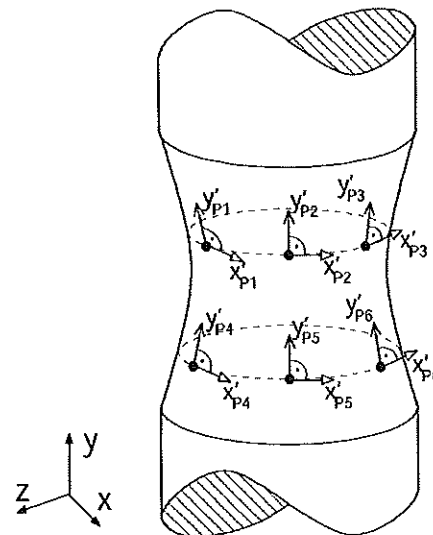


Figure g: Definition of the undeformed local surface strain coordinate system in 3D

In general, both directions ( $x'$  and  $y'$ ) are not parallel to the global coordinate system. This is shown in figure g. The dashed ellipses are parallel to the x-z plane and the different local  $y'$  directions are tangential to the surface.

As in figure e for the deformed state again an  $x''-y''$  coordinate system must be introduced as shown in figure h. In the deformed state, the  $x''-y''$  strain directions are still tangential to the surface in the local 3D points and are defined by the stretch tensor in the same way as in the

2D situation.

The unit square is deformed to a parallelogram. The geometry of the parallelogram together with the stretch tensor ( $\gamma_x$  and  $\gamma_y$ ) define the local strain directions ( $x''$  and  $y''$ ) in the deformed state.

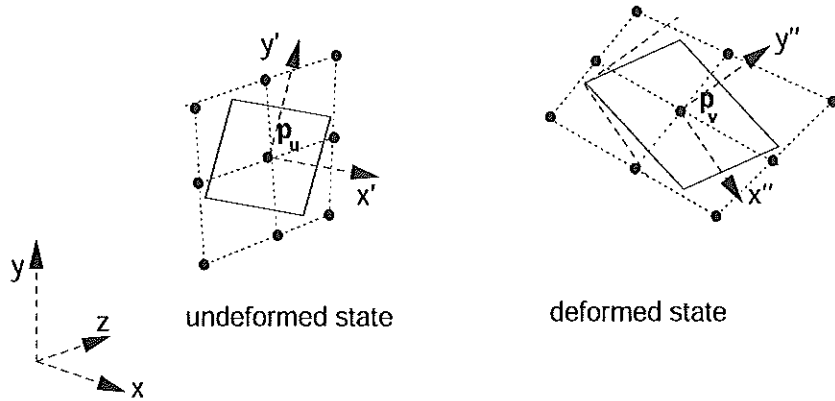


Figure h: Definition of the local surface strain coordinate system in 3D

Parallel to the definition of the directions, the 3D data must be transformed into the 2D space.

For this, two different models can be used. These models are based on planes or splines.

### J 3.2 The Plane Model

The first model assumes that the local neighborhood of a point can be well approximated by a tangential plane. Due to the arbitrary deformation of the surface, the tangential plane needs to be calculated separately for the deformed and undeformed state. The points in the local neighborhood are then projected perpendicularly onto the tangential plane. The result is two sets of points, for the deformed and undeformed state, in the two-dimensional space in which the strain now can be calculated. Summarized, this process consists of the following tasks:

- Calculation of the tangential plane
- Transformation of the 3D neighborhoods into the tangential planes
- Coordinate transformation of the tangential plane into the 2D space ( $x'-y'$  and  $x''-y''$  coordinate systems)
- Calculation of the deformation gradient tensor from the 2D sets of points

### J 3.3 The Spline Model

The tangential model described above provides good results as long as the assumption of the linearization of a local neighborhood of points is valid. In deep drawing, the deformed materials have in part strong locally curved planes. The problem now is to apply the characteristics to be measured to the respective object in such a frequency that the assumption of local linearity is still given. However, this characteristic can hardly be provided in reality. Therefore, it is better to use other models which are more accurate in modeling the true shape of the surface. Splines are a good model for continuously curved lines.

In order to calculate the side length not only according to a linear model, it is necessary to have more information than two points on a side. This means that the adjacent points of a four-sided facet have to be included in the calculations. Figure j shows the adjacent points of the hatched four-sided facet.

In the facet, the side lengths are calculated using the formed splines. The resulting lengths can be used to construct a quadrangle in the two-dimensional space. Now, the strain calculations described above can be used.

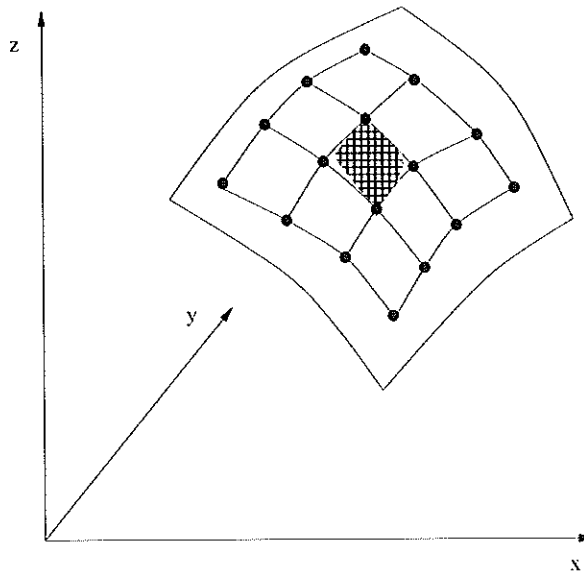


Figure j: Four-sided facet with adjacent points

## J 4 Bibliography for Strain Theory

[Hib] Hibbitt, Karlsson and Lorensen, Inc. *ABAQUS -Theory Manual*, 5.7 edition.

[BB75] Becker und Bürger. *Kontinuumsmechanik*. Teubner-Verlag, 1975

[Mal69] Malvern. *Introduction to the Mechanics of a Continuous Medium*. Prentice-Hall, 1969

[Hah84] Hahn. *Elastizitätstheorie*. Teubner-Verlag, 1984

[Kop98] Kopp und Wiegels. *Einführung in die Umformtechnik*. Verlag der Augustinus Buchhandlung, 1998

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## K Support

### K 1 Where Do You Find Help?

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

#### K 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.

#### K 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.

#### K 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.

#### K 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.

#### K 1.5 Direct Support

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

### K 2 Useful Support Data

#### K 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 (Linux), and send this file to the GOM support.

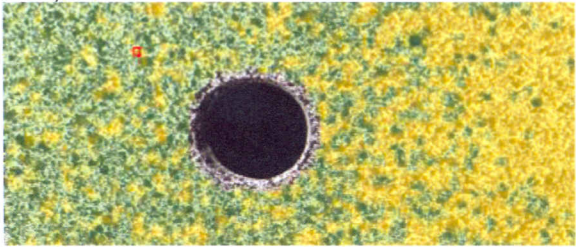
#### K 2.2 Snapshots in Linux

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.



### K 3 Troubleshooting

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 ARAMIS 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 ARAMIS application software?	As of version 5.4, the language of the application software can be changed in the preferences. For this purpose, open menu item <b>Edit ► Preferences ► Preferences ► General</b> and select the desired language in the selection list under <b>Language</b> . Confirm the selection with <b>OK</b> . When starting the program again, the application software appears in the newly selected language.
I cannot work with the ARAMIS project. The stages in the explorer are highlighted in gray.	The project is already open in a ARAMIS application. This effect may occur after the computer crashed and thus, temporary <b>lock</b> files were not correctly deleted.
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.
The color 3D representation is poor or not visible in the window.	Probably the specimen is shown from the rear side. Remedy: Rotate view.
	All was selected in the 3D view. Remedy: Click with the right mouse button (RMB) in the 3D view and choose <b>Deselect All</b> .
How do I cancel the Auto Start Point process?	Press Escape.
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!
ARAMIS cannot overwrite CD or DVD-RW media.	Delete the media completely by means of an external program.
How can I change the language of the Project Keywords?	In the project keyword window click on button <b>Edit</b> , then click with the right mouse button onto the list and select <b>Add Defaults</b> . Select the required language and confirm with <b>OK</b> .
What can I do if I cannot achieve the desired calibration values?	Check if the sensor is configured correctly.
How do I know if I need to calibrate the system again?	<p>If the value of the mean <b>Intersection deviation</b> is larger than 0.1 pixel and the frequency of the yellow facets in the camera images increase (see figure below).</p>  <p>In this case, you need to calibrate your system again.</p> <p>The system creates yellow facets if the intersection error of a 3D point is larger than 0.3 pixels (factory-adjusted setting).</p>

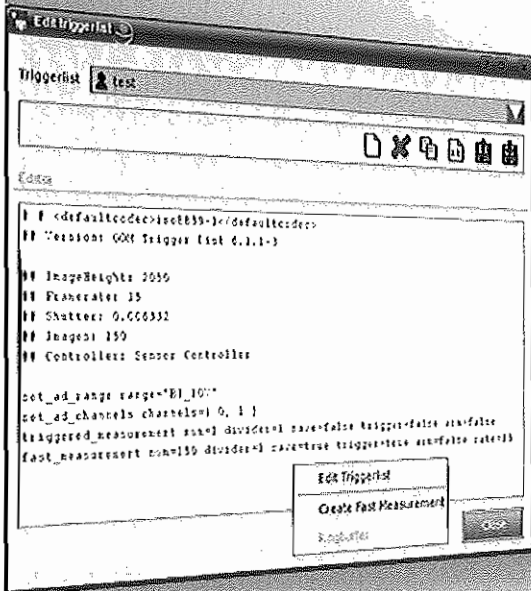


Problem:	Remedy:
The system decalibrates during operation.	Check if the screw connections of the cameras are tight and calibrate the system again.
The cameras cannot be initialized.	Is the sensor controller switched on? Normally, the sensor controller supplies power to the cameras. Did you connect all necessary cables? See <a href="#">User Information – Hardware</a> .
No camera images are displayed.	



# ARAMIS, PONTOS

User Manual - Software



triggerlisten\_v6.1.1\_en\_rev-e 7-Dec-2009

## Trigger Lists with Sensor Controller v6.1.1 and higher

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Optical Measuring Techniques

## Legal and Safety Notes

### Symbols

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

<b>⚠ WARNING</b>	This label points to a situation that might be dangerous and could lead to serious bodily harm or to death.
<b>⚠ CAUTION</b>	This label points to a situation that might be dangerous and could lead to light bodily harm.
<b>NOTICE</b>	This label points to a situation in which the product or an object in the vicinity of the product might be damaged.
<b>Info</b>	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 User Information - Hardware!

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

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## 1. Introduction

This user manual is intended for qualified personnel who have sufficient knowledge in how to handle the measuring system. This user manual is configured to the transfer of knowledge of: Creating measuring procedures by means of trigger lists, how to use such lists and how they are structured and generated.

### Info

The GOM systems are measuring systems that also address experts of digital optical deformation analysis. Therefore, it is unavoidable that the software contains menu items not intended for the standard user. Improper use of these menu items (expert parameters) may cause incorrect measurements.

### Info

This User Manual does not deal with the system installation and special user information of the sensor controller as well as with the general user information of the software. If necessary, this information is compiled in a separate user information.

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

To generate trigger lists you do not need to have programming knowledge, however, basic knowledge makes training easier.

This user information is divided into the following sections:

- The first page informs about important safety aspects.
- Sections 2 to 4 give basic information about the trigger lists and their handling.
- Section 5 informs about how to generate a trigger list using the trigger list macros.
- Section 6 describes important information for combining several list elements.
- Section 7 contains a complete list of commands and their description to create individual complex trigger lists.

## 2. Introduction

### 2.1 What is a Trigger List?

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.

This manual explains how to create simple and complex measuring procedures using trigger lists. For this purpose, we will mainly deal with the macro functionality of the measuring systems (especially trigger list macros) which allow creating trigger lists fast and automatically.

### 2.2 Advantages

Complex measurements may be created, consisting of a combination of numerous different elements. For example:

- External triggering (photoelectric sensor, TTL, etc.)
- Fast and slow measurements also with breaks
- Image acquisitions with predefined A/D values
- Manual or automatic start and cancel criteria

The sensor controller ensures the following:

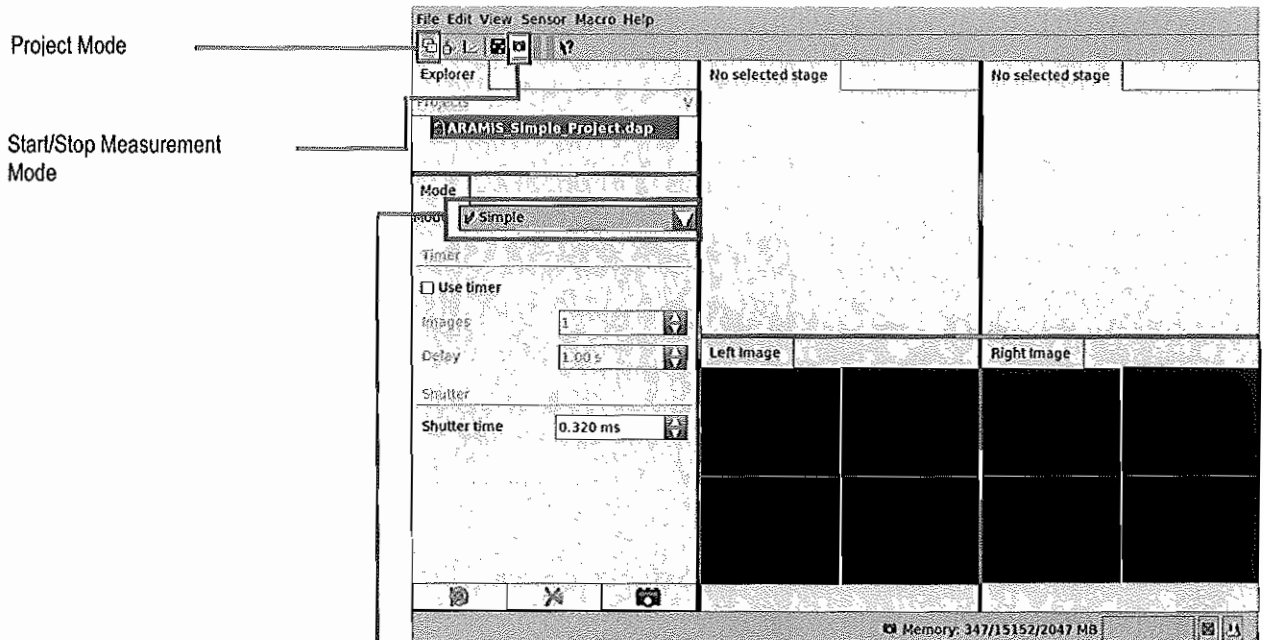
- Precise allocation of time stamps to the images
- Fast response to external signals
- Precise conversion and response to analog channels



### 3. Trigger List Operation

#### 3.1 General Trigger List Operation

After starting the software, go to the project mode and select the icon for Start/Stop Measurement Mode to change to the image acquisition mode.

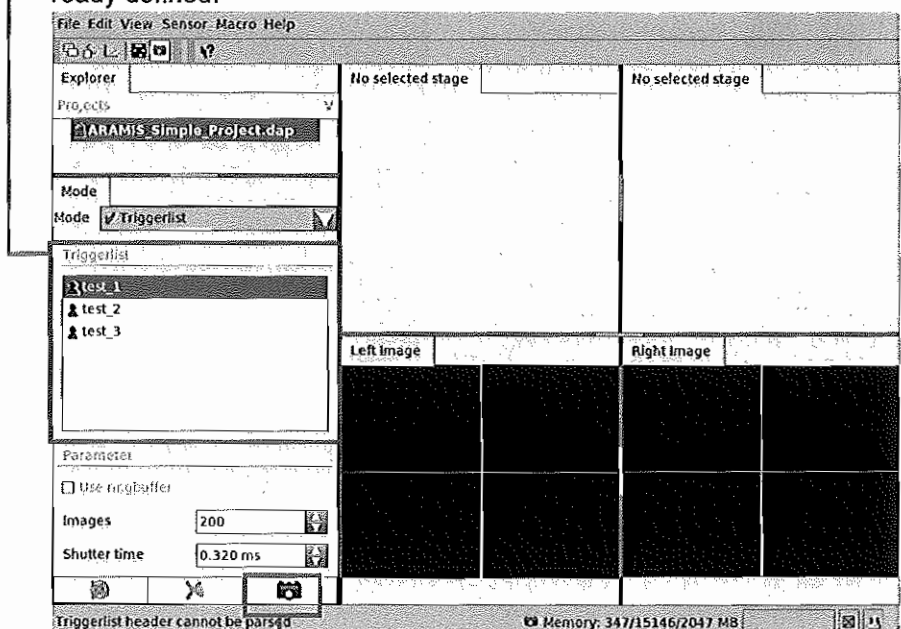


Project Mode

Start/Stop Measurement Mode

As mode, select Triggerlist here.

Now, a new selection window opens, containing the trigger lists already defined.



To start a measurement using a trigger list, select the respective list and start image acquisition by clicking on the camera button.

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**Info**

Image recording is only possible if a project exists and the currently defined number of cameras is identical to the required number of cameras of the project (2D project → one camera; 3D project → two cameras). If this is not the case, the camera button is disabled (dull).

**Info**

Depending on the definition of the trigger list used, the number of images and the shutter time of the cameras need to be set manually (fields highlighted in white). If these fields are highlighted in gray, the data is controlled by the trigger list.

### 3.2 Editing a Trigger List

Edit a trigger list by selecting the respective list from Triggerlist, press the right mouse button and choose Edit Triggerlist. Then, the following selection window opens:

**Info**

We recommend naming new trigger lists such that their purpose can easily be identified, for example stating the frame rate, the measurement type, cameras, etc.

The editor window shows the software code of the trigger list. Clicking with the right mouse button in this field, you generally get two selections:

- Edit Triggerlist opens the editor of the operating system to edit the code.
- Create Fast Measurement opens the "Script Wizard" to create a fast measurement.
- Ringbuffer

## 4. Create Fast Measurement

Using a simple example, we now describe how to create a fast measurement trigger list and explain its basic structure.

### 4.1 Procedure

**Info**

First, create a new trigger list with **New Trigger list**, as otherwise the selected list will be overwritten (see chapter 3.2).

After assigning a name (e.g. tl-fw201-fast-12Hz.tl) you may start the script wizard as described in chapter 3.2. Use the **Back** and **Next** buttons to navigate through the possible settings.

- **Parameters:** Limiting values for the following settings are determined by manual configuration or by the currently initialized sensor.
- **Frame rate:** Set the frame rate you would like to use (limited by the cameras).
- **Shutter time:** Set the shutter time you would like to use (maximum value is calculated from the frame rate).
- **Number of images:** Set the number of images (maximum value: memory of the computer, for Basler A504k cameras: memory of the frame grabber boards).
- **AD value acquisition:** Adjust which A/D channels in which value range shall be recorded (default: A/D 0 and A/D 1 enabled, +/- 10V). Up to 8 channels are possible.

The screenshot shows a 'Script wizard' dialog with four steps:

- Frame rate:** Frame rate is set to 12.0. Information: 'The frame rate in combination with the image height determines the maximum value for the shutter time. Current limit: 12 FPS. To achieve a higher frame rate reduce the image height.'
- Shutter:** Shutter is set to 0.079166 s. Information: 'The maximum shutter time is influenced by image height and frame rate. Current limit: 79.166 ms. To achieve longer shutter times reduce the frame rate or image height.'
- Number of images:** Number of images is set to 500. Information: 'All images will fit in memory. (500 < 1679)'
- AD value acquisition:** Record AD: Low is 0, High is 1, Value range is +/- 10V. Information: '2 AD channels will be recorded.'

Navigation buttons include '< Back', 'Next >', and 'Cancel' for the first three steps, and '< Back', 'Finish', and 'Cancel' for the final step.

"Script wizard"

After clicking on **Finish**, the created code appears in the editing window. Clicking on **Close** closes the dialog and the created trigger list is available in the mode **Triggerlist** and can now be used.

## 4.2 Entries in the Trigger List Fast Measurement

The created Fast Measurement trigger list looks as follows:

```

# # <defaultcodec>iso8259-1</defaultcodec>
## Version: GOM Trigger List 6.1.1-3

## ImageHeight: 2050
## Framerate: 15
## Shutter: 0.006332
## Images: 150
## Controller: Sensor Controller

set_ad_range range="BI_10V"
set_ad_channels channels={ 0, 1 }
triggered_measurement num=1 divider=1 save=false trigger=false arn=false
fast_measurement num=150 divider=1 save=true trigger=true arn=false rate=15
    
```

### Trigger list header:

The header is generated automatically and defines fixed basic conditions, valid for the entire measurement.

- **ImageHeight:**  
Number of image lines. When using camera Basler A504k PONTOS and ARAMIS HS) the image height can be decreased (1/2, 1/4, 1/8, 1/16) in order to increase the frame rate (x2, x4, x8, x16).
- **Framerate:**  
The defined maximum camera speed during this measurement.
- **Shutter:**  
Maximum shutter time, possible from a combination of the camera's read-out time and the frame rate. Higher shutter times cannot be set in the software before starting the trigger list.
- **Images:**  
The number of images during this measurement.
- **Controller:**  
The type of the sensor controller (trigger box or sensor controller). This defines the syntax of the trigger list.

Generally, it is helpful to define the trigger list header with the "script wizard" for each measurement type in order to create fixed basic conditions as here the mentioned dependencies are automatically observed.

**Info**

Lines starting with # are comment lines which are not executed by the computer and are just for information.

**Info**

Lines starting with ## form the header of the trigger list. They were created by the software. Modifications could affect the measurement. For more information and regarding the limits of the system, please see chapter 6.2.

triggered\_measurement:

- num=1      Sensor controller waits for an ON trigger signal and proceeds to the next element.
- save=false      No A/D values are recorded.
- trigger=false      No trigger signal is output (no image recording).

fast\_measurement:

- num=150      Number of images, here 150
- save=true      A/D values are recorded.
- trigger=true      A trigger signal is output (image recording is started, trigger for external devices).
- rate=15      Frame rate, here 15Hz

**Info**

"triggered\_measurement" does not record any images and "fast\_measurement" records the first image only after a time interval of  $1/\text{rate}$ . Therefore, first image of this measurement will only be recorded after a time interval of the element switching time (6.2.1) plus  $1/\text{rate}$  (5.3.5).

Here, we only listed the main entries. For a detailed description of the individual elements and their use, please see chapter 5.3. In addition, chapter 7 provides a detailed explanation of the individual commands and their use.

### 5. Trigger Lists with Macros

#### 5.1 Macros in General

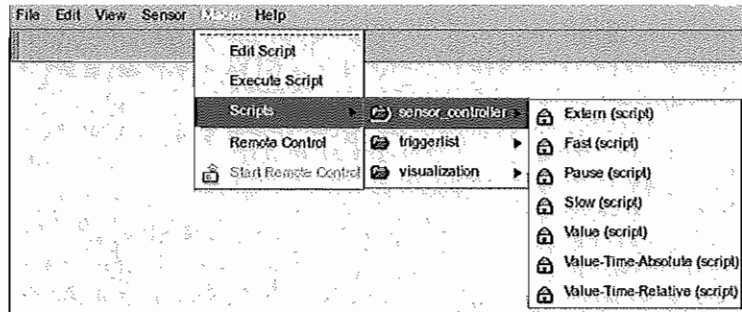
The macro functionality of the software provides for recording recurrent standard procedures in order to play them automatically. In addition, it is possible to link new functions or own programs with the software.

The trigger list macros were programmed in order to quickly and easily create trigger lists for different measurement procedures

#### 5.2 Starting a Macro

The macros can be started with menu item Macro ▶ Scripts ▶ sensor\_controller. There, they are combined in a submenu.

This can be done in any mode of the software.



After selecting a macro, a dialog window opens, e.g.:

To create a new triggerlist enter a filename with ending \*.tl.

To add an element to existing trigger list, select the triggerlist by clicking on select.

**Value Range:**

0 = -10 ... 10 V 2 = 0 ... 10 V  
1 = -5 ... 5 V 3 = 0 ... 5 V

Dialog box with fields for Triggerlist Name (test-fast), Value Range (0-3), Number of Images (200), and Framerate (FPS) (15). Includes Select, OK, and Cancel buttons.

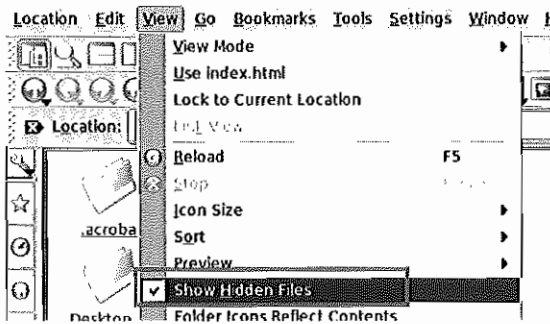
**Info**

Enter the name of the trigger list in the respective field. If the name does not end with \*.tl, the extension is automatically added.

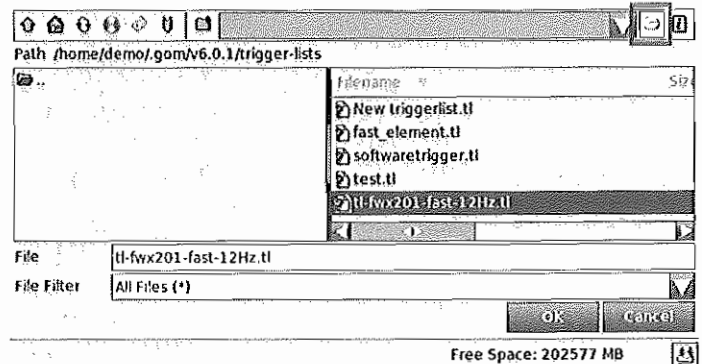
**Info**

If you enter the name of an already existing trigger list or choose it with Select (the trigger lists are saved in directory ~/ .gom/v6.x.x/sensor-controller), the element will be added to the already existing list! Thus, you may easily define complex trigger lists (see also chapter 6).

If the directory `.gom` is not visible in the file selection dialog, proceed as follows:



When working with the file manager (Konqueror)



When working with the menu (e.g. with Select)

At the end, you should again change the recording mode (**Mode**, see chapter 3.1) in order to update the dialog Triggerlist (e.g. change mode from Triggerlist to Fast Measurement and back again).

## 5.3 Macro Elements

### 5.3.1 General

The following macros have a similar basic structure, therefore we give some information here that is valid for each type.

#### 5.3.1.1 Macro Header:

The header contains information about the version and elements.

#### 5.3.1.2 A/D Channels:

Here, the A/D channels are configured.

`set_ad_channels channels={ 0, 1 }` The A/D channels stated in the list are measured.

`set_ad_range range="BI_10V"` The A/D channels are measured in the given range.

#### 5.3.1.3 Element Line:

The following parameters are always the same:

`num=1` Number of the events in this element

`divider=1` The event divider states which event will really start recording of an image (if you enter 1, the event rate = frame rate). This is useful if you do not want to record every trigger signal but every *n*th or if the sensor controller is to record A/D values at a higher rate than the sensor records images.

`save=true` Measuring A/D values? true - yes; false - no

`trigger=true` Start trigger (image recording)? true - yes; false - no

`arm=false` The event can only occur if the "Arm" status is active. true - yes; false - no

For detailed information, please read chapter 7.

### 5.3.2 Important Notes!

As during the operation of the macro elements the recording limits of the measuring system (see also chapter 6.2) are no longer shown, they can easily be exceeded. This causes wrong measurements and/or the loss of images. Therefore, it is important to explain some points. These points are:

#### 5.3.2.1 set\_ad\_range

This is the value range of a signal which is recorded at the A/D interfaces. In general, for most of the measurements, the default range of -10V to 10V ("BI\_10V") does not need to be changed.

In order to avoid damages to the sensor controller, the adjusted voltage range must not be exceeded!

#### 5.3.2.2 Basic Settings

The maximum number of images and the shutter time have to be entered separately in the image recording mode (Triggerlist setting) if these values are not directly controlled by the header of the trigger list.

Example: If the maximum number of images is set to 10 images, the measurement will be aborted after 10 images even if in the trigger list more images were defined. Therefore, always adjust a sufficient number of images.

#### Info

Generally, always make sure that the maximum frame rate in the trigger list does not exceed the maximum frame rate of the cameras and that the shutter time is short enough to achieve this image rate. A wrong setting may cause the images to be triggered not at all or at a wrong time. To check this, you may determine the maximum possible shutter time with the frame rate adjusted in the recording mode **Fast Measurement** (increase the shutter time to its maximum extent). This is the maximum shutter time you can use during a measurement (see also chapter 6.2).

Alternatively, it is advisable to use the "script wizard" (chapter 4) to determine basic conditions that are valid during the entire measurement.

### 5.3.3 Additional Notes

#### 5.3.3.1 Abort Button

Note that when using the abort button at connector **Abort**, the signal of the button is only registered if the sensor controller is scanning (e.g. recording the A/D values or an image). In case of slow measurements this might lead to the fact that the button needs to be pressed longer in order to abort the measurement (see chapters 6.4 and 6.5).



### 5.3.3.2 Later Editing

The individually created trigger lists (elements) can be modified manually at any time using dialog Edit Triggerlist (see chapter 3.2).

### 5.3.4 Element Extern

Using this macro, you may trigger images using an external signal (e.g. photoelectric sensor). Each signal corresponds to one image.

To create a new triggerlist enter a filename with ending ".tl".

To add an element to existing trigger list, select the triggerlist by clicking on choose.

**Value Range:**

0 = -10...10 V 2 = 0...10 V  
1 = -5...5 V 3 = 0...5 V

Triggerlist Name:

Value Range (0-3):

Number of Images:

Enter the required number of images in the field Number of Images.

Triggerlist:

Editor

```

# Triggerlist created by COM-Triggerlist Tool 2.0-0
#
## Version: Tom v6.1.1-3a
## Controller: Sensor Controller
#
# Enable A/D Channels
set_ad_channels channels={ 0, 1 }

## Element: Extern
set_ad_range range="BI_10V"
triggered_measurement num=50 divider=1 save=true trigger=true arm=false
    
```

Line of the element:

- triggered\_measurement external trigger
- num=50 at each trigger signal one image is recorded (50 times)

### 5.3.5 Element Fast

With this macro, you can define a fixed camera speed for the entire measurement.

To create a new triggerlist enter a filename with ending ".tl".

To add an element to existing trigger list, select the triggerlist by clicking on select.

**Value Range:**

0 = -10...10 V 2 = 0...10 V  
1 = -5...5 V 3 = 0...5 V

Triggerlist Name:

Value Range (0-3):

Number of Images:

Framerate (FPS):

Enter the required number of images in the field Number of Images. The desired Frame rate (FPS) is stated in frames per second (observe maximum value of camera and shutter time!). (See also chapter 6.2.2)

**Info**

The first image is only triggered after 1/rate.

Triggerlist:

Editor:

```

V
V Triggerlist created by GOM-Triggerlist Tool 2.0-0
V
## Version: Ton v6.1.1-3a
## Controller: Sensor Controller
V
V Enable A/D Channels
set_ad_channels channels={ 0, 1 }

## Element: Fast
set_ad_range range="BI_10V"
fast_measurement num=200 divider=1 save=true trigger=true arn=false rate=15

```

Line of the element:

- fast\_measurement fast image recording
- num=200 (number of images), 200 images per second are recorded
- rate=15 (frame rate), 15 images per second are recorded

**Info**

Generally, this element can be created with the "script wizard" for simple lists (chapter 4). The wizard automatically generates a header in

the trigger list which excludes operating errors and thus avoids errors when recording images (loss of images).

### 5.3.6 Element Pause

When linking several macro elements it is sometimes important to insert a short pause between two elements. This is done by the pause macro.

To create a **new triggerlist** enter a filename with ending ".tl".

To **add an element** to existing trigger list, select the triggerlist by clicking on choose.

Triggerlist Name

Max. Framerate of Camera

The waiting time is entered in format 1/x (1/12=0.833s waiting time).

Triggerlist

Editor

```

V
V Triggerlist created by GOM-Triggerlist Tool 2.0-0
V
V# Version: Tom v6.1.1-3a
V# Controller: Sensor Controller
V
V Enable A/D Channels
set_ad_channels channels={ 0, 1 }

V# Element: ShortDelay
fast_measurement num=1 divider=1 save=false trigger=false arm=false rate=12
    
```

This element corresponds to a fast measurement without image recording (trigger=0), with a sample rate of 12Hz (rate=12) and a single scanning signal (num=1) to end the element, i.e. exactly after 1/12 s.

**Info**

This element is used, for example, in order to ensure the mandatory dead time following the last image of an element (fast image sequence) before starting new image recording in the next element (e.g. External, Slow) (see also chapter 6.2.2). This element is NOT suitable for longer waiting times! Create them with element Slow (chapter 5.3.7).

### 5.3.7 Element Slow

Element Slow allows for slow measurements with fixed defined times between two images. This provides to easily carry out long-term measurements.

To create a new triggerlist enter a filename with ending ".tl".  
To add an element to existing trigger list, select the triggerlist by clicking on select.

#### Value Range:

0 = -10...10 V 2 = 0...10 V  
1 = -5...5 V 3 = 0...5 V

Time Step ( $\mu$ s) must have six numbers.

Triggerlist Name	<input type="text" value="test-slow"/>	<input type="button" value="Auswählen"/>
Value Range (0-3)	<input type="text" value="0"/>	<input type="button" value="v"/>
Number of Images	<input type="text" value="10"/>	<input type="button" value="v"/>
Time Step (s)	<input type="text" value="3600"/>	<input type="button" value="v"/>
Time Step ( $\mu$ s)	<input type="text" value="0"/>	<input type="button" value="v"/>
		<input type="button" value="OK"/> <input type="button" value="Abbrechen"/>

Enter the time between the images in the fields Time Step (s) and ( $\mu$ s).

#### Info

The first image is recorded immediately when starting the trigger list.

Triggerlist

---

f Gles

```

#
# Triggerlist created by GON-Triggerlist Tool 2.0-0
#
## Version: Ton v6.1.1-3a
## Controller: Sensor Controller
#
# Enable A/D Channels
set_ad_channels channels={ 0, 1 }

## Element: Slow
set_ad_range range="BI_107"
slow_measurement num=10 divider=1 save=true trigger=true aih=false intervall={ 3600, 0 }

```

Line of the element:

- slow\_measurement slow image recording
- num=10 (number of images), 10 images per second are recorded
- intervall={ 3600, 0 } time interval from image to image, here 3600s + 0 $\mu$ s = 1h

### 5.3.8 Element Value

When applying a signal (e.g. the force of a tensile testing machine) to an A/D channel it is possible to start and control a measurement by means of the electric voltage of an input signal.

To create a new triggerlist enter a filename with ending ".tl".  
 To add an element to existing trigger list, select the triggerlist by clicking on select.

**Value Range:**

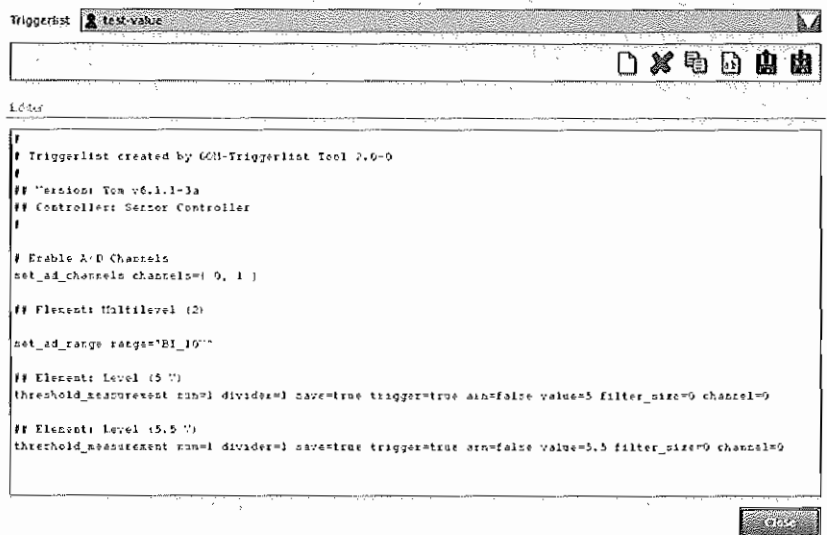
0 = -10...10 V 2 = 0...10 V  
 1 = -5...5 V 3 = 0...5 V

Triggerlist Name	test-value	Select
Value Range (0-3)	0	▼
Analog Channel (0-1)	0	▼
Start Value (V)	5.00	▼
Increment (V)	0.50	▼
Number of List Entries	2	▼
		OK Cancel

Here, input A/D 0 (Analog Channel:0) in the range -10 to +10V (Value Range:0) was used.

The measurement starts and records an image at 5 V (Start Value 5.00). After additional 0.5 V (Increment 0.50) the next image is recorded.

The total number of images in this example is 2 (Number of List Entries: 2)



In contrast to the other macros, here, each image is allocated a separate element with fixed voltage values.

The second line (first element) means:

- threshold\_measurement triggers at A/D value
- value=5 triggers at 5V

- filter\_size=0 A/D values are interpreted unfiltered (see also 5.3.9)
- channel=0 triggers at A/D channel 0 (the first channel from the list "set\_ad\_channels")

Element "complex\_measurement" provides for more complex image recording using AD values (e.g. chapters 5.3.9 and 5.3.10).

### 5.3.9 Element Value-Time-Absolute

To create a new triggerlist enter a filename with ending ".tl".  
To add an element to existing trigger list, select the triggerlist by clicking on select.

Dead time specifies the time after a trigger signal when no new trigger can be set up.

(Dead time > Shutter time)

Value Range:

0 = -10...10 V 2 = 0...10 V  
1 = -5...5 V 3 = 0...5 V

Compare Flag

1 = rising edge  
2 = falling edge  
3 = rising and falling edge

Triggerlist Name	test-time-absolute	Select
Value Range (0,3)	0	
Compare Flag (1,2,3)	3	
Analog Channel (0,1)	0	
Target Analog Value [V]	5.00	
Relative Time Step [s]	1.00	
Dead Time [s]	0.05	
Filter Size	10	
		OK Cancel

```
#
# Triggerlist created by GOM-Triggerlist Tool 2.0-0
#
## Version: Tom v6.1.1-3
## Controller: Sensor Controller
#
# Enable A/D Channels
set_ad_channels channels={ 0, 1 }

## Element: Abstract (absolute, 5.000000 V, timestep 1.000000)
set_ad_range range="BI_10V"
complex_measurement divider=1 save=true trigger=true arm=false compare_mode={ "absolute", "value" } value=5
snap_intervall={ 1, 0 } post_snap=true loops=1 loop_deadtime={ 0, 50000 } camera_deadtime={ 0, 50000 } filter_size=10 channel=0
```

Macro Value-Time-Absolute with its special trigger list command "complex\_measurement" is used for a combined time and value controlled measurement.

This macro triggers images at a defined time difference and when reaching a certain voltage value. In addition, it is possible to record the value-controlled image at raising, falling or both edges of the voltage signal.

In this example, we used the default setting with the voltage range of -10 to +10 Volt (Value Range 0) on channel 0 (Analog Channel 0).

For this measurement, an image is triggered each second (Relative Time Step 1.00) and additionally an image at 5V (Target Analog Value 5.00).

The dead time here is set to 0.05 s. Depending on the frame rate and

the cameras, the dead time needs to be adapted according to chapter 6.2.2). The dead time avoids that the "value image" coincides with the "time image". If the "value image" lies within this time slot, it is not triggered as a "time image" already exists which has almost the desired value.

In addition, choose a sufficient filter size (here 10) depending on the quality of the analog voltage signal used, in order to avoid that a "value image" is triggered unintentionally because of signal noise. A moving average is determined from the given number of analog values and compared with the desired value. The resulting time slot depends on the number of the measured A/D channels ("set\_ad\_channels"):

Number of the A/D channels	Converting rate [kHz]	averaged time slot at filter_size=10 [ms]
1	100	0.1
2	50	0.2
3	33.3	0.3
4	25	0.4
5	20	0.5
6	16.6	0.6
7	14.2	0.7
8	12.5	0.8

The most important parameters of the element line are:

- `compare_mode={"absolute","value"}` The system triggers at a fixed analog value.
- `value=5` Target value for "value images", here: 5V
- `snap_intervall={1, 0}` Time interval for "time images", here: 1s + 0 $\mu$ s = 1.0s
- `loops=1` is repeated until the analog value is reached once.
- `camera_deadtime={0,50000}` Dead time (see also chapter 6.2.2), here: 0s + 50000 $\mu$ s = 0.05s
- `loop_deadtime={0.50000}` Waiting time until analog values are measured again and compared (to avoid counting loops for the same value)
- `filter_size=10` filter size, here moving average of 10 analog values (see above)
- `channel=0` triggers at A/D channel 0 (the first channel from the list "set\_ad\_channels")

For more details with respect to the individual parameters in element "complex\_measurement", please refer to chapter 7.1.5.

5.3.10 Element Value-Time-Relative

Another macro for a time and value controlled measurement is macro element Time-Value-Relative. In contrast to macro Time-Value-Absolute, this macro allows for triggering at numerous equal voltage differences instead at just one voltage value. That means that with high voltage gradients many value images are recorded and without voltage gradients only time images are recorded. Thus, for example, a measurement can be made with a tensile testing machine where images are triggered not only at a fixed time interval but also at certain forces (e.g. every 100N, etc.).

To create a new triggerlist enter a filename with ending ".d".  
 To add an element to existing trigger list, select the triggerlist by clicking on select.  
 Dead time specifies the time after a trigger signal when no new trigger can be set up.  
 (Dead time > Shutter time)  
**Value Range:**  
 0 = -10...10 V 2 = 0...10 V  
 1 = -5...5 V 3 = 0...5 V  
**Compare Flag**  
 0 = both steps  
 4 = rising step

Triggerlist Name	test-value-time-relative	Select
Value Range (0..3)	0	
Compare Flag (0,4)	0	
Analog Channel (0,1)	0	
Relative Analog Step [V]	1.00	
Relative Time Step [s]	1.00	
Dead Time [s]	0.05	
Number of Analog Events	8	
Filter Size	10	
		OK Cancel

```
#
# Triggerlist created by GOM-Triggerlist Tool 2.0-0
#
## Version: Tom v6.1.1-3
## Controller: Sensor Controller
#

# Enable A/D Channels
set_ad_channels channels={ 0, 1 }

## Element: Abstract (relative, +/-1.000000 V, timestep 1.000000)
set_ad_range range="BI_10V"
complex_measurement divider=1 save=true trigger=true arm=false compare_mode={ "relative", "signed", "value" } value=1
snap_intervall={ 1, 0 } post_snap=true loops=8 loop_deadtime={ 0, 50000 } camera_deadtime={ 0, 50000 } filter_size=10 channel=0
```

In the dialog window of this macro, analogous to the macro Time-Value-Absolute, the values for Value Range, Analog Channel, Relative Time Step, Dead Time and Filter Size are entered (chapter 5.3.9).

However, here the Compare Flag is used with 0 (rising and falling) and 4 (signed; positive voltage value = rising, negative voltage value = falling). Relative Analog Step indicates the voltage difference and Number of Analog Events the number of the "value images".



The most important parameters of the element line are:

- `compare_mode={"relative","signed","value"}` Here, the system triggers at an analog value difference with corresponding sign.
- `value=1` analog value difference, here: 1V
- `snap_intervall={1, 0}` Time interval for "time images", here: 1s + 0 $\mu$ s = 1.0s
- `loops=8` is repeated eight times until the analog value difference was measured.
- `camera_deadtime={0,50000}` Dead time (see also chapter 6.2.2), here: 0s + 50000 $\mu$ s = 0.05s
- `loop_deadtime={0.50000}` Waiting time until analog values are measured again and compared (to avoid counting loops for the same value)
- `filter_size=10` filter size, here moving average of 10 analog values (5.3.9)
- `channel=0` triggers at A/D channel 0 (the first channel from the list "set\_ad\_channels")

For more details with respect to the individual parameters in element "complex\_measurement", please refer to chapter 7.1.5.

## 6. Complex Trigger Lists

### 6.1 General

As already shown in chapter 4.2, trigger lists may be made up of several elements. This can either be done easily by means of a macro (chapter 5.2, 6.3) or manually (chapter 3.2). The required dead times, the shutter time and the maximum number of images need to be taken into account in order to guarantee a correct function.

### 6.2 Limits

#### 6.2.1 Element Switching Time

**Info**

In a trigger list, there might be a delay of up to few milliseconds during switching from one element (command) to another.

#### 6.2.2 Required Dead Times

If measurements are made using a trigger list, the sensor controller decides (based on the loaded trigger list) when an image is recorded. The sensor controller sends the signal to record an image through the frame grabber boards (or FireWire hub, GigE hub) directly to the camera (the computer and the software are not involved). After the shutter time adjusted by the software, the image is transmitted from the camera to the computer (read-out time). During this time, the sensor controller is not allowed to send another trigger signal to the camera.

$$\text{min. dead time} = \text{read-out time} + \text{max. shutter time}$$

The minimum dead time differs depending on the camera type:

Camera (overlapped)	Max. frame rate [Hz]	Min. dead time [ms]= 1/max. frame rate	Max. shutter time [ms]
FWX201	12	84	79
FWX201 2x2 Binning	24	42	39
FWX401D	7	143	135
FWX401D 2x2 Binning	14	72	67
TXG50i	15	67	63
TXG50i 2x2 Binning	28	36	33
<i>Dalsa Falcon 4M60:</i>			
1/1 (2352x1728)	55	18.2	16.3
1/2 (2352x864)	110	9.1	8.1
1/4 (2352x432)	220	4.6	3.8
1/8 (2352x216)	440	2.3	1.9
<i>Baler A504k:</i>			
1/1 (1280x1024)	500	2	1.9
1/2 (1280x512)	1000	1	0.95
1/4 (1280x256)	2000	0.5	0.455
1/8 (1280x128)	4000	0.25	0.205

**Info**

If during the dead time a trigger signal is sent to the camera nevertheless, no image is recorded. Even though, a time stamp and the A/D values of the sensor controller are recorded. Later, when assigning the A/D values and the times to the images automatically, an error occurs that cannot be corrected.

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**Info**

The element "fast\_measurement" (7.1.2) ensures the dead time before the element starts. The first image is only triggered after 1/rate. The element ends immediately after the last image. This does not ensure a dead time after ending the element.

**Info**

The element "slow\_measurement" (7.1.4) does not ensure a dead time at the start of the element. The first image is recorded immediately. The element ends after the last image and only after the defined delay time. This ensures a dead time after ending the element.

### 6.2.3 Allowed Shutter Times / Definition of a Shutter Limit

As already described in chapter 6.2.2, it is not allowed to record a new image within the dead time after an image was triggered by a trigger list.

#### 6.2.3.1 Element Fast:

The maximum admissible frame rate (=trigger rate of the sensor controller) depends on the dead time. From the desired frame rate (depending on the camera used (see chapter 6.2.2)), the maximum admissible shutter time can be determined.

$$\begin{aligned} \text{max. shutter time} &= 1/\text{frame rate} - \text{read-out time} \\ &= \text{dead time} - \text{read-out time} \end{aligned}$$

or, for cameras working with overlap of shutter time and read-out time:

$$\begin{aligned} \text{max. shutter time} &= 1/\text{frame rate} - \text{safety} \\ &= \text{dead time} - \text{safety} \end{aligned}$$

This is done automatically in mode Fast Measurement and the adjustable shutter time is limited based on the frame rate selected before.

When creating a new trigger list using the "script wizard" (see chapter 4), the adjustable shutter time is also limited matching the frame rate and thus avoids errors.

In order to avoid errors in complex trigger lists, the header of a list that was defined by means of the "script wizard" can be used. Ensure that the maximum frame rate which will occur in the trigger list is used when defining the list by means of the wizard.

**The shutter time that is allowed for the desired frame rate can easily be determined with mode Fast Measurement or with the "script wizard".**

**Info**

When using external trigger signals (element triggered\_measurement) or A/D values of controlled image recording (elements threshold\_measurement and complex\_measurement) the user has to ensure that the maximum trigger rate does not exceed the maximum admissible frame rate. You can prevent operating errors if:

1. you limit the shutter time in the trigger list header (e.g. matching element Fast),
2. you insert additional pause elements (chapter 5.3.6) before the elements triggered\_measurement and complex\_measurement including the required dead times, and
3. if you set the correct dead time in the element complex\_measurement.

### 6.2.4 Maximum Number of Images

The maximum possible number of images depends on the main memory or the size available for image recording (max. 10,000 images).

With current Linux installations (GOM Linux 10, 64bit PC), maximally half of the available free main memory may be reserved. This results in the following maximum number of images:

Camera	No. of images with 64bit, for 16 GB main memory, 19" PC (GOM Linux 10)	No. of images with 64bit, for 32 GB main memory, 19" PC (GOM Linux 10)	No. of images with 64bit, for 4 GB main memory, Laptop (GOM Linux 10)
FWX201	1500	3400	380
FWX201 2x2 Binning	1500	3400	380
FWX401D	700	1600	160
FWX401D 2x2 Binning	700	1600	160
TXG50i	600	1300	120
TXG50i 2x2 Binning	600	1300	120
<b>Dallas Falcon 4M60</b>			
1/1 (2352x1728)	700	1600	-
1/2 (2352x864)	1400	3200	-
1/4 (2352x432)	2800	6400	-
1/8 (2352x216)	5600	10000	-

Baier A504k:	with 1GB BV board
1/1 (1280x1024)	800
1/2 (1280x512)	1600
1/4 (1280x256)	3200
1/8 (1280x128)	6400

When starting a trigger list, adjust the desired number of images. If the adjusted number is larger than the number of images created with the trigger list, recording will automatically be stopped at the end of the trigger list (see also chapter 6.7).

If the number adjusted here is smaller than the number of images in the trigger list, recording of images is stopped if the adjusted number is achieved.

#### Info

If you want to avoid the adjustment of a too small number of images, you may enter the required number of images in the trigger list header as a fixed value (see chapter 4). However, the predefined number must not exceed the available free main memory!

### 6.3 Combining Several Trigger List Elements

In order to be able to create a complex measurement with different requirements, the trigger list macros allow to combine the individual macro elements in any way.

Open the macro element you would like to use and enter the name of the existing trigger list or select a list manually with **Select**. The new element is then placed at the end of the list.

### 6.4 Manual Abortion of a Trigger List Element

During a trigger list measurement, individual elements may be aborted (e.g. if an analog value is no longer reached but you would like to continue measuring nevertheless). There are two possibilities to do this:

- **Skip** in the status dialog during the measurement aborts the current element and continues with the next following element.
- Pressing the button which is connected to **Abort**. The abort behavior of the abort input must be set to **Skip** in the Web interface of the sensor controller (see User Information - Hardware).

To abort the entire trigger list, there are three possibilities available:

- **Abort** in the status dialog during the measurement aborts the trigger list.
- Pressing the button which is connected to **Abort**. The abort behavior of the abort input must be set to **Abort** in the Web interface of the sensor controller (see User Information - Hardware).
- Pressing **Esc** during the measurement and confirming the abort dialog with **OK**.

Status

Running triggerlist.. (Element 2) (Images: 0)



### 6.5 Example: Trigger List Slow-Fast

We explain the combination of elements using trigger list Slow-Fast as example. The measurement should do the following:

- Starting via external trigger with image recording
- Slow measurement with a fixed frame rate of 1Hz max. 100 images
- Abortion of the slow measurement by means of the external button at **Abort**
- Fast measurement with high frame rate of 20 Hz, max. 511 images

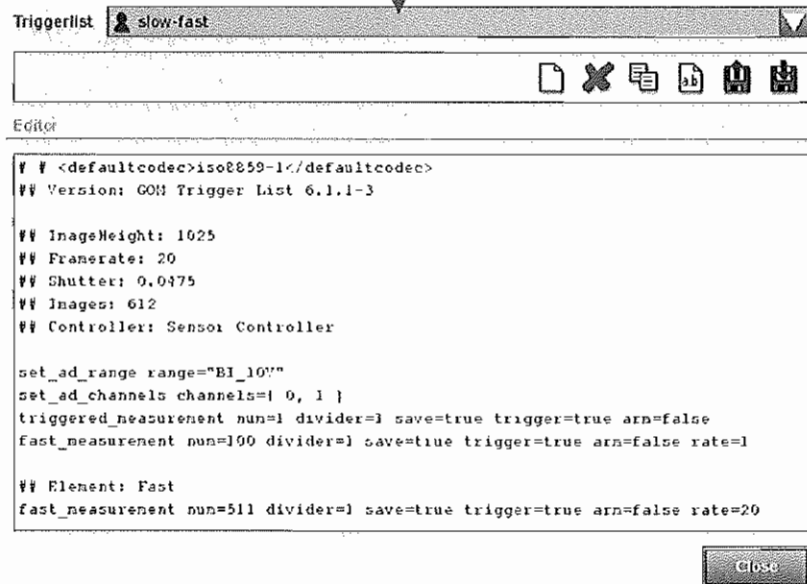
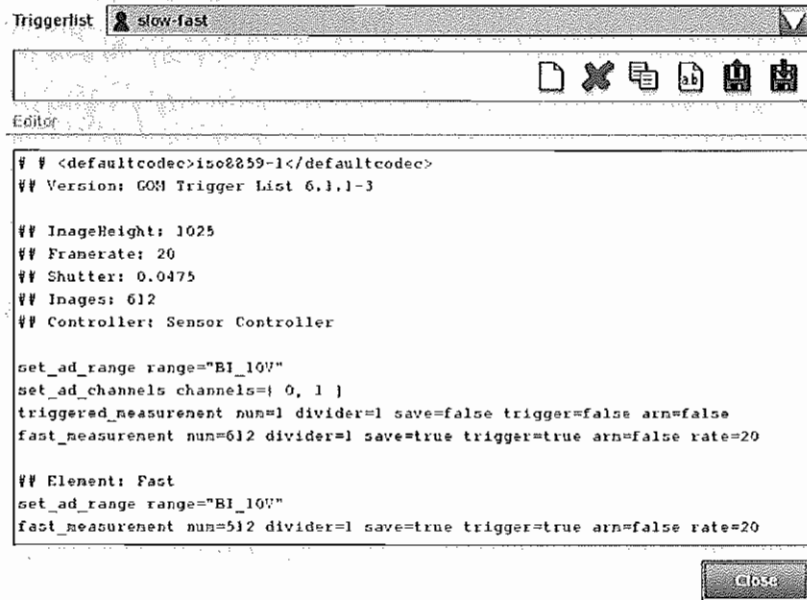
In order to create basic conditions that are valid for the entire measurement, we use the "script wizard" to create a **Fast Measurement** with the name "slow-fast". Here, the conditions (612 images, max. 20Hz, shutter time max. 0.01s) are defined as described in chapter 4. This is the basic structure of the measurement.

Then, the macro can be selected with Macro ► Scripts ► sensor\_controller ► Fast. Now, set Triggerlist Name = slow-fast (the same list name as for the previously created fast measurement), Number of Images = 511 and Framerate = 20. (Alternatively to the list name, you may also choose with Select the previously created list from ~/.gom/v6.x.x/sensor-controller.)

The new element is now automatically added to the existing list.

This is now a trigger list with linked elements. In order to be able to use it according to the given requirements, you need to make the following changes manually (Edit Triggerlist):

The header shows the version information and the basic conditions of the measurement that should not be changed.



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Starting via external trigger with image recording:

triggered\_measurement: Set "save=false trigger=false" to "save=true trigger=true", now the image recording is started at an external trigger and the A/D values are saved.

Slow measurement with a fixed frame rate of 1Hz max. 100 images

fast\_measurement: Set "num=612 rate=20" to "num=100 rate=1"

Fast measurement with high frame rate of 20 Hz, max. 511 images:

set\_ad\_range: This line may be dropped as the A/D value measuring range has already been defined in the upper part of the trigger list.

In addition, it is possible to add, for example, another fast measurement. For this, copy the entire area "#Element: Fast" and adapt the frame rate and the number of images as required.

### 6.6 Example: Trigger List for Extreme Values

A trigger list needs to meet the following conditions:

- Measurement of a cyclic test
- Image recording only at the minimum and maximum values of the force signal
- Maximum frame rate 5Hz

This task may be accomplished by using the element "complex\_measurement" (7.1.5). To create a predefined trigger list that contains this element and all parameters, you may use the macros Value-Time-Absolute (5.3.9) and Value-Time-Relative (5.3.10):  
**Macro ▶ Scripts ▶ sensor\_controller ▶ Value-Time-Absolute.**

To create a new triggerlist enter a filename with ending ".tl".

To add an element to existing trigger list, select the triggerlist by clicking on select.

Dead time specifies the time after a trigger signal when no new trigger can be set up.

(Dead time > Shutter time)

Value Range:

0 = -10...10 V 2 = 0...10 V

1 = -5...5 V 3 = 0...5 V

Compare Flag

1 = rising edge

2 = falling edge

3 = rising and falling edge

Triggerlist Name	extrema	OK
Value Range (0-3)	0	▼
Compare Flag (1,2,3)	3	▼
Analog Channel (0-7)	0	▼
Target Analog Value [V]	0.00	▼
Relative Time Step [s]	1.00	▼
Dead Time [s]	0.20	▼
Filter Size	20	▼
		OK Cancel

The created trigger list is shown in the measurement mode Trigger list. It can be opened in an editor with right mouse button ▶ Edit Trigger list ▶ right mouse button ▶ Edit Trigger list.

Edit the trigger list as follows:

```
set_ad_channels channels={ 0, 1 }
set_ad_range range="BI_10V"
complex_measurement num=1 divider=1 save=true trigger=true arm=false compare_mode={ "absolute", "unsigned", "gradient" } value=0 snap_interval={ 0, 0 } post_snap=true loops=20 loop_deadtime={ 0, 200000 } camera_deadtime={ 0, 200000 } filter_size=200 channel=0
```

The individual parameters have the following meaning:

compare\_mode={absolute,unsigned,gradient} value=0

The system triggers at a gradient ("gradient") of 0 ("value=0" means extreme value). Since it is "value=0", "unsigned"/"signed" does not matter. As the optional parameter "rising\_edge\_only"/"falling\_edge\_only" was left out, the system triggers at both edges of the gradient (maximum and minimum).

snap\_interval={0,0}

No additional images are recorded in a set period. If the parameter was dropped completely, the meaning would be the same.

loops=20

The system waits 20 times for an extrema and records one image.

loop\_deadtime={0,200000} camera\_deadtime={0,200000}

An image can only be recorded  $0.2\text{s} = 0\text{s} + 200000\mu\text{s}$  (=5Hz) after the last image ("camera\_deadtime"). If any trigger events occur before (e.g. with a smaller "loop\_deadtime"), the loops will be still counted but no image is recorded.

The system waits for the next extrema after  $0.2\text{s} = 0\text{s} + 200000\mu\text{s}$  (=5Hz) ("loop\_deadtime"). Other extrema will be ignored in the meantime.

filter\_size=200 channel=0

A moving average is determined of 200 values each of A/D channel 0, to make the detection of extrema more robust against interference signal and noise.

For more details with respect to the element "complex\_measurement", please refer to chapter 7.1.5.

## 6.7 Further Information

If the total number of images in the elements is less than the number specified in the header or if the measurement is terminated prematurely (e.g. by means of the external button), the following warning appears:

Less images as specified were fetched.

Do not show this message again

OK

In this case, you can ignore the message.



**Info**

However, this message may also indicate that images are missing due to wrong parameters in the trigger lists (see also chapter 6.2).

These combined macro trigger lists can be edited and complemented according to the measurement situation.

**Info**

If the elements "fast\_measurement" (7.1.2), "slow\_measurement" (7.1.4) and "triggered\_measurement" are combined, you need to pay attention to the different dead time behavior (6.2.2).

- „slow“ before „fast“: between the last image of "slow\_measurement" and the first image of "fast\_measurement" there is the time interval of "slow" plus the time interval of „fast“.
- „fast“ before „slow“: between the last image of "fast\_measurement" and the first image of "slow\_measurement" there is no time interval. You need to add the respective dead time (5.3.6).

## 7. Overview of the Element Commands

In the following, we explain all commands necessary to create trigger lists and describe their parameters.

An individual element consists of two parts:

- Command
- Parameter

### 7.1 Measuring Commands

The following commands can start image recording.

#### 7.1.1 triggered\_measurement

Element "triggered\_measurement" is used for recording images by means of an external trigger (e.g. photoelectric sensor, pushbutton at the input of the photoelectric sensor, TTL at the trigger input, clicking on **Trigger** in the status dialog). In case of fast trigger signals you may use parameter "divider" in order to maintain the dead times (see chapter 6.2.2). You may start image recording by means of an external trigger ("save=true trigger=true") or switch to the following element ("num=1 save=false trigger=false").

Parameters:	Value Range:		Description:
num	0 .. 2 <sup>32</sup>	32bit	Number of the individual triggers
divider	1 .. num	optional Default: 1	Divides the external trigger rate, only every nth external trigger will lead to an image
save	true	optional Default: true	Saves A/D values
	false		No A/D values are saved and no trigger is emitted
trigger	true	optional Default: true	Trigger output, trigger an image
	false		
arm	true	optional Default: false	Using the ARM switch, a trigger is only emitted if the ARM status is active (see User Information - Hardware)
	false		

Example for triggered\_measurement:

```
triggered_measurement num=100 divider=1 save=true trigger=true arm=false
```

7.1.2 fast\_measurement

Element "fast\_measurement" provides a fixed number of images at a predefined frame rate.

**Info**

The first image is only triggered after 1/rate.

Command:	Value Range:		Description:
num	0 .. 2 <sup>32</sup>	32bit	Number of the internal triggers
divider	1 .. num	optional Default: 1	Divides the internal trigger rate, only every nth internal trigger will lead to an image
save	true	optional Default: true	Saves A/D values
	false		No A/D values are saved and no trigger is emitted
trigger	true	optional Default: true	Trigger output, trigger an image
	false		
arm	true	optional Default: false	Using the ARM switch, a trigger is only emitted if the ARM status is active (see User Information - Hardware)
	false		
rate	0 .. 100.000	Decimal number	Internal trigger rate (rounded in the 10 MHz raster)

Example for fast\_measurement:

fast\_measurement num=100 divider=1 save=true trigger=true arm=false rate=20

7.1.3 threshold\_measurement

Element "threshold\_measurement" allows to trigger at voltages applied to the A/D inputs.

Command:	Value Range:		Description:
num	0 .. 2 <sup>32</sup>	32bit	Number of the events (reaching the given voltage)
divider	1 .. num	optional Default: 1	Divides the rate of the events, only every nth event will lead to an image
save	true	optional Default: true	Saves A/D values
	false		No A/D values are saved and no trigger is emitted
trigger	true	optional Default: true	Trigger output, trigger an image
	false		
arm	true	optional Default: false	Using the ARM switch, a trigger is only emitted if the ARM status is active (see User Information - Hardware)
	false		
value	-10 .. 10	Voltage in V	Voltage at which system should be triggered
channel	0 .. 7		Index (starting with 0) of the A/D channel in the list of "set_ad_channels" (7.2.1), at which the trigger voltage is applied to (e.g.: when "set_ad_channels channels={2,3,7}" and "channel=2", then A/D channel 7 is accessed)
filter_size	0 .. 4095		The recorded A/D signal is filtered with a moving average before it is compared to the value of "value". e.g.: filter_size=10: Averaging of the last 10 values filter_size=0: No filtering, direct value comparison

**Info**

The "filter\_size" should be high enough depending on the quality of the analog voltage signal used in order to avoid an unintentional event

due to the signal noise. The resulting time slot depends on the number of the measured A/D channels ("set\_ad\_channels" 7.2.1):

Number of the A/D channels	Converting rate [kHz]	Averaged time slot at filter_size=10 [ms]
1	100	0.1
2	50	0.2
3	33.3	0.3
4	25	0.4
5	20	0.5
6	16.6	0.6
7	14.2	0.7
8	12.5	0.8

For example: Low frequency measurement voltage with a 50Hz interference signal, 4 measured A/D channels:  $1/50\text{Hz} = 0.02\text{s}$ ;  $1/25\text{kHz} = 0.00004\text{s}$ ;  $0.02\text{s}/0.00004\text{s} = 500$ : "filter\_size = 500"; means a delay of approx. 0.01s caused by the filter.

**Info**

When an image is recorded, the actual A/D values will be saved and not the filtered ones.

Example for threshold\_measurement (write in one line):

```
threshold_measurement num=1 divider=1 save=true trigger=true arm=false value=5
channel=0 filter_size=0
```

**7.1.4 slow\_measurement**

Element "slow\_measurement" provides for carrying out long-term measurements.

**Info**

The first image is recorded immediately when starting the trigger list.

Command:	Value Range:		Description:
num	0 .. 2 <sup>32</sup>	32bit	Number of the internal triggers
divider	1 .. num	optional Default: 1	Divides the internal trigger rate, only every nth internal trigger will lead to an image
save	true	optional Default: true	Saves A/D values
	false		No A/D values are saved and no trigger is emitted
trigger	true	optional Default: true	Trigger output, trigger an image
	false		
arm	true	optional Default: false	Using the ARM switch, a trigger is only emitted if the ARM status is active (see User Information - Hardware)
	false		
intervall	0 .. 2 <sup>32</sup> , 0 .. 999.999		Fixed time difference between two images in the format: { s, μs }

Example for slow\_measurement (write in one line):

```
slow_measurement num=100 divider=1 save=true trigger=true arm=false
intervall={ 3600, 0 }
```

## 7.1.5 complex\_measurement

Element "complex\_measurement" allows for numerous time and value controlled measurements.

Command:	Value Range:		Description:
divider	1 .. loops	optional Default: 1	Divides the rate of the events, only every nth event will lead to an image
save	true	optional Default: true	Saves A/D values
	false		No A/D values are saved and no trigger is emitted
trigger	true	optional Default: true	Trigger output, trigger an image
	false		
arm	true	optional Default: false	Using the ARM switch, a trigger is only emitted if the ARM status is active (see User Information - Hardware)
	false		
compare_mode	absolute		Voltage value is measured absolutely
	relative		Voltage difference value is measured relatively to the last event
	signed		Sign behavior of the comparison
	unsigned		
	value	value states voltage ("absolute") or voltage difference ("relative") in V	Value type
	gradient	defined for "absolute" only; states the voltage change in V/s	
	rising_edge_only	defined for "absolute" only	Edge behavior, if nothing is specified both edges will be evaluated.
falling_edge_only			
value	-10 .. 10	Voltage in V	Value at which an event (trigger) is activated.
	-20 .. 20	Voltage difference in V	
	-9.999 .. 9.999	Voltage change in V/s	
snap_intervall	0 .. 2 <sup>32</sup> , 0 .. 999.999	optional	Minimum fixed time difference between two images in the format: { s, µs }, without this parameter only value images
post_snap	true	Standard	If the set analog value was reached, an image will be recorded. In case of "false" only loops will be counted and time images recorded.
	false		
loops	0 .. 2 <sup>32</sup>	32bit	Number of repetitions of this element = number that shows how often the set analog value was reached. The time images do not depend on it. ("loops=1" stands for an element with time images, which aborts after reaching the set analog value.)
loop_deadtime	0 .. 2 <sup>32</sup> , 0 .. 999.999	Repetition dead time	Minimum fixed time difference between two repetitions in the format: { s, µs }, otherwise, the sensor controller probably counts the loops at the same value. Generally, it can be equal to the "camera_deadtime". When "loop_deadtime" < "camera_deadtime", the loops can also be counted while an image is recorded.
camera_deadtime	0 .. 2 <sup>32</sup> , 0 .. 999.999	Camera dead time	Minimum fixed time difference between two images in the format: { s, µs }, otherwise the sensor controller probably triggers without the camera being ready (see chapter 6.2.2)
channel	0 .. 7		Index (starting with 0) of the A/D channel in the list of "set_ad_channels" (7.2.1) at which the trigger voltage is

			applied to (e.g.: when "set_ad_channels channels={2,3,7}" and "channel=2", then A/D channel 7 is accessed)
filter_size	0 .. 4095	optional	The recorded A/D signal is filtered with a moving average before it is compared to the value of "value". e.g.: filter_size=10: Averaging of the last 10 values filter_size=0: No filtering, direct value comparison

**Info**

The "filter\_size" should be high enough depending on the quality of the analog voltage signal used in order to avoid an unintentional event due to the signal noise. The resulting time slot depends on the number of the measured A/D channels ("set\_ad\_channels" 7.2.1):

Number of the A/D channels	Converting rate [kHz]	Averaged time slot at filter_size=10 [ms]
1	100	0.1
2	50	0.2
3	33.3	0.3
4	25	0.4
5	20	0.5
6	16.6	0.6
7	14.2	0.7
8	12.5	0.8

For example: Low frequency measurement voltage with a 50Hz interference signal, 4 measured A/D channels:  $1/50\text{Hz} = 0.02\text{s}$ ;  $1/25\text{kHz} = 0.00004\text{s}$ ;  $0.02\text{s}/0.00004\text{s} = 500$ : "filter\_size = 500"; means a delay of approx. 0.01s caused by the filter.

**Info**

When an image is recorded, the actual A/D values will be saved and not the filtered ones.

**Info**

With "compare\_mode={gradient}" a filter with the double slot size is used on the calculated signal gradient (since the interferences are stronger during the calculation of the gradient).

Application Examples:

compare_mode	Application
{absolute,signed,value, rising_edge_only} value=5	Events are triggered at 5V on the rising edge ("rising_edge_only").
{relative,unsigned,value} value=0.1	Events are always triggered after a voltage difference ("relative") of 0.1V. This applies to positive as well as to negative voltage differences ("unsigned").
{absolute,unsigned, gradient,rising_edge_only} value=0	Events are always triggered during the temporary minimum of the voltage curve ("rising_edge_only" -- the gradient rises in the minimum). Since it is "value=0", sign behavior ("unsigned") does not matter. "gradient" is mainly used for triggering at minimum or maximum values ("value=0").

Example for complex\_measurement (write in one line):

```
complex_measurement divider=1 save=true trigger=true arm=false compare_mode={
"relative", "signed", "value"} value=0.5 snap_intervall={ 1, 0} post_snap=true
loops=8 loop_deadtime={ 0, 5000} camera_deadtime={ 0, 67000} channel=0 fil-
ter_size=10
```

## 7.2 Further Commands

The following commands are used for controlling trigger lists and can be used like these as an individual line in trigger lists. Partly they are also created by the trigger list macros (see chapter 5).

### 7.2.1 set\_ad\_channels

Selects the A/D channels for which an A/D conversion shall be carried out. Channels 0 through 7 are available. They have to be transferred in a list. The list will be sorted before the evaluation starts.

Example:

```
set_ad_channels channels={ 0, 1, 4 }
```

### 7.2.2 set\_ad\_range

Selects the range for the 16bit A/D conversion for the active A/D channels (see chapter 7.2.1). The following ranges are available:

- UNI\_5V (0 .. 5V)
- UNI\_10V (0 .. 10V)
- BI\_5V (-5 .. 5V)
- BI\_5V (-10 .. 10V)

They are transferred to parameter "range" as character string.

Example:

```
set_ad_range range="UNI_5V"
```

### 7.2.3 set\_lamp

Controls the current for the LED illumination of the sensor.

```
set_lamp on=true (switches the light on)
```

```
set_lamp on=false (switches the light off)
```

### 7.2.4 set\_laser

Controls the laser pointers of the sensor.

```
set_laser on=true (switches the laser pointer on)
```

```
set_laser on=false (switches the laser pointer off)
```

### 7.2.5 set\_dac

Sets a voltage value at a D/A output. Four channels are available (dac0 through dac3). The voltage can be in the range 0 to 10 V and is transmitted as a value to the parameter which is listed as channel.

Example:

```
set_dac dac0=5.0
```

### 7.2.6 jump\_to\_list\_element

Is used to create endless loops or to skip several elements in trigger lists. Jumps to the specified command. The lines are counted as of 0.

Example:

```
jump_to_list_element line=2
```

### 7.2.7 `set_trigger2_delay`

Sets the delay of the delayed trigger output for special synchronization applications. The delay is transferred as multiples of 25ns.

Example:

```
set_trigger2_delay delay=4000 (sets an delay of 100µs)
```

### 7.2.8 `set_trigger_flip`

Defines if the delayed trigger is emitted before or after the actual trigger.

```
set_trigger_flip flip=true (sets the delayed trigger BEFORE  
the main trigger)
```

```
set_trigger_flip flip=false (sets the delayed trigger after the  
main trigger, default)
```

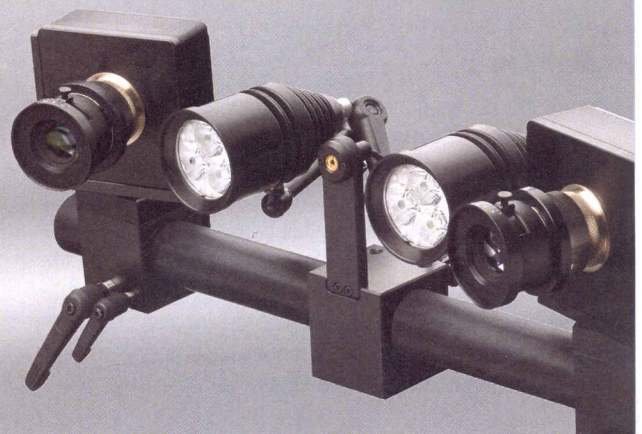
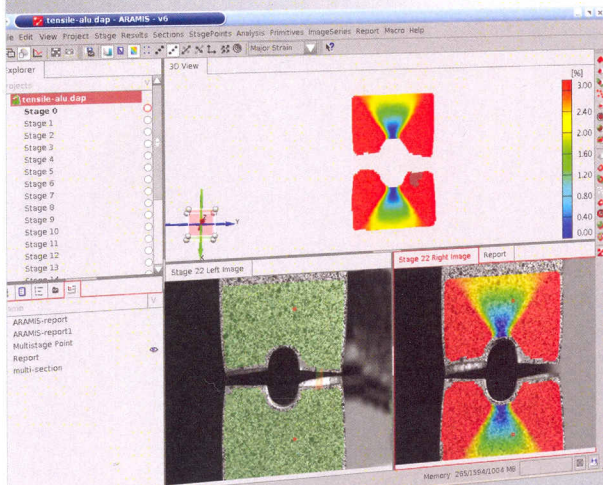
**Info**

Recording of the A/D values and the time stamp is always done at the first trigger. Thus, using "flip=true", the image recording is delayed with respect to the A/D values.



# ARAMIS

## User Manual - Software



**ARAMIS v6.1 and higher**

aramis-v6-1\_1st\_en\_rev-c 7-Aug-2009

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**gom**  
Optical Measuring Techniques

## Symbols, Legal and Safety Notes

### Symbols

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

<b>⚠ WARNING</b>	This label points to a situation that might be dangerous and could lead to serious bodily harm or to death.
<b>⚠ CAUTION</b>	This label points to a situation that might be dangerous and could lead to light bodily harm.
<b>NOTICE</b>	This label points to a situation in which the product or an object in the vicinity of the product might be damaged.
<b>Info</b>	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 User Information - Hardware!

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

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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 Project, this user manual mainly informs about the **Why** and imparts basic strategic knowledge.

For the ARAMIS hardware or special software functions, additional manuals are available.

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 ARAMIS system as well as basic knowledge about the Linux operating system and the application software.
- **Chapter B** informs about the calibration of the measuring system and about adapting the sensor.
- **Chapter C** contains a typical ARAMIS measuring procedure (choosing the measuring volume, preparing the specimen, creating a project, recording images, ...)
- **Chapter D** informs about the computation of the images (definition of facets, computation masks, creation of start points, strain computation).
- **Chapter E** informs about transformation methods for the measuring project and about eliminating rigid body movements.
- **Chapter F** deals with methods and functions to create or edit measuring results (result representations, filtering, interpolation, legends, primitives, analysis elements).
- **Chapter G** deals with methods to document measuring results (creating reports, snapshots, movies, image series, printing documentations).

- **Chapter H** informs about how to export measuring results and automate procedures in the software.
- **Chapter J** explains the theory of the basics of strain.
- **Chapter K** describes the support concepts and troubleshooting.

## ARAMIS with Linux and Windows

**Info**

This manual describes the software functionalities under Linux. Please note that when operating the software under Windows, operating steps may be slightly different, e.g. the starting of the software or file structures. However, the general system functionalities are identical except for the differences listed in the table.

**Info**

For directly operating the sensor with the ARAMIS application software, a Linux operating system is required. As of software version v6.0.2, the ARAMIS software is also available with limited functions on Windows systems.

### Functional Differences in the ARAMIS Application Software Depending on the Operating System

Function:	Linux	Windows
Direct image recording with camera	yes	no (Images can only be integrated into the software as external image series.)
Operation with the sensor controller	yes	no
Laser pointer function	yes	no
Software-supported calibration	yes	yes, but limited. (Calibration is only possible using external image series.)
Record CDs/DVDs directly in the application software	yes	no (CDs/DVDs can only be recorded using external software.)



## Main Hardware and Software Components

### Basic Requirements Under Linux

In order to achieve full functionality with the ARAMIS 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.
- Sensor controller
- 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.

### Basic Requirements Under Windows

- 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: 2GB 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: 1 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 ARAMIS software probably works with a considerably slower software rendering.

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

**Info**

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

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## A Basics

### A 1 Brief Introduction to the ARAMIS System

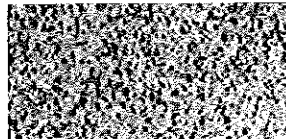
ARAMIS is a non-contact optical 3D deformation measuring system. ARAMIS analyzes, calculates and documents deformations. The graphical representation of the measuring results provides an optimum understanding of the behavior of the measuring object.

ARAMIS recognizes the surface structure of the measuring object in digital camera images and allocates coordinates to the image pixels. The first image in the measuring project represents the undeformed state of the object.

After or during the deformation of the measuring object, further images are recorded. Then, ARAMIS compares the digital images and calculates the displacement and deformation of the object characteristics.

**Info**

If the measuring object has only a few object characteristics, like it is the case with homogeneous surfaces, you need to prepare such surfaces by means of suitable methods, for example apply a stochastic color spray pattern.



Stochastic pattern

ARAMIS is particularly suitable for three-dimensional deformation measurements under static and dynamic load in order to analyze deformations and strain of real components.

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 or dialog windows.

### A 2 Fields of Application

- Material testing
- Strength assessment
- Component dimensioning
- Examination of non-linear behavior
- Characterization of creep and aging processes
- Determination of **Forming Limit Curves (FLC)**
- Verification of FE models
- Determination of material characteristics
- Analysis of the behavior of homogeneous and inhomogeneous materials during deformation
- Strain computation

### A 3 Features of the ARAMIS System

- Used as 2D or 3D measuring system.
- ARAMIS assigns square or rectangular image details, so-called facets (e.g. 15 x 15 pixels), in different images to each other.
- Varying lighting conditions of different images are automatically compensated.
- Simple preparation of the specimen as the raster method used only requires the application of a stochastic or regular pattern in case the surface of the specimen is not structured sufficiently.
- Large measuring area: Both, small and large objects (from 1 mm to 2000 mm) can be measured with the same sensor. Deformations can be measured in a range of 0,01% up to several 100%.
- Full-field and graphical 3D representation of the measuring results with high data point density.
- The graphical representation of the measuring results provides an optimum understanding of the component behavior.
- High mobility as the system can easily be accommodated in the transport cases included in the delivery. Thus, it can be transported by car or plane without any problems.  
For more mobility, the ARAMIS FireWire system is available with a powerful notebook PC.
- Transformations e.g. according to the 3-2-1 method.
- Quality control: Calculation and display of the measuring results with default or customer-specific color representations.
- Report generation and export functions for measuring and result data.
- Automation due to macro functions. Recurring command sequences can easily be automated.
- Option: Creation of user profiles for customer-specific adaptation of the user interface.

### A 4 Main Hardware and Software Components

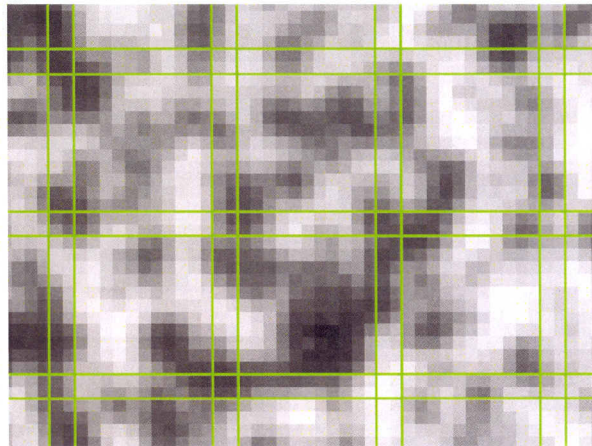
- Sensor with two cameras (only for 3D setup)
- Stand for secure and steady hold of the sensor
- Sensor controller for power supply of the cameras and to control image recording
- High-performance PC system
- ARAMIS application software v6.1 and GOM Linux 10 system software or higher

## A 5 Principle of Deviation Measurements

In general, the ARAMIS sensor unit is operated on a stand in order to optimally position the sensor with respect to the specimen. For a 3D measurement setup, two cameras are used (stereo setup) that are calibrated prior to measuring. The specimen needs to be within the resulting measuring volume (calibrated 3D space). After creating the measuring project in the software, images are recorded (monochrome, right camera, left camera) in various load stages of the specimen.

After the area to be evaluated is defined (computation mask) and a start point is determined, the measuring project is computed.

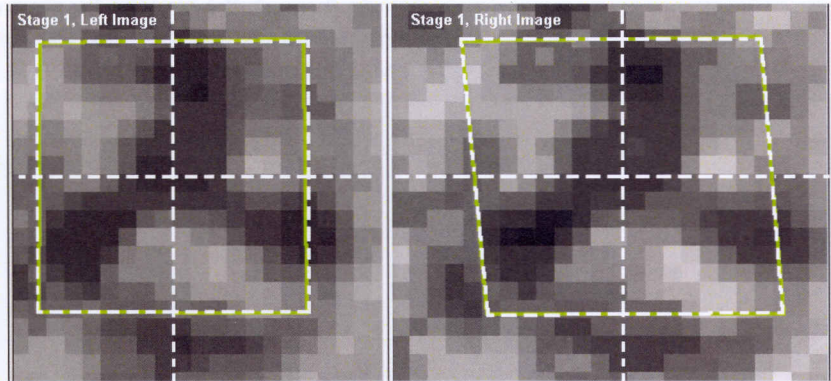
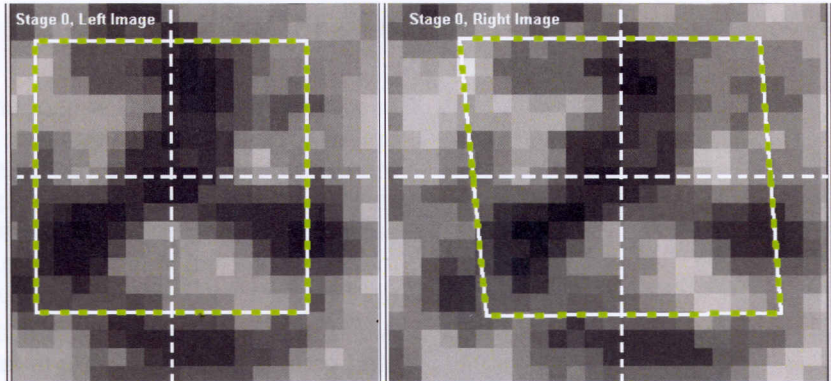
During computation, ARAMIS observes the deformation of the specimen through the images by means of various square or rectangular image details (facets). The following figure shows 15 x 15 pixel facets with a 2 pixel overlapping area in stage 0.



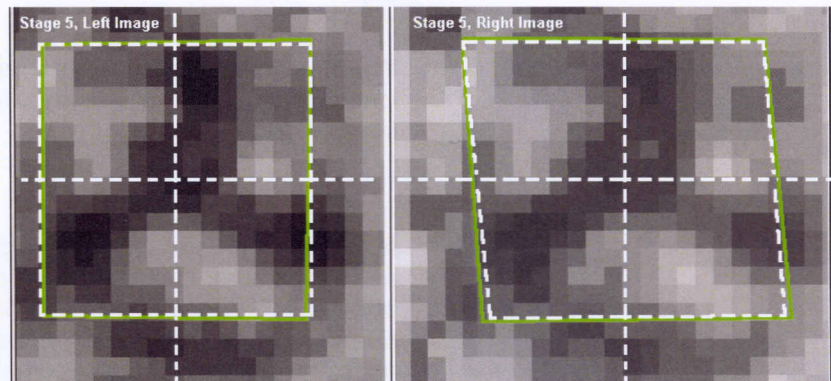
15x15 facets with 2 pixels overlapping (made visible in the 2D image via the right mouse button)

You may adjust the facet size in pixels in the software. In the different load stages, the facets are identified and followed by means of the individual gray level structures.

In the following, we show a pair of facets (15 x 15 pixels) of the right and left camera, the gray values of which were observed through six deformation stages (**Stage 0** to **Stage 5**). **Stage 0** is the undeformed reference state and **Stage 5** is the final deformation state. In these images, the white dashed line visualizes the undeformed state in order to make clear the factual relation between facets and deformation.



Stage 2, Left Image	Stage 2, Right Image
Stage 3, Left Image	Stage 3, Right Image
Stage 4, Left Image	Stage 4, Right Image



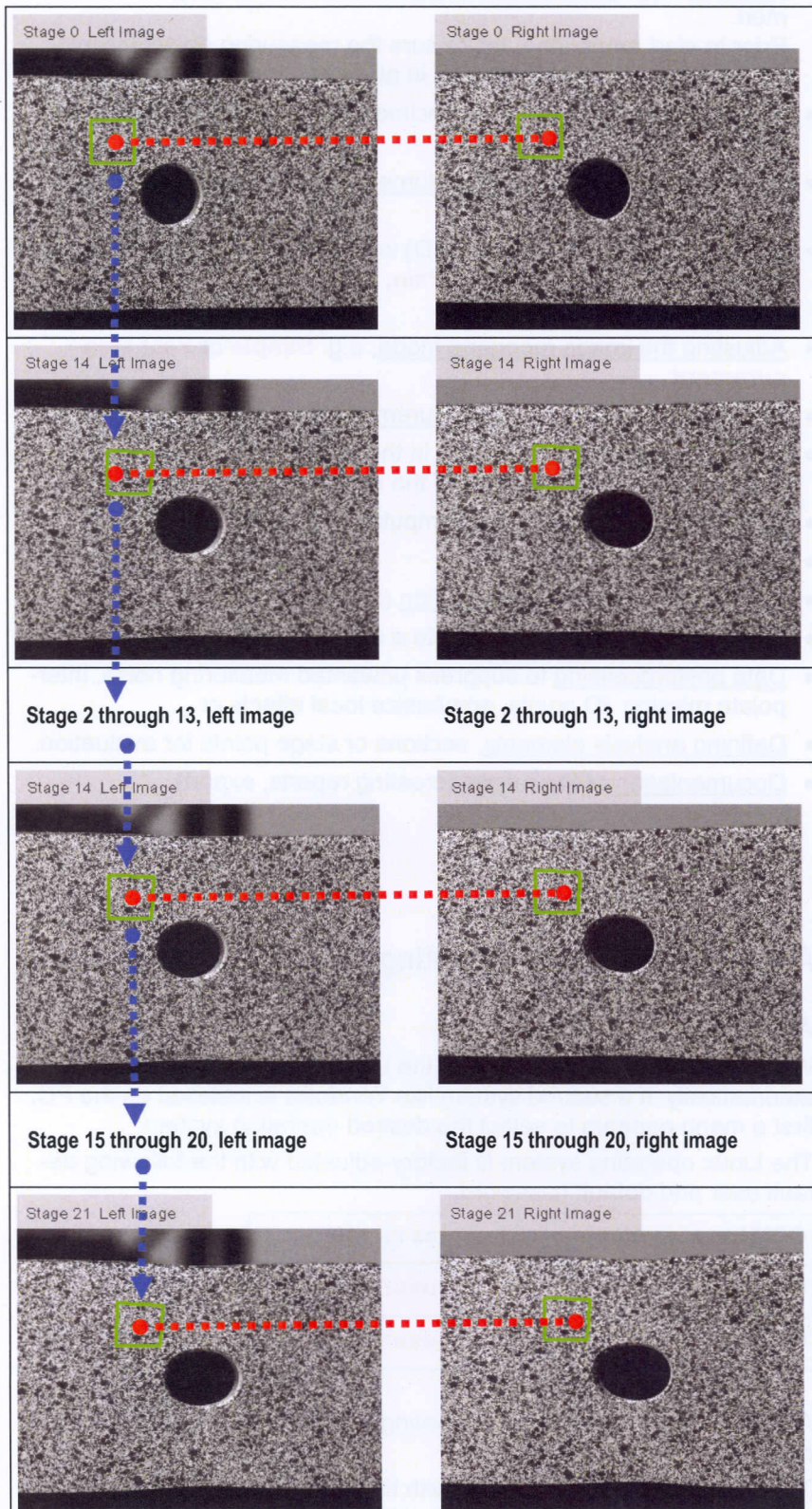
The system determines the 2D coordinates of the facets from the corner points of the green facets and the resulting centers. Using photogrammetric methods, the 2D coordinates of a facet, observed from the left camera and the 2D coordinates of the same facet, observed from the right camera, lead to a common 3D coordinate.

After successful computation, the data may undergo a post-processing procedure in order to e.g. reduce measuring noise or suppress other local perturbations.

The measuring result is now available as 3D view. All further result representations like statistical data, sections, reports, etc. are derived thereof.

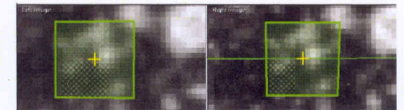


### A 5.1 Facet Computation



Using a single facet (enlarged representation) as example, we explain the computation principle for a 3D point through several deformation stages.

- The facet computation requires start points in all stages.



Start point definition (automatically or manually)

- The size of the green facet results from the facet field definition when creating the project.
- Computation is started in **Stage 0, Left Image**.

- Due to the start point definition, the software in principle knows the position of the facets and their adjacent facets in the 2D image. By identifying the individual spray pattern of a facet in the right and left image, the facet quadrangle is optimized. From the resulting 2D image coordinates of the facet (central point of the facet) in the right and left camera image, the software now calculates the 3D position of the facet.

- After the computation of the 3D positions of one stage, the software automatically continues with the next stage. Here as well, in principle the position of the facet is known because of the start point definition. Now, computation of the 3D position of the facet starts again.

- The strain computation results from the displacements of the 3D points.

**A 5.2 Steps to Carry Out a Typical Measuring Procedure**

- Determination of Measuring Volume and Preparation of the Specimen.  
Prior to start measuring, make sure the measuring object fits into the selected measuring volume in all its deformation stages.
- Specimen preparation if the specimen has only little surface structure.
- Calibration of the measuring volume in case of a 3D measuring project.
- Creating a new project (2D or 3D) in the software and defining the project parameters (Facets, Strain, Keywords, Stage Parameter ...).
- Adjusting the image recording mode, e.g. Simple or Fast Measurement.
- Recording images during measurement (e. g. tensile test)
- Defining the computation mask in the measuring images, so that only deviation relevant areas of the specimen will be computed.
- Defining a start point for the computation process.
- Compute project
- Selecting the result representation (Major Strain, Minor Strain, ...).
- Transformation of the project into a defined coordinate system.
- Data postprocessing to suppress unwanted measuring noise, interpolate missing 3D points, emphasize local effects or ... .
- Defining analysis elements, sections or stage points for evaluation.
- Documentation of the results (creating reports, export).

**A 6 The GOM Linux Operating System**

**A 6.1 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:

<b>GOM Linux version</b>	<b>as of v10</b>
<b>Default user</b>	<b>user</b>
<b>Password</b>	<b>user</b>

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 ARAMIS software.

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**A 6.1.1 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 6.1.2 Home Directory**

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

**A 6.1.3 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 6.1.4 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 6.1.5 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 6.1.6 Loudspeakers**

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

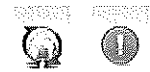
**A 6.1.7 Linux Operating System Updates**

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 6.1.8 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 6.1.9 Starting the ARAMIS Software**

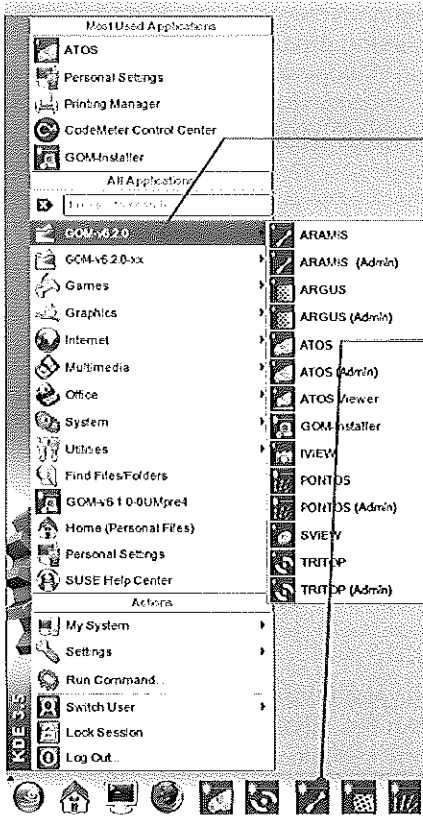
You may start the software in two ways:

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 **ARAMIS (Admin)**. Only with this start routine you will reach the user profile management.

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

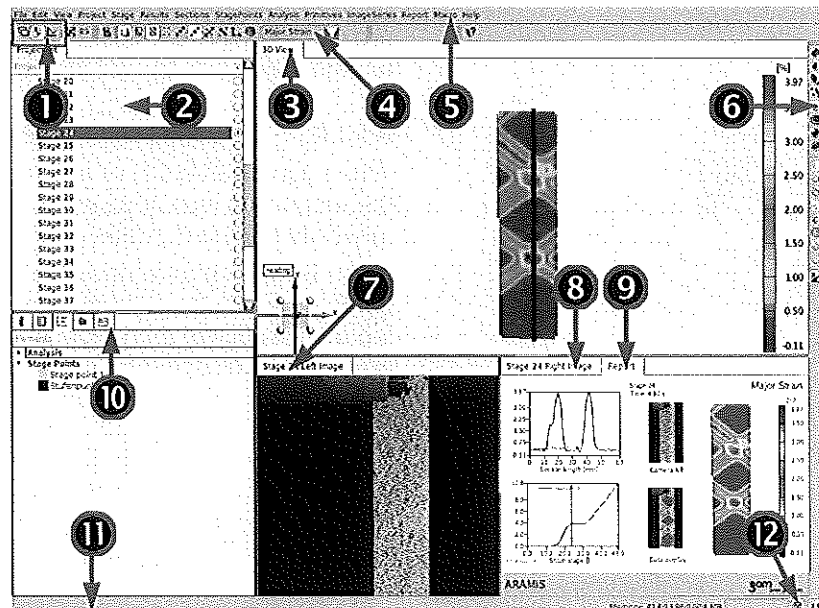
If you start the software using the icon , the user profile management is not available.

**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 7 The ARAMIS Application Software**

**A 7.1 The Default Screen Arrangement**



**A 7.1.1 Screen elements:**

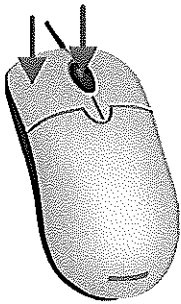
<b>1</b>	Selection between the operating modes (from left to right: project mode, evaluation mode, FLC mode)								
<b>2</b>	<p>Tab Explorer. Here, you will find all open projects and all stages of each project. Using the arrow keys of the keyboard you may navigate forward and backward. Of the selected stage (  ) you will see the 3D strain data of the surface on the right, the camera image on the bottom left and the report for this stage on the bottom right.</p> <p>Symbols in the project list:</p> <table border="1"> <tr> <td><input type="radio"/></td> <td>Strain reference stage not selected.</td> </tr> <tr> <td><input checked="" type="radio"/></td> <td>Strain reference stage selected.</td> </tr> <tr> <td><input type="radio"/></td> <td>Strain stage not selected.</td> </tr> <tr> <td><input checked="" type="radio"/></td> <td>Strain stage selected.</td> </tr> </table>	<input type="radio"/>	Strain reference stage not selected.	<input checked="" type="radio"/>	Strain reference stage selected.	<input type="radio"/>	Strain stage not selected.	<input checked="" type="radio"/>	Strain stage selected.
<input type="radio"/>	Strain reference stage not selected.								
<input checked="" type="radio"/>	Strain reference stage selected.								
<input type="radio"/>	Strain stage not selected.								
<input checked="" type="radio"/>	Strain stage selected.								
<b>3</b>	3D view								
<b>4</b>	Selecting the result representations.								
<b>5</b>	Icon bar to select the functions (strain directions, visualizations, 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).								
<b>6</b>	Icon bar to choose selection and deselection tools.								
<b>7</b>	Tab to display the left 2D camera image of the selected stage.								
<b>8</b>	Tab to display the right 2D camera image of the selected stage.								
<b>9</b>	Tab for viewing and editing reports.								
<b>10</b>	Sub-explorer with various tabs:								
	 Tab Info: Here, you will find information about the selected stage and about the project.								
	 Tab Stage Data: This tab contains a list of all stage data for each stage.								
	 Tab Stage Elements: Here, you will find Sections, Stage Points, Analysis and Primitives. This tab contains a list of all elements that were created for the project.								
	 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.									
<b>11</b>	Status indicator line. Here, all important information about the project and the current commands are displayed.								
<b>12</b>	Cancel button for computation-intensive operating steps.								

**A 7.2 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).

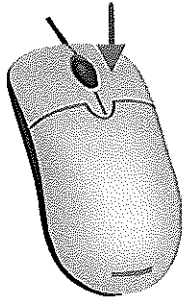
### A 7.3 Mouse Functions

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 7.3.1 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.
- When pressing the **Shift** key and clicking with the **left** mouse button (LMB) in the 3D view, the software arranges the view of the object such that the normal direction of the point clicked points to you.
- 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, and select stage points in the 3D view.
- 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 (on the position of the mouse pointer).
- 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 , 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  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  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 7.3.2 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 7.4 Status Indicator Line**

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

Point-Point Line: Select point with CTRL + left mouse button in the 3D view

**A 7.5 Operating Modes**

	<p><b>Project Mode</b> After creating a new project and defining the project parameters, the ARAMIS software automatically is in the project mode.</p> <p>In this mode, you calibrate the system and record the images.</p> <p>After image recording, the images need to be prepared for computation. For this purpose, you define a mask in the left image of the undeformed stage (0) which limits the area (green area) of the specimen to be computed (stochastic pattern). Here as well, a start point is defined (automatically or manually). This start point is identified by means of the gray level distribution typical for this point in the right image (for creation of 3D data) and in each other stage (for creation of strain data). It is used as basis for the entire computation of the specimen.</p> <p>The image information outside the green area (blue area) will not be used for computation.</p> <p>Then, the specimen is computed and the evaluation mode starts automatically. If required, you may edit stages (delete, add, disable) or change stage or project parameters in this mode.</p>
	<p><b>Start/Stop Measurement Mode</b> This mode can only be opened from the project mode In this mode, you record the images.</p>
	<p><b>Evaluation Mode</b> In the evaluation mode, all computed results, e.g. strain, displacements, are visualized on the entire surface of the specimen.</p> <p>Various visualizations may be displayed and edited. To understand the behavior of the specimen to be examined, numerous functions like sections, stage points, measurements, primitives, etc. are available and may be displayed in diagrams or in the 3D view.</p> <p>To present the results, you may create and edit own or preadjusted reports in this mode.</p> <p>Using the export functions, you may make available the computed data for subsequent systems. This is just a small overview of the functionalities in the evaluation mode.</p>

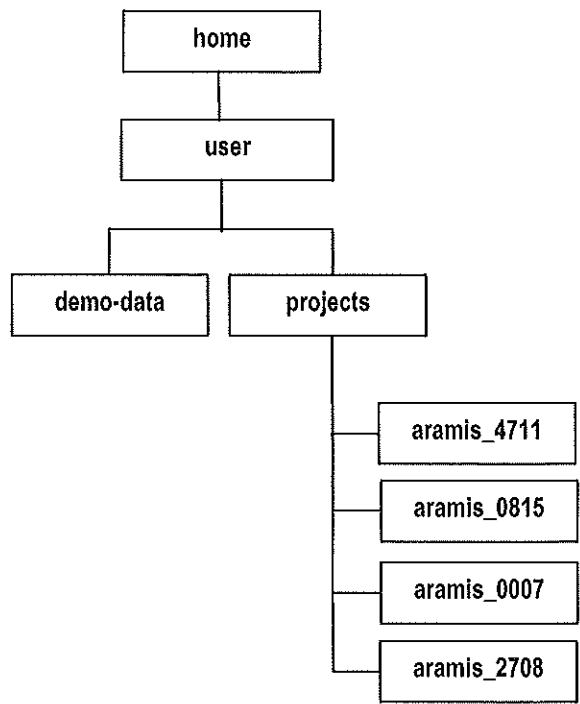
	<p><b>FLC Mode</b> (optional)</p> <p>In the FLC mode (FLC = Forming Limit Curve), section data gained from a series of Nakajima tests is evaluated and a forming limit curve is calculated. In this mode, you may create a material file which you may use in ARAMIS. For more information see the special documentation ARAMIS FLC Computation.</p> <p>When forming components, generally there are very different states of deformation. Failure when forming a single material is not a constant but depends on the local forming state. Therefore, in addition to the local deformation conditions, information about the respective limits is required. This is given by the forming limit curve (FLC). It assigns a critical value of the major strain to each value of the minor strain and is to be considered as material characteristic. The results of a forming analysis (major and minor strain) are represented together with the forming limit curve (FLC) in the so-called forming limit diagram (FLD). They allow an easy evaluation of the forming state.</p>
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**A 7.6 ARAMIS Directory Structure**

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.

Recommended Directory Structure:

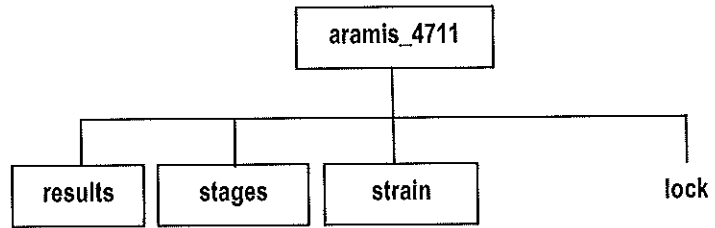


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<b>projects</b>	Save your deformation projects here. For each measuring project, the software automatically creates a directory. The name of the directory is identical to the project name. A measuring project always consists of several files and directories (see A 7.7). The figure shows as an example the structure for two measuring projects (4711 and 0815). Save your export data according to the project name.
<b>demo-data</b>	Saved data for demonstration purposes only.

**Automatically Created Project Directory**



<b>aramis4711.dap</b> (example)	Deformation project file. With this file, a deformation project is opened in ARAMIS.
<b>results</b>	Recommended directory in which you may save your result data (snapshots, images, exported data, movies, ...).
<b>stages</b>	Directory containing all stages and the corresponding images and files together with your project settings. <b>NOTICE</b> Do not remove any files or directories here! Your measuring project might be destroyed!
<b>strain</b>	Directory containing all strain data and the corresponding images and files. <b>NOTICE</b> Do not remove any files or directories here! Your measuring project might be destroyed!
<b>lock</b>	Temporarily created file when a measuring project is open.

**A 7.7 Save Data**

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

**NOTICE**

Remember that most of the operating steps cannot be undone!

### A 7.8 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 8 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 9 Summary

- Brief introduction
- Hardware and software components
- Linux operating system
- Software operating structure
- Most important mouse functions
- Operating modes
- Directory structure
- Saving data
- User profiles

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## B Sensor

### B 1 Sensor Setup

#### B 1.1 Adapting the Sensor to Other Measuring Volumes

##### B 1.1.1 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 [ARAMIS User Information – Hardware](#). 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 [ARAMIS User Information – Hardware](#).

#### B 1.2 Adjust Lenses

##### B 1.2.1 Why do Lenses Need to be Adjusted?

You need to adjust the lenses again, if, for example,

- the adjustment changed due to vibrations or
- 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 [ARAMIS User Information – Hardware](#).

#### B 1.3 Changing the Camera Support

##### B 1.3.1 Why Should the Camera Support be Changed?

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 [ARAMIS User Information - Hardware](#).

#### B 1.4 Adjust Cameras

##### B 1.4.1 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.

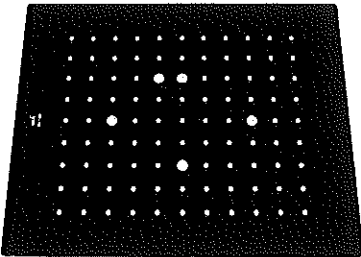
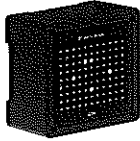
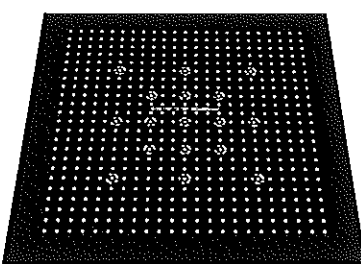
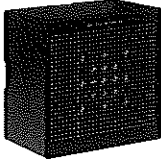
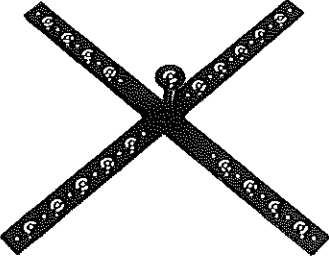
If, for example, you adjusted your sensor to a new measuring volume or if you changed the camera support, the cameras need to be correctly adjusted again. The required steps are described in the [ARAMIS User Information - Hardware](#).

## B 2 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 2.1 Calibration Objects**

For the ARAMIS measuring system, two different calibration objects are used, calibration panels for small measuring volumes and calibration crosses for large measuring volumes. Calibration panels are also available cube-shaped in order to calibrate particularly small measuring volumes (10x8 to 66x44 mm). 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 reference points.

Calibration panel with one scale bar	Calibration panel with two scale bars	Calibration cross with two scale bars
 <p>Cubic calibration panel:</p> 	 <p>Cubic calibration panel:</p> 	

The calibration object contains the scale bar information. Depending on the type, a calibration panel has one or two scale bars. A scale bar is the specified distance between two specific points. A calibration cross always has two scale bars (one scale bar on each cross section).

**B 2.1.1 Calibration Object Selection**

Which calibration object you need to choose depends on the measuring volume you would like to use. In the [ARAMIS User Information – Hardware](#) ► [Sensor Configurations](#) the corresponding measuring volumes for each calibration object are listed.

**NOTICE**

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

## B 2.1.2 How to Handle Calibration Objects

### Calibration Panel, Calibration Cross

#### 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 panels object if possible. After each use, accommodate the calibration panels at the places dedicated for that.

### Calibration Cube

#### NOTICE

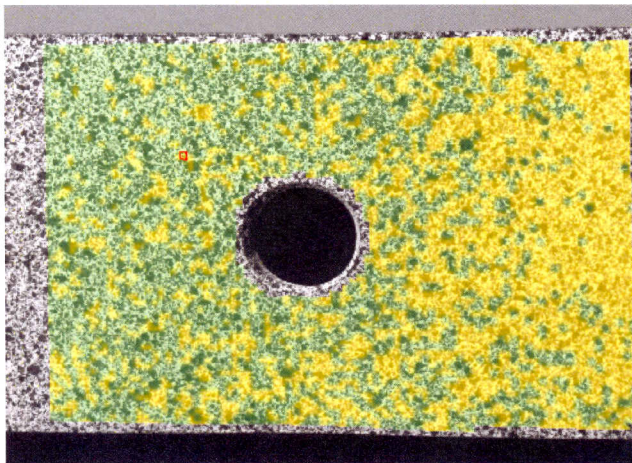
The surface of the calibration panel is made of ceramic and is therefore very susceptible to touch. Finger prints or any other kind of dirt can probably not be removed any more. Therefore, avoid contact of the surface!

Please wear gloves during the calibration to protect the ceramic panel!

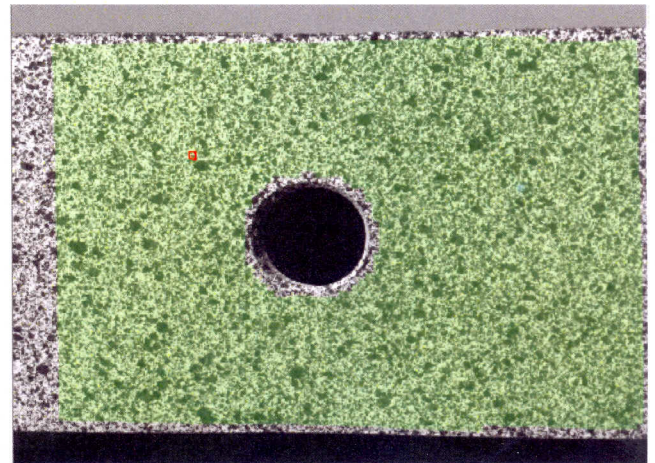
## B 2.2 Calibration Conditions

### B 2.2.1 When is Calibration Required?

- Before starting measurements for the first time, the respective 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.
- If the ARAMIS system shows many yellow facets in the camera images after computation, the system might be decalibrated.



Camera image of a stage in a decalibrated state



Camera image of the same stage in a calibrated state

The system automatically creates yellow image areas (yellow facets) if the intersection error of a 3D point (facet) is larger than 0.3 pixels (factory-adjusted setting). The average intersection error of all 3D points should not be larger than 0.1 pixel (see tab **Info** in the **Project Mode**).

### B 2.2.2 Prerequisites

We recommend calibrating the sensor under operating conditions.

**Info**

Do not expose the sensor to unnecessary temperature variations. Avoid that a possible specimen lighting strongly heats up the sensor.

A prerequisite for successful calibration is the correct setup of the sensor. For further information, please refer to the [ARAMIS User Information – Hardware](#). The measuring object defines the measuring volume and thus the set of lenses to be used. Depending on the measuring volume, you either need to use a calibration panel or a calibration cross for calibrating the system.

The measuring distance to the calibration object has to be adjusted according to the sensor head used, see [ARAMIS User Information – Hardware](#) ► [Sensor Configuration](#).

### B 2.3 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). Follow the instructions in the software.

**Info**

Calibrate the system with the same lighting conditions as used for measuring.

#### B 2.3.1 Positioning of the Calibration Object

First, position the calibration object in the center of the measuring volume such that the laser pointer hits the center of the calibration object. Now, move the calibration object in parallel such that the vertical red line of the cross hairs approximately coincides with the laser point in the right and left camera image. After that, follow the instructions in the software.

In order to extend the measuring volume in the viewing direction of the sensor, you need to move the calibration object relatively to the sensor during calibration. For this, the following general rule applies: Move the calibration object (in the viewing direction of the sensor) 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.

**NOTICE**

When using a calibration cross: Make sure that the calibration cross does not touch the floor when being tilted as otherwise deformation effects may lead to wrong results during the calibration.

#### B 2.3.2 Calibration Results

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

**Info**

For a correct calibration, the calibration deviation may be between 0.01 and 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 a wrong or damaged calibration object or also incorrect scale parameters.



## B 2.4 Calibration Using 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), calibration images are also required. As in this case the ARAMIS software cannot automatically guide you through the necessary calibration steps, you need to simulate the corresponding calibration steps. Make sure you move the calibration object within the measuring volume according to the instructions (see the [ARAMIS User Information – Hardware](#)) and record the respective images. It is not necessary to record the images in the order of the calibration steps.

### Info

After you loaded your calibration images into the ARAMIS software, you need to disable the function Instructions so that a calibration with a any order of images is possible.

## B 2.5 Background Information About Calibration

### B 2.5.1 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 lenses 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 2.5.2 Calibration Deviation

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

### B 2.5.3 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 (wrong adjustment of lenses). If the sensor configuration changes, the calculated reference point deviation changes as well, see B 2.2. You might notice a beginning decalibration of the system if, for example, the Avg. intersection deviation of all 3D points (Project Mode ► tab Info ► Facet field) is larger than 0.1 pixels.

## B 2.6 Quick Calibration

If it is indicated that the system might be decalibrated (e.g. if you slightly 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 and
- 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.

**Info**

However, the image characteristics of the cameras must not have changed! If, for example, you inserted new or incorrectly adjusted 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 Summary

- Calibration objects
- Calibration conditions
- Calibration process
- Calibration results, calibration deviation
- Calibration using external image series
- Calibration theory
- Average intersection deviation of all 3D points
- Quick calibration
- Adapting the sensor to other measuring volumes
- Lens adjustment
- Changing the camera support
- Adjust cameras

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## C Measuring

This chapter describes the typical measuring procedure with the ARAMIS system, the preparation of the specimen, the creation of a new measuring project in the ARAMIS software up to recording a series of images. The sensor is already adjusted and calibrated (see [ARAMIS User Information – Hardware](#) and [Chapter B](#) of this User Manual).

### C 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!

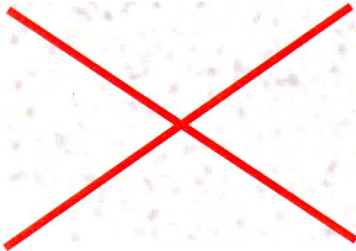
If it is necessary to adapt the measuring volume, you need to readjust and calibrate the sensor again (see [ARAMIS User Information – Hardware](#) and [Chapter B](#) of this User Manual).

### C 2 Preparing a Specimen

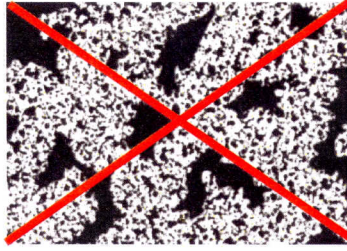
The surface structure is important for carrying out a measurement. The specimen's surface must meet the following requirements:

- The surface of the measuring object must have a pattern in order to clearly allocate the pixels in the camera images (facets). Thus, a pixel area in the reference image can be allocated to the corresponding pixel area in the target image.
- The surface pattern must be able to follow the deformation of the specimen. The surface pattern must not break early.
- The optimum specimen surface is smooth. Highly structured surfaces may cause problems in facet identification and 3D point computation.
- The pattern on the object should show a good contrast because otherwise such an allocation (matching) does not work.
- The surface pattern must be dull. Reflections cause a bad contrast and brightness differences between the right and left camera which prevent the facet computation in the areas of reflection.
- On one hand, the size of the surface characteristics should be small enough to allow a fine raster of calculation facets during evaluation. On the other hand, the pattern should be large enough to be completely resolved by the camera.
- Best suitable are stochastic patterns which are adapted to the measuring volume, camera resolution and facet size. In addition, for calculation, it is advantageous if the patterns do not have larger areas of constant brightness, e.g. large spots. Structures with changing gray values as they occur with random patterns are more

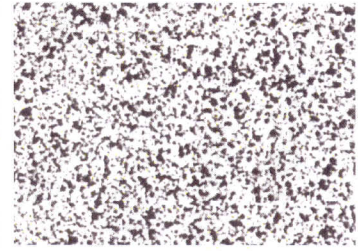
appropriate. The left figure shows a pattern that is not really suitable. The right figure shows a good and clearly better pattern.



Unsuitable low contrast stochastic pattern



High contrast stochastic pattern with disturbing large spots



Good high contrast stochastic pattern

In most cases, the specimens are pretreated with suitable lacquers or powder sprays.

### Info

## C 2.1 Spraying a Stochastic Pattern

Before you start spraying, make sure the surface of the specimen is free of grease and oil!

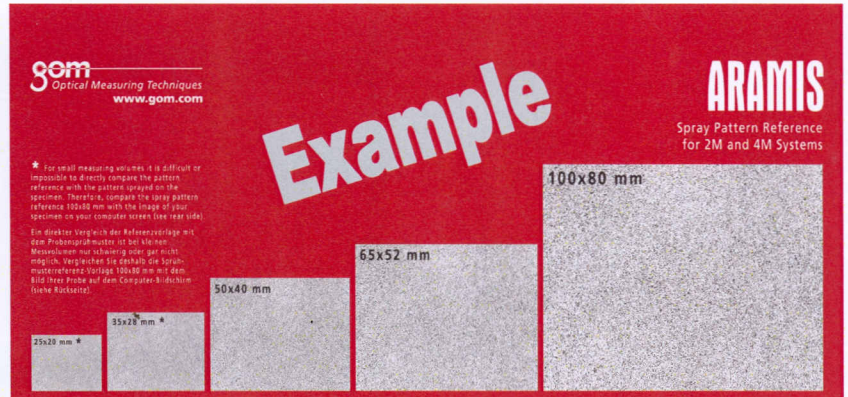
What lacquers or powder sprays you may use for your specimens largely depends on the measuring task and on the ambient conditions during the measuring process. Please contact the GOM support for more information.

GOM may give you spray recommendations for tests up to 300% strain and for high-speed tests up to 1500 °C.

In a first step, if required, you need to apply a white and dull base layer. In a second step, spray a black stochastic pattern.

Press the spray button of the black spray very softly so that the spray can “spit” and a high contrast, stochastic pattern results. Smaller measuring volumes require a finer pattern than large measuring volumes.

In order to check if your spray pattern is suitable for your measuring volume, specific reference patterns are available for the measuring volumes.

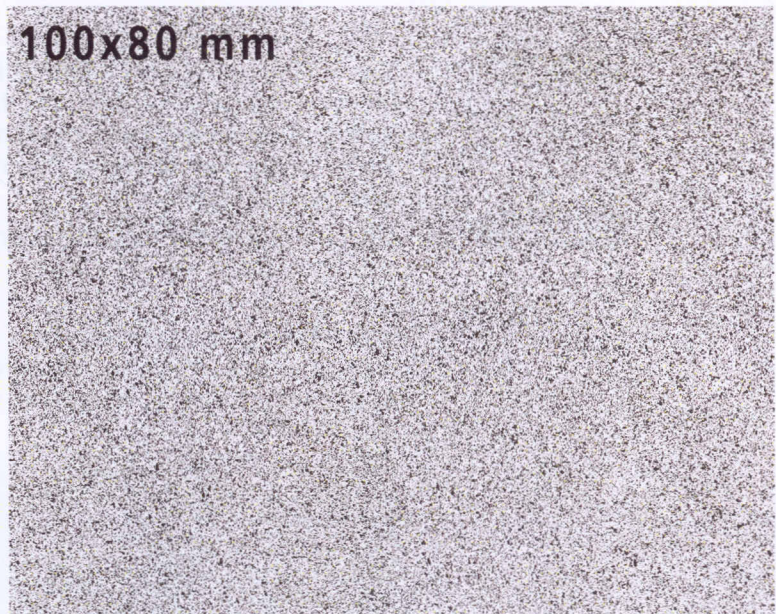


Info

For comparison, only use the original ARAMIS spray pattern reference!

However, you may judge your spray pattern on your computer screen as well. The advantage of this procedure is that independent of your measuring volume you just need one reference pattern (100 x 80 mm).

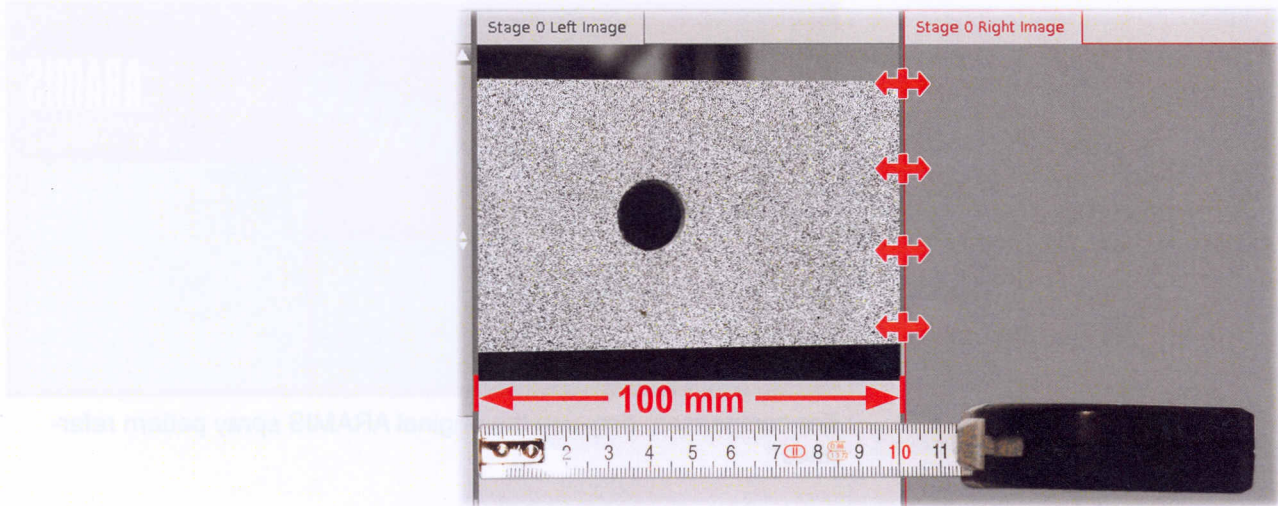
### C 2.2 ARAMIS Spray Pattern Reference



Spray pattern reference

To compare the spray patterns, please use your computer screen and the spray pattern reference for the volume 100x80 mm, regardless of the real measuring area. If you do not have an original spray pattern reference, you may also use this page of the user manual. Only use original pages of the user manual. Other printouts may probably have an insufficient display quality.

- Position your specimen with the spray pattern in the measuring distance in front of the camera.
- On your computer screen, adjust the window of the camera image to the same dimensions as the spray pattern reference 100x80 mm (see figure).



Window set to 100 mm

- Reset the zoom (left mouse button click on the image and key R).
- Compare the pattern of the camera image with the spray pattern reference for volume 100x80 mm.

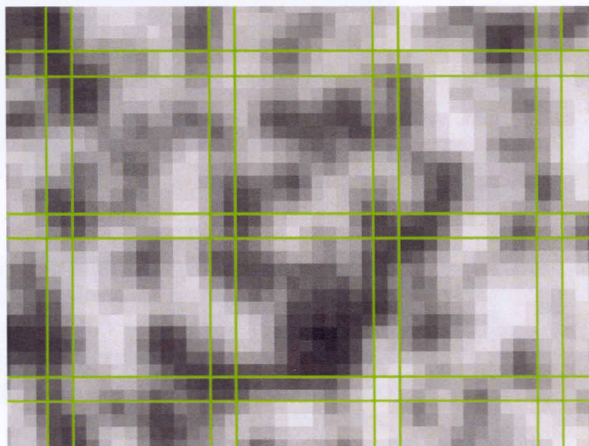
**CAUTION**

The spray may contain solvents! Please observe the warnings printed on the spray can. Do not inhale the fumes, only use the spray with the sufficient ventilation. Avoid contact with your skin and your eyes. Spray fumes may be highly inflammable - do not smoke! Keep away from ignition source.

**NOTICE**

Check the suitability of plastics and other non-metallic surfaces before you spray them.

The following figure shows some 15 pixel facets with a 2 pixel overlapping area and a good gray level distribution. With these settings, an unproblematic facet computation and a precise strain measurement are possible.



15x15 facets with 2 pixels overlapping made visible in the 2D image via the right mouse button



### C 2.3 Spraying Patterns For Large Measuring Volumes

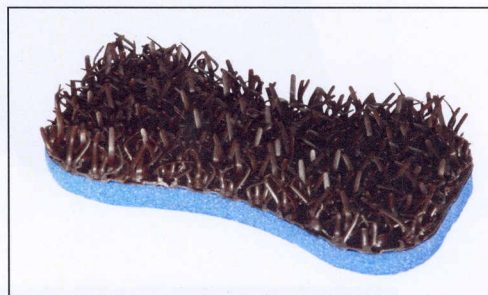
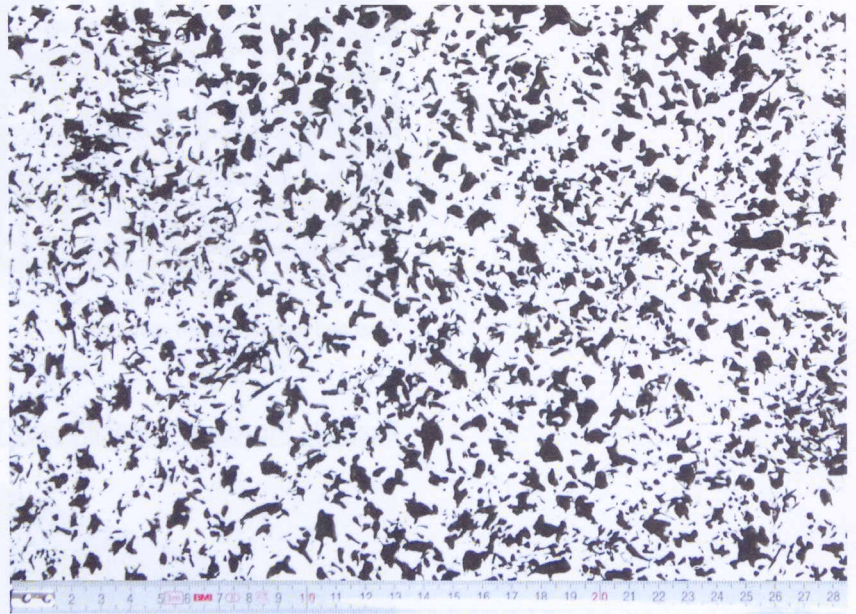
For large measuring volumes (e.g. 1m x 1m) the spray method described in section C 2.1 reaches its limits.

In this case, GOM recommends working with structural patterns that were applied to the surface of the specimen either with a pattern brush, a felt-tip pen or by means of the stencil/spray technique.

**Info**

When applying these structural patterns, make sure the pattern in the camera image is smaller than the selected facet size.

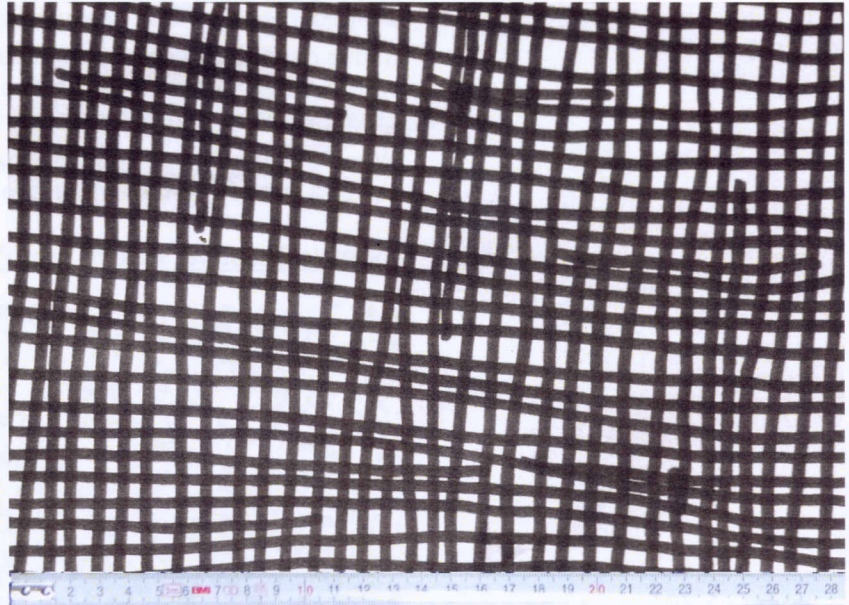
#### Example Structure "Pattern Brush"



Pattern brush

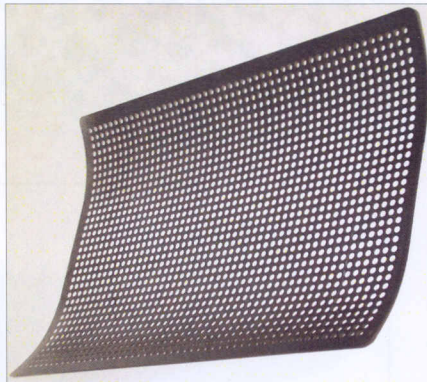
The pattern was created with a pattern brush using black paint on a white background. A slightly overlapping dabbing technique was used. Depending on the pressure you apply to the brush, you may create fine to rough patterns.

Example Structure "Felt-Tip Pen"



Freehand pattern created with a pen

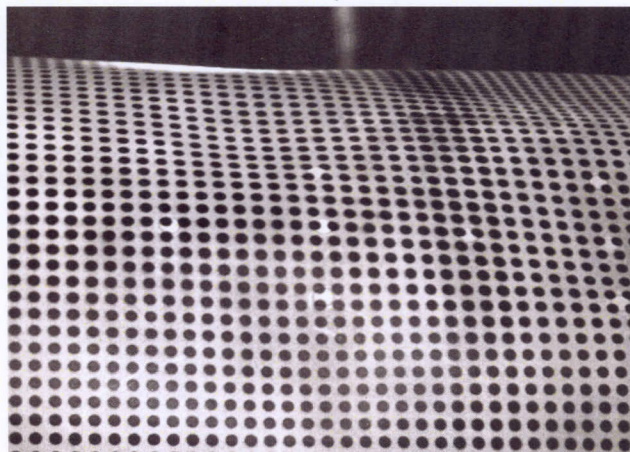
Example Structure "Stencil/Spray Technique"



Spray stencil



Spray stencil in practical use



Point pattern created with the stencil/spray technique

### C 3 Creating a New Project

In order to analyze the material deformations of an object, many camera images of various deformation stages are required. As all data collected during a measurement is automatically stored in a measurement project, you first need to create a **New 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**, ARAMIS directory structure). It is defined together with the project name.

How you create a project you will find in the Online Help (key F1).

#### C 3.1 2D, 3D Project

ARAMIS distinguishes between 2D and 3D measuring projects.

If you have a sensor unit with two cameras, normally only a 3D project is reasonable.

For the special case you have very small specimens (< 3 mm), perhaps a 2D measuring project may be suitable.

In this case, these specimen dimensions may result in large camera angles. A 3D point based on image data can only be computed if this point is visible for both cameras! This is not always the case for distinct specimen geometries.

In order to get information about displacements in a 2D project, it is necessary to define in the 2D parameters the 2D scaling (line distance) as substitute for the scale bar information.

#### C 3.2 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 (key F1).

#### C 3.3 Project Parameters

The project parameters define important parameters of a project. Normally, the default settings are sufficient but may be changed depending on the task. Parameters that are changed using **Project ► Project Parameter** only take effect on the current project.

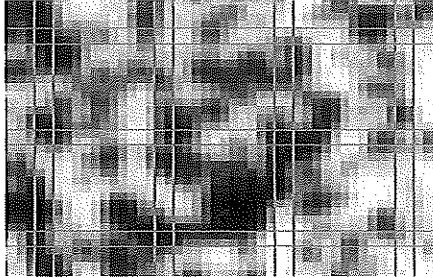
Do not change the settings of these menus if you do not have any background knowledge!

For standard measuring projects, use the default settings of the project parameters.

**Info**

### C 3.3.1 Facet Parameters

ARAMIS observes the deformation of the specimen through the images by means of various square or rectangular facets. The following figure shows the ARAMIS default settings, 15x15 pixel facets with a facet step of 13 pixels (corresponds to a 2 pixel overlapping area).



From each valid facet, a measuring point results after computation. For further information, please refer to **Chapter D**.

### C 3.3.2 Strain

For strain computation, ARAMIS distinguishes between two methods, **Linear strain** and **Spline strain** computation.

In ARAMIS measuring projects, normally only **Linear strain** computation is used. The default parameters of linear strain are **Computation size 3** and **Validity quote 55%**.

For the exception you would like to analyze your specimen in areas of small curvature radii, the **Spline strain** computation method is available (expert function!).

For further information, please refer to **Chapter D**.

### C 3.3.3 Stage Data

If required, you may define here additional stage information (like information about time and force) which will then be displayed in the explorer under stage data or are included in a report.

### C 3.3.4 Automatic Start Point

A start point is the facet with which the computation process is started. The function **Auto Start Point** is used for a project running automatically. Normally, the start point is defined later (e.g. after the measuring images are recorded).

## C 3.4 Stage Parameters

In the stage parameters, you determine a template containing the parameter constellation for processing your project. The factory pre-adjusted default templates are **Standard**, **Fast** and **High Accuracy**.

You also may determine the parameters yourself:

- Computation method
- Accuracy
- Iteration limit
- Pixel thinning
- Graylevel check

For more information see the Online Help (key F1).



### C 3.5 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 3.6 and Online Help) and start the actual measurement using the start button.

### C 3.6 Adjusting the Shutter Time, Specimen Lighting

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

ARAMIS does not have any special requirements for the ambient light. The light source (specimen lighting or daylight) should illuminate the specimen equally, and the available light intensity should be sufficient for overexposing the camera images with a longer shutter time. Specimen lighting with polarization filters should be set to minimum intensity of shiny points.

The maximum and minimum possible shutter time depends on the cameras connected and on the speed with which the specimen to be measured moves.

### C 3.7 Standard Recording Modes

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

#### C 3.7.1 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 (e.g. for force and distance information) can also be recorded.

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

This mode is limited to one image per second.

For further information, please refer to the Online Help (key F1).

#### C 3.7.2 Fast Measurement (Main Memory)

In this mode, a temporal equidistant sequence of images is recorded the maximum number of which you may define. The images are saved directly in the PC.

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 maximum possible frame rate depends on the ARAMIS sensor (cameras) and the PC:

ARAMIS 4M (max. image resolution)	max. 55 image/s (19" PC)
ARAMIS 5M (max. image resolution)	max. 15 image/s (19" PC) max. 7 image/s (laptop)
ARAMIS HS (max. image resolution)	max. 40 image/s (19" PC)

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. For further information, please refer to the Online Help (key F1).

## C 4 Advanced Measuring Methods

### C 4.1 Sensor Controller

#### C 4.1.1 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, laser pointers and specimen lighting.

#### C 4.1.2 Function

Depending on the signal which should start image recording, the sensor controller provides different trigger inputs (e.g. for TTL signals, analog signals, pushbutton, photoelectric sensor).

According to the selected mode, a switching operation which is coupled to image recording is released in the sensor controller, e.g. in case a certain voltage is exceeded.

For further information, please refer to the [ARAMIS User Information – Hardware](#).

### C 4.2 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 8 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 4.3 Additional Recording Modes

#### C 4.3.1 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 (key F1).

### C 4.3.2 Fast Measurement FG-Board Memory (For ARAMIS HS Systems Only)

In case of a fast measurement, a sequence of many images is recorded the number of which you may define. In this mode, you achieve the highest possible frame rate.

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.

As the images are first stored in the frame grabber boards (FG-Board Memory), the maximum recording speed is limited by the maximum frame rate of the cameras, and the max. number of images is limited by the RAM range of the frame grabber boards.

In this mode, frame rates of 500 full frames/s are possible and with reduced camera resolution (1/4, 1/8, 1/16) up to max. 8000 images/s.

The sensor controller releases the start pulse for image recording equidistant in time 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 (key F1).

## C 5 Measuring For Experts

### C 5.1 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 [User Manual – Trigger Lists](#).

### C 5.2 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 (key F1).

## C 6 Summary

- Selecting the measuring volume
- Preparing the specimen
- Spraying stochastic patterns
- Creating a new project
- Project keywords
- Project parameters
- Facet parameters
- Strain computation
- 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



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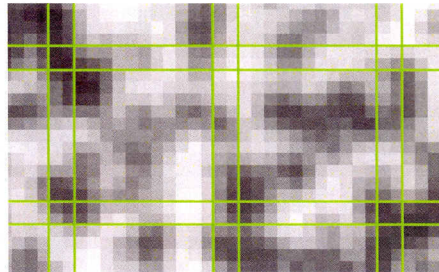
## D Computation

In the previous chapters, we already described the typical measuring procedure for an ARAMIS project (preparation of the specimen, creating a measuring project with default project parameters up to recording the series of images).

This chapter now extends the basic knowledge with respect to the most important project parameters which you also may adapt in the project mode of the software after having recorded an image series, explains the strain computation, and shows corresponding 3D representations.

### D 1 Facets (Project Parameter)

ARAMIS observes the deformation of the specimen through the images by means of various square or rectangular facets. The following figure shows 15x15 pixel facets with a facet step of 13 pixels (corresponds to a 2 pixel overlapping area, default setting).



**Info**

From each valid facet, a measuring point results after computation. Therefore, the adjustment parameters of the facets are important for strain computation and visualization.

#### D 1.1 Facet Size, Facet Step

The default facet (15 x 15 pixels) is a compromise between accuracy and computation time. For normal deformation projects, you should aim for this size and, if possible, adapt the surface pattern accordingly. This means, the typical stochastic pattern structure should clearly result within the facet.

You may of course deviate from the default settings if, for example, your surface pattern or the measuring test requires it. For facet dimensioning, the following factual relations apply:

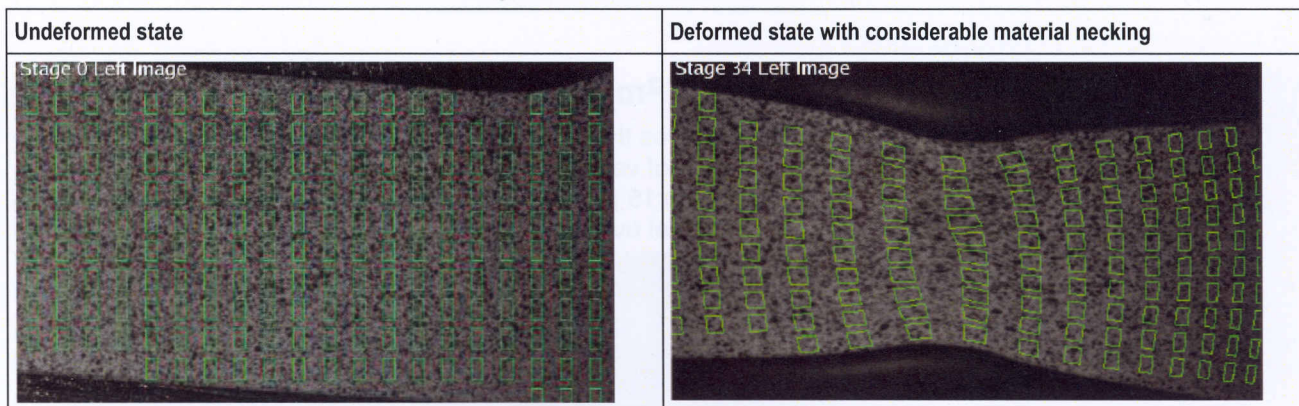
<b>The facet size is larger than the default value</b>	<ul style="list-style-type: none"> <li>▪ The accuracy of the resulting measuring point improves.</li> <li>▪ The computation requires more time.</li> <li>▪ Local effects within the facet size cannot be captured.</li> </ul>
<b>The facet size is smaller than the default value</b>	<ul style="list-style-type: none"> <li>▪ The accuracy of the resulting measuring point decreases.</li> <li>▪ The computation requires less time.</li> <li>▪ Local effects can be captured better.</li> </ul>
<b>The facet step is smaller than the default value</b>	<ul style="list-style-type: none"> <li>▪ The measuring point density increases.</li> <li>▪ The computation requires more time.</li> <li>▪ Overlapping areas up to 50% are still suitable for representing the measuring results.</li> </ul>
<b>The facet step is larger than the default value</b>	<ul style="list-style-type: none"> <li>▪ The measuring point density decreases.</li> <li>▪ The computation requires less time.</li> </ul>

### D 1.2 Facet Shapes

The facet shape (square, rectangular, quadrangular) influences the computability of the measuring project. Square and rectangular facets in the reference stage are always aligned according to the x-y orientation of the 2D image.

#### D 1.2.1 Rectangular Facets

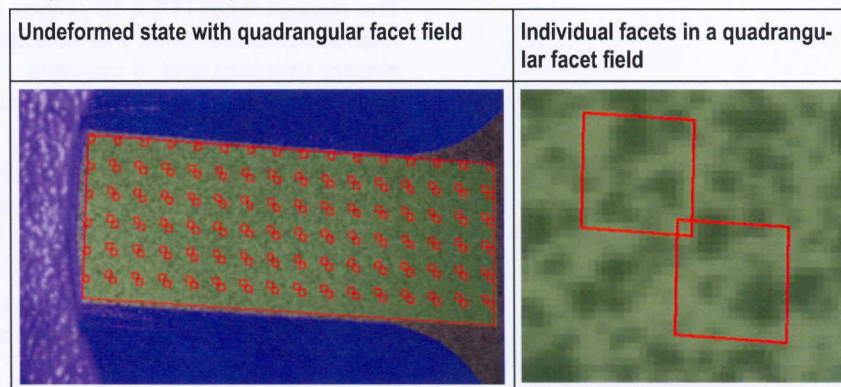
For strain measurements where the specimen is subject to high levels of strain, use rectangular facets according to the figure below in order to get evaluable facet fields.



#### D 1.2.2 Quadrangular Facets

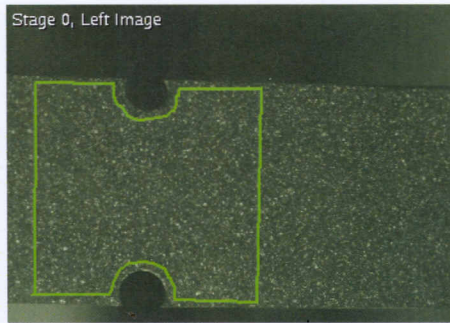
If, in case of quadrangular specimens you would like to create valid facets up to the edge, you may create a facet field manually which follows the specimen's geometry. The individual facets result within this field. The x-y orientation is based on this field as well.

As computation here is only done within the facet field, it is not necessary to mask the specimen.

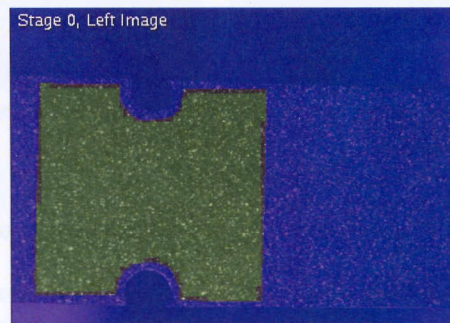


## D 2 Computation Masks

Computation masks allow the software to carry out facet computations in defined areas of the 2D camera images only. To define computation masks, the software provides extensive tools.



Computation mask during definition



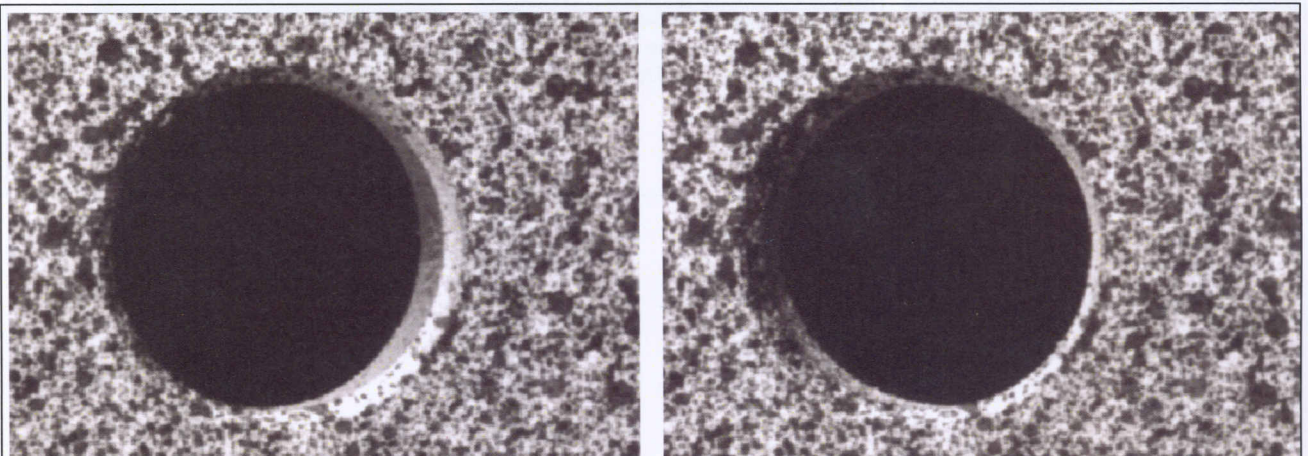
Finished computation mask (only the green area will be computed)

**Info**

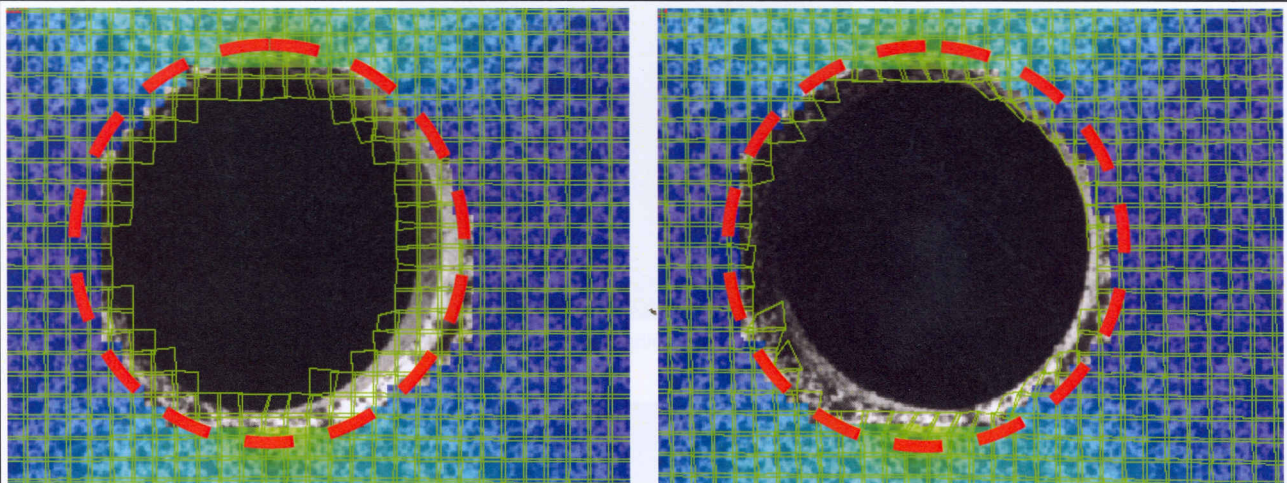
Only areas on a specimen that are relevant for deformation shall be calculated. Thus, for example, fixtures, backgrounds, specimen edges and contour jumps are not included in the computation.

As the 3D computation of the measuring points is based on facets that need to be seen from the right and left camera with the individual facet pattern, a correct 3D computation and strain computation is not possible for specimen edges and contour jumps in specimens!

The following measuring images explain this fact (tensile test specimen with circular hole):



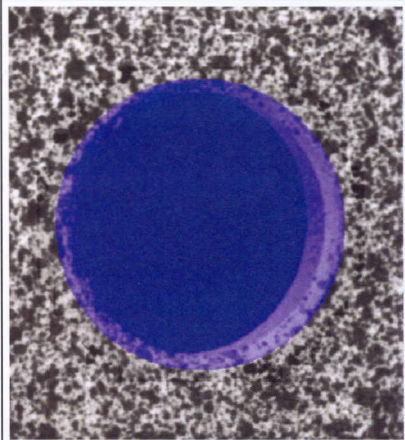
The images show a tensile test specimen with a hole in stage 1 of a strain measuring project, seen from the left and right camera. While the surface pattern almost looks the same, considerable differences result at the hole edges due to the different camera locations.



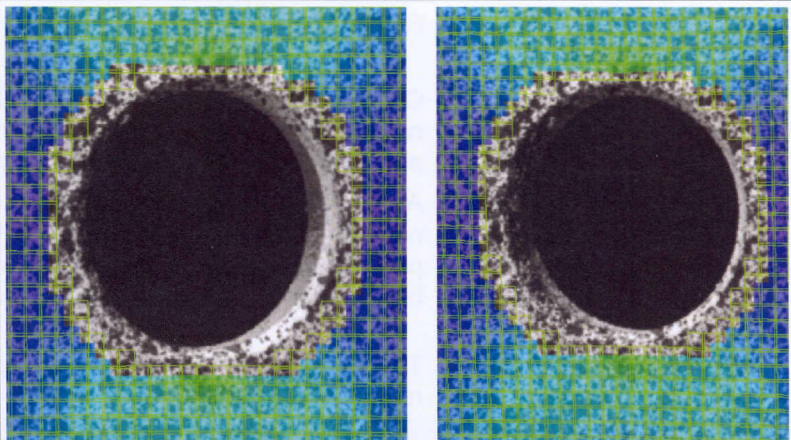
The image shows the same example as above but in an already computed state. 3D overlapping and facets are set visible, and no computation mask was defined.

The example shows the facet problem in the edge region of the hole. Although measures are already effective that only permit facets with the same information content of the right and left image, it is impossible for the software to decide between strain and perspective view of the cameras (facets with homogeneous content, e.g. only white or black, are generally not used).

The red framed area shows strain which cannot be computed correctly because of the mentioned problems.



The image shows a tensile test specimen with hole and a computation mask.  
In the blue area, facets will not be computed.



The image shows the same specimen but prior to computation a computation mask was defined. This excludes the facet problems in the edge region.

### D 3 Define Start Point (Project Mode)

For facet computation, all stages require the definition of a start point. Generally, the start point refers to the same facet in all stages. However, it is possible to work with different start points in one measuring project, for example, if after computation it turns out that for some stages ARAMIS could not calculate any facets.

If a specimen breaks apart and if you want to record the deformation in the fragments as well, you need to define another start point in the area of the fragments.

A start point is nothing else than a calculated facet.

ARAMIS allows three different methods to create start points:

#### Manual or Semi-Automatic Start Point Creation

With **Add Start Point ▶ Simple**, you define the start point semi-automatically or manually. With this method, the first start point is always defined manually, then you may decide if for the remaining stages the start point shall be created manually or automatically.

This method is particularly recommendable, because you may control the start point definition in all stages.

Define start points only in those areas of a specimen that are subject to the least relative movement within the ARAMIS measuring volume. Thus, you ensure that the semi-automatic start point creation works through all stages.

#### Fully Automatic Start Point Creation

**Auto Start Point** is a fully automatic start point definition process which searches for a start point in the middle of the area to be calculated.

Info

**Auto Start Point** only works correctly if the pattern of the specimen is good and if the stages were recorded without too large deformation steps.

Only use this function in automated measuring processes, e.g. for series measurements of similar specimens.

#### Complex Start Point Creation

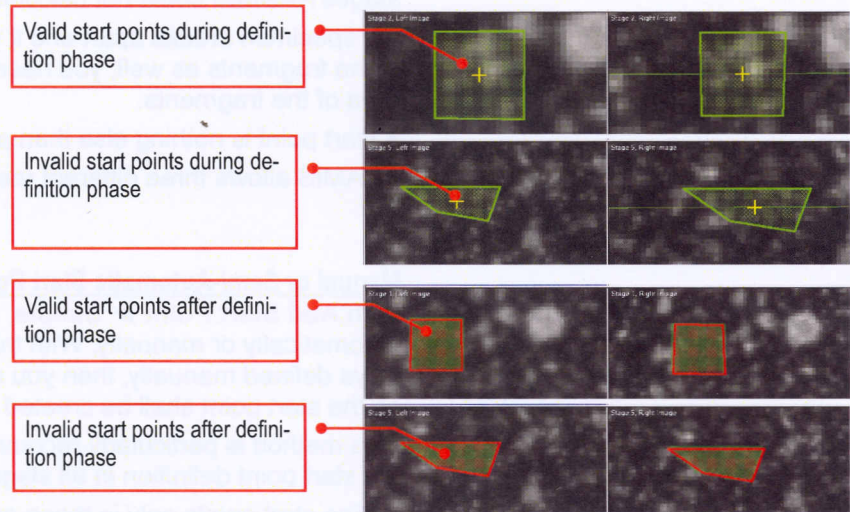
With **Add Start Point ▶ Complex**, you need to create the start points manually in all images.

For rotating specimens, for example, this is the only possibility to create start points.

### D 3.1 Checking the Start Points

Independent of the definition method you choose, you should check the start points in the images.

The figure shows valid and invalid start points of a project.



### D 3.2 Clicking Start Points

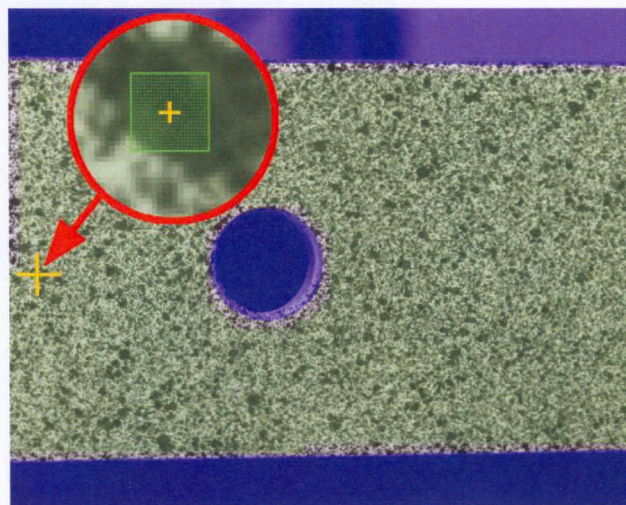
Click the start points in the 2D images with Ctrl and left mouse button.

**Info**

Always click a start point in the left image first and then in the right image!

The following examples are from a tensile test. With this test setup, the smallest relative movement is in the left image area.

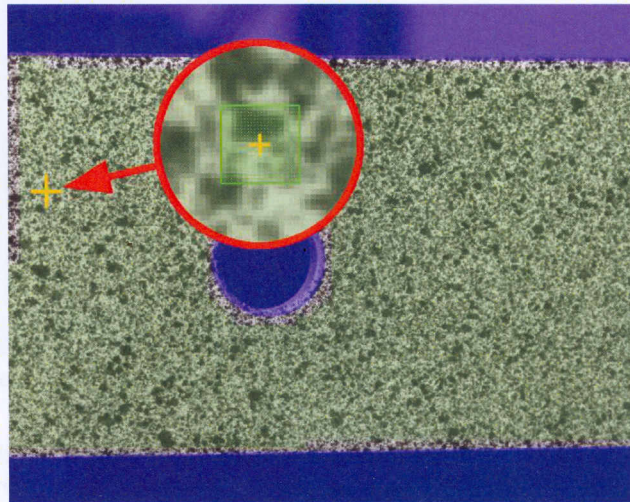
#### Example of a Poor Start Point



The semi-automatic start point creation may fail in the following stages because the facet content shows only little stochastic pattern structure.

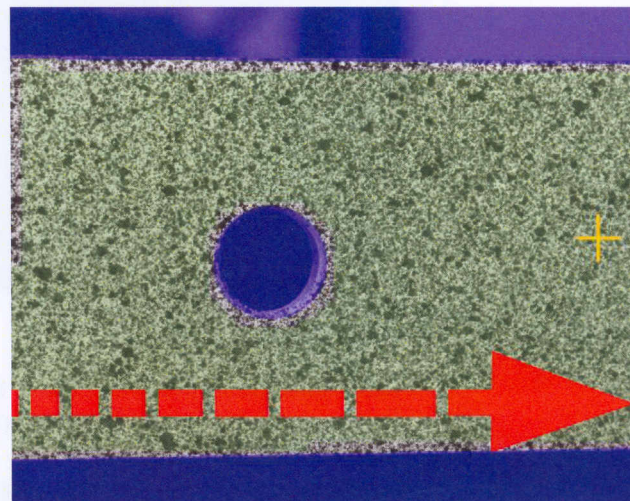


**Example of a Good Start Point**



In the following stages, the semi-automatic start point creation can fall back on a well perceptible stochastic pattern structure.

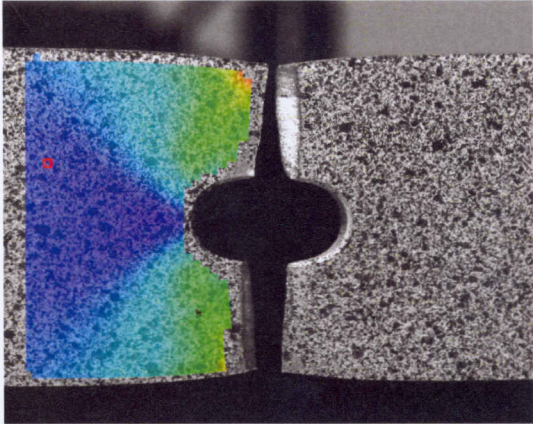
**Example of a Poor Start Point**



As the start point is located in the right-hand image and the relative movement here is the highest, there is a chance that the point will move out of the cameras' view during subsequent images.

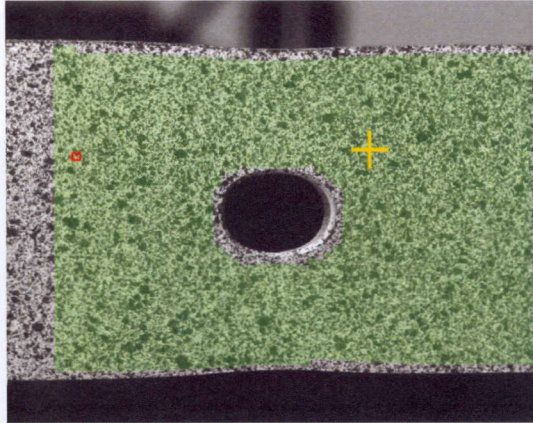
**D 3.3 Start Point Creation For Torn Specimens**

If a specimen tears apart during the test, strain will only be computed on that part of the specimen where the start point is located.



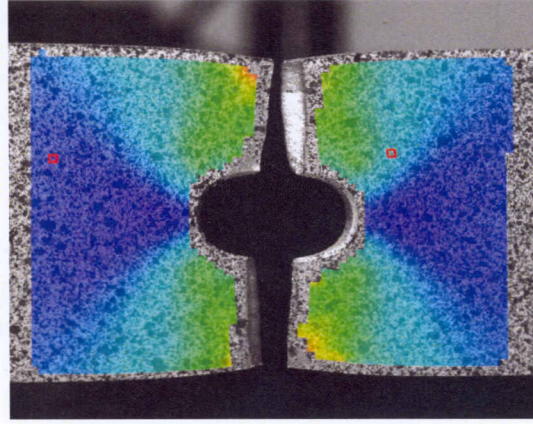
Torn specimen with one-sided strain computation

In order to compute the strain in the torn apart area of the specimen as well, define a second start point (project mode) as of the stage preceding the crack. This procedure optimizes the computation time.



Definition of the second start point

After calculating the project with the second start point, now strain data are also available in the torn apart area.



Torn specimen now with complete strain computation

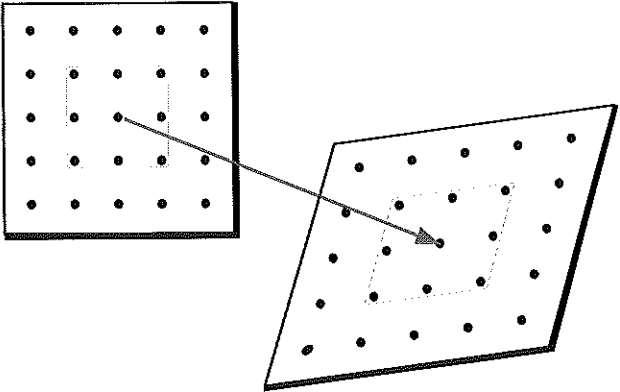
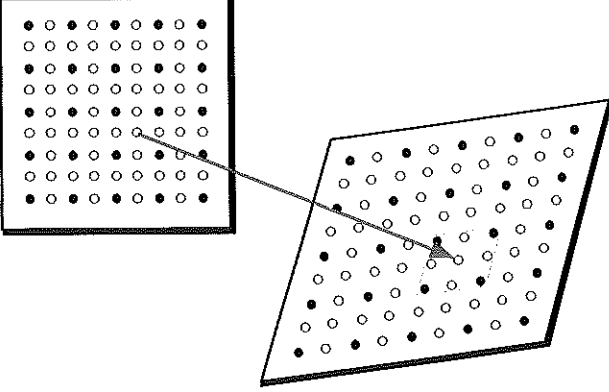
aramis-v6-1\_d\_en\_rev-c 7-Aug-2009

## D 4 Strain Computation

For strain computation, ARAMIS distinguishes between two methods, Linear strain and Spline strain computation. In ARAMIS measuring projects, normally only Linear strain computation is used. For the exception you would like to analyze your specimen in areas of small curvature radii, the Spline strain computation method is available (expert function!).

### D 4.1 Comparison Linear Strain and Spline Strain

The following table shows the practical differences between the computation methods.

Linear strain	Spline strain (expert function)
 <p>Principle of a specimen in the undeformed (left) and deformed (right) state. In this example, we consider the strain for a measuring point (red arrow) together with the surrounding measuring points (blue quadrangle). The strain is computed in connection with the surrounding measuring points which are directly derived from the facets.</p>	 <p>Principle of a specimen in the undeformed (left) and deformed (right) state. The black points are measuring points which are directly derived from the facets. The white points were interpolated from the black points using the spline function. Here, strain computation also considers the interpolated (white) points.</p>
<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>• Fast strain computation</li> <li>• Low measuring noise</li> <li>• Real points are the reference location for the strain</li> <li>• Small deviations of the measuring points from the local plane are compensated.</li> </ul>	<p><b>Advantages:</b></p> <p>Valid strain computation also in case of clear curvature (radii) in the blue quadrangle.</p>
<p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>• No strain computation for curvature radii of the specimen that are smaller or equal to a facet.</li> <li>• <b>Info</b> The surface of the blue quadrangle may only be curved slightly as otherwise the surface strain is falsified (narrow radii → spline strain is required).</li> </ul>	<p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>• Longer computation time (fourfold point amount)</li> <li>• More measuring noise</li> <li>• Interpolated points are the reference location for the strain.</li> </ul>

Linear strain	Spline strain (expert function)
<p><b>Computation parameters</b></p> <p><b>Size:</b> Computation size includes the adjacent points around a point in the strain calculation. The default setting is the lowest possible value 3. This means that a 3x3 field of 3D points is used to calculate the strain value of the center point. This setting is particularly suitable for the assessment of local strain. If you increase this value, the noise decreases and in the marginal area less strain can be calculated.</p> <p><b>Validity quote:</b> If not all adjacent points exist for a calculation, the strain for the center point can be calculated nevertheless. The Validity quote determines how many points have to exist for calculation. A quote of 100% means that all 9 points (for a field of 3x3) must exist. As default setting, use a Validity quote of 55%.</p>	<p><b>Computation parameters</b></p> <p><b>Computation location:</b> Due to the system, the 3D point calculation of ARAMIS is always carried out on the surface of the specimen. However, as e.g. in case of material bendings the strain on the surface, in the middle and on the rear side of the specimen are different, this effect may be compensated if strain values for the middle of the specimen are required.</p> <p><b>Material thickness:</b> Enter the original material thickness for the definition of the computation location.</p>

## D 4.2 Strain Reference

### Info

Please do not confuse the strain reference with the reference stages in the project mode. Reference stages in the project mode only influence start point and facet computation!

Normally (Project Parameter ► Strain ► Strain method ► Total), the strain reference always refers to Stage 0. However, you may set any other stage as strain reference (Evaluation Mode ► Stage ► Set as Strain Reference).

For the special case you only need strain from one stage to the next, e.g. in order to achieve acceleration from strain (only for image series with a defined temporal image sequence), function Project Parameter ► Strain ► Strain method ► Step by step is available.

## D 5 Summary

- Facet size
- Facet step
- Facet shapes
- Computation masks
- Defining start points
- Start points for torn specimens
- Strain computation linear
- Strain computation spline
- Strain reference

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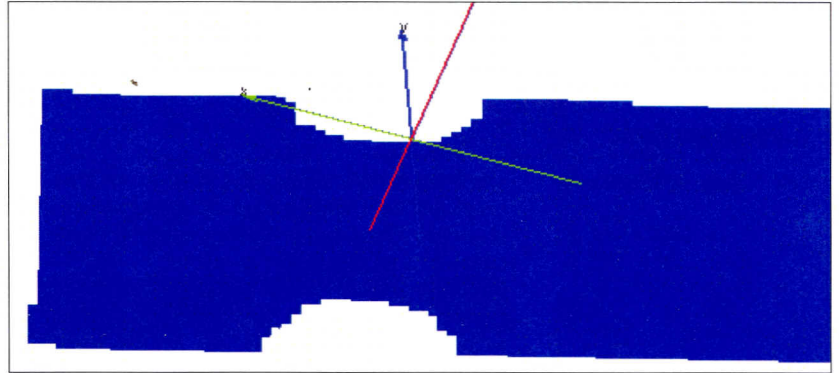
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## E Transformations

### E 1 Why are Transformations Required?

The position of the coordinate system depends on the calibration of the cameras and usually has no logical relation to the specimen.



Specimen in stage 0 with undefined coordinate system

The coordinate system allows for unambiguously describing the position of points in the 3D space by stating three numerical values (X, Y, Z coordinates). The point where all numerical values are 0 is also called the origin of the coordinate system.

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

#### Transform ARAMIS Projects According to Specimen Geometry

Often it is necessary to define the coordinate system based on the geometry of the specimen. So, for example, edges of the specimen or drilled holes are important to define axes or the origin.

#### Transformations of Several ARAMIS Projects

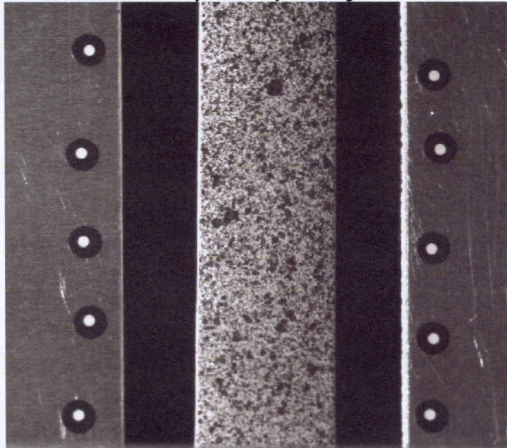
For ARAMIS projects which observe a 3D deformation simultaneously by several ARAMIS sensor units, a transformation by reference points (circular markers) is required. The 3D coordinates of these reference points were previously recorded by the photogrammetric system TRITOP. The ARAMIS sensor units partly recorded the same reference points. In a last step, the measuring data from the different views of the ARAMIS sensor units are transformed into the coordinate system of the TRITOP reference points by means of the best-fit method.

This method is also suitable for static deformation projects in which the static deformations are captured with just one ARAMIS sensor from different positions and are then transformed into the same coordinate system using the common reference points.

#### Transformations of Individual Stages in a Project

If the ARAMIS sensor or the entire test setup moves, a transformation of individual stages by reference points may be useful.

## E 2 Overview of the Transformation Methods

<b>Project transformations:</b>	
<b>3-2-1 Transformation</b>	At least 6 coordinates of 3D points according to the 3-2-1 definition need to be known, e.g. three Z, two Y coordinates and one X coordinate. The direction of the coordinate system can be adjusted as you like.
<b>Best-Fit by Reference Points</b>	If the measuring project contains photogrammetrically recorded reference points (e.g. points recorded by TRITOP), and in the images of the ARAMIS reference stage sufficient (at least 3) reference points were seen, the entire ARAMIS project can be transformed into the coordinate system of the reference points. During measurements, the reference points must not change their position.
<b>Stage transformations:</b>	
<b>Transform Stage by Reference</b>	<p>This is the same function as described above (<b>Best-Fit by Reference Points</b>), with the difference that the transformation refers to a stage. <b>Transform Stage by Reference</b> is only used in special cases. If the specimen has a fixed relation to reference points (frames, bars), all the stages can be transformed into a common coordinate system any time again even if the ARAMIS sensor or the entire test setup moved.</p>  <p>Camera image of a tensile test with reference points</p>
<b>Movement Correction</b>	The movement correction is a stage transformation which is able to eliminate rigid body movements through all project stages without influencing the global coordinate system. If you would like to analyze displacements of a specimen, <b>Movement Correction</b> is useful.

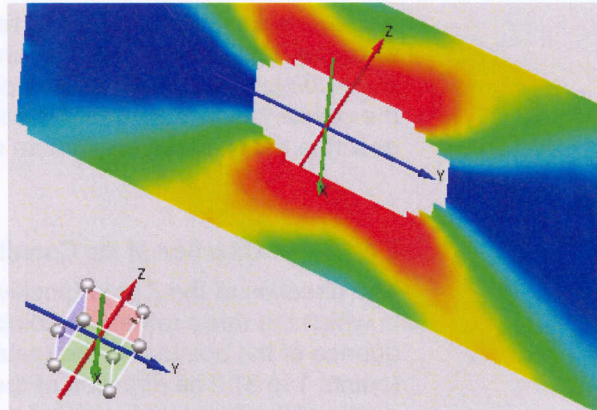
For further information, please refer to the Online Help (key F1).

## E 3 Visualization of the Coordinate System

ARAMIS 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.





Possibilities to display the coordinate system in the 3D view (bottom left corner or in the origin)

### E 3.1 Views in the Software

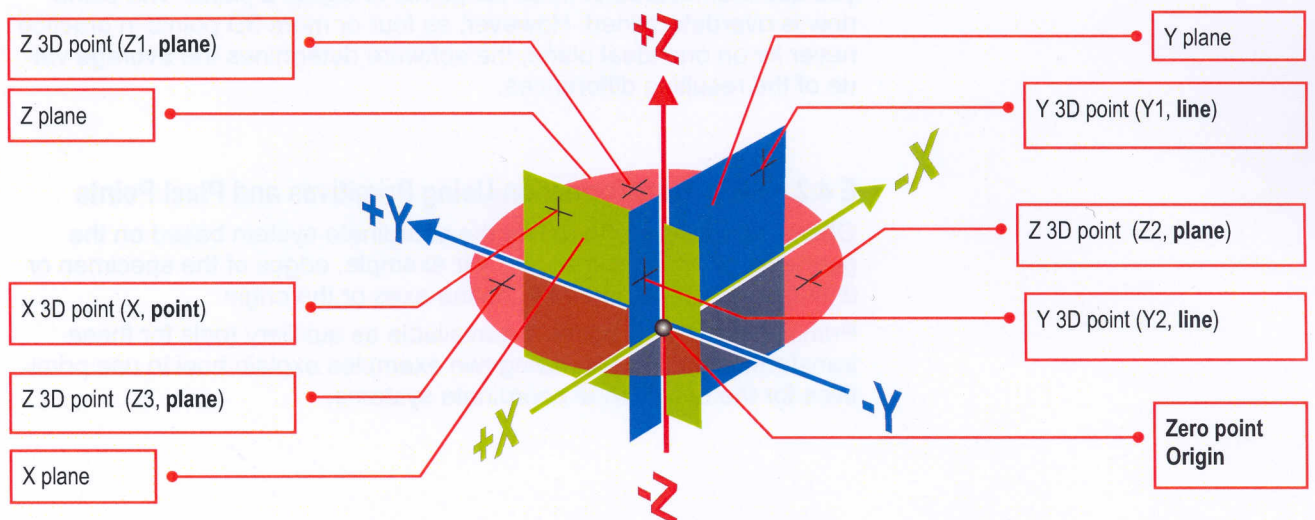
The software offers several views. **View** shows the measuring object from top, bottom, left, right, front and back and **ISO View** displays the measuring object additionally in the respective diagonal views (see also Online Help).

## E 4 Principle of the 3-2-1 Transformation

**3-2-1 Transformation** is one of the mostly used methods. Therefore, we introduce the basics here.

3-2-1 means that three 3D points ( $Z_1, Z_2, Z_3$ , located as far as possible from each other and not in a line) describe a plane, two additional 3D points describe a line ( $Y_1, Y_2$ , 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 ( $Z_1, Z_2, Z_3$ , red plane) define the Z plane. The additional two Y points ( $Y_1, Y_2$ , 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 example shows the factual relations using the minimum number of points required for this transformation method. You may use reference points, pixel points or 3D points. In this case, the points define the coordinate system directly. It is important that the points reliably describe the required coordinate system.

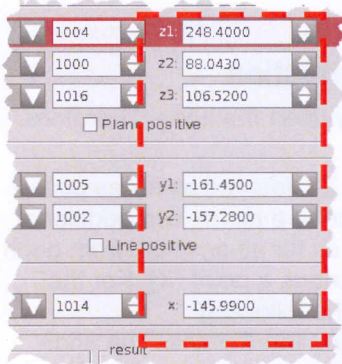
#### E 4.1.1 Direction of the Coordinate Axes

The direction of the Z axis (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 4.1.2 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 4.1.3 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.

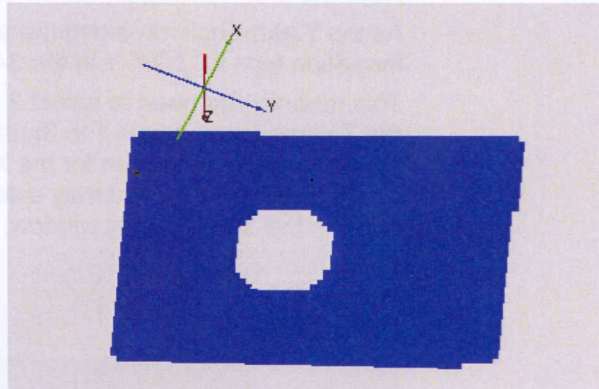
### E 4.2 3-2-1 Transformation Using Primitives and Pixel Points

Often it is necessary to define the coordinate system based on the geometry of the specimen. So, for example, edges of the specimen or drilled holes are important to define axes or the origin.

Primitives and pixel points are available as auxiliary tools for these transformations. The following two examples explain how to use primitives for the definition of coordinate systems.

**E 4.2.1 Transformation Using the Edge of the Specimen**

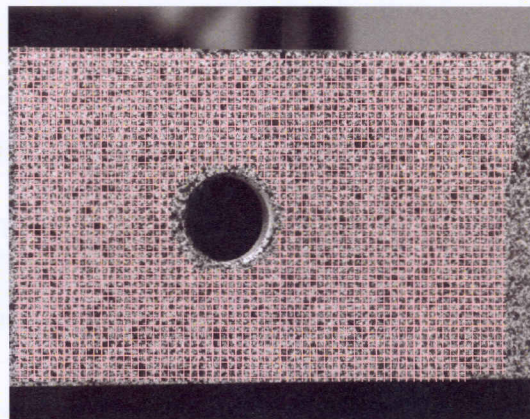
For this specimen, the Y axis shall follow the edge of the specimen.



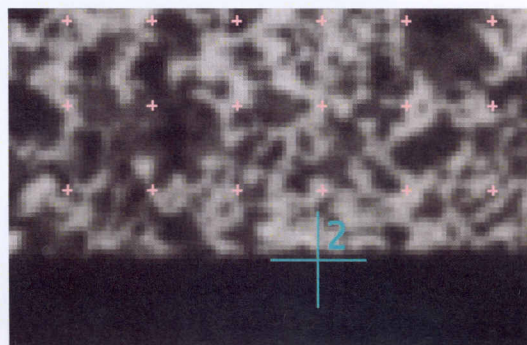
3D view with undefined coordinate system

Before you carry out the actual 3-2-1 transformation, you need to create pixel points in the 2D images based on the specimen edges.

**Pixel points** are 3D points that were created based on image pixels in the 2D images. **Pixel points** can be created in the entire 2D image range. Here, the computation mask has no effect. For creating **Pixel points**, information about the reference plane is required in order to get the 3D positions. You may define the reference plane when creating these points. A reference plane can only be created in areas where facets have been computed. You may create a reference plane automatically or manually. In case of flat specimens, you should define all facets as reference plane (manual creation).



2D camera view with selected reference plane

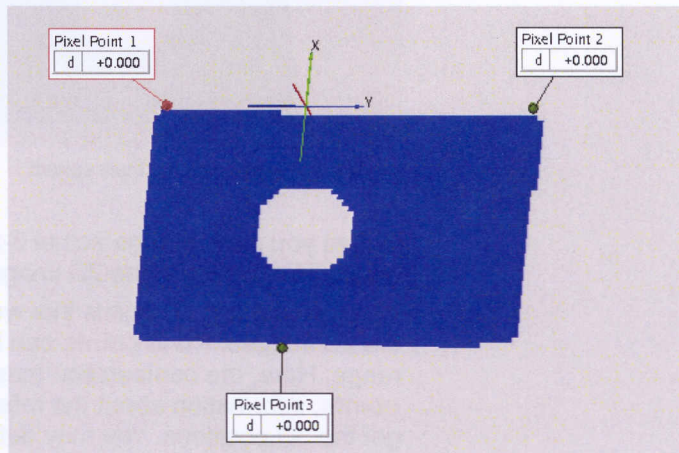


Pixel point at the edge of the specimen during definition

Now, the **3-2-1 Transformation** can be started.

As the Y axis shall run along the edge of the specimen, select transformation type **ZZZ-XX-Y** in the 3-2-1 dialog.

This means, you need to select 3 points on the specimen's surface for the Z plane (pixel points 1 to 3), the two points (pixel points 1 and 2) of the edge of the specimen for the X line and any point for Y (in this example pixel point 3). You may select the corresponding pixel points directly in the 3-2-1- dialog window.



Y axis along the edge of the specimen

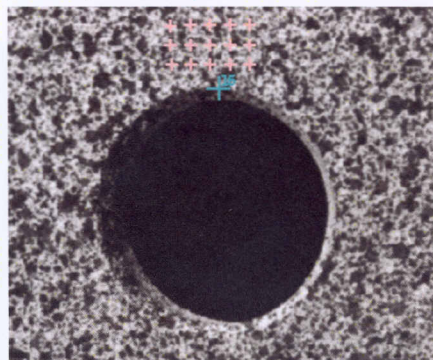
At the end, the coordinate system is positioned along the edge of the specimen.

#### E 4.2.2 Transformation Using the Edge of the Specimen and Circular Hole

If, in addition to the edge of the specimen, a circular hole is available, the coordinate system may be aligned along the edge and at the same time with respect to the circular hole. Using this example, we will show how you may create primitives for transformation.

##### Step 1:

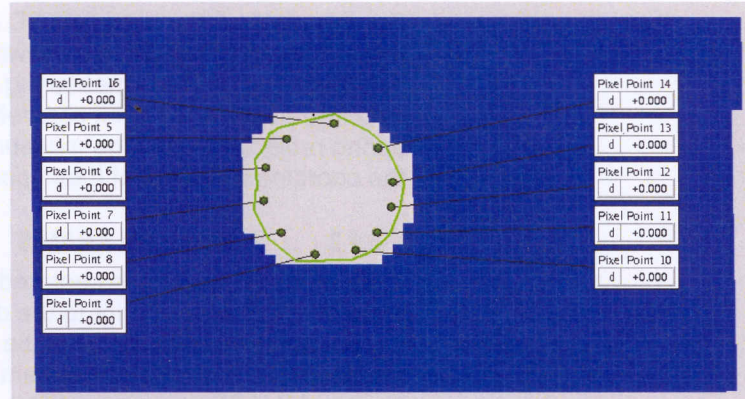
Click the pixel points on the edge of the hole and select the reference plane (**Manual plane** or **Best-fit plane**).



Pixel point with support plane during definition

**Step 2:**

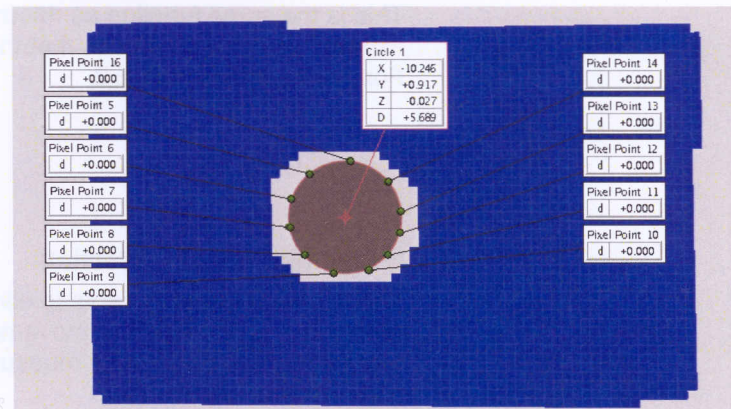
Select the corresponding points in the 3D view with the selection tool **Select on Surface** (Ctrl and space key).



Pixel points with selection lasso in the 3D view

**Step 3:**

Now, you can create a circle through the selected pixel points using **Primitives** ► **Circle** ► **Best-Fit Circle**.



Best-fit view in the 3D view

You may use the **Best-Fit Circle** now for 3-2-1 transformation.

## E 5 Other Transformation Methods

### E 5.1 Best-Fit by Reference Points

#### E 5.1.1 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 5.1.2 Procedure in ARAMIS

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 specimen's coordinate system in a reference point file. Load this file into ARAMIS using menu item **Best-Fit by Ref. Points** and thus transform your project into the correct TRITOP coordinate system.

### E 5.2 Transform Stage by Reference

This is the same function as described above (**Best-Fit by Reference Points**), with the difference that the transformation refers to a stage. For practical hints see E 2.

### E 5.3 Movement Correction

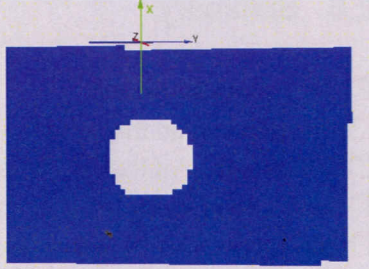
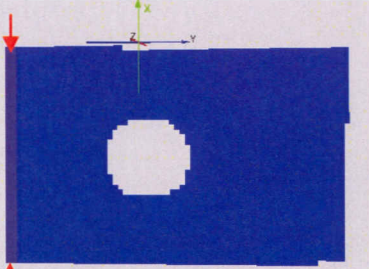
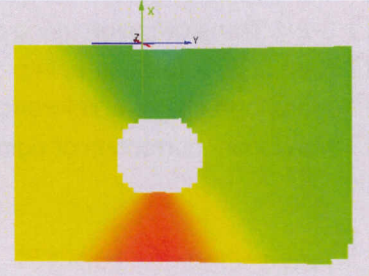
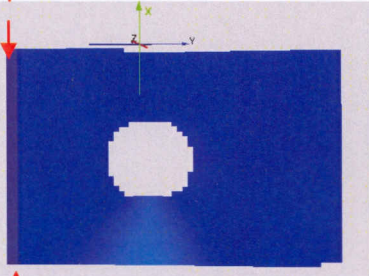
The ARAMIS system is able to eliminate unwanted rigid body movements in a specimen. The movement correction is a stage transformation through all stages of a measuring project without influencing the global coordinate system.

If, for example, you would like to analyze displacements in a specimen, **Movement Correction** is useful.

If you would like to record a movie without the specimen jumping back and forth, then **Movement Correction** can also be useful.

You may reset the movement correction any time (**Reset Stage Transformation**).

The following example shows the X displacement of a specimen in stages 0 (reference) and 2 with and without **Movement Correction**.

Specimen in stages 0 and 2 without movement correction	Specimen in stages 0 and 2 with movement correction
	
	
<p>For the <b>Movement Correction</b>, you need to select an area (or individual 3D points) which shows no or just insignificant strain (see red arrow) prior to transformation. The area is assumed to have not changed throughout all stages. You can see the selected area in the right-hand images on the left edge.</p>	

## E 6 Summary

- Why transformations
- Transformation methods
- Visualization of the coordinate system
- Principle of the 3-2-1 transformation
- Basics of 3-2-1 transformation
- 3-2-1 transformation using the specimen edge
- 3-2-1 Transformation using primitives
- Best-fit by reference points
- Transform stage by reference
- Movement correction of rigid body movements



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## F Creating and Editing Results

After strain computation, the data are available as color 2D or 3D view in each stage.

Before you edit the results, you need to select the correct 3D result representation. You may select from a variety of visualizations and compile the most important in a pull-down menu.

### F 1 Overview of the 3D Result Representations


Visualization:	Category:	Visualization:	Category:
Distance FLC	Strain	Yield Stress	Stress
Mises Strain	Strain	Major Strain	Strain
Tresca Strain	Strain	Minor Strain	Strain
Thickness Reduction	Strain	Surface	Surface
diff. Mises Strain	diff. Strain	Difference Radial	Displacement
diff. Tresca Strain	diff. Strain	Difference Radial Angle	Angle
diff. Thickness Reduction	diff. Strain	Radius	Displacement
diff. Epsilon X	diff. Strain	Shear Angle	Angle
diff. Epsilon XY	diff. Angle	Sigma 1	Stress
diff. Epsilon Y	diff. Strain	Sigma 2	Stress
diff. Major Strain	diff. Strain	Sigma X	Stress
diff. Minor Strain	diff. Strain	Sigma Y	Stress
diff. Difference Radial	diff. Displacement	Sigma Z	Stress
diff. Difference Radial Angle	diff. Angle	Displacement E	Displacement
diff. Shear Angle	diff. Angle	Displacement X	Displacement
diff. Displacement E	diff. Displacement	Displacement Y	Displacement
diff. Displacement X	diff. Displacement	Displacement Z	Displacement
diff. Displacement Y	diff. Displacement	Visualization 0	User-Defined
diff. Displacement Z	diff. Displacement	...	User-Defined
Epsilon X	Strain	Visualization 9	User-Defined
Epsilon XY	Angle	Z on XYZ	Displacement
Epsilon Y	Strain		

The result representations of strain can be visualized as Technical, Logarithm or according to Green.

Software tools for post processing allow for filtering or interpolating these result data, if required.


For the result representation in diagrams or as labels in the 3D view, you may create stage points, sections (plane sections, circular sections, spline sections) or primitives. The created elements follow the 3D points in each stage. For additional considerations, analysis elements are available for distances and angles.

## F 2 Info Points, Stage Points

**Info points**  are individually definable points in the 3D view of the specimen. The info point is used for getting fast and temporary information. Clicking with Ctrl and left mouse button in the 2D camera image or in the 3D view creates an **info point**. **Info Points** may be defined on the surface of the specimen (facet center points) or on sections.

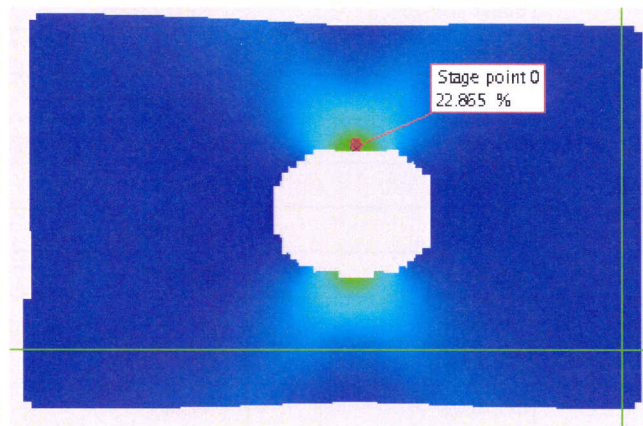
### Info

You may create just one **Info Point** in a measuring project. Only one info point is shown in the 3D view and in the 2D camera image.

You may set an **Info Point**  as a **Stage Point** any time, the coordinates and computation results of which may now be evaluated. Thus, it is possible to create e.g. a point behavior diagram over all stages.

Defined **Stage Points** and the **Info Point**  will be highlighted by color and listed in tab **Stage Points**  in the **sub-explorer**.

The following figure shows a stage point in a tensile test.



Stage point with visible text label and display of the major strain

The text label was set visible with **Edit Properties** and the default label template **Value** was chosen.

## F 3 Sections

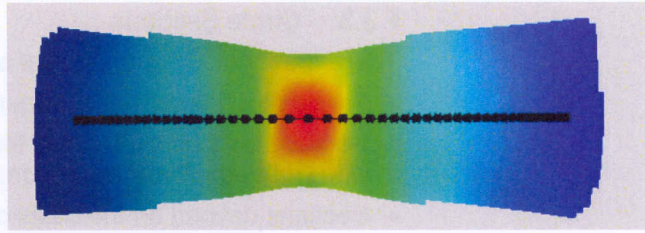
ARAMIS provides for cutting the computed 3D data. This function allows for creating plane sections, circular sections and spline sections in all stages of the specimen.

You may create several parallel sections in one process.

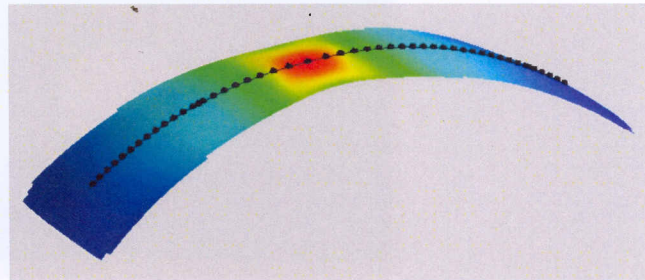
Defined sections will be highlighted by color and listed in tab **Sections**  in the **sub-explorer**.

### F 3.1 Plane Sections

There are two types of plane sections, free defined ones and sections according to the XYZ planes of the coordinate system.



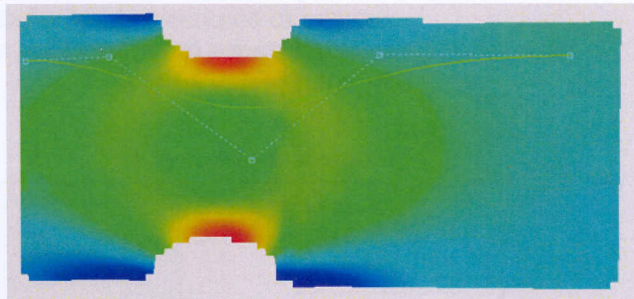
Direct view of a specimen's section



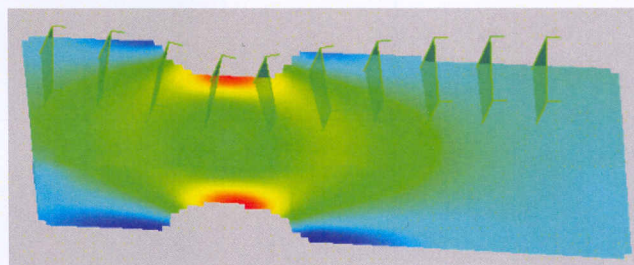
Perspective view of a section

### F 3.2 Spline Sections

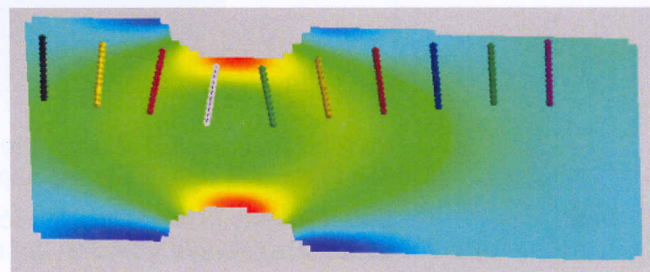
The section planes based on the spline curve always result perpendicular to the screen view.



Selected points in the 3D object and the resulting curve during definition



Cutting planes along the curve during definition

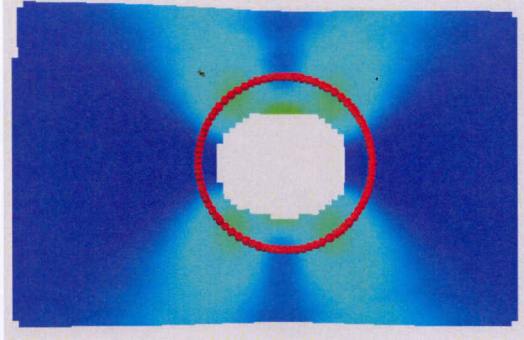


Final sections

### F 3.3 Circle Sections

There are three types of circular sections:

- Free defined ones in the screen view.
- Sections defined by 3 points that are directly clicked in the 3D view with Ctrl and left mouse button.
- Sections defined on the basis of primitives.

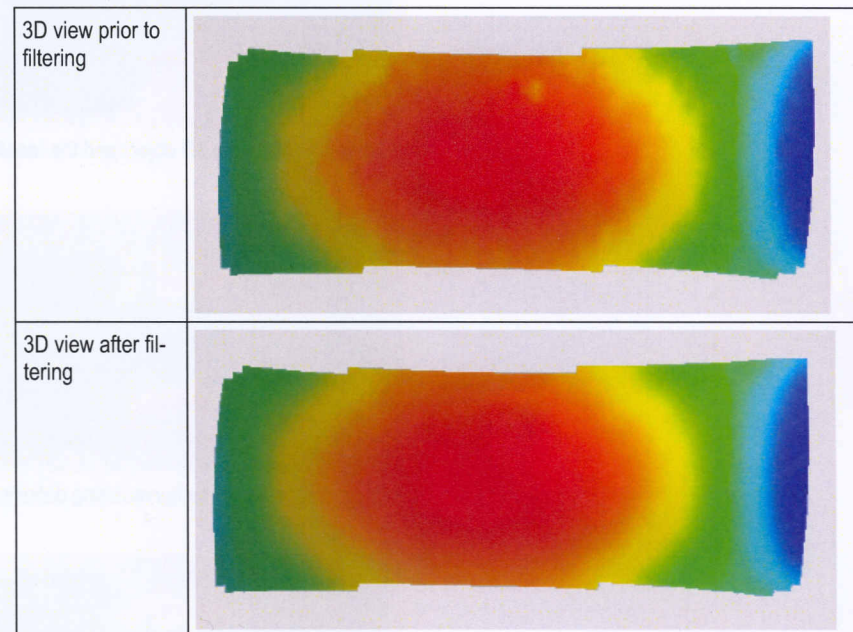


Circular section

### F 4 Filtering

You may filter result data in order, for example, to suppress possible noise or to emphasize local effects. The filter function may be used for selected stages or for all stages and additionally for selected areas or for not selected areas.

Example for filtering:

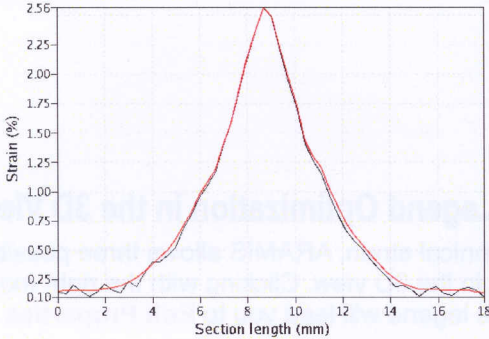
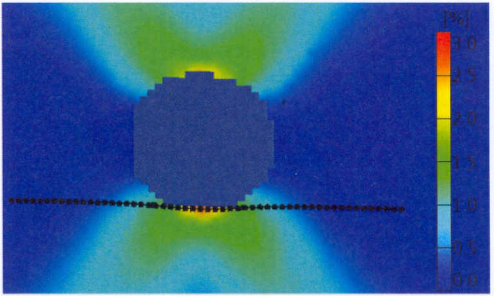


No filter function will change the coordinates of the 3D points. Function **Filter** only influences the result data.

**Info**

**Filtering** may deteriorate the accuracy of an individual point as the filter function always works on the entire surface.

### F 4.1 Filter Parameters

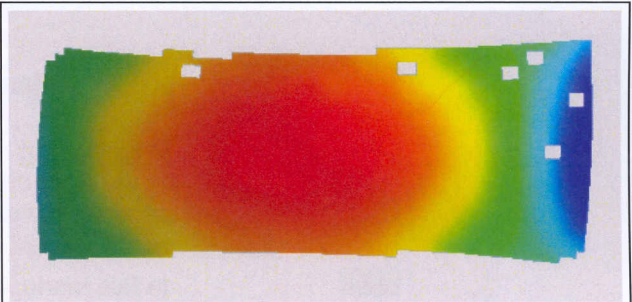
Parameters:		Brief Description:
Filter type	<b>Average</b>	The statistic average is calculated.
	<b>Median</b>	The central value is calculated (the values are sorted by size and the value in the middle is used).
	<b>Gradient</b>	<p>This filter type corresponds to the filter type <b>Average</b> as long as no point in the amount of points is outside the adjusted gradient value. The gradient value determines the max. admissible slope between two grid points at which filtering still is allowed.</p> <p>As the function of the filter is not always clearly visible in the 3D view, the following example shows a section. The black line in the diagram is the non-filtered state, the red line is the filtered one. Here, you clearly see that areas above the max. gradient were not filtered.</p>  
<b>Runs</b>	Number of runs for the adjusted filter parameters. If the value is 0, no filtering is performed.	
<b>Size</b>	Number of grid points for filter computation, e.g. <b>3</b> means that the center point of a 3x3 grid is filtered. The filter function is based on the adjacent grid points.	
<b>Max. gradient</b>	Only active with filter type <b>Gradient</b> , see filter type <b>Gradient</b> . The required value depends on the specimen. If the value is 0, no filtering is performed.	
<b>Filter quote</b>	Input of the validity quota of grid points in %. If, for example, <b>Size 3</b> and <b>Filter quote 50%</b> is adjusted, at least 50% of the grid points must be present in the 3x3 grid in order to be filtered.	
<b>Behavior</b>	Depending on the selected <b>Filter quote</b> , a grid point is deleted or not filtered. Accordingly, select <b>Remove</b> or <b>No filter</b> .	

### F 5 Interpolating 3D Points

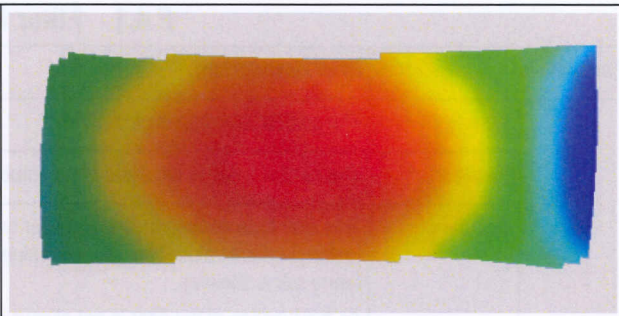
If your result representation has holes because, for example, the spray pattern failed at a point, you may fill these holes by means of interpolation.

In the interpolation parameters, you may adjust the maximum size of the hole to be filled.

3D view prior to interpolation:



3D view after interpolation:



## F 6 Legend Optimization in the 3D View

For technical strain, ARAMIS allows three possibilities for the legend scaling in the 3D view. Clicking with the right mouse button (RMB) onto the legend will lead you to **Edit Properties**.

### F 6.1 Fixed Legends With Manual Maximum and Minimum

**Prerequisite:**

**Scaling** ► **Min/Max.** ► **Manually** is selected in the **Properties!**

**Advantages/Disadvantages:**

In case of fixed limits and high strain, small strain cannot be made visible.

### F 6.2 Automatic Scaling Without Constraints

**Prerequisite:**

In the **Properties** for legends **Scaling** ► **Min/Max.** ► **Automatic** is selected!

**Advantages/Disadvantages:**

If no strain or just small strain amounts occur, the very small measuring noise of the system is displayed in the 3D view and in the diagrams although these values are very low.

### F 6.3 Automatic Scaling With Constraints

**Prerequisite:**

In the **Properties** for legends **Scaling** ► **Min/Max.** ► **Constraints** is selected! When clicking on **Constraints on** or **Constraints off** you reach menu **Legend Constraints**.

**Info**

In this menu **Automatic** must not be selected for both, minimum and maximum!



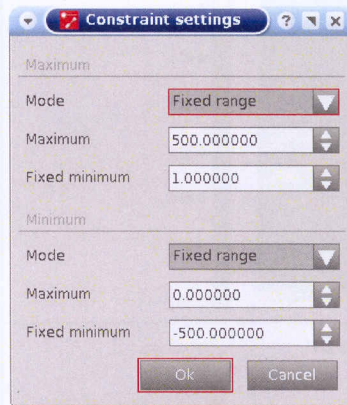
**Advantages/Disadvantages:**

Using this function, you may restrict the automatic scaling. The individual functions can be adjusted independently for the upper and lower part of the legend (**Maximum**, **Minimum**).

For example, it is possible to set the lower legend range to a fixed value (mode **Fixed value**), while the upper range is scaled automatically (mode **Auto scaling**).

The mode **Fixed range** only allows automatic scaling within a fixed range.

In the following example, automatic scaling will be carried out in the lower range from 0 to -500 and in the upper range from 1 to 500 (strain in %).



Info

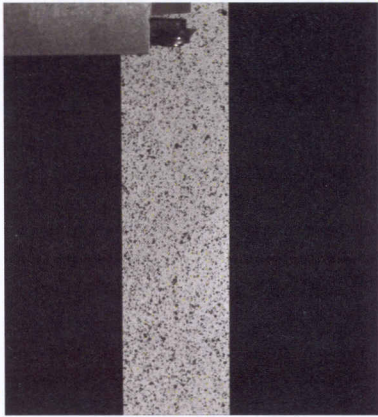
That is, if the value range is between 0 and 1%, the scaling always is from 0 to 1%. If, however, the strain values exceed 1%, the upper limit is scaled automatically based on the largest measuring value. If the smallest value falls below 0%, the lower limit as well is scaled automatically.

These settings were taken as ARAMIS default settings for strain and proved successful for technical strain.

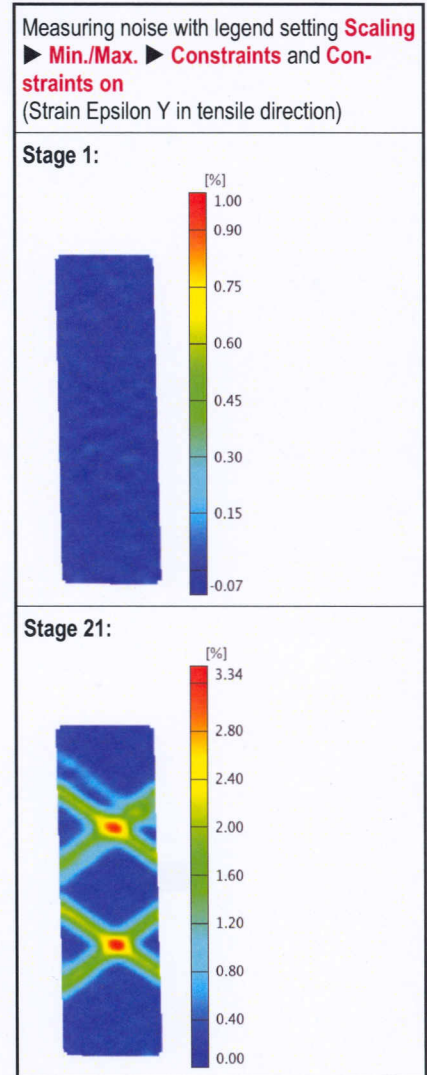
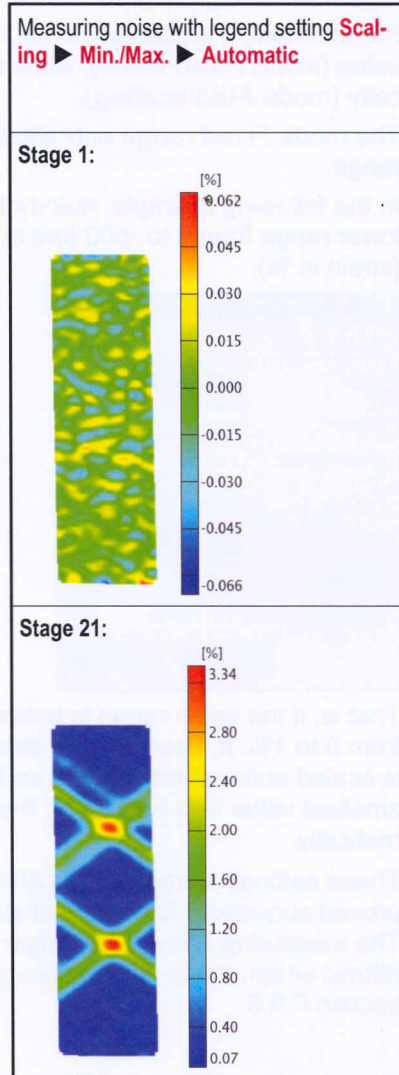
The measuring noise is no longer displayed in detail. In case of logarithmic strain, these settings are not useful. For more information see section F 6.5.

### F 6.4 Comparison Constraint On With Constraint Off

The following example of a tensile test specimen clearly shows the differences between automatic and restricted (with constraints) **Scaling**.



Stage 0: Left camera image of the specimen



While for strain around 3% no differences occur in the settings, stage 1 shows a considerably improved image as the measuring noise is completely suppressed.

Thus, expressive images can be obtained quickly without the need to edit them.

### F 6.5 Optimizing the Legend for Logarithmic Strain

The settings described in sections F 6.1 and F 6.4 are valid for technical strain. For the technical strain, the settings are factory-preadjusted.

If you work with logarithmic strain, you need to define the default setting again. According to the settings for technical strain (**Scaling** ► **Min./Max.** ► **Constraints** with **Constraints on** or **off** and **Fixed value**) we recommend the following settings for logarithmic strain:

<b>Maximum:</b>	<b>Fixed range</b>	<b>Fixed minimum</b> 0.01	<b>Maximum</b> 1
<b>Minimum:</b>	<b>Fixed range</b>	<b>Fixed minimum</b> -1	<b>Maximum</b> 0

Change the settings as follows:

If not done already, switch the ARAMIS software globally to logarithmic strain:

In the preferences (Edit ► Preferences ► Preferences), item Evaluation Mode ► Strain semantics you need to change every value of interest for you to Logarithm.



Confirm the changes with Apply and OK. The settings are now automatically taken over for the next project that is opened.

In the same way, you may change the values for the constraints settings (Edit ► Preferences ► Preferences) item Evaluation Mode ► Legend ► Scaling ► Min./Max. ► Constraints with Constraints on or off).

### F 7 Primitives


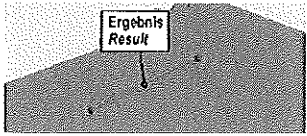
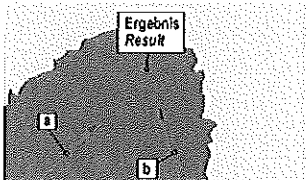
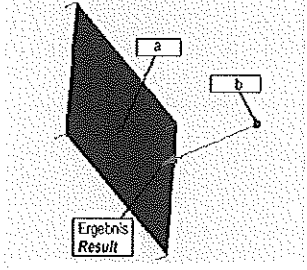
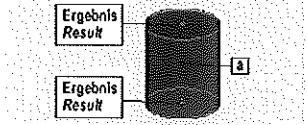
Primitives (points, lines, circles, planes, spheres, ...) are user-defined objects in the 3D view. You need primitives, for example, for transformation, for analysis or for the documentation of measuring results.

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

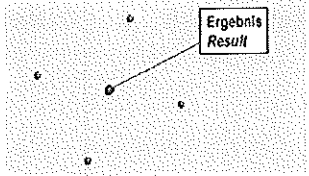
- Editing labels, label visibility
- Changing the appearance of the primitive

The following table informs you in extracts about possible primitives and particularities when creating them. All primitives are generated based on 3D points 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.

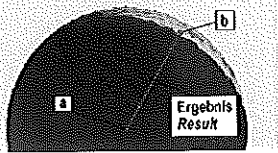
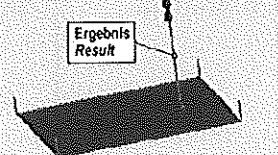
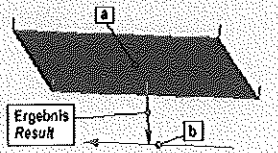
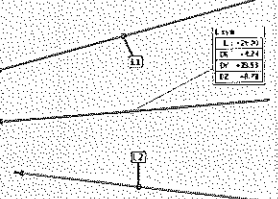
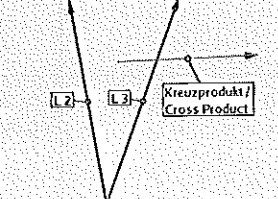
#### F 7.1 Primitive Point

Element	Description	Example
Point	Creates a single 3D point by clicking with the left mouse button.	 Point on 3D mesh
Division Point	Creates an individual 3D point between 2 points. The position between the points can be defined in 100 steps (%).	 Point between two points on 3D mesh with center value 50%.
Intersection Point	Active if corresponding primitives exist in the measuring project. Creates an intersection point between primitives. 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.	 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. Here, you may choose the 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.	 Projection of point (b) onto plane (a).
Points from Line	Extracts the start or end points of lines, intersection lines and rotation axes of cylinders (a) and cones.	 Ergebnis Result

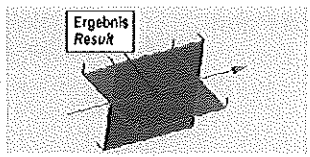
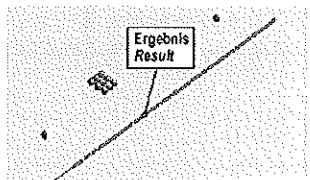
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<b>Best-Fit Point</b>	Creates a geometrical average value from selected 3D points and/or 3D meshes.	 <p>The result is the geometrical average value.</p>
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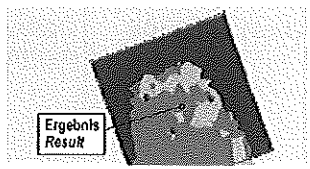
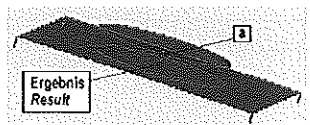
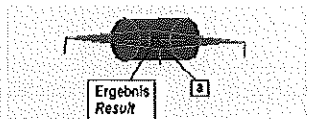

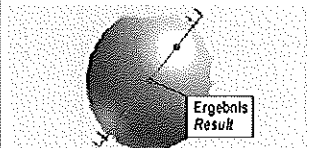
### F 7.2 Primitive Line

Element	Description	Example								
<b>Point-Point Line</b>	Creates a line between two points.	 <p>Line between two individual points</p>								
<b>Point-Direction Line</b>	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.	 <p>Line from the starting point on the plane in normal direction of the plane.</p>								
<b>Perpendicular Line</b>	Creates a line from the start point (plane a) orthogonal to another line (b).	 <p>On plane (a), we selected a start point for the perpendicular line which runs perpendicular to line (b).</p>								
<b>Symmetric Line</b>	Creates a line symmetrically to two other elements which contain a line (e.g. line, cylinder, cone, etc.).	 <table border="1"> <tr><td>L3</td><td>250</td></tr> <tr><td>L3</td><td>424</td></tr> <tr><td>L3</td><td>2633</td></tr> <tr><td>L3</td><td>878</td></tr> </table> <p>Symmetric line (here in red)</p>	L3	250	L3	424	L3	2633	L3	878
L3	250									
L3	424									
L3	2633									
L3	878									
<b>Line by Cross Product</b>	Creates a line that is perpendicular to two other lines or direction vectors and has its origin in the point you clicked.	 <p>The cross product was created from lines 2 and 3. The new line is perpendicular to both other lines.</p>								

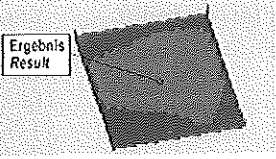
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<p><b>Intersection Line</b></p>	<p>Creates intersection lines between surfaces of primitives.</p>	 <p>Intersection line between two planes.</p>
<p><b>Best-Fit Line</b></p>	<p>Creates a line according to the best-fit principle based on selected 3D meshes, 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.</p>	 <p>Best-fit line, created on previously selected (red) 3D points.</p>

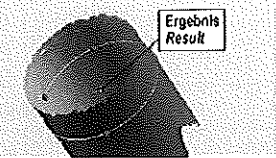
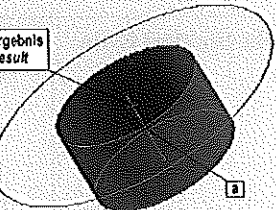
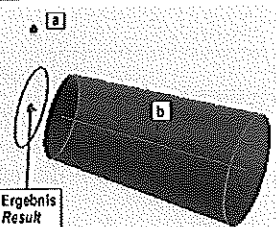
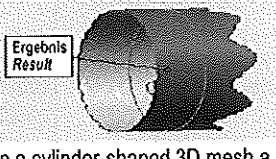
**F 7.3 Primitive Plane**

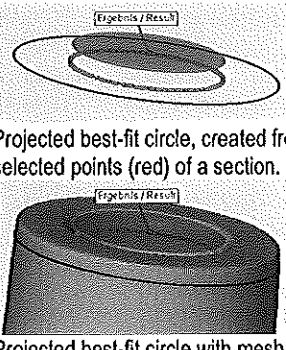
Element	Description	Example
<p><b>Point-Point-Point Plane</b></p>	<p>Creating a plane through 3 points.</p>	 <p>The plane was created by selecting three 3D points.</p>
<p><b>Point-Normal Plane</b></p>	<p>Creates a plane through one point in the direction of other objects like lines, cylinders, etc.</p>	 <p>The plane was created using a point on the rotation axis of cylinder (a) and the normal direction of cylinder (a).</p>
<p><b>Axis Parallel Plane</b></p>	<p>Creates a plane through a point (a) and parallel to the axis of the current coordinate system.</p>	 <p>A point on the rotation axis of cylinder (a) was selected, and the Z axis was selected as axially parallel plane.</p>
<p><b>Parallel Plane</b></p>	<p>Creates a plane parallel to a circle, a rectangular hole, a slotted hole or another plane.</p>	 <p>The plane was created in parallel to circle (a), stating an offset value.</p>
<p><b>Plane in Viewing Direction</b></p>	<p>Creates a plane through two points or a temporary defined line (using the selection tool of the menu) in the current viewing direction.</p>	 <p>Plane through two points on a sphere-shaped 3D mesh in viewing direction of the screen.</p>

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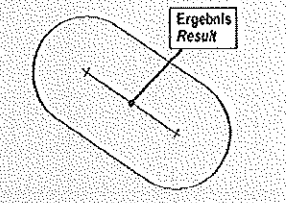
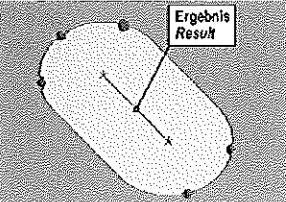
<b>Best-Fit Plane</b>	<p>Creates a plane according to the best-fit principle based on selected 3D mesh or sections. Based on the selected points, the plane can be calculated for All points or with the help of statistical methods with 1 Sigma to 5 Sigma. In case of a large amount of points, 1 Sigma is 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.</p>	 <p>Best-fit plane, created on previously selected 3D points.</p>
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## F 7.4 Primitive Circle

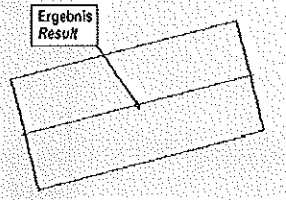
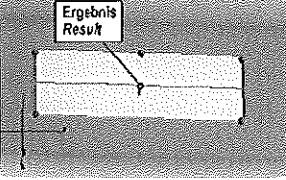
Element	Description	Example
<b>Point-Point-Point Circle</b>	<p>Creates a circle through three points.</p>	 <p>On a cylinder-shaped 3D mesh a 3D mesh section was created. By selecting three points on the 3D mesh section, the circle was created. The white 3D mesh section is superimposed by the green primitive circle.</p>
<b>Point-Normal-Radius Circle</b>	<p>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.</p>	 <p>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.</p>
<b>Cylinder/Cone Intersection Circle</b>	<p>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.</p>	
<b>Best-Fit Circle</b>	<p>Creates a circle according to the best-fit principle based on selected 3D mesh or sections. 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.</p>	 <p>On a cylinder-shaped 3D mesh a 3D mesh section was created. By selecting this 3D mesh section, the circle was created by means of the best-fit principle. The selected 3D mesh section is superimposed by the green primitive circle.</p>

<p><b>Projected Best-Fit Circle</b></p>	<p>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.</p>	 <p>Projected best-fit circle, created from the selected points (red) of a section.</p> <p>Projected best-fit circle with mesh data.</p>
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**F 7.5 Primitive Slotted Hole**

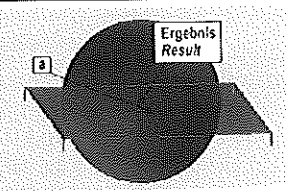
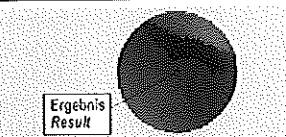
Element	Description	Example
<p><b>Point-Normal-Direction Slotted Hole</b></p>	<p>Creates a slotted hole based on externally entered values or derived from other primitives or feature elements. The function requires the following information: Point (center point coordinates), Normal, Direction, Length, Width.</p>	
<p><b>5-Points Slotted Hole</b></p>	<p>Creates a slotted hole by clicking on five points on the edge (circular area) of a slotted hole in the CAD data.</p>	

**F 7.6 Primitive Rectangular Hole**

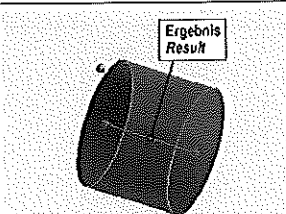
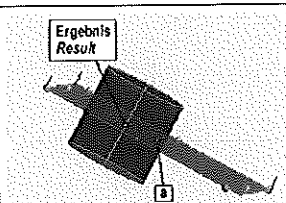
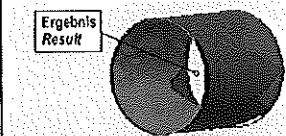
Element	Description	Example
<p><b>Point-Normal-Direction Rectangular Hole</b></p>	<p>Creates a rectangular hole based on externally entered values or derived from other primitives or feature elements. The function requires the following information: Point (center point coordinates), Normal, Direction, Length, Width.</p>	
<p><b>5-Points Rectangular Hole</b></p>	<p>Creates a rectangular hole by clicking on five points on the edge of a rectangular hole in the CAD data.</p>	



F 7.7 Primitive Sphere

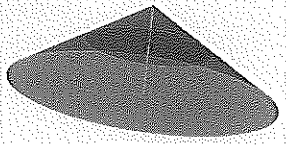
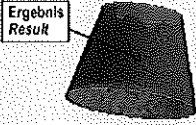
Element	Description	Example
<b>Point-Radius Sphere</b>	Creates a sphere by means of stating the center of the sphere and the radius. The radius can be defined by selecting the points or by entering the radius value directly.	 <p>Freely defined sphere with the center on plane (a). The center of the sphere was determined by selecting a point with Ctrl and left mouse button.</p>
<b>Best-Fit Sphere</b>	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.	 <p>Best-fit sphere, created on a selected spherical 3D mesh.</p>

F 7.8 Primitive Cylinder

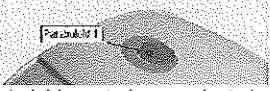
Element	Description	Example
<b>Point-Point-Radius Cylinder</b>	Creates a cylinder through two points. Point 1 determines the beginning of the cylinder's rotation axis. Point 2 determines the end point of the rotation axis. Use Radius to adjust the circumference of the cylinder.	 <p>The cylinder was created based on a line. The end points of the line were created with Ctrl and left mouse button. The radius was entered as value.</p>
<b>Point-Direction-Radius Cylinder</b>	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.	 <p>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.</p>
<b>Best-Fit Cylinder</b>	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.	 <p>Example: Best-fit cylinder, created on a selected cylindrical 3D mesh.</p>

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F 7.9 Primitive Cone

Element	Description	Example
<b>Point-Direction-Angle Cone</b>	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.	
<b>Best-Fit Cone</b>	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.	 <p>Best-fit cone, created on previously selected cone-shaped 3D points.</p>

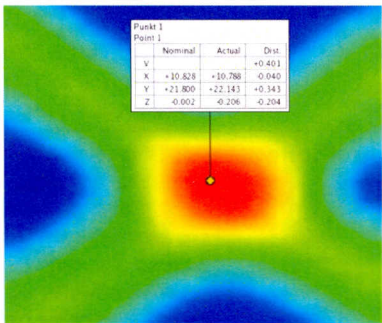
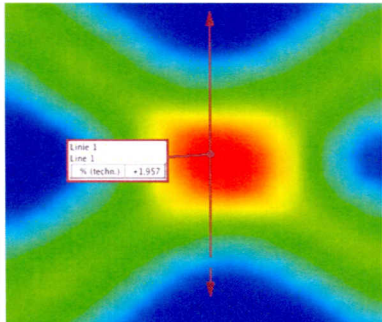
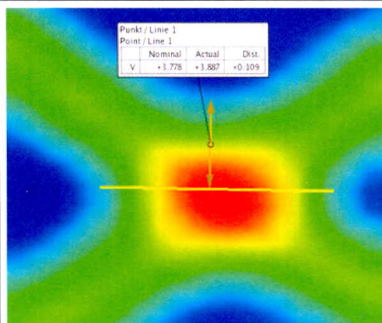
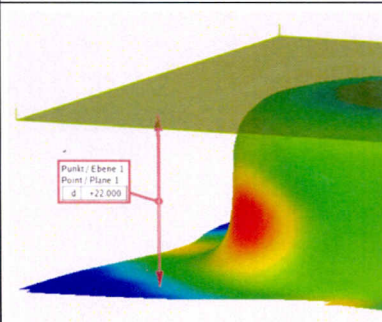
F 7.10 More Primitives

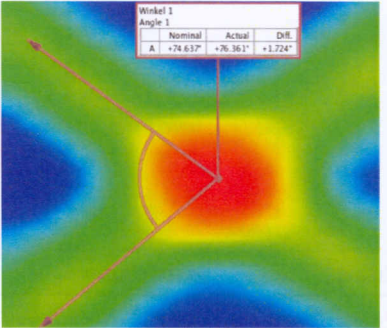
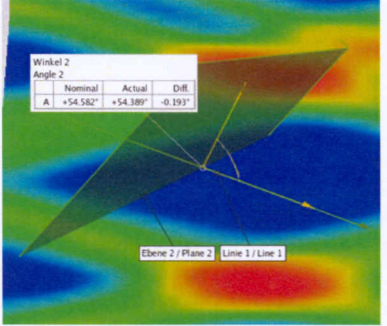
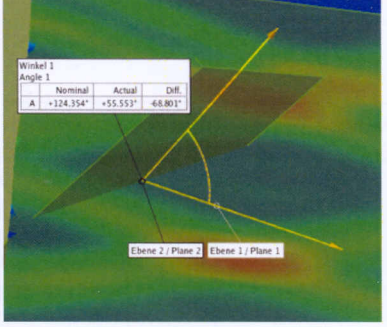
Element	Description	Example
<b>Best-Fit Paraboloid</b>	Creates a paraboloid. Based on the selected points, the paraboloid can be calculated for All points or with the help of statistical methods with 1 Sigma to 5 Sigma. In case of a large amount of points, 1 Sigma is approx. 68.3%, 2 Sigma approx. 95.4% and 3 Sigma approx. 99.7% of all points.	 <p>Paraboloid created on a selected area of 3D points.</p>

## F 8 Analysis Elements

Using the analysis elements, you may evaluate the deformation at or between certain points. These evaluations may be visualized in form of a report and may also be exported. Using text labels, you may display information interesting for you in the 3D view either automatically by means of a template or you may create your own template manually.

There are various functions available for distance and angle analyses.

Element	Description	Example
<b>Point Position</b>	Using this function, you may display the displacement of individual points with respect to the basic stage. When changing the stages, the respective valid value is shown for the respective current stage.	
<b>Point-Point Distance</b>	This function provides for measuring changes in the distance between object points and/or primitives. You may create the respective reference element either directly by clicking points or you may select primitives. The distance is shown with an arrow. The corresponding label shows the deviation. When changing the stages, the calculated deformation value changes and displays the valid measure for the current stage.	
<b>Point-Line Distance</b>	This function provides for measuring changes in the distance between a point and a line (object points and primitives). You may create the respective reference element either directly by clicking points or you may select primitives. The software always calculates the shortest perpendicular distance from the point to the line. The distance is shown with an arrow. The corresponding label shows the deviation. When changing the stages, the calculated deformation value changes and displays the valid measure for the current stage.	
<b>Point-Plane Distance</b>	This menu item provides for measuring changes in the distance between a point and a plane (object points and primitives). You may create the respective reference element either directly by clicking points or you may select primitives. The software always calculates the shortest perpendicular distance from the point to the plane. The distance is shown with an arrow. The corresponding label shows the deviation. When changing the stages, the calculated deformation value changes and displays the valid measure for the current stage. First, select the point for which you would like to display the deviation. Then, define the reference element.	

Element	Description	Example
<p><b>Line-Line Angle</b></p>	<p>Using this menu item, you may measure angle variances between two lines. You may create the respective reference element either directly by clicking points or you may select primitives.</p> <p>The angle is shown with two arrows. The corresponding label shows the angle variance. You may adapt labels individually. For this purpose, there are also keywords available with the help of which you may analyze the measured angle projected on the planes of the coordinate system.</p> <p>The length of the angle sides and the origin of the angle may later be changed with <b>Edit Properties</b>.</p> <p>When changing the stages, the calculated deformation value changes and displays the valid measure for the current stage.</p> <p><b>Info</b> Angles in the 3D view 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°.</p>	
<p><b>Line-Plane Angle</b></p>	<p>Using this menu item, you may measure angle variances between a line and a plane. You may create the respective reference element either directly by clicking points or you may select primitives.</p> <p>The angle is shown with two arrows. The corresponding label shows the angle variance. You may adapt labels individually. For this purpose, there are also keywords available with the help of which you may analyze the measured angle projected on the planes of the coordinate system.</p> <p>The length of the angle sides and the origin of the angle may later be changed with <b>Edit Properties</b>.</p> <p>When changing the stages, the calculated deformation value changes and displays the valid measure for the current stage.</p> <p><b>Info</b> Angles in the 3D view 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°.</p>	
<p><b>Plane-Plane Angle</b></p>	<p>Using this menu item, you may measure angle variances between two planes. The angle is shown with two arrows. The corresponding label shows the angle variance. You may adapt labels individually. For this purpose, there are also keywords available with the help of which you may analyze the measured angle projected on the planes of the coordinate system.</p> <p>The length of the angle sides and the origin of the angle may later be changed with <b>Edit Properties</b>.</p> <p>When changing the stages, the calculated deformation value changes and displays the valid measure for the current stage.</p> <p><b>Info</b> Angles in the 3D view 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°.</p>	

### F 9 Evaluate Results Statistically

ARAMIS offers the possibility to evaluate results statistically.

For this purpose, you need to select the respective areas in the 3D view.

The parameters Points, Maximum, Minimum, Average and Sigma are available for evaluation.

The results are shown in the result window and are automatically updated for all changes of the visualization made in the 3D view.

Current data							
0->12	Visualization	Value	Points	Minimum	Maximum	Average	Sigma
Selection	Major Strain (Technical) [%]	-	596	2.266	16.557	5.662	2.028
Statistic data							
0->6	Visualization	Points	Minimum	Maximum	Average	Sigma	
Statistic Data	Major Strain (Technical) [%]	596	1.315	8.757	3.289	1.107	
0->7	Visualization	Points	Minimum	Maximum	Average	Sigma	
Statistic Data	Major Strain (Technical) [%]	596	1.468	9.891	3.657	1.238	
0->8	Visualization	Points	Minimum	Maximum	Average	Sigma	
Statistic Data	Major Strain (Technical) [%]	596	1.629	11.034	4.029	1.373	

Result window with current data and multistage data

For comparative evaluations you may define statistic data sets. For this data set, the data type is not changed, i.e. any changes made in display and selection of the 3D View have no effect on these results. Thus, the statistical information e.g. of Major Strain and Minor Strain of selected areas can be looked at simultaneously.

These data will be saved such that you may access this information e.g. by means of a statistics diagram (report function). In addition, you may create a Point Statistic from an info point. Multistage data shows the data of all stages selected in the explorer.

Statistic data can be exported.

## F 10 Summary

- Creating results
- Info points
- Stage points
- Plane section, spline section, circular section
- Filtering, using filter parameters
- Interpolating 3D Points
- Primitives
- Analysis elements
- Evaluate results statistically

**Chapter G** - Table of Contents (rev-c)

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## G Documentation

ARAMIS allows for presenting result data in various ways. The results in the 3D view with sections, primitives and analysis elements always are the basis for the different documentation possibilities. So, for example, image series may be created as movies or you may document your results using default report templates.

If you wish to document your results in external applications, you may also export your result data.

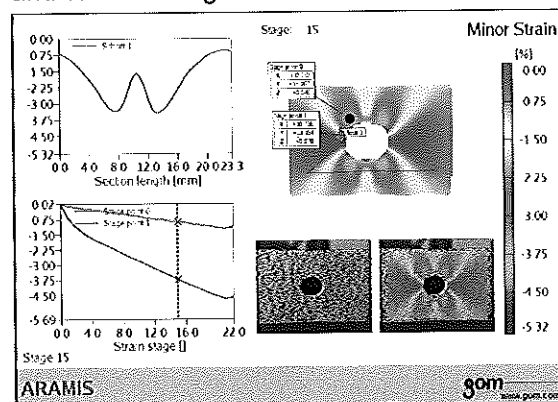
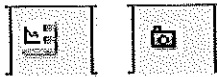
### G 1 Reports

#### G 1.1 Standard Reports

Deformation results can clearly be illustrated in reports. Different 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.

The standard reports Report-ARAMIS contain result images, diagrams and camera images.



#### Info

If the images or diagrams are empty or do not contain the required data, you may edit the corresponding connections by double clicking on the element in the report.

The standard reports contain the result images as project image strain overlay or as user-defined image series, see G 1.2.

In case of a modification, the project images in a report are automatically updated. For user-defined Image Series you need to create a new Image Series in case of a modification.

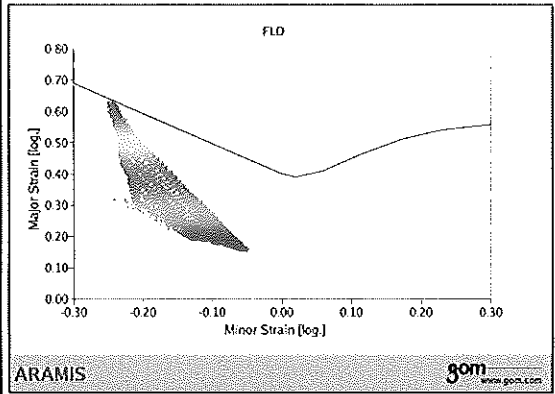
#### Info

Primitives may only be included into reports by means of image series.

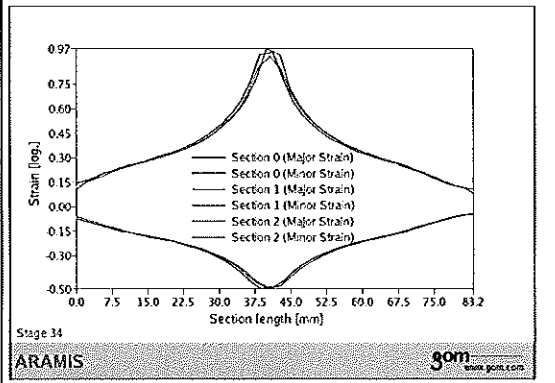
For further information, please refer to the Online Help (key F1).

G 1.2 Overview of Default Report Templates

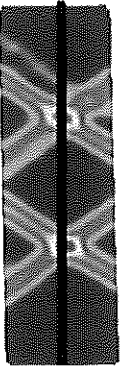
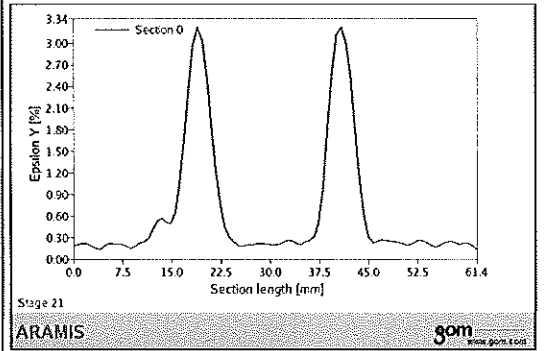
**FLD**  
**(Forming Limit Diagram)**  
 This diagram shows the major strain with respect to the minor strain. The color is displayed according to the current visualization.  
 Together with the known material data (FLC = Forming Limit Curve), the failure of the specimen can be determined.  
 How to change to logarithmic strain see chapter F, section "Optimizing the Legend for Logarithmic Strain".



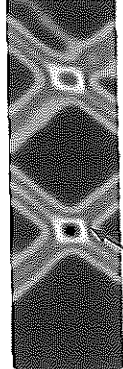
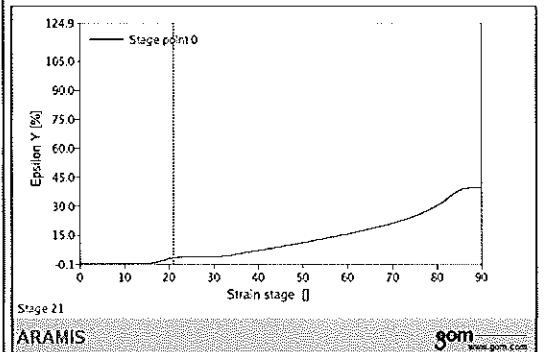
**Multi-Section FLC**  
**(Forming Limit Curve)**  
 Representation of the data used for FLC computation. For further information, please refer to the User Manual – Software FLC Computation.



**Multi-Section**  
 Diagram representation of one or more sections of the current load stage.  
 This diagram shows the selected visualization (here Epsilon Y) with respect to the length of a section per stage. Several sections are displayed in different colors. The current stage is shown on the bottom left. This way, values can be examined over the entire specimen.



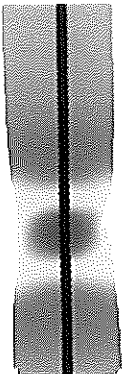
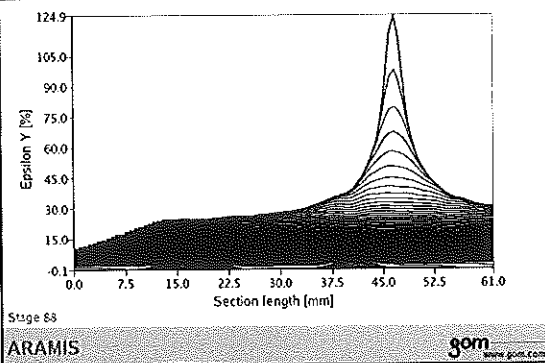
**Multi-Stage-Point**  
 Diagram representation of one or several stage points through all load stages.  
 Analysis of the point curve. Here, all values of the selected visualization and of one point are displayed through all computed stages. The current stage is displayed on the bottom left as well as in the diagram as a bar. This function provides for analyzing the behavior at critical points of a specimen.



**Multi-Stage-Section**

Diagram representation of a section through all load stages.

Here, one section of all stages is displayed with respect to the length of the section. The current section is colored.



**Project-Keyword-ARAMIS**

Shows the project keywords to be used in other report templates. You may transfer the keywords with copy (Ctrl and C) and paste (Ctrl and V).

You may also change the language of the keywords, see troubleshooting in **Chapter K**.

Project Keywords + Stage Data / Stufen-daten

Inspector:	Peter	Length:	mm	Comment 1:	
Company:	GOM mbH	Width:	mm	Comment 2:	
Department:	TechWills	Thickness:	mm	Comment 3:	
Location:	Braunschweig				
Date:	15.03.2005				

Project:	Stain Abl
Change Nr.:	012345678
Part No.:	587654321
Test method:	
Material:	
Temperature:	°C
Test Speed:	

For Copy and Paste

**Report-ARAMIS**

Example reports with the most important report elements for standard ARAMIS applications.

- Section diagram (Multi-Section)
- Stage point diagram (Multi-Stage-Point)
- Camera images (project images)
- Visualization of the deformation with an image of Strain overlay (project image)

Report-ARAMIS is the most used report. This report contains the most important data of a measurement and displays it clearly.

This report is particularly suitable for flat specimens, e.g. tensile test specimens.

The result image of the specimen's surface is displayed live and does not need to be integrated separately.

Stage 21  
Time: 4.20 s

**Statistics**

Statistic diagram for extensive evaluations.

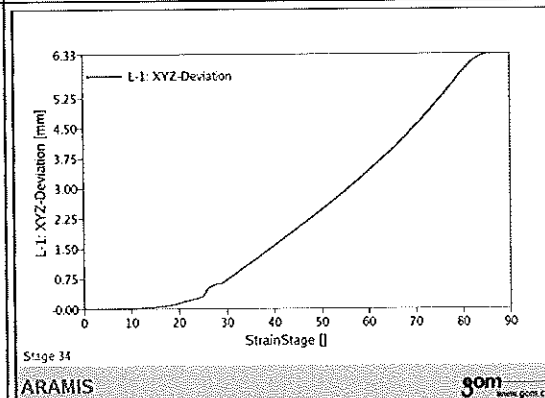
This diagram is the most versatile of all report diagrams. On the one hand, you may display the data of a measurement and on the other hand it provides many combination possibilities between:

**X axis**

- Number of stages
- Stage data (A/D values, time, calculated values from this)
- Statistics

**Y axis**

- Measurements
- Stage data
- Statistics



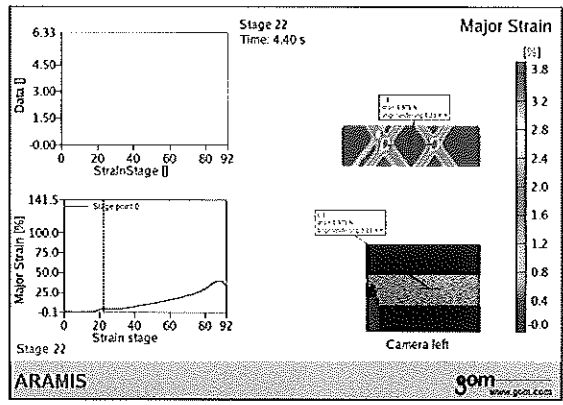
### G 1.3 Analysis Elements in a Report

You may integrate analysis elements in reports. If the result images are project images, e.g. Strain overlay, the analysis elements may appear automatically in the report image if the function Add to report is enabled.

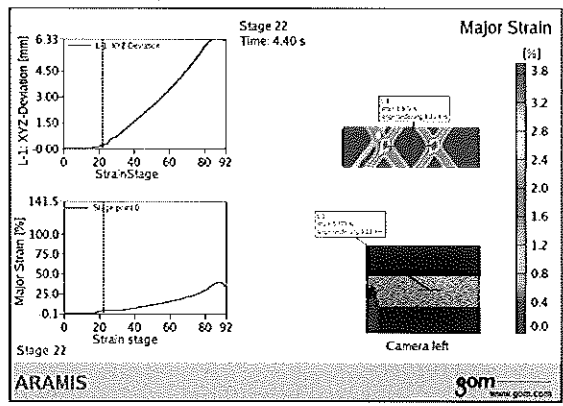
In the following, we show an example report (based on Report-ARAMIS).

Here, the analysis element Point-Point Distance was included.

The upper diagram still is empty because the connection to the analysis element has not yet been established.



A finished report could look like this:



When double clicking on the diagram, you may establish the connections. In this example, we chose for the X axis Visualization ► Project ► Point stage and for the Y axis Data ► Measurements ► L1 ► Line differences ► XYZ-Deviation.

## G 1.4 Special Settings in the Report Diagrams

### G 1.4.1 Legend Setting 3D

As default, legend setting 3D is preadjusted for the Y axis in each diagram (double clicking in the diagram ► tab Axis ► Y axis ► Maximum or Minimum).

#### Info

The advantage of this setting is the link to the legend in the 3D view. If you change the scaling or the visualization (e.g. Major Strain, Minor Strain, etc.) in the 3D view, this new setting is directly transferred to the report diagram.

Setting 3D enables the definition of an "own" axis setting (= value range) for each visualization which is displayed accordingly in the diagram by optimally adapting the legend of the 3D view.

Thus, you may quickly create report and diagram series which match the 3D image series without the need to permanently adapt the scaling of the diagram to the 3D legend manually.

If several visualizations are displayed in one diagram, the setting 3D automatically scales the value range of the diagram to the maximum and minimum value.

Example: Section data in a common major/minor diagram (Multi-Section Diagram)

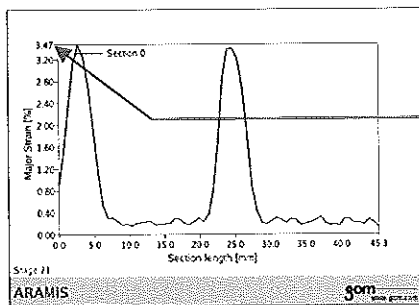


Diagram Major Strain

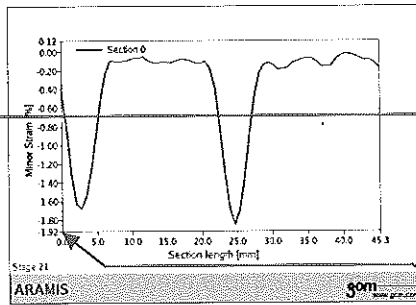


Diagram Minor Strain

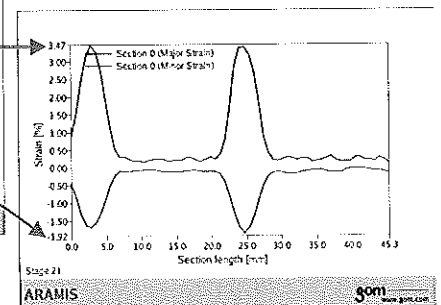


Diagram Major/Minor Strain

To load two data sets into one diagram proceed as follows:

Change the diagram parameter of the Y axis to Strain and of the X axis to Section length (double click on the diagram ► Visualization ► Main ► ...).

In tab Visualization ► Visualization select the desired visualization parameters, in this example Major Strain and Minor Strain.

If several sections exist, you may adjust here how they should be distinguished in the diagram.

When choosing Different colors, the sections keep the color you assigned them in the section explorer.

If, in the section explorer you assigned 2D symbols to a section (double clicking on the section ► Rendering ► ...), then, you may include these symbols into the diagram.

You take over the symbols into the diagram with the setting Different symbols (double clicking on the diagram ► Visualization ► Main ► Section mode).

### G 1.4.2 Legend Settings Fixed and Auto

If you wish to scale the individual axis of a diagram manually or automatically, i.e. independent of the 3D legend, you need to disable the 3D setting.

For effectively creating diagrams, we recommend setting 3D.

### G 1.5 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 Image Series and Movies

An image series is a sequence of individual images.

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.



3D view	With a right mouse button (RMB) click, you may select areas in the 3D view and select the alternate color for the background.
Left Image	
Right image	
Project Images	<ul style="list-style-type: none"> <li>• Source undeformed camera left</li> <li>• Source undeformed camera right</li> <li>• Source deformed camera left</li> <li>• Source deformed camera right</li> <li>• Facet overlay camera left</li> <li>• Facet overlay camera right</li> <li>• Strain overlay camera left</li> <li>• Strain overlay camera right</li> </ul>
Reports	Image series of existing reports.

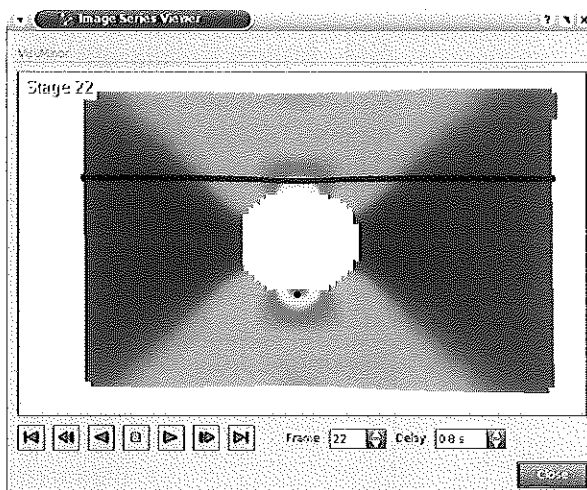
You may integrate image series in reports. Thus, for example, it is possible to display 3D views interesting for you through all stages.

If you created several user-defined result image series (major strain, minor strain, Mises strain, ...) with the function **Use result selection**, the images will change in the report if you change the result selection.

An image series may also contain images of an external camera which can be imported. Thus, for example, it is possible to display images 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!

### G 2.1 Play Image Series

In the explorer, click with the right mouse button (RMB) on the image series you want to play and select **View Image Series**.



### G 2.2 Export Image Series as Individual Images

You may export an image series as individual images in PNG, TIFF or JPEG format. You may define the export format in the Preferences.

For further information, please refer to the Online Help.

### G 2.3 Export Image Series as Movie

You may also export image series as movie. The individual images will be combined in a movie and saved in the AVI or MPEG format. You may define the export format in the Preferences.

For further information, please refer to the Online Help.

## G 3 Snapshots

Using the snapshot function, you may save the screen representation of the 3D view, of the left or right 2D camera image or of reports as an image and print or copy this image to the clipboard.

A snapshot is a static image that does not change through the stages. Using the right mouse button (RMB) you may limit the snapshot function to defined areas.

## G 4 Printing Documentations

Printing in ARAMIS is only possible using the snapshot function (see G 3).



## G 5 Summary

- ☐ Standard reports
- ☐ Analysis elements in a report
- ☐ Special report diagram settings
- ☐ Individual reports
- ☐ Image series and movies
- ☐ Snapshots
- ☐ Printing documentations



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## H Export, Automation

### H 1 Export

ARAMIS provides extensive export functions to make your measuring results available for subsequent systems or applications in defined formats.

#### H 1.1 Overview of the Export Options

Export functions:	Comment:	Format:
Export Tables	<ul style="list-style-type: none"> <li>For analysis elements and primitives</li> <li>Configurable export using export templates (default export templates or user-defined templates).</li> <li><b>Info</b> For more information, please refer to the Online Help.</li> </ul>	ASCII, HTML and OpenOffice format.
Export 3D Data	<ul style="list-style-type: none"> <li>Export of all 3D points of the current 3D view (just of one stage)</li> </ul>	One ASCII file.
Export All Points	<ul style="list-style-type: none"> <li>Exports all data of a 3D point.</li> <li>Export using a configuration file (default configurations or user-defined configurations).</li> <li><b>Info</b> For more information, please refer to the Online Help.</li> <li>Exports all or selected stages.</li> </ul>	One ASCII file for each stage.
Export Stage Points	<ul style="list-style-type: none"> <li>Exports the data of one or several stage points (selected in the explorer).</li> <li>Export using a configuration file (default configurations or user-defined configurations).</li> <li><b>Info</b> For more information, please refer to the Online Help.</li> <li>Exports all or selected stages.</li> </ul>	One ASCII file for each point.
Export Section 3D	<ul style="list-style-type: none"> <li>Exports the data of one or several sections (selected in the explorer).</li> <li>Export using a configuration file (default configurations or user-defined configurations).</li> <li><b>Info</b> For more information, please refer to the Online Help.</li> <li>Exports all or selected stages.</li> </ul>	One ASCII file for each section and each stage.
Export Section FLC	<ul style="list-style-type: none"> <li>Exports the data of one or several sections (selected in the explorer) for FLC applications (Forming Limit Curve).</li> <li>Exports sections of one defined stage (selected in the explorer)</li> <li>Enter the crack width for further computations</li> </ul>	One ASCII file for each section and a defined stage.
Export Diagram Data	<ul style="list-style-type: none"> <li>Exports the data of one diagram (selected in the explorer ► Report).</li> </ul>	One or several ASCII files (depends on the diagram type and the stage selection).
Export Statistics	<ul style="list-style-type: none"> <li>Export of statistic data</li> <li>Configurable export</li> </ul>	ASCII
Export Image Series	<ul style="list-style-type: none"> <li>Exports result images</li> <li>Exports user-defined image series, project images or reports (selected in the explorer ► Image Series)</li> <li>Configurable export</li> </ul>	One image for each stage in PNG, JPEG or TIFF format (selectable in the Preferences).
Export Movie	<ul style="list-style-type: none"> <li>Function as for Export Image Series</li> <li>Individual images are combined in a movie</li> </ul>	MPEG or AVI (selectable in the Preferences).

Export functions:	Comment:	Format:
Export Linear Strain	<ul style="list-style-type: none"> <li>• Special format for ARAMIS applications with multi sensor systems</li> </ul>	
Export Spline Strain		
Export Session	<ul style="list-style-type: none"> <li>• Exports the 3D result data in order to use them in other GOM applications, e.g. TRITOP, ATOS, ATOS Viewer.</li> <li>• 3D data are available again as stages in other GOM applications if they were selected for the export in the explorer.</li> <li>• Export as monochrome mesh</li> <li>• Export as colored mesh</li> <li>• Export as surface deviation with legend</li> </ul>	.session (GOM format)
Export STL	<ul style="list-style-type: none"> <li>• Exports all 3D result data in one common file or in separate files (one file for each stage).</li> <li>• In case of a common file, the 3D representations of the individual stages are merged</li> </ul>	One or several STL files.
Export Ref. Points	<ul style="list-style-type: none"> <li>• Exports the reference points of a stage (selected in the explorer)</li> </ul>	One ASCII file.
Export Stage Images	<ul style="list-style-type: none"> <li>• Exports the right and left camera image of selected stages or of all stages.</li> </ul>	Each image in one TIFF file.

## H 2 Macros

### H 2.1 Automation

For recurrent measurements with very complex analysis elements, the ARAMIS 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 2.2 Functional Extensions

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

## H 3 Summary

- Export functions
- Automation due to macros
- Functional extensions by macros

**Chapter J - Table of Contents (rev-c)**

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## J The Basics of Strain

In this section, we explain the basics of strain and strain calculation. This description follows closely the following books: [Hib], [BB75], [Mal69] and [Hah84].

Note:

- In the GOM software, the German conventions (letters) are used for the strain values:

Technical strain:  $\varepsilon$

Logarithmic (true) strain:  $\varphi$

In the legends, log. is used as abbreviation for logarithm. Mathematically however, the natural logarithm (ln) is meant (see J 1.1).

- With optical measurement techniques (e.g. ARAMIS, ARGUS) coordinates, displacements and strains will be determined only on the surface of objects. This means that the calculation is limited to local strains, which are tangential to the surface. As additional information perpendicular to the surface is missing, it is not possible to calculate a complete 3D strain tensor (strain values). In this case, the calculation of the thickness change is based on the assumption of volume constancy of the material during loading. Should the thickness reduction be used for the complete material thickness, a constant strain distribution in the thickness direction (orthogonal to the surface) has to be valid. If this is not valid, bending influences of thin metal sheets can be compensated by the material thickness compensation (available for the spline strain model). In all other cases, the calculated thickness change belongs to a thin area of the material close to the surface only.

### J 1 Basics of 2D Strain Computation

#### J 1.1 The Term "Strain"

Strain is the measure for the deformation of a line element and can be defined as follows:

$$\lambda = \lim_{l \rightarrow 0} \left( \frac{l + \Delta l}{l} \right)$$

The stretch ratio  $\lambda$  is the relative elongation of an infinitesimal line element. A strain value  $\varepsilon$  can be defined as the function of the stretch ratio  $\lambda$ :

The following known functions are frequently used strain measures:

- Technical strain:

$$\varepsilon^T = f(\lambda) = \lambda - 1$$

- Logarithmic or true strain:

$$\varepsilon^L = \varphi = f(\lambda) = \ln(\lambda)$$

- Green's strain:

$$\varepsilon^G = f(\lambda) = \frac{1}{2}(\lambda^2 - 1)$$

**J 1.2 The Deformation Gradient Tensor**

The previous section defined the stretch ratio in the one-dimensional case and the general description of a strain measure. This will now be extended to the two-dimensional case.

**J 1.2.1 Deformation Gradient Tensor Definition**

In order to quantitatively display the deformation of a surface element, the deformation gradient tensor  $F$  is introduced. The deformation gradient tensor transforms a line element  $dX$  into the line element  $dx$ . In both cases, the line element connects the same material coordinates. Theoretically, it must be an infinitesimal line element. The following figure illustrates this case.

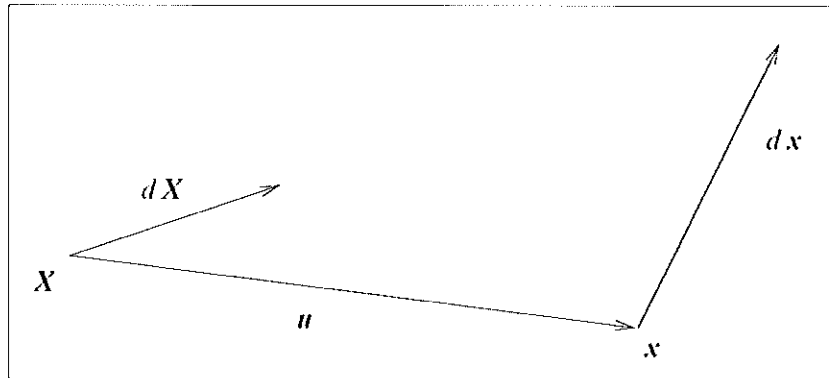


Figure a: Translation ( $u$ ) and strain of a line element

Thus, the deformation gradient tensor is defined as:

$$dx = F \cdot dX$$

**J 1.2.2 Decomposing the Deformation Gradient Tensor**

A disadvantage of the deformation gradient tensor is that rotation and stretch are modeled using one matrix only. This can be compensated by splitting the deformation gradient into two tensors: purely rotation matrix and pure stretch tensor. The matrix can be decomposed in two different ways:

- Decomposition into rotation  $R$  and right stretch tensor  $U$ . Mathematically, the deformation gradient tensor is decomposed as follows:

$$F = R \cdot U$$

- Decomposition into left stretch tensor and rotation. Mathematically, the deformation gradient tensor is decomposed as follows:

$$F = V \cdot R$$

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**J 1.3 Definition of the x-y Strain Values in 2D**

Values  $\epsilon_x$ ,  $\epsilon_y$ , and  $\epsilon_{xy}$  can directly be read from the symmetric stretch tensor  $U$  with the following form:

$$U = \begin{pmatrix} U_{11} & U_{12} \\ U_{21} & U_{22} \end{pmatrix} = \begin{pmatrix} 1 + \epsilon_x & \epsilon_{xy} \\ \epsilon_{xy} & 1 + \epsilon_y \end{pmatrix}$$

The strain values  $\epsilon_x$ ,  $\epsilon_y$ , and  $\epsilon_{xy}$  have the disadvantage of being defined as dependent on the coordinate system. The geometrical interpretation of strain values is described with the following example values:

$$\begin{aligned} \epsilon_x &= 40\% \\ \epsilon_y &= 0\% \\ \epsilon_{xy} &= 0.2 \end{aligned}$$

So the stretch tensor is given by:

$$U = \begin{pmatrix} u_{11} & u_{12} \\ u_{21} & u_{22} \end{pmatrix} = \begin{pmatrix} 1.4 & 0.2 \\ 0.2 & 1 \end{pmatrix}$$

Regarding a unit square in the 2D space (points (0/0), (0/1), (1/0), (1/1)) the deformation introduced by this stretch tensor is shown in figure b.

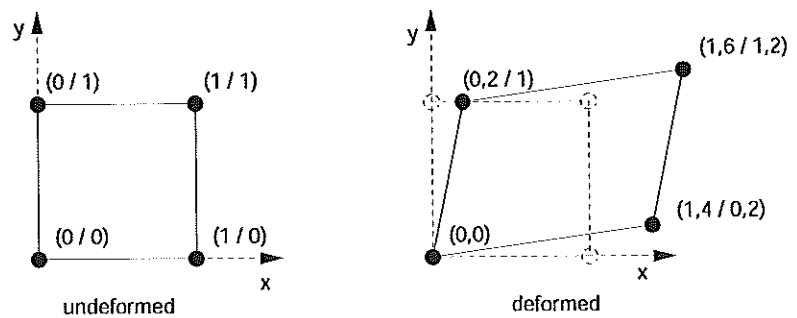


Figure b: Example for the deformation of a unit square

For the geometrical interpretation of the values  $\epsilon_{xy}$  the shear angle  $\gamma_{xy}$  is used. This angle describes the change of an angle of 90° in the undeformed state to a new angle in the deformed state.

For large strain values and angles as used in this example, the assumption for small strains from the elastic strain theories must NOT be used:

$$\gamma_{xy} \neq 2 \epsilon_{xy}$$

**Info**

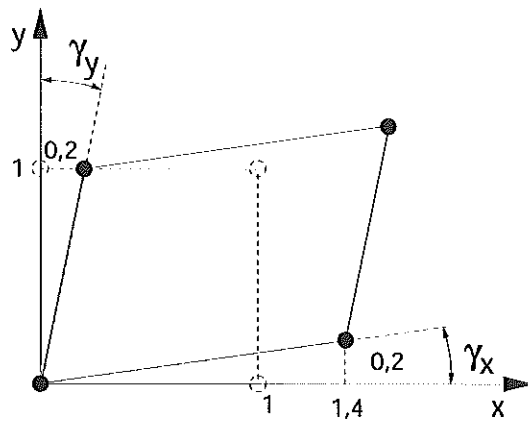


Figure c: Shear angle definition

Based on the example values used, the definition of the shear angle can be generally separated from figure c as follows:

$$\begin{aligned} \gamma_{xy} &= \gamma_x + \gamma_y \\ \gamma_x &= \arctan(\epsilon_{xy} / (1 + \epsilon_x)) = \arctan(0.2 / (1.4)) \\ \gamma_y &= \arctan(\epsilon_{xy} / (1 + \epsilon_y)) = \arctan(0.2 / (1)) \end{aligned}$$

Notes:

- As given by this example, the values for  $\gamma_x$  and  $\gamma_y$  can be different.
- With a symmetric stretch tensor only a parallelogram can be realized for the local deformation field.
- The fixed values for  $\gamma_x$  and  $\gamma_y$  show that the orientation of the parallelogram to the coordinate system is fixed. The stretch tensor cannot describe rotations. The coordinate system is defined as "x"-y" system.

### J 1.4 Definition of the 2D Coordinate System and Strain Directions

The deformation gradient tensor  $F$  creates a functional connection of the coordinates of the deformed points  $P_{v,i}$  with the coordinates of the undeformed points  $P_{u,i}$  ( $i$  being the index for the different points). The functional connection for each local point is as follows:

$$P_{v,i} = u_i + F \cdot P_{u,i} \tag{1}$$

With:

- $P_{v,i}$  Coordinates of the deformed point
- $P_{u,i}$  Coordinates of the undeformed point
- $u_i$  Rigid body translation

The deformation gradient tensor  $F=R U$  can be split to the rotation matrix  $R$  and the stretch tensor  $U$ . The rotation matrix  $R$  describes the rotation of the points and the directions only.

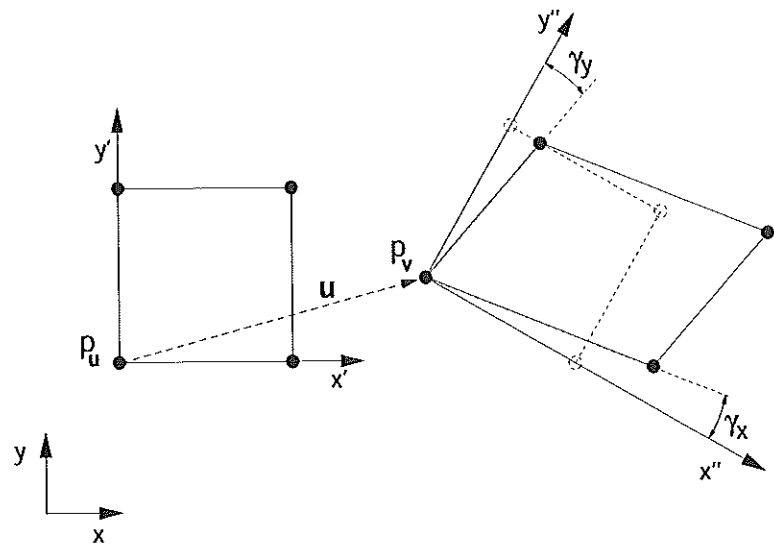


Figure d: Definition of the coordinate system (based on the deformation of a unit square)

This context is shown in figure d. Different coordinate systems are used.

- x-y: global coordinate system
- x'-y': local undeformed coordinate system
- x''-y'': local deformed coordinate system  
= directions of strain

The coordinates of the point (e.g.  $p_u$  and  $p_v$ ) are calculated in the global x-y coordinate system. For the 2D discussion, the coordinate system x'-y' is parallel to x-y, but is placed in the undeformed position of the point of interest  $P_{u,i}$ .

The rotation matrix  $R$  defines the rotation from the x'-y' to the x''-y'' system. The coordinate system x''-y'' for the strain calculation is independent from rigid body movement and rotation. It shows the deformation introduced by the stretch tensor  $U$  and defines the direction of the strain values similar to figure c. This leads to:

- X'' direction == direction of strain x
- Y'' direction == direction of strain y

The coordinate system can be visualized, e.g. in ARAMIS-v6 in the 3D result window.

### J 1.5 Major and Minor Strain Derived From the Deformation Gradient Tensor

The strain measures  $\epsilon_x$  and  $\epsilon_y$  have the disadvantage of being defined as dependent on the coordinate system. This disadvantage can be eliminated by calculating major and minor strain values. The symmetrical matrix  $U$  can be transformed to the main diagonal form. The two eigenvalues  $\lambda_1$  and  $\lambda_2$  can be calculated as follows:

$$\lambda_{1,2} = 1 + \frac{\epsilon_x + \epsilon_y}{2} \pm \sqrt{\left(\frac{\epsilon_x + \epsilon_y}{2}\right)^2 - (\epsilon_x \cdot \epsilon_y - \epsilon_{xy}^2)}$$

Depending on the choice of the strain measure, the stretch ratios  $\lambda_1$  and  $\lambda_2$  can be transformed into corresponding strain values. Based on the larger eigenvalue, the major strain is determined ( $\epsilon_1$  or  $\varphi_1$ ), and based on the smaller eigenvalue the minor strain ( $\epsilon_2$  or  $\varphi_2$ ). The corresponding eigenvectors determine the two directions of major and minor strain. The strain values thus determined are independent of the coordinate system and are universally applicable.

If the material thickness with respect to the entire surface is small, it is frequently necessary to deduce the remaining material thickness from the deformation of the surface. As the optical measuring techniques used cannot obtain any data in this dimension, the third principle strain  $\epsilon_3$  can be calculated from major and minor strain  $\epsilon_1$  and  $\epsilon_2$ , assuming a constant volume. Without determining a strain value, the relationship between the stretch ratios can be expressed more generally. The volume constancy can be defined as follows:

$$\lambda_1 \cdot \lambda_2 \cdot \lambda_3 = 1$$

Frequently, the effective strains are needed. The effective strains according to von Mises and von Tresca are available. The effective strain according to von Mises results from the following formula:

$$\varphi_V = \sqrt{\frac{2}{3}(\varphi_1^2 + \varphi_2^2 + \varphi_3^2)}$$

As  $\varphi_3$  is included in the formula, the effective strain is only valid if the volume constancy is valid.

The effective strain according to von Tresca results from the following formula:

$$\varphi_V = |\varphi|_{max}$$

#### Info

The technical values for the effective strain according to von Mises and von Tresca are calculated based on the logarithmic values  $\varphi_i = f(\varphi)$  with subsequent conversion  $\epsilon = e^{\varphi}$  (new for Tresca as of v6.2.0).

#### Example:

$\varphi_1 = 0.2$ ;  $\varphi_2 = -0.3$ ;  $\varphi_3 = 0.1$ ;

are converted to  $\epsilon_1 = 22\%$ ;  $\epsilon_2 = -26\%$ ;  $\epsilon_3 = 10\%$ ;

which results in  $|\varphi|_{max} = 0.3 \rightarrow \epsilon_V = 35\% \neq |-26\%$

## J 2 Calculation of the Deformation Gradient Tensor From a 2D Displacement Field

This section explains the calculation of the deformation gradient tensor  $F$  from a given 2D displacement field of points. For this purpose, the 2D coordinates of each point must be known both, in its undeformed and in its deformed state. The definition of the deformation gradient tensor  $F$  explains how an undeformed line element is transformed into a deformed one. In order to calculate the deformation gradient tensor for a point, a number of points in the neighborhood is needed. For this model of calculation, a homogeneous state of strain must be assumed for this set of adjacent points.

Formula (1) describes a linear system of equations and the unknown variables are the four parameters of the deformation gradient tensor  $F$ . The deformation gradient tensor  $F$  can be interpreted as an affine transformation which transforms a unit square into a parallelogram.

If more than three points are chosen for the calculation, the result is overdetermined and an adjustment is used.

For calculating the deformation gradient tensor for a point  $p$ , the used number of neighboring points can be adjusted. The width of the field is the strain reference length. In figure e for example, the neighborhood of 3 x 3 points is shown.

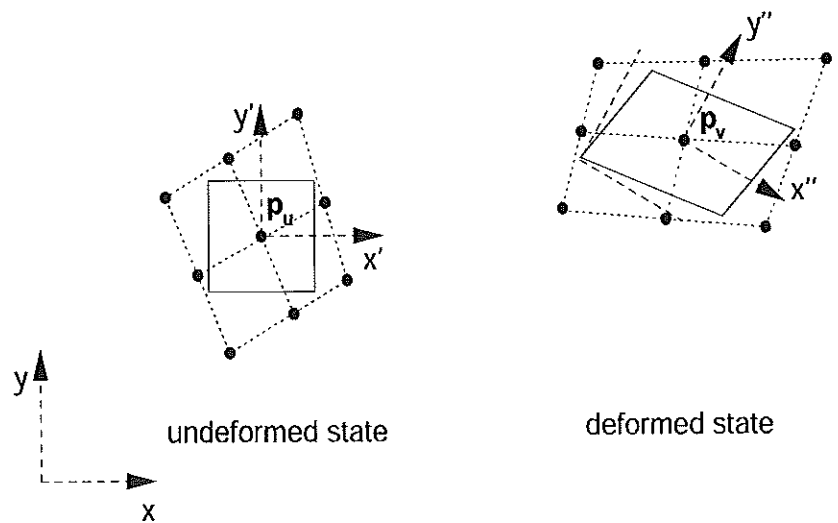


Figure e: 3 x 3 neighborhood for 2D strain calculation

For this figure, the following definition is valid:

- Dashed lines = coordinate systems
  - x-y: global
  - x'-y': locally undeformed
  - x''-y'': locally deformed
- Dotted lines: logical grid of measurement points (3x3)
- Solid lines: unit square and deformed quadrangle

In general, the logic grid of the undeformed points has not to be oriented in the global x-y coordinate system. In a 2D displacement field, the global and local undeformed coordinate system are equally oriented.

For calculation of  $F$  the  $x'$ - $y'$  coordinate system is used, and the coordinates of the complete neighborhood of the deformed  $3 \times 3$  points must be translated so that the point  $P_v$  is shifted to the origin of the  $x'$ - $y'$  system (= to the position of  $P_u$ ).

For a better understanding of figure f, a unit square is shown in the undeformed state. Based on  $F$  this square will be deformed to the quadrangle field in the deformed state. This field visualizes the shear strain  $\varepsilon_{xy}$  and the shear angle  $\gamma_{xy}$ . The coordinate system  $x''$ - $y''$  represents the strain directions from section J 1.4.

### J 3 Definition of the x-y Strain Values and the Strain Directions in 3D

The description so far showed in detail the calculation of strain in 2D. However, the measurement data in general consists of 3D points of the specimen's surface.

To be able to use the above defined 2D models of calculation, an extended definition for the local directions is needed. The local strain coordinate systems must be tangential to the local surface, and for the strain calculation the 3D data must be transformed into the 2D space.

#### J 3.1 Definition of Strain Directions in 3D

In figure g, the definition of the local strain directions is shown. The global coordinate system x-y-z cannot be used in general for the local strain values. The x-y-z coordinate system in general is not parallel to the local tangential directions. For the local strain calculation in ARAMIS and ARGUS an  $x'$ - $y'$  coordinate system is defined for the undeformed state as follows:

For each point (e.g. point  $P_i$  in figure g)

- the local strain direction  $x'$  is:
  - tangential to the surface of the local point
  - parallel to the x-z plane
- the local strain direction  $y'$  is:
  - tangential to the surface of the local point
  - perpendicular to the local  $x'$



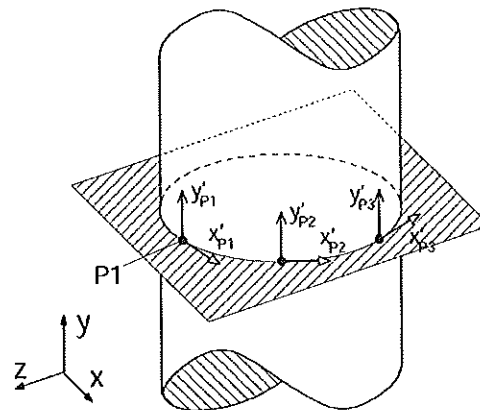


Figure f: Definition of the undeformed local surface strain coordinate system in 3D based on a plane parallel to x-z

In figure f, the local coordinate system ( $x'_{p1} - y'_{p1}$ ;  $x'_{p2} - y'_{p2}$ ;  $x'_{p3} - y'_{p3}$ ) is shown for a cylindrical specimen for three different points ( $P_1, P_2, P_3$ ). In this case, the global y direction is parallel to the axis of the cylinder. For this special case, the y' directions for all surface points are parallel to the global y direction.

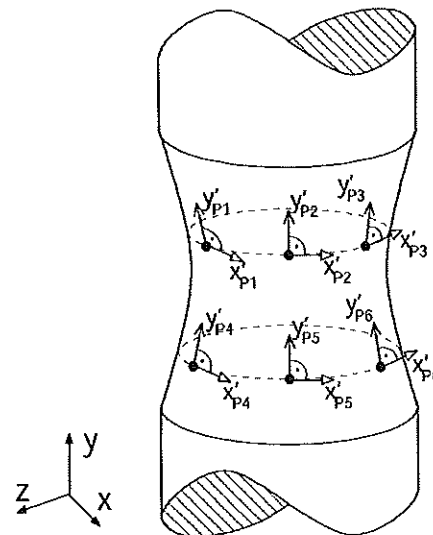


Figure g: Definition of the undeformed local surface strain coordinate system in 3D

In general, both directions ( $x'$  and  $y'$ ) are not parallel to the global coordinate system. This is shown in figure g. The dashed ellipses are parallel to the x-z plane and the different local  $y'$  directions are tangential to the surface.

As in figure e for the deformed state again an  $x''-y''$  coordinate system must be introduced as shown in figure h. In the deformed state, the  $x''-y''$  strain directions are still tangential to the surface in the local 3D points and are defined by the stretch tensor in the same way as in the

2D situation.

The unit square is deformed to a parallelogram. The geometry of the parallelogram together with the stretch tensor ( $\gamma_x$  and  $\gamma_y$ ) define the local strain directions ( $x''$  and  $y''$ ) in the deformed state.

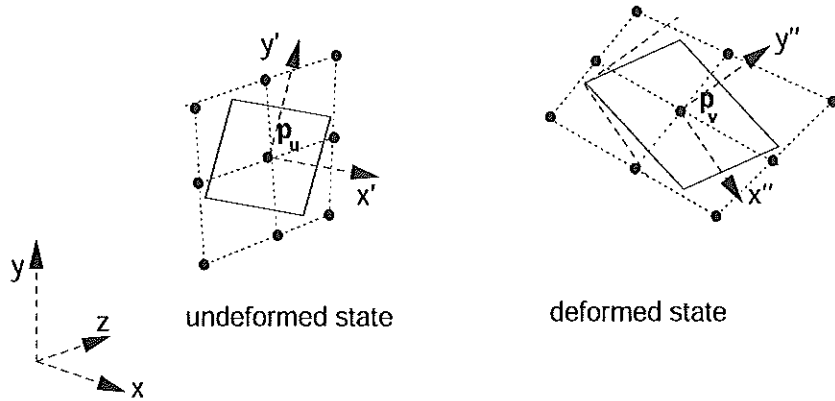


Figure h: Definition of the local surface strain coordinate system in 3D

Parallel to the definition of the directions, the 3D data must be transformed into the 2D space.

For this, two different models can be used. These models are based on planes or splines.

### J 3.2 The Plane Model

The first model assumes that the local neighborhood of a point can be well approximated by a tangential plane. Due to the arbitrary deformation of the surface, the tangential plane needs to be calculated separately for the deformed and undeformed state. The points in the local neighborhood are then projected perpendicularly onto the tangential plane. The result is two sets of points, for the deformed and undeformed state, in the two-dimensional space in which the strain now can be calculated. Summarized, this process consists of the following tasks:

- Calculation of the tangential plane
- Transformation of the 3D neighborhoods into the tangential planes
- Coordinate transformation of the tangential plane into the 2D space ( $x'-y'$  and  $x''-y''$  coordinate systems)
- Calculation of the deformation gradient tensor from the 2D sets of points

### J 3.3 The Spline Model

The tangential model described above provides good results as long as the assumption of the linearization of a local neighborhood of points is valid. In deep drawing, the deformed materials have in part strong locally curved planes. The problem now is to apply the characteristics to be measured to the respective object in such a frequency that the assumption of local linearity is still given. However, this characteristic can hardly be provided in reality. Therefore, it is better to use other models which are more accurate in modeling the true shape of the surface. Splines are a good model for continuously curved lines.

In order to calculate the side length not only according to a linear model, it is necessary to have more information than two points on a side. This means that the adjacent points of a four-sided facet have to be included in the calculations. Figure j shows the adjacent points of the hatched four-sided facet.

In the facet, the side lengths are calculated using the formed splines. The resulting lengths can be used to construct a quadrangle in the two-dimensional space. Now, the strain calculations described above can be used.

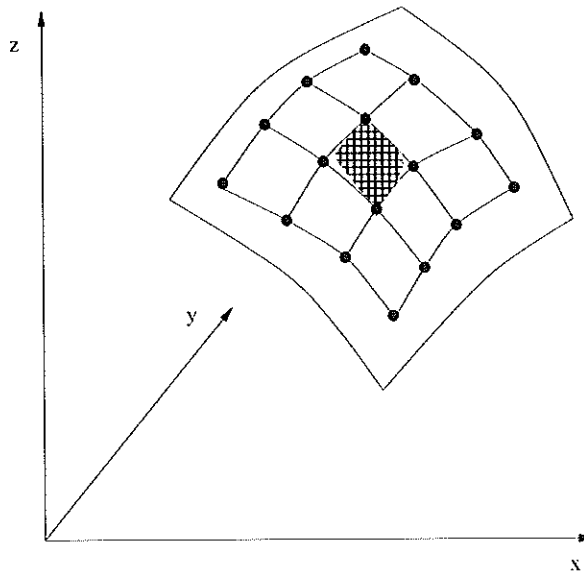


Figure j: Four-sided facet with adjacent points

## J 4 Bibliography for Strain Theory

[Hib] Hibbitt, Karlsson and Lorensen, Inc. *ABAQUS -Theory Manual*, 5.7 edition.

[BB75] Becker und Bürger. *Kontinuumsmechanik*. Teubner-Verlag, 1975

[Mal69] Malvern. *Introduction to the Mechanics of a Continuous Medium*. Prentice-Hall, 1969

[Hah84] Hahn. *Elastizitätstheorie*. Teubner-Verlag, 1984

[Kop98] Kopp und Wiegels. *Einführung in die Umformtechnik*. Verlag der Augustinus Buchhandlung, 1998

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## K Support

### K 1 Where Do You Find Help?

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

#### K 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.

#### K 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.

#### K 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.

#### K 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.

#### K 1.5 Direct Support

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

### K 2 Useful Support Data

#### K 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 (Linux), and send this file to the GOM support.

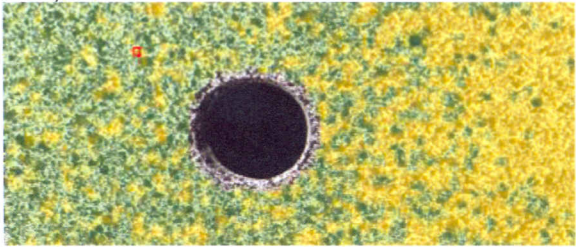
#### K 2.2 Snapshots in Linux

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.



### K 3 Troubleshooting

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 ARAMIS 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 ARAMIS application software?	As of version 5.4, the language of the application software can be changed in the preferences. For this purpose, open menu item <b>Edit ► Preferences ► Preferences ► General</b> and select the desired language in the selection list under <b>Language</b> . Confirm the selection with <b>OK</b> . When starting the program again, the application software appears in the newly selected language.
I cannot work with the ARAMIS project. The stages in the explorer are highlighted in gray.	The project is already open in a ARAMIS application. This effect may occur after the computer crashed and thus, temporary <b>lock</b> files were not correctly deleted.
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.
The color 3D representation is poor or not visible in the window.	Probably the specimen is shown from the rear side. Remedy: Rotate view.
	All was selected in the 3D view. Remedy: Click with the right mouse button (RMB) in the 3D view and choose <b>Deselect All</b> .
How do I cancel the Auto Start Point process?	Press Escape.
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!
ARAMIS cannot overwrite CD or DVD-RW media.	Delete the media completely by means of an external program.
How can I change the language of the Project Keywords?	In the project keyword window click on button <b>Edit</b> , then click with the right mouse button onto the list and select <b>Add Defaults</b> . Select the required language and confirm with <b>OK</b> .
What can I do if I cannot achieve the desired calibration values?	Check if the sensor is configured correctly.
How do I know if I need to calibrate the system again?	<p>If the value of the mean <b>Intersection deviation</b> is larger than 0.1 pixel and the frequency of the yellow facets in the camera images increase (see figure below).</p>  <p>In this case, you need to calibrate your system again.</p> <p>The system creates yellow facets if the intersection error of a 3D point is larger than 0.3 pixels (factory-adjusted setting).</p>

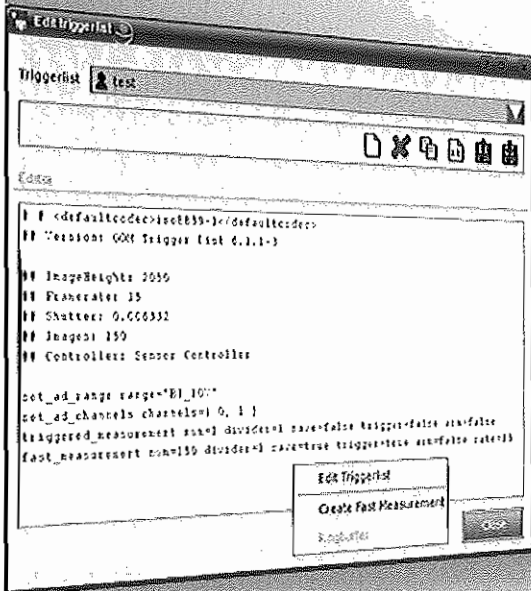


Problem:	Remedy:
The system decalibrates during operation.	Check if the screw connections of the cameras are tight and calibrate the system again.
The cameras cannot be initialized.	Is the sensor controller switched on? Normally, the sensor controller supplies power to the cameras. Did you connect all necessary cables? See <a href="#">User Information – Hardware</a> .
No camera images are displayed.	



# ARAMIS, PONTOS

User Manual - Software



triggerlisten\_v6.1.1\_en\_rev-e 7-Dec-2009

## Trigger Lists with Sensor Controller v6.1.1 and higher

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Optical Measuring Techniques

## Legal and Safety Notes

### Symbols

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

<b>⚠ WARNING</b>	This label points to a situation that might be dangerous and could lead to serious bodily harm or to death.
<b>⚠ CAUTION</b>	This label points to a situation that might be dangerous and could lead to light bodily harm.
<b>NOTICE</b>	This label points to a situation in which the product or an object in the vicinity of the product might be damaged.
<b>Info</b>	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 User Information - Hardware!

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

### Legal Notes

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## 1. Introduction

This user manual is intended for qualified personnel who have sufficient knowledge in how to handle the measuring system. This user manual is configured to the transfer of knowledge of: Creating measuring procedures by means of trigger lists, how to use such lists and how they are structured and generated.

### Info

The GOM systems are measuring systems that also address experts of digital optical deformation analysis. Therefore, it is unavoidable that the software contains menu items not intended for the standard user. Improper use of these menu items (expert parameters) may cause incorrect measurements.

### Info

This User Manual does not deal with the system installation and special user information of the sensor controller as well as with the general user information of the software. If necessary, this information is compiled in a separate user information.

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

To generate trigger lists you do not need to have programming knowledge, however, basic knowledge makes training easier.

This user information is divided into the following sections:

- The first page informs about important safety aspects.
- Sections 2 to 4 give basic information about the trigger lists and their handling.
- Section 5 informs about how to generate a trigger list using the trigger list macros.
- Section 6 describes important information for combining several list elements.
- Section 7 contains a complete list of commands and their description to create individual complex trigger lists.

## 2. Introduction

### 2.1 What is a Trigger List?

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.

This manual explains how to create simple and complex measuring procedures using trigger lists. For this purpose, we will mainly deal with the macro functionality of the measuring systems (especially trigger list macros) which allow creating trigger lists fast and automatically.

### 2.2 Advantages

Complex measurements may be created, consisting of a combination of numerous different elements. For example:

- External triggering (photoelectric sensor, TTL, etc.)
- Fast and slow measurements also with breaks
- Image acquisitions with predefined A/D values
- Manual or automatic start and cancel criteria

The sensor controller ensures the following:

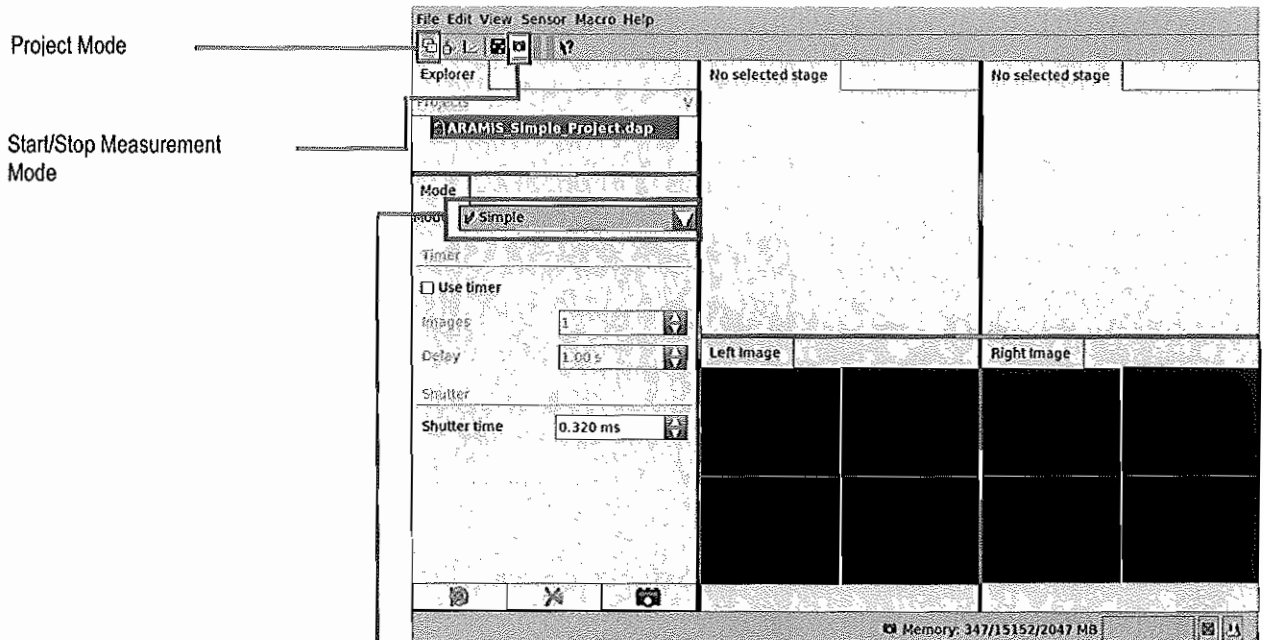
- Precise allocation of time stamps to the images
- Fast response to external signals
- Precise conversion and response to analog channels



### 3. Trigger List Operation

#### 3.1 General Trigger List Operation

After starting the software, go to the project mode and select the icon for Start/Stop Measurement Mode to change to the image acquisition mode.

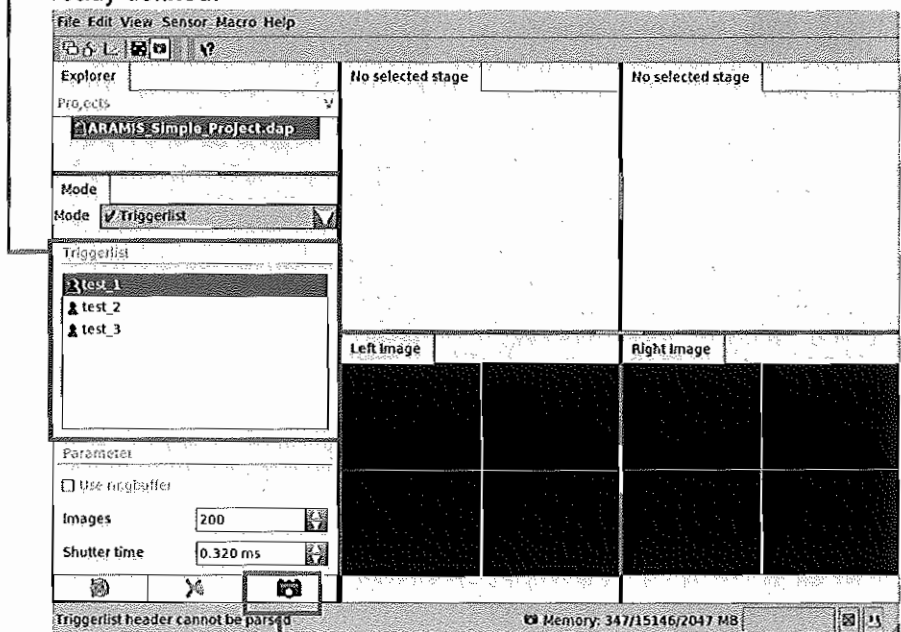


Project Mode

Start/Stop Measurement Mode

As mode, select Triggerlist here.

Now, a new selection window opens, containing the trigger lists already defined.



To start a measurement using a trigger list, select the respective list and start image acquisition by clicking on the camera button.

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**Info**

Image recording is only possible if a project exists and the currently defined number of cameras is identical to the required number of cameras of the project (2D project → one camera; 3D project → two cameras). If this is not the case, the camera button is disabled (dull). Depending on the definition of the trigger list used, the number of images and the shutter time of the cameras need to be set manually (fields highlighted in white). If these fields are highlighted in gray, the data is controlled by the trigger list.

**Info**

### 3.2 Editing a Trigger List

Edit a trigger list by selecting the respective list from Triggerlist, press the right mouse button and choose Edit Triggerlist. Then, the following selection window opens:

Select trigger list



New trigger list



Delete trigger list



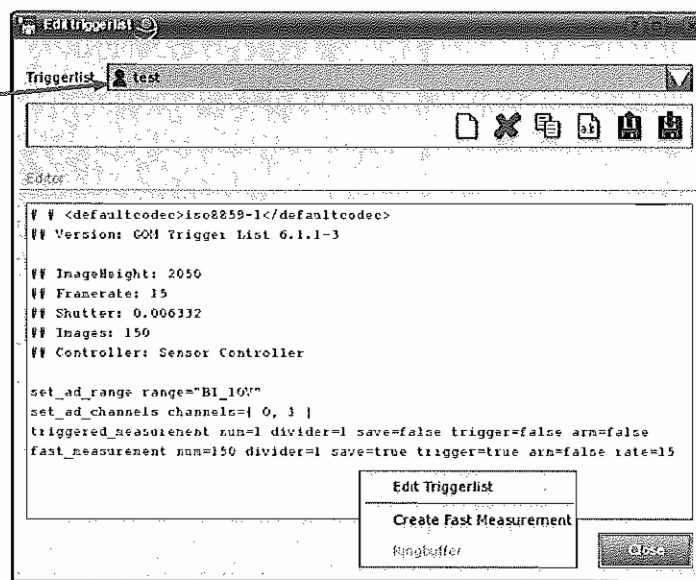
Copy trigger list



Rename trigger list



Import/export trigger list



**Info**

We recommend naming new trigger lists such that their purpose can easily be identified, for example stating the frame rate, the measurement type, cameras, etc.

The editor window shows the software code of the trigger list. Clicking with the right mouse button in this field, you generally get two selections:

- Edit Triggerlist opens the editor of the operating system to edit the code.
- Create Fast Measurement opens the "Script Wizard" to create a fast measurement.
- Ringbuffer

## 4. Create Fast Measurement

Using a simple example, we now describe how to create a fast measurement trigger list and explain its basic structure.

### 4.1 Procedure

**Info**

First, create a new trigger list with **New Trigger list**, as otherwise the selected list will be overwritten (see chapter 3.2). After assigning a name (e.g. tl-fw201-fast-12Hz.tl) you may start the script wizard as described in chapter 3.2. Use the **Back** and **Next** buttons to navigate through the possible settings.

- **Parameters:** Limiting values for the following settings are determined by manual configuration or by the currently initialized sensor.
- **Frame rate:** Set the frame rate you would like to use (limited by the cameras).
- **Shutter time:** Set the shutter time you would like to use (maximum value is calculated from the frame rate).
- **Number of images:** Set the number of images (maximum value: memory of the computer, for Basler A504k cameras: memory of the frame grabber boards).
- **AD value acquisition:** Adjust which A/D channels in which value range shall be recorded (default: A/D 0 and A/D 1 enabled, +/- 10V). Up to 8 channels are possible.

The screenshot shows a 'Script wizard' dialog with four main sections:

- Frame rate:** A text box containing '12.0'. Below it, an information box states: 'The frame rate in combination with the image height determines the maximum value for the shutter time. Current limit: 12 FPS. To achieve a higher frame rate reduce the image height.' Buttons: '< Back', 'Next >', 'Cancel'.
- Shutter:** A text box containing '0.079166 s'. Below it, an information box states: 'The maximum shutter time is influenced by image height and frame rate. Current limit: 79.166 ms. To achieve longer shutter times reduce the frame rate or image height.' Buttons: '< Back', 'Next >', 'Cancel'.
- Number of images:** A text box containing '500'. Below it, an information box states: 'All images will fit in memory. (500 < 1679)'. Buttons: '< Back', 'Next >', 'Cancel'.
- AD value acquisition:** A section with 'Record AD' containing 'Low' (0) and 'High' (1) dropdowns, and 'Value range' containing '+/- 10V'. Below it, an information box states: '2 AD channels will be recorded.' Buttons: '< Back', 'Finish', 'Cancel'.

Arrows indicate the flow from the Frame rate and Shutter sections to the AD value acquisition section, and from the Number of images section to the AD value acquisition section.

"Script wizard"

After clicking on **Finish**, the created code appears in the editing window. Clicking on **Close** closes the dialog and the created trigger list is available in the mode **Triggerlist** and can now be used.

## 4.2 Entries in the Trigger List Fast Measurement

The created Fast Measurement trigger list looks as follows:

Triggerlist: 5M-fast-15/ps

Editor

```

## <defaultcodec>iso8259-1</defaultcodec>
## Version: GOM Trigger List 6.1.1-3

## ImageHeight: 2050
## Framerate: 15
## Shutter: 0.006332
## Images: 150
## Controller: Sensor Controller

set_ad_range range="BI_10V"
set_ad_channels channels={ 0, 1 }
triggered_measurement num=1 divider=1 save=false trigger=false arn=false
fast_measurement num=150 divider=1 save=true trigger=true arn=false rate=15
    
```

Close

### Trigger list header:

The header is generated automatically and defines fixed basic conditions, valid for the entire measurement.

- **ImageHeight:**  
Number of image lines. When using camera Basler A504k (PONTOS and ARAMIS HS) the image height can be decreased (1/2, 1/4, 1/8, 1/16) in order to increase the frame rate (x2, x4, x8, x16).
- **Framerate:**  
The defined maximum camera speed during this measurement.
- **Shutter:**  
Maximum shutter time, possible from a combination of the camera's read-out time and the frame rate. Higher shutter times cannot be set in the software before starting the trigger list.
- **Images:**  
The number of images during this measurement.
- **Controller:**  
The type of the sensor controller (trigger box or sensor controller). This defines the syntax of the trigger list.

Generally, it is helpful to define the trigger list header with the "script wizard" for each measurement type in order to create fixed basic conditions as here the mentioned dependencies are automatically observed.

**Info**

Lines starting with # are comment lines which are not executed by the computer and are just for information.

**Info**

Lines starting with ## form the header of the trigger list. They were created by the software. Modifications could affect the measurement. For more information and regarding the limits of the system, please see chapter 6.2.

triggered\_measurement:

- num=1      Sensor controller waits for an ON trigger signal and proceeds to the next element.
- save=false      No A/D values are recorded.
- trigger=false      No trigger signal is output (no image recording).

fast\_measurement:

- num=150      Number of images, here 150
- save=true      A/D values are recorded.
- trigger=true      A trigger signal is output (image recording is started, trigger for external devices).
- rate=15      Frame rate, here 15Hz

**Info**

"triggered\_measurement" does not record any images and "fast\_measurement" records the first image only after a time interval of  $1/\text{rate}$ . Therefore, first image of this measurement will only be recorded after a time interval of the element switching time (6.2.1) plus  $1/\text{rate}$  (5.3.5).

Here, we only listed the main entries. For a detailed description of the individual elements and their use, please see chapter 5.3. In addition, chapter 7 provides a detailed explanation of the individual commands and their use.

### 5. Trigger Lists with Macros

#### 5.1 Macros in General

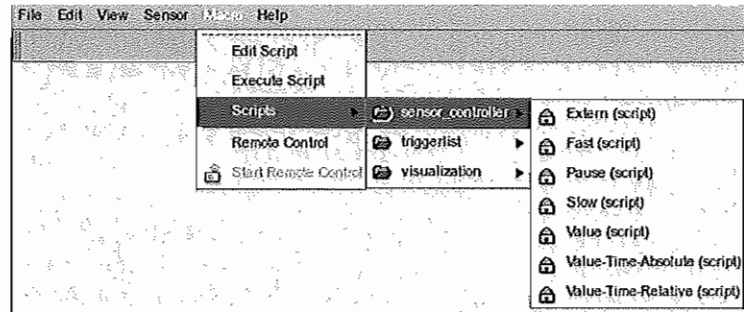
The macro functionality of the software provides for recording recurrent standard procedures in order to play them automatically. In addition, it is possible to link new functions or own programs with the software.

The trigger list macros were programmed in order to quickly and easily create trigger lists for different measurement procedures

#### 5.2 Starting a Macro

The macros can be started with menu item Macro ▶ Scripts ▶ sensor\_controller. There, they are combined in a submenu.

This can be done in any mode of the software.



After selecting a macro, a dialog window opens, e.g.:

To create a new triggerlist enter a filename with ending \*.tl.

To add an element to existing trigger list, select the triggerlist by clicking on select.

**Value Range:**

0 = -10 ... 10 V 2 = 0 ... 10 V  
1 = -5 ... 5 V 3 = 0 ... 5 V

Triggerlist Name: test-fast [Select]  
Value Range (0-3): 0 [dropdown]  
Number of Images: 200 [dropdown]  
Framerate (FPS): 15 [dropdown]  
[OK] [Cancel]

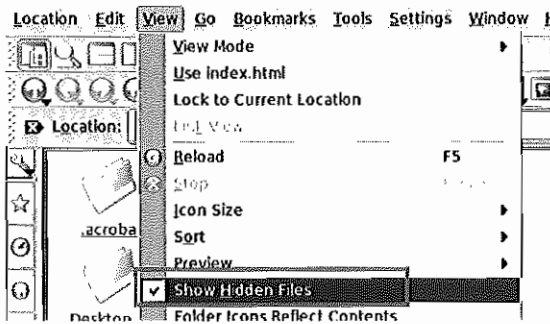
**Info**

Enter the name of the trigger list in the respective field. If the name does not end with \*.tl, the extension is automatically added.

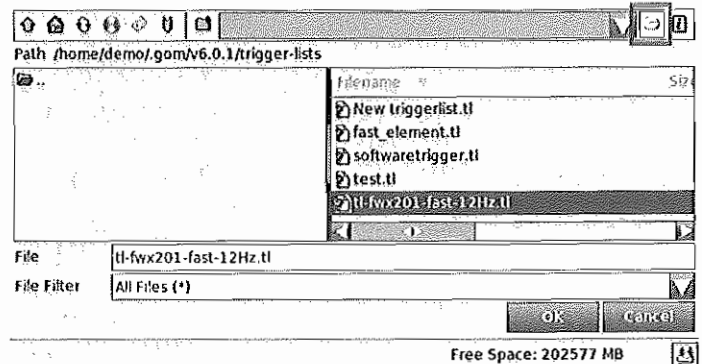
**Info**

If you enter the name of an already existing trigger list or choose it with Select (the trigger lists are saved in directory ~/ .gom/v6.x.x/sensor-controller), the element will be added to the already existing list! Thus, you may easily define complex trigger lists (see also chapter 6).

If the directory `.gom` is not visible in the file selection dialog, proceed as follows:



When working with the file manager (Konqueror)



When working with the menu (e.g. with Select)

At the end, you should again change the recording mode (**Mode**, see chapter 3.1) in order to update the dialog Triggerlist (e.g. change mode from Triggerlist to Fast Measurement and back again).

## 5.3 Macro Elements

### 5.3.1 General

The following macros have a similar basic structure, therefore we give some information here that is valid for each type.

#### 5.3.1.1 Macro Header:

The header contains information about the version and elements.

#### 5.3.1.2 A/D Channels:

Here, the A/D channels are configured.

`set_ad_channels channels={ 0, 1 }` The A/D channels stated in the list are measured.

`set_ad_range range="BI_10V"` The A/D channels are measured in the given range.

#### 5.3.1.3 Element Line:

The following parameters are always the same:

- `num=1` Number of the events in this element
- `divider=1` The event divider states which event will really start recording of an image (if you enter 1, the event rate = frame rate). This is useful if you do not want to record every trigger signal but every nth or if the sensor controller is to record A/D values at a higher rate than the sensor records images.
- `save=true` Measuring A/D values? true - yes; false - no
- `trigger=true` Start trigger (image recording)? true - yes; false - no
- `arm=false` The event can only occur if the "Arm" status is active. true - yes; false - no

For detailed information, please read chapter 7.

### 5.3.2 Important Notes!

As during the operation of the macro elements the recording limits of the measuring system (see also chapter 6.2) are no longer shown, they can easily be exceeded. This causes wrong measurements and/or the loss of images. Therefore, it is important to explain some points. These points are:

#### 5.3.2.1 set\_ad\_range

This is the value range of a signal which is recorded at the A/D interfaces. In general, for most of the measurements, the default range of -10V to 10V ("BI\_10V") does not need to be changed.

In order to avoid damages to the sensor controller, the adjusted voltage range must not be exceeded!

#### 5.3.2.2 Basic Settings

The maximum number of images and the shutter time have to be entered separately in the image recording mode (Triggerlist setting) if these values are not directly controlled by the header of the trigger list.

Example: If the maximum number of images is set to 10 images, the measurement will be aborted after 10 images even if in the trigger list more images were defined. Therefore, always adjust a sufficient number of images.

#### Info

Generally, always make sure that the maximum frame rate in the trigger list does not exceed the maximum frame rate of the cameras and that the shutter time is short enough to achieve this image rate. A wrong setting may cause the images to be triggered not at all or at a wrong time. To check this, you may determine the maximum possible shutter time with the frame rate adjusted in the recording mode **Fast Measurement** (increase the shutter time to its maximum extent). This is the maximum shutter time you can use during a measurement (see also chapter 6.2).

Alternatively, it is advisable to use the "script wizard" (chapter 4) to determine basic conditions that are valid during the entire measurement.

### 5.3.3 Additional Notes

#### 5.3.3.1 Abort Button

Note that when using the abort button at connector **Abort**, the signal of the button is only registered if the sensor controller is scanning (e.g. recording the A/D values or an image). In case of slow measurements this might lead to the fact that the button needs to be pressed longer in order to abort the measurement (see chapters 6.4 and 6.5).



### 5.3.3.2 Later Editing

The individually created trigger lists (elements) can be modified manually at any time using dialog Edit Triggerlist (see chapter 3.2).

### 5.3.4 Element Extern

Using this macro, you may trigger images using an external signal (e.g. photoelectric sensor). Each signal corresponds to one image.

To create a new triggerlist enter a filename with ending ".tl".

To add an element to existing trigger list, select the triggerlist by clicking on choose.

**Value Range:**

0 = -10...10 V 2 = 0...10 V  
1 = -5...5 V 3 = 0...5 V

Triggerlist Name:

Value Range (0-3):

Number of Images:

Enter the required number of images in the field Number of Images.

Triggerlist:

Editor

```

#
# Triggerlist created by COM-Triggerlist Tool 2.0-0
#
## Version: Tom v6.1.1-3a
## Controller: Sensor Controller
#
# Enable A/D Channels
set_ad_channels channels={ 0, 1 }

## Element: Extern
set_ad_range range="BI_10V"
triggered_measurement num=50 divider=1 save=true trigger=true arm=false
    
```

Line of the element:

- triggered\_measurement external trigger
- num=50 at each trigger signal one image is recorded (50 times)

### 5.3.5 Element Fast

With this macro, you can define a fixed camera speed for the entire measurement.

To create a new triggerlist enter a filename with ending ".tl".

To add an element to existing trigger list, select the triggerlist by clicking on select.

**Value Range:**

0 = -10...10 V 2 = 0...10 V  
1 = -5...5 V 3 = 0...5 V

Triggerlist Name:

Value Range (0-3):

Number of Images:

Framerate (FPS):

Enter the required number of images in the field Number of Images. The desired Frame rate (FPS) is stated in frames per second (observe maximum value of camera and shutter time!). (See also chapter 6.2.2)

**Info**

The first image is only triggered after 1/rate.

Triggerlist:

Editor:

```

V
V Triggerlist created by GOM-Triggerlist Tool 2.0-0
V
## Version: Ton v6.1.1-3a
## Controller: Sensor Controller
V
V Enable A/D Channels
set_ad_channels channels={ 0, 1 }

## Element: Fast
set_ad_range range="BI_10V"
fast_measurement num=200 divider=1 save=true trigger=true arn=false rate=15

```

Line of the element:

- fast\_measurement fast image recording
- num=200 (number of images), 200 images per second are recorded
- rate=15 (frame rate), 15 images per second are recorded

**Info**

Generally, this element can be created with the "script wizard" for simple lists (chapter 4). The wizard automatically generates a header in

the trigger list which excludes operating errors and thus avoids errors when recording images (loss of images).

### 5.3.6 Element Pause

When linking several macro elements it is sometimes important to insert a short pause between two elements. This is done by the pause macro.

To create a **new triggerlist** enter a filename with ending ".tl".

To **add an element** to existing trigger list, select the triggerlist by clicking on choose.

Triggerlist Name

Max. Framerate of Camera

The waiting time is entered in format 1/x (1/12=0.833s waiting time).

Triggerlist

Editor

```

V
V Triggerlist created by GOM-Triggerlist Tool 2.0-0
V
V# Version: Tom v6.1.1-3a
V# Controller: Sensor Controller
V
V Enable A/D Channels
set_ad_channels channels={ 0, 1 }

V# Element: ShortDelay
fast_measurement num=1 divider=1 save=false trigger=false arm=false rate=12
    
```

This element corresponds to a fast measurement without image recording (trigger=0), with a sample rate of 12Hz (rate=12) and a single scanning signal (num=1) to end the element, i.e. exactly after 1/12 s.

**Info**

This element is used, for example, in order to ensure the mandatory dead time following the last image of an element (fast image sequence) before starting new image recording in the next element (e.g. External, Slow) (see also chapter 6.2.2). This element is NOT suitable for longer waiting times! Create them with element Slow (chapter 5.3.7).

### 5.3.7 Element Slow

Element Slow allows for slow measurements with fixed defined times between two images. This provides to easily carry out long-term measurements.

To create a new triggerlist enter a filename with ending ".tl". To add an element to existing trigger list, select the triggerlist by clicking on select.

**Value Range:**

0 = -10...10 V 2 = 0 ... 10 V  
1 = -5...5 V 3 = 0 ... 5 V

Time Step (µs) must have six numbers.

Triggerlist Name:

Value Range (0-3):

Number of Images:

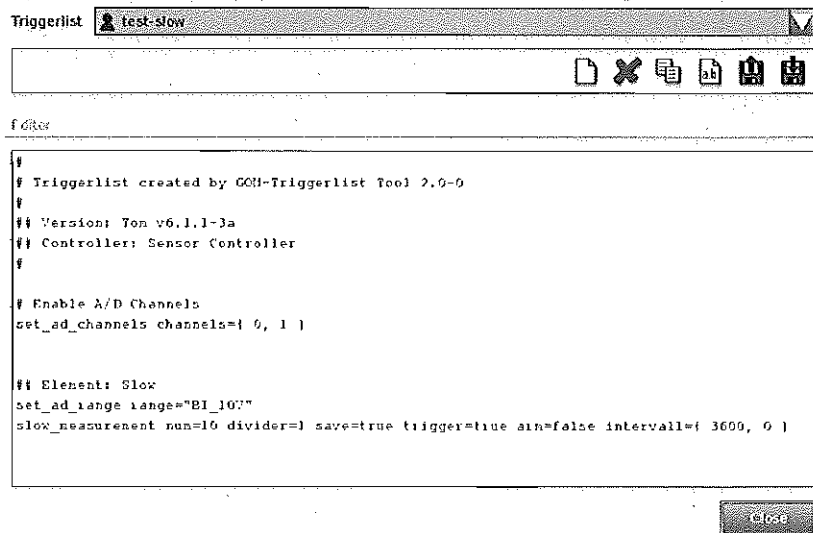
Time Step (s):

Time Step (µs):

Enter the time between the images in the fields Time Step (s) and (µs).

**Info**

The first image is recorded immediately when starting the trigger list.



Line of the element:

- slow\_measurement slow image recording
- num=10 (number of images), 10 images per second are recorded
- intervall={ 3600, 0 } time interval from image to image, here 3600s + 0µs = 1h



- filter\_size=0 A/D values are interpreted unfiltered (see also 5.3.9)
- channel=0 triggers at A/D channel 0 (the first channel from the list "set\_ad\_channels")

Element "complex\_measurement" provides for more complex image recording using AD values (e.g. chapters 5.3.9 and 5.3.10).

### 5.3.9 Element Value-Time-Absolute

To create a new triggerlist enter a filename with ending ".tl".  
To add an element to existing trigger list, select the triggerlist by clicking on select.

Dead time specifies the time after a trigger signal when no new trigger can be set up.

(Dead time > Shutter time)

Value Range:

0 = -10...10 V 2 = 0...10 V  
1 = -5...5 V 3 = 0...5 V

Compare Flag

1 = rising edge  
2 = falling edge  
3 = rising and falling edge

Triggerlist Name	test-time-absolute	Select
Value Range (0,3)	0	
Compare Flag (1,2,3)	3	
Analog Channel (0,1)	0	
Target Analog Value [V]	5.00	
Relative Time Step [s]	1.00	
Dead Time [s]	0.05	
Filter Size	10	
		OK Cancel

```
#
# Triggerlist created by GOM-Triggerlist Tool 2.0-0
#
## Version: Tom v6.1.1-3
## Controller: Sensor Controller
#
# Enable A/D Channels
set_ad_channels channels={ 0, 1 }

## Element: Abstract (absolute, 5.000000 V, timestep 1.000000)
set_ad_range range="BI_10V"
complex_measurement divider=1 save=true trigger=true arm=false compare_mode={ "absolute", "value" } value=5
snap_intervall={ 1, 0 } post_snap=true loops=1 loop_deadtime={ 0, 50000 } camera_deadtime={ 0, 50000 } filter_size=10 channel=0
```

Macro Value-Time-Absolute with its special trigger list command "complex\_measurement" is used for a combined time and value controlled measurement.

This macro triggers images at a defined time difference and when reaching a certain voltage value. In addition, it is possible to record the value-controlled image at raising, falling or both edges of the voltage signal.

In this example, we used the default setting with the voltage range of -10 to +10 Volt (Value Range 0) on channel 0 (Analog Channel 0).

For this measurement, an image is triggered each second (Relative Time Step 1.00) and additionally an image at 5V (Target Analog Value 5.00).

The dead time here is set to 0.05 s. Depending on the frame rate and

the cameras, the dead time needs to be adapted according to chapter 6.2.2). The dead time avoids that the "value image" coincides with the "time image". If the "value image" lies within this time slot, it is not triggered as a "time image" already exists which has almost the desired value.

In addition, choose a sufficient filter size (here 10) depending on the quality of the analog voltage signal used, in order to avoid that a "value image" is triggered unintentionally because of signal noise. A moving average is determined from the given number of analog values and compared with the desired value. The resulting time slot depends on the number of the measured A/D channels ("set\_ad\_channels"):

Number of the A/D channels	Converting rate [kHz]	averaged time slot at filter_size=10 [ms]
1	100	0.1
2	50	0.2
3	33.3	0.3
4	25	0.4
5	20	0.5
6	16.6	0.6
7	14.2	0.7
8	12.5	0.8

The most important parameters of the element line are:

- `compare_mode={"absolute","value"}` The system triggers at a fixed analog value.
- `value=5` Target value for "value images", here: 5V
- `snap_intervall={1, 0}` Time interval for "time images", here: 1s + 0µs = 1.0s
- `loops=1` is repeated until the analog value is reached once.
- `camera_deadtime={0,50000}` Dead time (see also chapter 6.2.2), here: 0s + 50000µs = 0.05s
- `loop_deadtime={0.50000}` Waiting time until analog values are measured again and compared (to avoid counting loops for the same value)
- `filter_size=10` filter size, here moving average of 10 analog values (see above)
- `channel=0` triggers at A/D channel 0 (the first channel from the list "set\_ad\_channels")

For more details with respect to the individual parameters in element "complex\_measurement", please refer to chapter 7.1.5.

5.3.10 Element Value-Time-Relative

Another macro for a time and value controlled measurement is macro element Time-Value-Relative. In contrast to macro Time-Value-Absolute, this macro allows for triggering at numerous equal voltage differences instead at just one voltage value. That means that with high voltage gradients many value images are recorded and without voltage gradients only time images are recorded. Thus, for example, a measurement can be made with a tensile testing machine where images are triggered not only at a fixed time interval but also at certain forces (e.g. every 100N, etc.).

To create a new triggerlist enter a filename with ending ".d".  
 To add an element to existing trigger list, select the triggerlist by clicking on select.  
 Dead time specifies the time after a trigger signal when no new trigger can be set up.  
 (Dead time > Shutter time)  
**Value Range:**  
 0 = -10...10 V 2 = 0...10 V  
 1 = -5...5 V 3 = 0...5 V  
**Compare Flag**  
 0 = both steps  
 4 = rising step

Triggerlist Name	test-value-time-relative	Select
Value Range (0..3)	0	
Compare Flag (0,4)	0	
Analog Channel (0,1)	0	
Relative Analog Step [V]	1.00	
Relative Time Step [s]	1.00	
Dead Time [s]	0.05	
Number of Analog Events	8	
Filter Size	10	
		OK Cancel

```
#
# Triggerlist created by GOM-Triggerlist Tool 2.0-0
#
## Version: Tom v6.1.1-3
## Controller: Sensor Controller
#

# Enable A/D Channels
set_ad_channels channels={ 0, 1 }

## Element: Abstract (relative, +/-1.000000 V, timestep 1.000000)
set_ad_range range="BI_10V"
complex_measurement divider=1 save=true trigger=true arm=false compare_mode={ "relative", "signed", "value" } value=1
snap_intervall={ 1, 0 } post_snap=true loops=8 loop_deadtime={ 0, 50000 } camera_deadtime={ 0, 50000 } filter_size=10 channel=0
```

In the dialog window of this macro, analogous to the macro Time-Value-Absolute, the values for Value Range, Analog Channel, Relative Time Step, Dead Time and Filter Size are entered (chapter 5.3.9).

However, here the Compare Flag is used with 0 (rising and falling) and 4 (signed; positive voltage value = rising, negative voltage value = falling). Relative Analog Step indicates the voltage difference and Number of Analog Events the number of the "value images".

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The most important parameters of the element line are:

- `compare_mode={"relative","signed","value"}` Here, the system triggers at an analog value difference with corresponding sign.
- `value=1` analog value difference, here: 1V
- `snap_intervall={1, 0}` Time interval for "time images", here: 1s + 0 $\mu$ s = 1.0s
- `loops=8` is repeated eight times until the analog value difference was measured.
- `camera_deadtime={0,50000}` Dead time (see also chapter 6.2.2), here: 0s + 50000 $\mu$ s = 0.05s
- `loop_deadtime={0.50000}` Waiting time until analog values are measured again and compared (to avoid counting loops for the same value)
- `filter_size=10` filter size, here moving average of 10 analog values (5.3.9)
- `channel=0` triggers at A/D channel 0 (the first channel from the list "set\_ad\_channels")

For more details with respect to the individual parameters in element "complex\_measurement", please refer to chapter 7.1.5.

## 6. Complex Trigger Lists

### 6.1 General

As already shown in chapter 4.2, trigger lists may be made up of several elements. This can either be done easily by means of a macro (chapter 5.2, 6.3) or manually (chapter 3.2). The required dead times, the shutter time and the maximum number of images need to be taken into account in order to guarantee a correct function.

### 6.2 Limits

#### 6.2.1 Element Switching Time

**Info**

In a trigger list, there might be a delay of up to few milliseconds during switching from one element (command) to another.

#### 6.2.2 Required Dead Times

If measurements are made using a trigger list, the sensor controller decides (based on the loaded trigger list) when an image is recorded. The sensor controller sends the signal to record an image through the frame grabber boards (or FireWire hub, GigE hub) directly to the camera (the computer and the software are not involved). After the shutter time adjusted by the software, the image is transmitted from the camera to the computer (read-out time). During this time, the sensor controller is not allowed to send another trigger signal to the camera.

$$\text{min. dead time} = \text{read-out time} + \text{max. shutter time}$$

The minimum dead time differs depending on the camera type:

Camera (overlapped)	Max. frame rate [Hz]	Min. dead time [ms]= 1/max. frame rate	Max. shutter time [ms]
FWX201	12	84	79
FWX201 2x2 Binning	24	42	39
FWX401D	7	143	135
FWX401D 2x2 Binning	14	72	67
TXG50i	15	67	63
TXG50i 2x2 Binning	28	36	33
<i>Dalsa Falcon 4M60:</i>			
1/1 (2352x1728)	55	18.2	16.3
1/2 (2352x864)	110	9.1	8.1
1/4 (2352x432)	220	4.6	3.8
1/8 (2352x216)	440	2.3	1.9
<i>Baler A504k:</i>			
1/1 (1280x1024)	500	2	1.9
1/2 (1280x512)	1000	1	0.95
1/4 (1280x256)	2000	0.5	0.455
1/8 (1280x128)	4000	0.25	0.205

**Info**

If during the dead time a trigger signal is sent to the camera nevertheless, no image is recorded. Even though, a time stamp and the A/D values of the sensor controller are recorded. Later, when assigning the A/D values and the times to the images automatically, an error occurs that cannot be corrected.

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**Info**

The element "fast\_measurement" (7.1.2) ensures the dead time before the element starts. The first image is only triggered after 1/rate. The element ends immediately after the last image. This does not ensure a dead time after ending the element.

**Info**

The element "slow\_measurement" (7.1.4) does not ensure a dead time at the start of the element. The first image is recorded immediately. The element ends after the last image and only after the defined delay time. This ensures a dead time after ending the element.

### 6.2.3 Allowed Shutter Times / Definition of a Shutter Limit

As already described in chapter 6.2.2, it is not allowed to record a new image within the dead time after an image was triggered by a trigger list.

#### 6.2.3.1 Element Fast:

The maximum admissible frame rate (=trigger rate of the sensor controller) depends on the dead time. From the desired frame rate (depending on the camera used (see chapter 6.2.2)), the maximum admissible shutter time can be determined.

$$\begin{aligned} \text{max. shutter time} &= 1/\text{frame rate} - \text{read-out time} \\ &= \text{dead time} - \text{read-out time} \end{aligned}$$

or, for cameras working with overlap of shutter time and read-out time:

$$\begin{aligned} \text{max. shutter time} &= 1/\text{frame rate} - \text{safety} \\ &= \text{dead time} - \text{safety} \end{aligned}$$

This is done automatically in mode **Fast Measurement** and the adjustable shutter time is limited based on the frame rate selected before.

When creating a new trigger list using the "script wizard" (see chapter 4), the adjustable shutter time is also limited matching the frame rate and thus avoids errors.

In order to avoid errors in complex trigger lists, the header of a list that was defined by means of the "script wizard" can be used. Ensure that the maximum frame rate which will occur in the trigger list is used when defining the list by means of the wizard.

**The shutter time that is allowed for the desired frame rate can easily be determined with mode Fast Measurement or with the "script wizard".**

**Info**

When using external trigger signals (element triggered\_measurement) or A/D values of controlled image recording (elements threshold\_measurement and complex\_measurement) the user has to ensure that the maximum trigger rate does not exceed the maximum admissible frame rate. You can prevent operating errors if:

1. you limit the shutter time in the trigger list header (e.g. matching element Fast),
2. you insert additional pause elements (chapter 5.3.6) before the elements triggered\_measurement and complex\_measurement including the required dead times, and
3. if you set the correct dead time in the element complex\_measurement.

### 6.2.4 Maximum Number of Images

The maximum possible number of images depends on the main memory or the size available for image recording (max. 10,000 images).

With current Linux installations (GOM Linux 10, 64bit PC), maximally half of the available free main memory may be reserved. This results in the following maximum number of images:

Camera	No. of images with 64bit, for 16 GB main memory, 19" PC (GOM Linux 10)	No. of images with 64bit, for 32 GB main memory, 19" PC (GOM Linux 10)	No. of images with 64bit, for 4 GB main memory, Laptop (GOM Linux 10)
FWX201	1500	3400	380
FWX201 2x2 Binning	1500	3400	380
FWX401D	700	1600	160
FWX401D 2x2 Binning	700	1600	160
TXG50i	600	1300	120
TXG50i 2x2 Binning	600	1300	120
<b>Dallas Falcon 4M60</b>			
1/1 (2352x1728)	700	1600	-
1/2 (2352x864)	1400	3200	-
1/4 (2352x432)	2800	6400	-
1/8 (2352x216)	5600	10000	-

Baier A504k:	with 1GB BV board
1/1 (1280x1024)	800
1/2 (1280x512)	1600
1/4 (1280x256)	3200
1/8 (1280x128)	6400

When starting a trigger list, adjust the desired number of images. If the adjusted number is larger than the number of images created with the trigger list, recording will automatically be stopped at the end of the trigger list (see also chapter 6.7).

If the number adjusted here is smaller than the number of images in the trigger list, recording of images is stopped if the adjusted number is achieved.

#### Info

If you want to avoid the adjustment of a too small number of images, you may enter the required number of images in the trigger list header as a fixed value (see chapter 4). However, the predefined number must not exceed the available free main memory!

### 6.3 Combining Several Trigger List Elements

In order to be able to create a complex measurement with different requirements, the trigger list macros allow to combine the individual macro elements in any way.

Open the macro element you would like to use and enter the name of the existing trigger list or select a list manually with **Select**. The new element is then placed at the end of the list.

### 6.4 Manual Abortion of a Trigger List Element

During a trigger list measurement, individual elements may be aborted (e.g. if an analog value is no longer reached but you would like to continue measuring nevertheless). There are two possibilities to do this:

- **Skip** in the status dialog during the measurement aborts the current element and continues with the next following element.
- Pressing the button which is connected to **Abort**. The abort behavior of the abort input must be set to **Skip** in the Web interface of the sensor controller (see User Information - Hardware).

To abort the entire trigger list, there are three possibilities available:

- **Abort** in the status dialog during the measurement aborts the trigger list.
- Pressing the button which is connected to **Abort**. The abort behavior of the abort input must be set to **Abort** in the Web interface of the sensor controller (see User Information - Hardware).
- Pressing **Esc** during the measurement and confirming the abort dialog with **OK**.

Status

Running triggerlist.. (Element 2) (Images: 0)



### 6.5 Example: Trigger List Slow-Fast

We explain the combination of elements using trigger list Slow-Fast as example. The measurement should do the following:

- Starting via external trigger with image recording
- Slow measurement with a fixed frame rate of 1Hz max. 100 images
- Abortion of the slow measurement by means of the external button at **Abort**
- Fast measurement with high frame rate of 20 Hz, max. 511 images

In order to create basic conditions that are valid for the entire measurement, we use the "script wizard" to create a **Fast Measurement** with the name "slow-fast". Here, the conditions (612 images, max. 20Hz, shutter time max. 0.01s) are defined as described in chapter 4. This is the basic structure of the measurement.

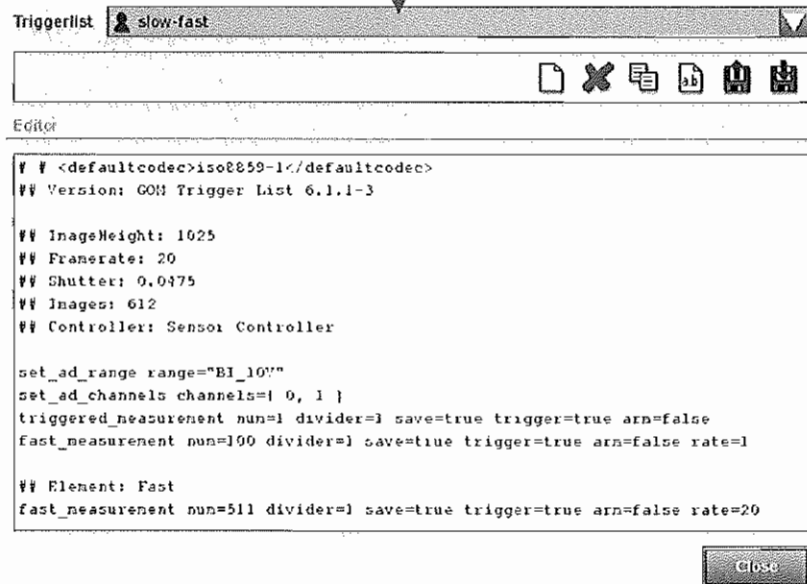
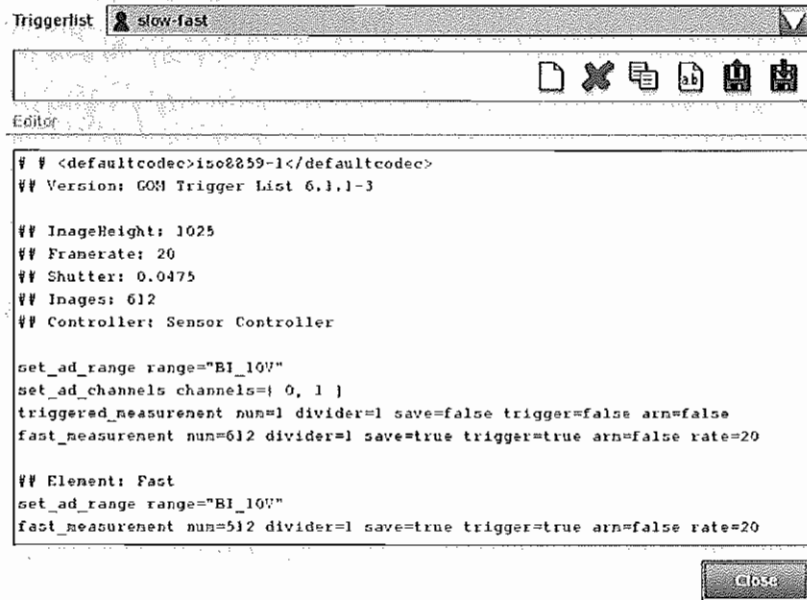
# Complex Trigger Lists

Then, the macro can be selected with Macro ► Scripts ► sensor\_controller ► Fast. Now, set Triggerlist Name = slow-fast (the same list name as for the previously created fast measurement), Number of Images = 511 and Framerate = 20. (Alternatively to the list name, you may also choose with Select the previously created list from ~/.gom/v6.x.x/sensor-controller.)

The new element is now automatically added to the existing list.

This is now a trigger list with linked elements. In order to be able to use it according to the given requirements, you need to make the following changes manually (Edit Triggerlist):

The header shows the version information and the basic conditions of the measurement that should not be changed.



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Starting via external trigger with image recording:

triggered\_measurement: Set "save=false trigger=false" to "save=true trigger=true", now the image recording is started at an external trigger and the A/D values are saved.

Slow measurement with a fixed frame rate of 1Hz max. 100 images

fast\_measurement: Set "num=612 rate=20" to "num=100 rate=1"

Fast measurement with high frame rate of 20 Hz, max. 511 images:

set\_ad\_range: This line may be dropped as the A/D value measuring range has already been defined in the upper part of the trigger list.

In addition, it is possible to add, for example, another fast measurement. For this, copy the entire area "#Element: Fast" and adapt the frame rate and the number of images as required.

### 6.6 Example: Trigger List for Extreme Values

A trigger list needs to meet the following conditions:

- Measurement of a cyclic test
- Image recording only at the minimum and maximum values of the force signal
- Maximum frame rate 5Hz

This task may be accomplished by using the element "complex\_measurement" (7.1.5). To create a predefined trigger list that contains this element and all parameters, you may use the macros Value-Time-Absolute (5.3.9) and Value-Time-Relative (5.3.10):  
**Macro ▶ Scripts ▶ sensor\_controller ▶ Value-Time-Absolute.**

To create a new triggerlist enter a filename with ending ".tl".  
 To add an element to existing trigger list, select the triggerlist by clicking on select.  
 Dead time specifies the time after a trigger signal when no new trigger can be set up.  
 (Dead time > Shutter time)

**Value Range:**

0 = -10...10 V 2 = 0...10 V  
 1 = -5...5 V 3 = 0...5 V

**Compare Flag**

1 = rising edge  
 2 = falling edge  
 3 = rising and falling edge

Triggerlist Name	extrema	OK
Value Range (0-3)	0	▼
Compare Flag (1,2,3)	3	▼
Analog Channel (0-7)	0	▼
Target Analog Value [V]	0.00	▼
Relative Time Step [s]	1.00	▼
Dead Time [s]	0.20	▼
Filter Size	20	▼
		OK Cancel

The created trigger list is shown in the measurement mode Trigger list. It can be opened in an editor with right mouse button ▶ Edit Trigger list ▶ right mouse button ▶ Edit Trigger list.

Edit the trigger list as follows:

```
set_ad_channels channels={ 0, 1 }
set_ad_range range="BI_10V"
complex_measurement num=1 divider=1 save=true trigger=true arm=false compare_mode={ "absolute", "unsigned", "gradient" } value=0 snap_interval={ 0, 0 } post_snap=true loops=20 loop_deadtime={ 0, 200000 } camera_deadtime={ 0, 200000 } filter_size=200 channel=0
```

The individual parameters have the following meaning:

compare\_mode={absolute,unsigned,gradient} value=0

The system triggers at a gradient ("gradient") of 0 ("value=0" means extreme value). Since it is "value=0", "unsigned"/"signed" does not matter. As the optional parameter "rising\_edge\_only"/"falling\_edge\_only" was left out, the system triggers at both edges of the gradient (maximum and minimum).

snap\_interval={0,0}

No additional images are recorded in a set period. If the parameter was dropped completely, the meaning would be the same.

loops=20

The system waits 20 times for an extrema and records one image.

loop\_deadtime={0,200000} camera\_deadtime={0,200000}

An image can only be recorded  $0.2\text{s} = 0\text{s} + 200000\mu\text{s}$  (=5Hz) after the last image ("camera\_deadtime"). If any trigger events occur before (e.g. with a smaller "loop\_deadtime"), the loops will be still counted but no image is recorded.

The system waits for the next extrema after  $0.2\text{s} = 0\text{s} + 200000\mu\text{s}$  (=5Hz) ("loop\_deadtime"). Other extrema will be ignored in the meantime.

filter\_size=200 channel=0

A moving average is determined of 200 values each of A/D channel 0, to make the detection of extrema more robust against interference signal and noise.

For more details with respect to the element "complex\_measurement", please refer to chapter 7.1.5.

## 6.7 Further Information

If the total number of images in the elements is less than the number specified in the header or if the measurement is terminated prematurely (e.g. by means of the external button), the following warning appears:

Less images as specified were fetched.

Do not show this message again

OK

In this case, you can ignore the message.



**Info**

However, this message may also indicate that images are missing due to wrong parameters in the trigger lists (see also chapter 6.2).

These combined macro trigger lists can be edited and complemented according to the measurement situation.

**Info**

If the elements "fast\_measurement" (7.1.2), "slow\_measurement" (7.1.4) and "triggered\_measurement" are combined, you need to pay attention to the different dead time behavior (6.2.2).

- „slow“ before „fast“: between the last image of "slow\_measurement" and the first image of "fast\_measurement" there is the time interval of "slow" plus the time interval of „fast“.
- „fast“ before „slow“: between the last image of "fast\_measurement" and the first image of "slow\_measurement" there is no time interval. You need to add the respective dead time (5.3.6).

## 7. Overview of the Element Commands

In the following, we explain all commands necessary to create trigger lists and describe their parameters.

An individual element consists of two parts:

- Command
- Parameter

### 7.1 Measuring Commands

The following commands can start image recording.

#### 7.1.1 triggered\_measurement

Element "triggered\_measurement" is used for recording images by means of an external trigger (e.g. photoelectric sensor, pushbutton at the input of the photoelectric sensor, TTL at the trigger input, clicking on **Trigger** in the status dialog). In case of fast trigger signals you may use parameter "divider" in order to maintain the dead times (see chapter 6.2.2). You may start image recording by means of an external trigger ("save=true trigger=true") or switch to the following element ("num=1 save=false trigger=false").

Parameters:	Value Range:		Description:
num	0 .. 2 <sup>32</sup>	32bit	Number of the individual triggers
divider	1 .. num	optional Default: 1	Divides the external trigger rate, only every nth external trigger will lead to an image
save	true	optional Default: true	Saves A/D values
	false		No A/D values are saved and no trigger is emitted
trigger	true	optional Default: true	Trigger output, trigger an image
	false		
arm	true	optional Default: false	Using the ARM switch, a trigger is only emitted if the ARM status is active (see User Information - Hardware)
	false		

Example for triggered\_measurement:

```
triggered_measurement num=100 divider=1 save=true trigger=true arm=false
```

7.1.2 fast\_measurement

Element "fast\_measurement" provides a fixed number of images at a predefined frame rate.

**Info**

The first image is only triggered after 1/rate.

Command:	Value Range:		Description:
num	0 .. 2 <sup>32</sup>	32bit	Number of the internal triggers
divider	1 .. num	optional Default: 1	Divides the internal trigger rate, only every nth internal trigger will lead to an image
save	true	optional Default: true	Saves A/D values
	false		No A/D values are saved and no trigger is emitted
trigger	true	optional Default: true	Trigger output, trigger an image
	false		
arm	true	optional Default: false	Using the ARM switch, a trigger is only emitted if the ARM status is active (see User Information - Hardware)
	false		
rate	0 .. 100.000	Decimal number	Internal trigger rate (rounded in the 10 MHz raster)

Example for fast\_measurement:

fast\_measurement num=100 divider=1 save=true trigger=true arm=false rate=20

7.1.3 threshold\_measurement

Element "threshold\_measurement" allows to trigger at voltages applied to the A/D inputs.

Command:	Value Range:		Description:
num	0 .. 2 <sup>32</sup>	32bit	Number of the events (reaching the given voltage)
divider	1 .. num	optional Default: 1	Divides the rate of the events, only every nth event will lead to an image
save	true	optional Default: true	Saves A/D values
	false		No A/D values are saved and no trigger is emitted
trigger	true	optional Default: true	Trigger output, trigger an image
	false		
arm	true	optional Default: false	Using the ARM switch, a trigger is only emitted if the ARM status is active (see User Information - Hardware)
	false		
value	-10 .. 10	Voltage in V	Voltage at which system should be triggered
channel	0 .. 7		Index (starting with 0) of the A/D channel in the list of "set_ad_channels" (7.2.1), at which the trigger voltage is applied to (e.g.: when "set_ad_channels channels={2,3,7}" and "channel=2", then A/D channel 7 is accessed)
filter_size	0 .. 4095		The recorded A/D signal is filtered with a moving average before it is compared to the value of "value". e.g.: filter_size=10: Averaging of the last 10 values filter_size=0: No filtering, direct value comparison

**Info**

The "filter\_size" should be high enough depending on the quality of the analog voltage signal used in order to avoid an unintentional event

due to the signal noise. The resulting time slot depends on the number of the measured A/D channels ("set\_ad\_channels" 7.2.1):

Number of the A/D channels	Converting rate [kHz]	Averaged time slot at filter_size=10 [ms]
1	100	0.1
2	50	0.2
3	33.3	0.3
4	25	0.4
5	20	0.5
6	16.6	0.6
7	14.2	0.7
8	12.5	0.8

For example: Low frequency measurement voltage with a 50Hz interference signal, 4 measured A/D channels:  $1/50\text{Hz} = 0.02\text{s}$ ;  $1/25\text{kHz} = 0.00004\text{s}$ ;  $0.02\text{s}/0.00004\text{s} = 500$ : "filter\_size = 500"; means a delay of approx. 0.01s caused by the filter.

**Info**

When an image is recorded, the actual A/D values will be saved and not the filtered ones.

Example for threshold\_measurement (write in one line):

```
threshold_measurement num=1 divider=1 save=true trigger=true arm=false value=5 channel=0 filter_size=0
```

**7.1.4 slow\_measurement**

Element "slow\_measurement" provides for carrying out long-term measurements.

**Info**

The first image is recorded immediately when starting the trigger list.

Command:	Value Range:		Description:
num	0 .. 2 <sup>32</sup>	32bit	Number of the internal triggers
divider	1 .. num	optional Default: 1	Divides the internal trigger rate, only every nth internal trigger will lead to an image
save	true	optional Default: true	Saves A/D values
	false		No A/D values are saved and no trigger is emitted
trigger	true	optional Default: true	Trigger output, trigger an image
	false		
arm	true	optional Default: false	Using the ARM switch, a trigger is only emitted if the ARM status is active (see User Information - Hardware)
	false		
intervall	0 .. 2 <sup>32</sup> , 0 .. 999.999		Fixed time difference between two images in the format: { s, μs }

Example for slow\_measurement (write in one line):

```
slow_measurement num=100 divider=1 save=true trigger=true arm=false intervall={ 3600, 0 }
```

7.1.5 complex\_measurement

Element "complex\_measurement" allows for numerous time and value controlled measurements.

Command:	Value Range:		Description:
divider	1 .. loops	optional Default: 1	Divides the rate of the events, only every nth event will lead to an image
save	true	optional Default: true	Saves A/D values
	false		No A/D values are saved and no trigger is emitted
trigger	true	optional Default: true	Trigger output, trigger an image
	false		
arm	true	optional Default: false	Using the ARM switch, a trigger is only emitted if the ARM status is active (see User Information - Hardware)
	false		
compare_mode	absolute		Voltage value is measured absolutely
	relative		Voltage difference value is measured relatively to the last event
	signed		Sign behavior of the comparison
	unsigned		
	value	value states voltage ("absolute") or voltage difference ("relative") in V	Value type
	gradient	defined for "absolute" only; states the voltage change in V/s	
	rising_edge_only	defined for "absolute" only	Edge behavior, if nothing is specified both edges will be evaluated.
falling_edge_only			
value	-10 .. 10	Voltage in V	Value at which an event (trigger) is activated.
	-20 .. 20	Voltage difference in V	
	-9.999 .. 9.999	Voltage change in V/s	
snap_intervall	0 .. 2 <sup>32</sup> , 0 .. 999.999	optional	Minimum fixed time difference between two images in the format: { s, µs }, without this parameter only value images
post_snap	true	Standard	If the set analog value was reached, an image will be recorded. In case of "false" only loops will be counted and time images recorded.
	false		
loops	0 .. 2 <sup>32</sup>	32bit	Number of repetitions of this element = number that shows how often the set analog value was reached. The time images do not depend on it. ("loops=1" stands for an element with time images, which aborts after reaching the set analog value.)
loop_deadtime	0 .. 2 <sup>32</sup> , 0 .. 999.999	Repetition dead time	Minimum fixed time difference between two repetitions in the format: { s, µs }, otherwise, the sensor controller probably counts the loops at the same value. Generally, it can be equal to the "camera_deadtime". When "loop_deadtime" < "camera_deadtime", the loops can also be counted while an image is recorded.
camera_deadtime	0 .. 2 <sup>32</sup> , 0 .. 999.999	Camera dead time	Minimum fixed time difference between two images in the format: { s, µs }, otherwise the sensor controller probably triggers without the camera being ready (see chapter 6.2.2)
channel	0 .. 7		Index (starting with 0) of the A/D channel in the list of "set_ad_channels" (7.2.1) at which the trigger voltage is

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			applied to (e.g.: when "set_ad_channels channels={2,3,7}" and "channel=2", then A/D channel 7 is accessed)
filter_size	0 .. 4095	optional	The recorded A/D signal is filtered with a moving average before it is compared to the value of "value". e.g.: filter_size=10: Averaging of the last 10 values filter_size=0: No filtering, direct value comparison

**Info**

The "filter\_size" should be high enough depending on the quality of the analog voltage signal used in order to avoid an unintentional event due to the signal noise. The resulting time slot depends on the number of the measured A/D channels ("set\_ad\_channels" 7.2.1):

Number of the A/D channels	Converting rate [kHz]	Averaged time slot at filter_size=10 [ms]
1	100	0.1
2	50	0.2
3	33.3	0.3
4	25	0.4
5	20	0.5
6	16.6	0.6
7	14.2	0.7
8	12.5	0.8

For example: Low frequency measurement voltage with a 50Hz interference signal, 4 measured A/D channels:  $1/50\text{Hz} = 0.02\text{s}$ ;  $1/25\text{kHz} = 0.00004\text{s}$ ;  $0.02\text{s}/0.00004\text{s} = 500$ : "filter\_size = 500"; means a delay of approx. 0.01s caused by the filter.

**Info**

When an image is recorded, the actual A/D values will be saved and not the filtered ones.

**Info**

With "compare\_mode={gradient}" a filter with the double slot size is used on the calculated signal gradient (since the interferences are stronger during the calculation of the gradient).

Application Examples:

compare_mode	Application
{absolute,signed,value, rising_edge_only} value=5	Events are triggered at 5V on the rising edge ("rising_edge_only").
{relative,unsigned,value} value=0.1	Events are always triggered after a voltage difference ("relative") of 0.1V. This applies to positive as well as to negative voltage differences ("unsigned").
{absolute,unsigned, gradient,rising_edge_only} value=0	Events are always triggered during the temporary minimum of the voltage curve ("rising_edge_only" -- the gradient rises in the minimum). Since it is "value=0", sign behavior ("unsigned") does not matter. "gradient" is mainly used for triggering at minimum or maximum values ("value=0").

Example for complex\_measurement (write in one line):

```
complex_measurement divider=1 save=true trigger=true arm=false compare_mode={
"relative", "signed", "value"} value=0.5 snap_intervall={ 1, 0} post_snap=true
loops=8 loop_deadtime={ 0, 5000} camera_deadtime={ 0, 67000} channel=0 fil-
ter_size=10
```

## 7.2 Further Commands

The following commands are used for controlling trigger lists and can be used like these as an individual line in trigger lists. Partly they are also created by the trigger list macros (see chapter 5).

### 7.2.1 set\_ad\_channels

Selects the A/D channels for which an A/D conversion shall be carried out. Channels 0 through 7 are available. They have to be transferred in a list. The list will be sorted before the evaluation starts.

Example:

```
set_ad_channels channels={ 0, 1, 4 }
```

### 7.2.2 set\_ad\_range

Selects the range for the 16bit A/D conversion for the active A/D channels (see chapter 7.2.1). The following ranges are available:

- UNI\_5V (0 .. 5V)
- UNI\_10V (0 .. 10V)
- BI\_5V (-5 .. 5V)
- BI\_5V (-10 .. 10V)

They are transferred to parameter "range" as character string.

Example:

```
set_ad_range range="UNI_5V"
```

### 7.2.3 set\_lamp

Controls the current for the LED illumination of the sensor.

```
set_lamp on=true (switches the light on)
```

```
set_lamp on=false (switches the light off)
```

### 7.2.4 set\_laser

Controls the laser pointers of the sensor.

```
set_laser on=true (switches the laser pointer on)
```

```
set_laser on=false (switches the laser pointer off)
```

### 7.2.5 set\_dac

Sets a voltage value at a D/A output. Four channels are available (dac0 through dac3). The voltage can be in the range 0 to 10 V and is transmitted as a value to the parameter which is listed as channel.

Example:

```
set_dac dac0=5.0
```

### 7.2.6 jump\_to\_list\_element

Is used to create endless loops or to skip several elements in trigger lists. Jumps to the specified command. The lines are counted as of 0.

Example:

```
jump_to_list_element line=2
```

### 7.2.7 `set_trigger2_delay`

Sets the delay of the delayed trigger output for special synchronization applications. The delay is transferred as multiples of 25ns.

Example:

```
set_trigger2_delay delay=4000 (sets an delay of 100µs)
```

### 7.2.8 `set_trigger_flip`

Defines if the delayed trigger is emitted before or after the actual trigger.

```
set_trigger_flip flip=true (sets the delayed trigger BEFORE  
the main trigger)
```

```
set_trigger_flip flip=false (sets the delayed trigger after the  
main trigger, default)
```

**Info**

Recording of the A/D values and the time stamp is always done at the first trigger. Thus, using "flip=true", the image recording is delayed with respect to the A/D values.