SmartRay

WeldVision Seam Inspection

Getting Started

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1 Inhaltsverzeichnis

Introduction

This document uses a step-by-step approach to describe the settings and measures required for the successful commissioning and parameterisation of the SmartRay WeldVision seam checking system. It contains an extensive collection of information and a great number of useful tips on all relevant subjects, such as robots, sensors, parameterisation and settings.

8 steps to success:

1. General system settings
2. Component information and testing procedure
3. Robot path and sensor settings
4. Recording or loading reference image(s)
5. Parameterisation of the seam evaluation
    a. Segmentation
    b. Image data filtering
    c. Orientation / position correction (alignment)
    d. Root point progression
    e. Contour model
    f. Characteristics (seam limits, hole detection, etc.)
6. Tolerance of measuring results
7. Viewing, equilibrating and optimising results
8. Additional functions (statistics, line stop)

1 General system settings

This section describes the programs and services needed for operation, discusses the requisite folder structure, illustrates which basic settings need to be made and how the field bus is set up.

1.1 Installation and programs required

There is an installation program for the WeldVision system that installs all the necessary programs and takes care of various settings.

It is strongly recommended that you log in as an administrator.

Attention! SmartRay only guarantees problem-free operation on SmartRay SmartBoxes.

The following drivers and programs are installed:
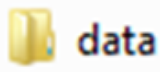
- WeldVision
- WeVi Tool
    - o Data management service (deletion and synchronisation)
- National Instruments software
    - o NI CVI runtime
    - o NI Vision runtime
    - o NI Service Pack(s)
- Field bus software
    - o Beckhoff TwinCAT IO
- RamDisk
- Database
    - o BitNami Wappstack (PostgreSQL). Installed on partition D.
- TimeSync
    - o If the BV (process) and statistics computer are running on the network, the Windows time will need to be synchronised.

1.2 Folder tree

The following folder tree is found on the SSD or HDD of the BV computer as well as on the D:\ partition of the ST computer (automatic backup of the BV computer).

Drive:\..\WeldVision

The "SmartRay" folder contains the "App" and the "Data" folders.

app	• Contains all files that WeldVision requires to run.
	   o Software data
	   o Configuration data
	   o Created components with their jobs, incl. parameter settings

data	• Contains all recorded image files • Database with archived measuring results

Drive:\..\WeldVision\app

The "app" folder contains the following sub-folders:

bin	Program files for the WeldVision software
config	Configuration files for the WeldVision software
tasks	Created components, associated jobs and their parameter settings

Drive:\..\WeldVision\tasks

The tasks folder contains all the created components as sub-folders.
This might look, for example, as follows:

	• all created components • a separate folder for each component • taskList and taskList_groups: Contains the components list and the group list as an XML file.

Drive:\..\WeldVision\tasks\selected task

A completed task folder might look as follows:

	• all created jobs for the selected component • a separate folder for each job • the file named after the component containing all jobs for this component as an XML file. • taskImg: This is the stored component image

Drive:\..\WeldVision\tasks\selected task\ selected job

	This folder contains:
cam_corr_ref_intensity cam_corr_ref_profile cam_corr_reference cam1.par lötnaht_links ref_intensity ref_profile rootSpline.bin timestamps	 • parameters for the job (e.g. correlator settings, evaluation parameters) • reference images for the job (e.g. for the correlator and evaluation)

1.3 Configuration file

Before the WeldVision software is launched, the sr_configure.exe tool should be used to make the general settings. The tool loads and processes the config.xml file in the config folder.

Attention! Ensure that you load the correct config.xml file. Check the path.
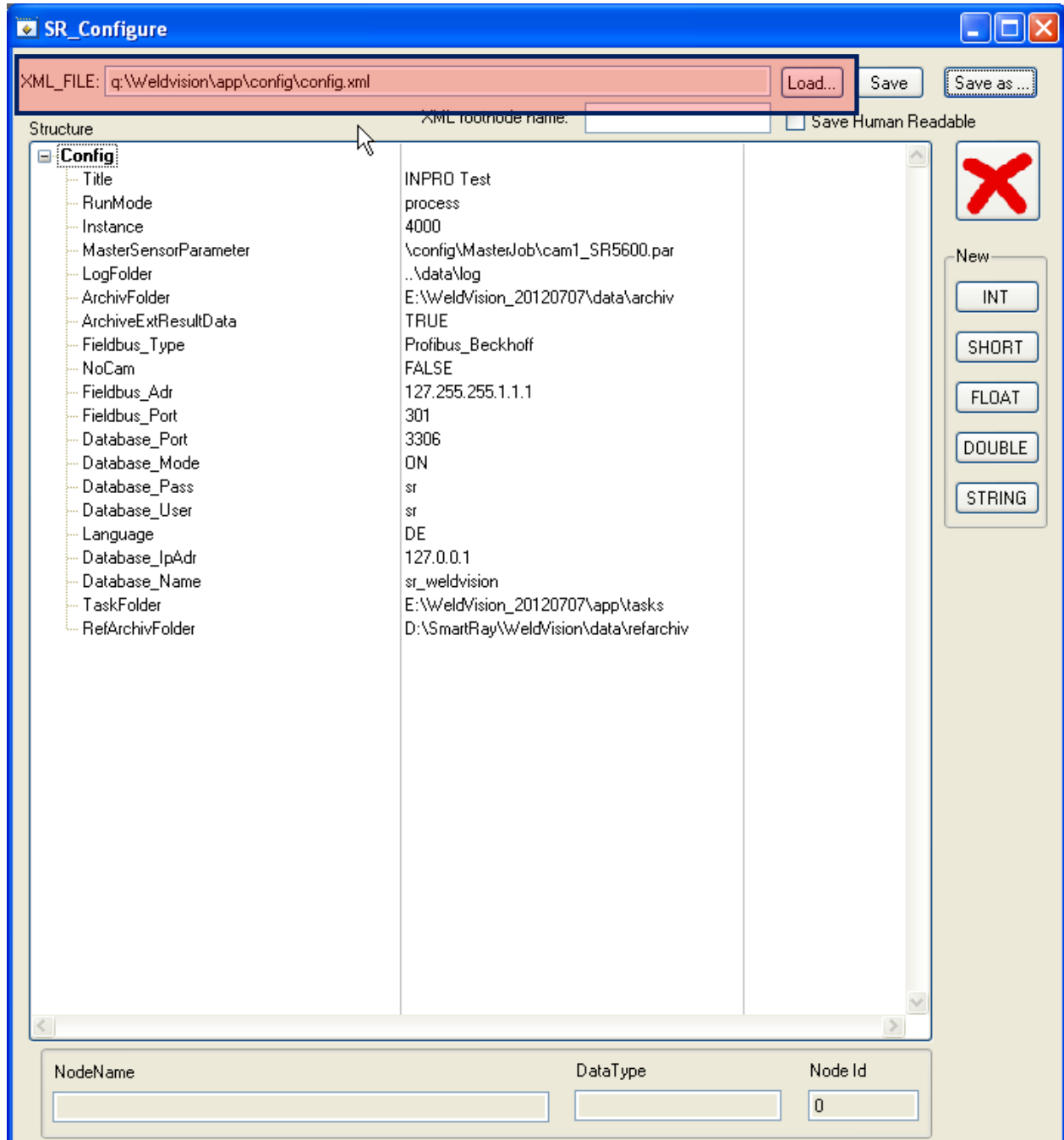
1.3.1 Parameters

Parameters printed in bold are essential and should be checked even in the event of a clean installation. The rest are optional and can be set as appropriate depending on the application, or can even be omitted.

The entries are not case-sensitive.

Parameters	*Possible value*	Explanation
ProgramName	*WeldVision*	The name of the program that is displayed in the banner and on the software's start screen.
Title	*Station1*	The title of the program displayed in the software's banner.
RunMode	*process*	WeldVision is running on the BV computer and actively evaluating images
	statistics	WeldVision is running on the statistics computer and is only used to display the statistics / component faults
	visu	WeldVision is running on a Visu computer to visualise the results of a BV computer
	demo_loop	WeldVision is starting in demo mode, the activated job is re-selected immediately after completion and is ready for the next measurement
	demo_seq	WeldVision is starting in demo mode, the jobs of the activated task are reselected immediately in sequence after completion and WV is ready for the next measurement
Instance	*0*	Standard
	1-4	Number of the station. It will be charged with the component ID of the PLC: Instance x 10 + taskID. The ID's of the parameter-sets must be oriented in it, this allows to safe the parameters across stations in a single task folder.
	99	Reserved
	1000	Reserved
	2000	Reserved
MasterSensorParameter	*\config\MasterJob\cam1_SR1400.par*	Path to the camera parameter that is used as standard for newly created jobs (relative to the "WeldVision/app" folder)
Fieldbus_Type	*Interbus_Phoenix*	Activates communication via Interbus
	Profibus_Beckhoff	Activates communication via Profibus
	Dual_Bus	Activates communication via Interbus AND Profibus
Fieldbus_Adr	*127.255.255.1.1.1*	Field bus IP address
Fieldbus_Port	*301*	Field bus port
Database_Mode	*On*	Database active
	Off	Database inactive
Database_Name	*sr_weldvision_1*	Name of the main database
Database_Name2 … Database_NameN	*sr_weldvision_2* … *sr_weldvision_N*	Names of other databases (for statistics computer)
Database_IpAdr	*127.0.0.1*	IP address of the main database (2..N same as Database_Name)
Database_Port	*5432*	Port of the main database (2..N same as Database_Name)
Database_Engine	*postgres*	Database type Postgre_SQL

	Mysql	Database type MySQL
	Odbc	Database connection via ODBC driver
Database_User	*Sr*	User name for database access
Database_Pass	*Sr*	Password for database access
TaskFolder	*/tasks_test_1/*	Folder from which tasks are loaded. If not set, "tasks" folder in the app directory is used (relative to the "WeldVision/app" folder or absolute path)
Language	*de* *en* *ch*	Language abbreviation once the loc table has been searched for dynamic parameters; if this parameter is missing, a language selection box appears when WeldVision is launched
SaveImageMode	*Async*	For saving in a separate thread -> usually better performance
	Sync	For synchronous saving
NoCam	*true*	No camera support (for offline stations), e.g. Visu
	false	or not set: Camera support active
Locality	*en* *de*	Localisation of text outputs (1000 separator, etc.)
Visu_IpAdr	[IP address]	IP address of the counterstation In *process* mode, the IP of the remote Visu station In visu mode, the IP of the remote BV station
Visu_PortNum	[Port No]	Port of the counterstation
Visu_Mode	*SERVER*	For BV station in process mode, WeldVision is Visu server -> provides results images and sends report to Visu station
	CLIENT	for Visu station: Receives report from BV-Visu server: Component ID for result display
	NONE	If no Visu station is active, e.g. statistics computer
LogFolder	*..\data\log*	Path to the folder for log files (relative to the "WeldVision/app" folder)
ArchivFolder	*..\data\archiv*	Path to the folder for archive data (relative to the "WeldVision/app" folder)
RefArchivFolder	*..\data\refArchiv*	Path to the folder for reference archive data (relative to the "WeldVision/app" folder)
Task_Name	*Component1*	Default task selection in the Statistics tab
RSI_Active	*true*	This parameter defines whether the RSI robot guidance is active in WeldVision or not. Possible parameters: If this parameter is not given or if it is FALSE, the robot guidance tab is not displayed
RSI_Local_IP	*192.168.179.1*	The IP of the local network card to which the RSI is connected. If several network cards are present, it serves to choose the correct card
RSI_Robot_IP	*192.168.179.123*	IP of the robot for the RSI robot guidance. Required to check the connection to the robot
RSI_Port	*1500*	Port set in the RSIethernet.xml file for facilitating communication between the robot and the PC
RSI_KrcType	KRC2	Defines that a KRC2 with a 12 ms RSI cycle is being used
	KRC4	Defines that a KRC4 with a 4 ms RSI cycle is being used

1.4   Data synchronisation and system monitoring

The WeVi tool is an independent service that monitors all required services within the entire system and which takes care of the cleaning and synchronisation of data records and other important data.

Detailed information on how to use the WeVi tool can be found in its manual.

Attention! The tool is not absolutely necessary for the basic functions of WeldVision. The manual does not therefore need to be studied to begin with.

1.5   Access control via password protection

Once the WeldVision software is launched, the system is blocked using password protection, particularly in the case of systems used in the field. As the installation engineer, you should therefore first log on as Admin or Supervisor, since the next few steps will not be possible if you do not hold the necessary rights.
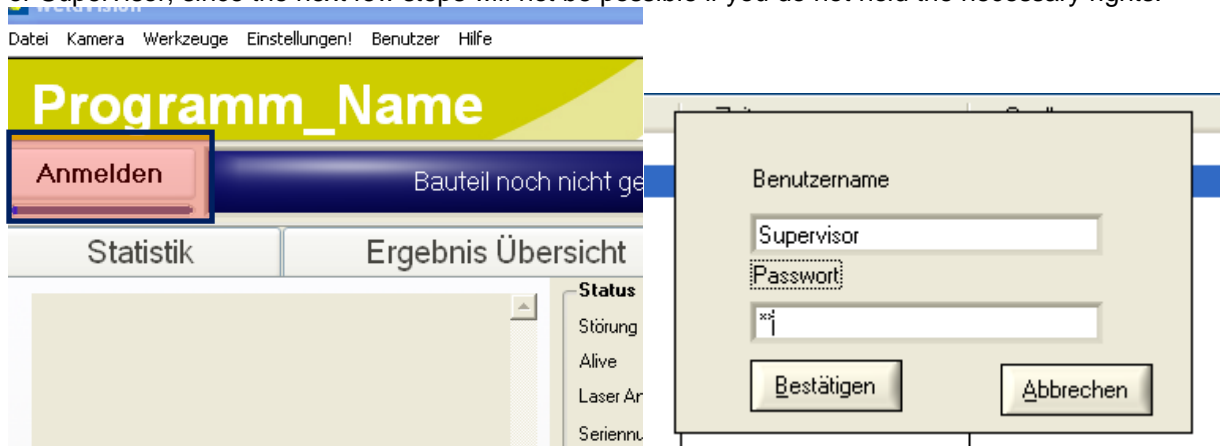
The default setting is:

User	Password
Supervisor	sr

Attention! The password for the user "Supervisor" must be changed in order to prevent unauthorised access. All activities are also logged in the log file stored for the currently logged-on user. It is therefore possible to track who has changed what at any time. For this to happen, however, each authorised individual must be allocated their own separate access.

New accesses can be entered or existing ones edited via the Users / Administration menu item.
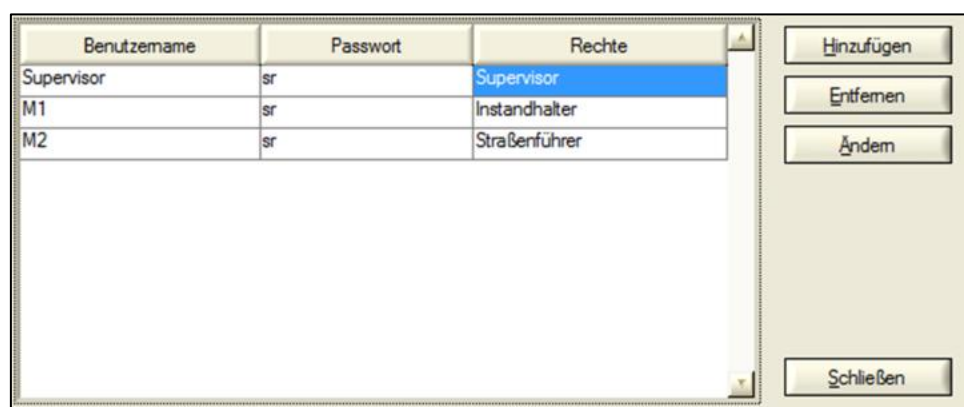
1.6 Field bus

This section familiarises you with the configuration of the field bus module so that you can set up separate interfaces to the field bus connection. WeldVision communicates with the actual field bus drive / system via a freely configurable module.

Settings need to be made in a total of three xml files.

Config.xml	WeldVision configuration file.
DeviceConfig.xml	Contains the field bus specifications (type, port, IP, etc.)
ProtocolConfigDevice.xml	Defines the mapping of the data present on the field bus for WeldVision.

1.6.1 Graphical representation of the field bus signals

The individual field bus signals are displayed in the System tab under the Messages window; they are divided up into the two tabs SPS and Robot. The system ensures that the signals are split into SPS and Robot signals when they are displayed. The actual mapping on the bus is independent of this, however, with the result that all signals can only come from 1 bus interface.

Unconfigured signals are always initialised with 0. The LED marked red lights up green when a connection has been established with the field bus. In Setup mode, the check box "Field bus test" can be selected.

In this case, WeldVision is disconnected from the bus and the input signals can only be set directly via the user interface. The output signals to the bus can also only be set via the user interface in this mode. The two LEDs framed in blue display the two modes; yellow means "Test" for test mode and green means "Run" for "normal" operation connected to the bus.

1.6.2 Adaptations in the config.xml file

To activate and operate field bus connections, three parameters need to be set in the "config.xml" file.

Config key	Command	Description
Fieldbus_Type	NONE	No bus connection, e.g. for offline mode
	Profibus_Beckhoff	TwinCat interface is initialised
	Reserved	
Fieldbus_Timer	Integer [1…100][ms]	Refresh rate
Fieldbus_Config	Absolute path	Path information to the XML configuration files "DeviceConfig.xml" and "ProtocolConfigDevice.xml"

1.6.3 Configuration of the DeviceConfig.xml file

This configuration file is used to define the field bus interface. The root tag must be "DeviceConfig" in order to be recognised as a permissible XML file. All of the descriptions required for physical access to the bus are performed in the "hardware" node.

Attention! At the time of printing, only the connection via TwinCat (Beckhoff) is supported.

1.6.3.1 Beckhoff Device (TwinCat)

Currently, the following four entries are needed for the configuration of a Beckhoff connection.

XML key	Description
outputsize	Register size (byte number) of the data to be written to the bus; must correspond with the software task in TwinCat,
inputsize	Register size (byte number) of the data to be read from the bus; must correspond with the software task in TwinCat
address	The TwinCat AMS Net ID consists of 6 blocks of one byte each
port	The port of the software task defined in TwinCat which is to be accessed

Under TwinCat, a software task must be created via which the WeldVision's field bus module then connects. See also the TwinCat documentation from Beckhoff.

1.6.4 Configuration of ProtocolConfig.xml

This configuration file defines the mapping between WeldVision and the transferred field bus register. This file can be used to define how the individual bits on the field bus are read and described by WeldVision. The protocol is independent of the defined field bus hardware. The XML file's root tag must be "SRPCProtocol" in order to be recognised as a protocol configuration file.

The root tag has the three nodes "Settings", "OutputConfig" and "InputConfig", which are described below.

1.6.4.1 Settings tag

This is where general protocol settings are managed that apply to all output and input buffers.

XML key	Command	Description
ByteOrder	big-Endian	Sorts bytes for integer expressions in big-Endian format
	little-Endian	Sorts bytes for integer expressions in little-Endian format

1.6.5 Configuration of input and output data

The actual mapping is described by the two tags "OutputConfig" for the signals being output by WeldVision and "InputConfig" for the signals coming in from the field bus. The meaning of the individual xml keys is described in the following two tables. The structure of the attributes is the same for all xml keys.

1.6.5.1 Structure of attributes

The attribute is made up of three entries that are separated by a bar (|) sign. An example of this would be "3|5|bit" or "4|3|Byte". The third entry specifies whether the mapping relates to whole bytes or bits.

If bit is defined, the first entry reflects the byte position on the field bus registers. However the entry 0 already describes the first byte. In the first example, this means that the 5th bit is addressed in the 4th byte.

If "byte" is selected in the third position, the defined range is interpreted as a byte array. This means that the first entry is interpreted as above as a byte start position, but the second now specifies the number of bytes. Note that if one byte is being addressed here, a 1 must be entered, a 2 for two bytes, and so on. A byte is the minimum quantity to be addressed.

1.6.5.2 XML keys for the WeldVision outputs

The table below describes which WeldVision signal which XML key stands for, and which attribute definitions are permitted.

Signal name	XML key	Permitted attributes
System ready	SysReady_RobOut	1 bit
With measurement	MitMessung_RobOut	1 bit
Live bit	Alive_RobOut	1 bit
Sequence interrupted (stopped)	Stop_RobOut	1 bit
Control in manual mode	Einrichten_RobOut	1 bit
Control in automatic mode	Automatik_RobOut	1 bit
Measurement OK	ErgebnisIO_RobOut	1 bit
Measurement NOK	ErgebnisNIO_RobOut	1 bit
Sensor ready for measurement	SensorReady_RobOut	1 bit
Measurement running	MessRun_RobOut	1 bit
Laser and image capture ON	LaserOn_RobOut	1 bit
Energy saving mode is on	EnergySave_RobOut	1 bit
Sensor test / calibration is requested	CalibReq_RobOut	1 bit
Sensor test / calibration is complete	CalibEnd_RobOut	1 bit
Calibration / sensor test OK	CalibIO_RobOut	1 bit
Calibration / sensor test NOK	CalibNIO_RobOut	1 bit
Job number	JobNr_RobOut	1 byte
Reserved	failure0_RobOut	1 bit
Reserved	failure1_RobOut	1 bit
Reserved	failure2_RobOut	1 bit
Reserved	failure3_RobOut	1 bit
Air conditioning alarm	failure_AirCon_RobOut	1 bit
24 V failure	failure_Energy_RobOut	1 bit
Measuring system failure	failure_MessSys_RobOut	1 bit
Group failure	failure_Collection_RobOut	1 bit
Error code W1	error_w1_RobOut	1 bit
Error code W2	error_w2_RobOut	1 bit

Error code W4	error_w4_RobOut	1 bit
Error code W8	error_w8_RobOut	1 bit
Error code W16	error_w16_RobOut	1 bit
Error code W32	error_w32_RobOut	1 bit
Error code W64	error_w64_RobOut	1 bit
Error code W128	error_w128_RobOut	1 bit
Robot guidance active	rg_dataValid_RobOut	1 bit
Robot guidance running	rg_messRun_RobOut	1 bit
Lane contour found	rg_foundContur_RobOut	1 bit
Robot guidance error	rg_collectErr_RobOut	1 bit
Collision warning	rg_collision_RobOut	1 bit
Position deviation	rg_disPos_RobOut	2 bytes
Height deviation	rg_height_RobOut	2 bytes
Tilt angle lateral	rg_roll_RobOut	2 bytes
Tilt angle longitudinal	rg_pitch_RobOut	2 bytes
Component number to testing station	partId1_SpsOut	Maximum 20 bytes
Component type (whole)	type_SpsOut	1 byte
Type A (component type)	typA_SpsOut	1 bit
Type B (component type)	typB_SpsOut	1 bit
Type C (component type)	typC_SpsOut	1 bit
Measurement OK SPS	messQualIO_SpsOut	1 bit
Measurement NOK SPS	messQualNIO_SpsOut	1 bit
Line stop	lineStop_SpsOut	1 bit
Teach mode reset taking place	teachModus_SpsOut	1 bit
Component number Rework1	rwOneID_SpsOut	Maximum 20 bytes
Rework1 OK	rwOneIO_SpsOut	1 bit
Rework1 NOK	rwOneNIO_SpsOut	1 bit
Rework1 not measured	rwOneNoMess_SpsOut	1 bit
Rework1 NOK left side	rwOneNioLeft_SpsOut	1 bit
Rework1 NOK right side	rwOneNioRight_SpsOut	1 bit
Component number Rework2	rwTwoID_SpsOut	Maximum 20 bytes
Rework2 OK	rwTwoIO_SpsOut	1 bit
Rework2 NOK	rwTwoNIO_SpsOut	1 bit
Rework2 not measured	rwTwoNoMess_SpsOut	1 bit
Rework2 NOK left side	rwTwoNioLeft_SpsOut	1 bit
Rework2 NOK right side	rwTwoNioRight_SpsOut	1 bit

A control attribute bearing the label "numMapElements" is now added as the final entry. This specifies the number of entries (parameters) used. It should be noted that the control attribute itself is not counted.

1.6.5.3   XML keys for the WeldVision inputs
The table below describes which WeldVision input signal which XML key stands for, and which attribute definitions are permitted.

Signal name	XML key	Permitted attributes
Reset / acknowledge error	Quit_RobIn	1 bit
Deselect station / no measurement	Deselect_RobIn	1 bit
Live bit	Alive_RobIn	1 bit
Interrupt sequence / stop system	Stop_RobIn	1 bit

Switch station to manual mode	RobHand_RobIn	1 bit
Switch station to automatic mode	RobAuto_RobIn	1 bit
Blow component clear / compressed air on	AirOn_RobIn	1 bit
Pilot laser ON	PilotLaserOn_RobIn	1 bit
Start measurement	StartMeasure_RobIn	1 bit
Laser and image capture ON	LaserOn_RobIn	1 bit
Activate energy saving mode	EnergySave_RobIn	1 bit
Request sensor test / calibration	CalibActiv_RobIn	1 bit
Job number	JobNr_RobIn	1 byte
Robot guidance robot ready	rg_RoboReady_RobIn	1 bit
Search drive active	rg_Search_RobIn	1 bit
Robot guidance active	rg_Track_RobIn	1 bit
Robot error1 robot guidance	rg_Error_1_RobIn	1 byte
Robot error2 robot guidance	rg_Error_2_RobIn	1 byte
Lane speed	rg_Speed_RobIn	2 bytes
Component number of testing station	partID_SpsIn	maximum 20 bytes
Component type (whole)	partType_SpsIn_	2 bytes
Type A (component type)	typeA_SpsIn	1 bit
Type B (component type)	typeB_SpsIn	1 bit
Type C (component type)	typeC_SpsIn	1 bit
Reset line stop	resetLineStop_SpsIn	1 bit
Teach mode selected	teachMode_SpsIn	1 bit
Component number Rework1	reworkID1_SpsIn	maximum 20 bytes
Component number Rework2	reworkID2_SpsIn	maximum 20 bytes

A control attribute bearing the label "numMapElements" is now added as the final entry. This specifies the number of entries (parameters) used. It should be noted that the control attribute itself is not counted.

1.6.6   Sequence and handshake

This chapter uses flowcharts to describe the sequences involved in a measurement and the handshake with the superordinate system(s).

The following applies to all sequences: If a fault develops in the measuring system, the sequence is interrupted and the field bus master is alerted. A fault must be acknowledged either via the button in the System tab or by setting the reset bit on the bus. The sensor network connection is the exception to this. Once the fault has been remedied, i.e. once the connection has been restored, the system is also once again ready for operation.

Attention: One set of signals is not controlled via the WeldVision bus participants described above, but rather via an additional 24V IO bus module. This also supplies the sensor's 24V inputs for the laser signals (In0) and measurement / image capture (In1).

The signals can be defined in the ProtocolConfig, however they are ignored since they do not run via the WeldVision software, but instead represent purely hardware signals.

Signal direction	Seamvision -> field bus master	Meaning
SmartRay -> Master	24V fault or air conditioning alarm	Fault (0); No fault (1) Only present in the SmartRay distribution cabinet

SmartRay -> Master	Laser feedback	On (0); Off (1)
Master -> SmartRay	Blowing ON	On (1); Off (0)
Master -> SmartRay	Laser and image capture ON	On (1); Off (0)
Master -> SmartRay	Start measurement	On (1); Off (0)

1.6.6.1   *Automatic measuring mode controlled by the field bus master*

This flowchart illustrates how WeldVision is controlled via the field bus master in normal mode for a measurement.

```
                    ┌──────────────────┐
                    │   Startsequenz   │
                    │     Roboter      │
                    └──────────────────┘
                             │
         ┌───────────────────┴───────────────────────┐
         │                                            │
         │        ┌────────────────────────────┐      │
         │        │ Abfrage Eingangssignale:   │      │
         │        │ Störung Meßsystem ==0       │      │
         │        │ Störung Meßsystem ==0       │      │
         │        │ Steuerung in Automatik ==1  │      │
         │        └────────────────────────────┘      │
         │                     │                       │
         │              ╱──────────────╲               │
         │             ╱  Abgefragte    ╲      Nein     │
         │             ╲  Signale gesetzt ╱─────────────┘
         │              ╲──────────────╱
         │               Ja │
         │        ╱──────────────────╲    Nein
         │ Ja    ╱  Bauteiltyp setzen? ╲───────────┐
         ├──────╲                      ╱           │
         │       ╲──────────────────╱             │
         │                                         │
┌──────────────────┐                               │
│ Setze Ausgangssignal:│                           │
│     Bauteiltyp      │                            │
└──────────────────┘                               │
         │                                         │
         └────────────────┬────────────────────────┘
                          │
                ┌────────────────────┐
                │ Setze Ausgangssignal: │
                │   ProgrammNummer    │
                └────────────────────┘
                          │
         ┌────────────────┴──────────────┐
         │                               │
         │     ┌────────────────────┐    │
         │     │ Abfrage Eingangssignale:│ │
         │     │ Sensor messbereit==1  │   │
         │     └────────────────────┘    │
         │              │                 │
         │       ╱──────────────╲   Nein  │
         │      ╱  Abgefragte    ╲────────┘
         │      ╲  Signale gesetzt ╱
         │       ╲──────────────╱
         │         Ja │
         │     ┌────────────────────┐
         │     │ Setze Ausgangssignale: │
         │     │  Messung starten=1   │
         │     └────────────────────┘
                          │
                          ▼
```

Setze Ausgangssignale:
Laser und Bildaufnahme=1

Roboter fährt Naht ab

Setze Ausgangssignale:
Laser und Bildaufnahme=0

Letzte Naht

Nein

Ja

Setze Ausgangssignale:
Messung starten=0

Abfrage Eingangssignal:
Messung läuft

Messung läuft==0

Nein

Ja

Abfrage Eingangssignale:
Messung IO
Messung NIO

1.6.6.2 *Verification drive controlled by the field bus master*

The flowchart below illustrates how the verification drive for the sensor is controlled via the field bus master. A special verification job is selected for this which is coded with job number 99. The robot must shut down the verification plate.

```
                          ┌──────────────┐
                          │    Start     │
                          └──────────────┘
                                 │
                                 ▼
                  ┌────────────────────────────────┐
                  │ Abfrage Eingangssignale:        │◄─────────┐
                  │ Störung Meßsystem ==0           │          │
                  │ Störung Meßsystem ==0           │          │
                  │ Steuerung in Automatik ==1      │          │
                  └────────────────────────────────┘          │
                                 │                              │
                                 ▼                              │
                            ◇ Abgefragte                        │
                              Signale gesetzt ◇──── Nein ───────┘
                                 │
                                Ja
                                 │
                                 ▼
                            ◇ Bauteiltyp setzen? ◇
                    Ja ◄────────┘         └──────► Nein
                     │                               │
                     ▼                               ▼
         ┌──────────────────────┐       ┌──────────────────────┐
         │ Setze Ausgangssignal: │       │ Setze Ausgangssignal: │
         │ Kalib aktiv=1         │       │ Kalib aktiv=1         │
         │ Bauteiltyp=?          │       │                       │
         └──────────────────────┘       └──────────────────────┘
                     │                               │
                     └──────────────┬────────────────┘
                                    ▼
                      ┌──────────────────────────┐
                      │ Setze Ausgangssignal:     │
                      │ ProgrammNummer=99         │
                      └──────────────────────────┘
                                    │
                                    ▼  ◄──────────┐
                      ┌──────────────────────────┐│
                      │ Abfrage Eingangssignale:  ││
                      │ Sensor messbereit==1      ││
                      └──────────────────────────┘│
                                    │              │
                                    ▼              │
                            ◇ Abgefragte           │
                              Signale gesetzt ◇── Nein ┘
                                    │
                                   Ja
                                    │
                                    ▼
```
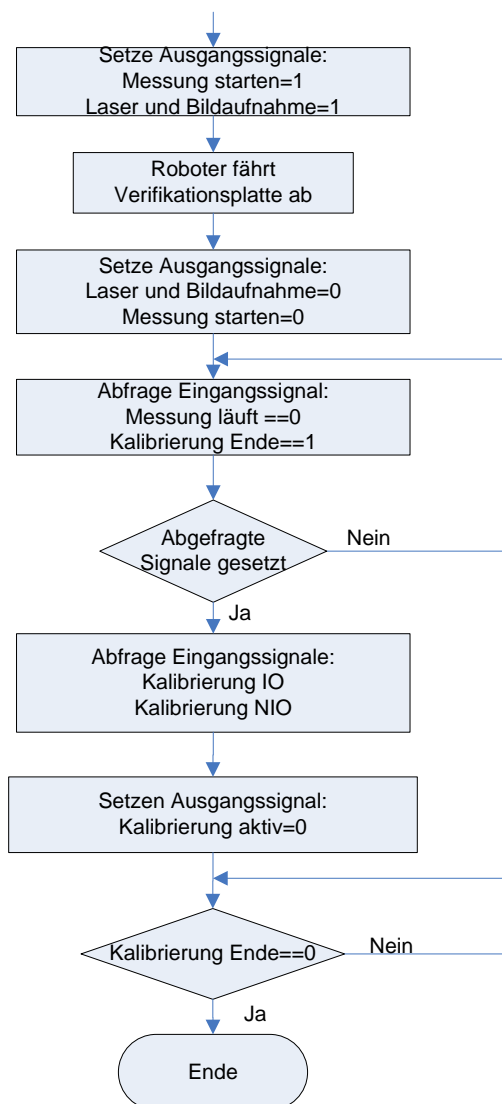
1.6.7 Examples of the configuration of the field bus DLL XML files

1.6.7.1 Example of a "DeviceConfig" file for Beckhoff (TwinCat) components

```
<?xml version='1.0' encoding='utf-8' standalone='yes'?>

<DeviceConfig>

<hardware outputsize="24"  inputsize="24" address="10.255.2.15.1.1" port="301"/>

</DeviceConfig>
```

1.6.7.2   Example of a "ProtocolConfig" file

```xml
<?xml version='1.0' encoding='utf-8' standalone='yes'?>

<SRPCProtocol>

<Settings ByteOrder="big-Endian"   />

 <OutputConfig

SysReady_RobOut="0|0|Bit"    MitMessung_RobOut="0|1|bit"   Alive_RobOut="0|2|bit" Stop_RobOut="0|3|bit"
        Einrichten_RobOut="0|4|bit"     Automatik_RobOut="0|5|bit" ErgebnisIO_RobOut="0|6|bit"
        ErgebnisNIO_RobOut="0|7|bit"

SensorReady_RobOut="1|0|bit"        MessRun_RobOut="1|1|bit"           LaserOn_RobOut="1|2|bit"
EnergySave_RobOut="1|3|bit"         CalibReq_RobOut="1|4|bit"          CalibEnd_RobOut="1|5|bit"
CalibIO_RobOut="1|6|bit"            CalibNIO_RobOut="1|7|bit"

JobNr_RobOut="2|1|Byte"

failure0_RobOut="3|0|Bit"           failure1_RobOut="3|1|Bit"          failure2_RobOut="3|2|Bit"
failure3_RobOut="3|3|Bit"           failure_AirCon_RobOut="3|4|bit"    failure_Energy_RobOut="3|5|bit"
failure_MessSys_RobOut="3|6|bit"     failure_Collection_RobOut="3|7|bit"

error_w1_RobOut="4|0|bit"           error_w2_RobOut="4|1|bit"          error_w4_RobOut="4|2|bit"
error_w8_RobOut="4|3|bit"           error_w16_RobOut="4|4|bit"         error_w32_RobOut="4|5|bit"
error_w64_RobOut="4|6|bit"          error_w128_RobOut="4|7|bit"

rg_dataValid_RobOut="5|0|bit"       rg_messRun_RobOut="5|1|bit"        rg_foundContur_RobOut="5|2|bit"
rg_collectErr_RobOut="5|3|bit"      rg_collision_RobOut="5|4|bit"

rg_disPos_RobOut="7|2|Byte"         rg_height_RobOut="9|2|Byte"        rg_roll_RobOut="11|2|Byte"
rg_pitch_RobOut="13|2|Byte"

partId1_SpsOut="15|7|Byte"          type_SpsOut="22|2|Byte"            typA_SpsOut="22|7|bit"
typB_SpsOut="22|6|bit"              typC_SpsOut="22|5|bit"

partId2_SpsOut="24|7|Byte"          messQualIO_SpsOut="31|0|bit"       messQualNIO_SpsOut="31|1|bit"
lineStop_SpsOut="31|4|bit"          teachModus_SpsOut="31|5|bit"

rwOneID_SpsOut="32|7|Byte"          rwOneIO_SpsOut="39|0|bit"          rwOneNIO_SpsOut="39|1|bit"
rwOneNoMess_SpsOut="39|2|bit"       rwOneNioLeft_SpsOut="39|3|bit" rwOneNioRight_SpsOut="39|4|bit"

rwTwoID_SpsOut="40|7|Byte"          rwTwoIO_SpsOut="47|0|bit"          rwTwoNIO_SpsOut="47|1|bit"
rwTwoNoMess_SpsOut="47|2|bit"       rwTwoNioLeft_SpsOut="47|3|bit" rwTwoNioRight_SpsOut="47|4|bit"

numMapElements="63"

 />
```

```
<InputConfig

Quit_RobIn="0|0|bit"          Deselect_RobIn="0|1|bit"       Alive_RobIn="0|2|bit"          Stop_RobIn="0|3|bit"
RobHand_RobIn="0|4|bit"       RobAuto_RobIn="0|5|bit"        AirOn_RobIn="0|7|bit"

PilotLaserOn_RobIn="1|0|bit"       StartMeasure_RobIn="1|1|bit"        LaserOn_RobIn="1|2|bit"
EnergySave_RobIn="1|3|bit"         CalibActiv_RobIn="1|4|bit"

JobNr_RobIn="2|1|Byte"

rg_RoboReady_RobIn="5|0|bit"       rg_Search_RobIn="5|1|bit"           rg_Track_RobIn="5|2|bit"

rg_Error_1_RobIn="7|1|Byte"        rg_Error_2_RobIn="8|1|Byte"

rg_Speed_RobIn="15|2|Byte"

partID_SpsIn="17|7|Byte"           partType_SpsIn="24|2|Byte"          typeA_SpsIn="24|0|bit"
typeB_SpsIn="24|1|bit"             typeC_SpsIn="24|2|bit"

resetLineStop_SpsIn="26|4|bit"     teachMode_SpsIn="26|5|bit"

reworkID1_SpsIn="28|7|Byte"

reworkID2_SpsIn="36|7|Byte"

numMapElements="28"



/>

</SRPCProtocol>
```

1.7   System commissioning checklist

In order to make the commissioning process as quick and smooth as possible, a few questions need to be clarified in advance.

- Is the power supply to the sensor, computer and required peripherals (robot, conveyor technology, etc.) intact?
- Are the sensor, power and field bus cables laid?
- In the case of setup without a distribution cabinet: Are the monitor, keyboard and mouse present?
- Has the field bus interface been clarified and the field bus connected or easily connectable to the SmartBox?
- Is the sensor fitted on the robot (sensor mount)?
- Are the robots and SPS programs prepared as per the interface description and job allocation?
- Is the TCP set up and the robot lane prepared as well as possible? (e.g. via RobCAD)
- Are a robot programmer, SPS programmer and system operator available on site?
- Are the accessibility and availability of the system ensured?
- Are there enough components available?
- Is the quality of the components representative (process-specific)?
- Has everything been agreed with the relevant project scheduler / person responsible?
- Have the general system settings been prepared?
- Are the steps from the following chapters 2 and 3 extensively understood, prepared and ideally already implemented?

2 Component information and setting up the testing procedure

This chapter provides an overview of what things need to be clarified or completed in advance before starting image capture and parameterisation. It also offers valuable tips that may be of use when planning the testing sequence.

The general component information is managed in the 'Setup' tab. The various component types are entered and managed in the Task list. Each type is divided up into a specific number of testing stages, which are known as jobs. The seams are then grouped together in one job into exactly one image. The job parameters and therefore also the seams are managed in the Parameters tab. The sub-division of the testing sequence into jobs helps to accelerate the testing process, especially for components with a large number of seams.

Component overview images in common formats can be loaded for each type in which the seam positions are defined for the subsequent visualisation of results.
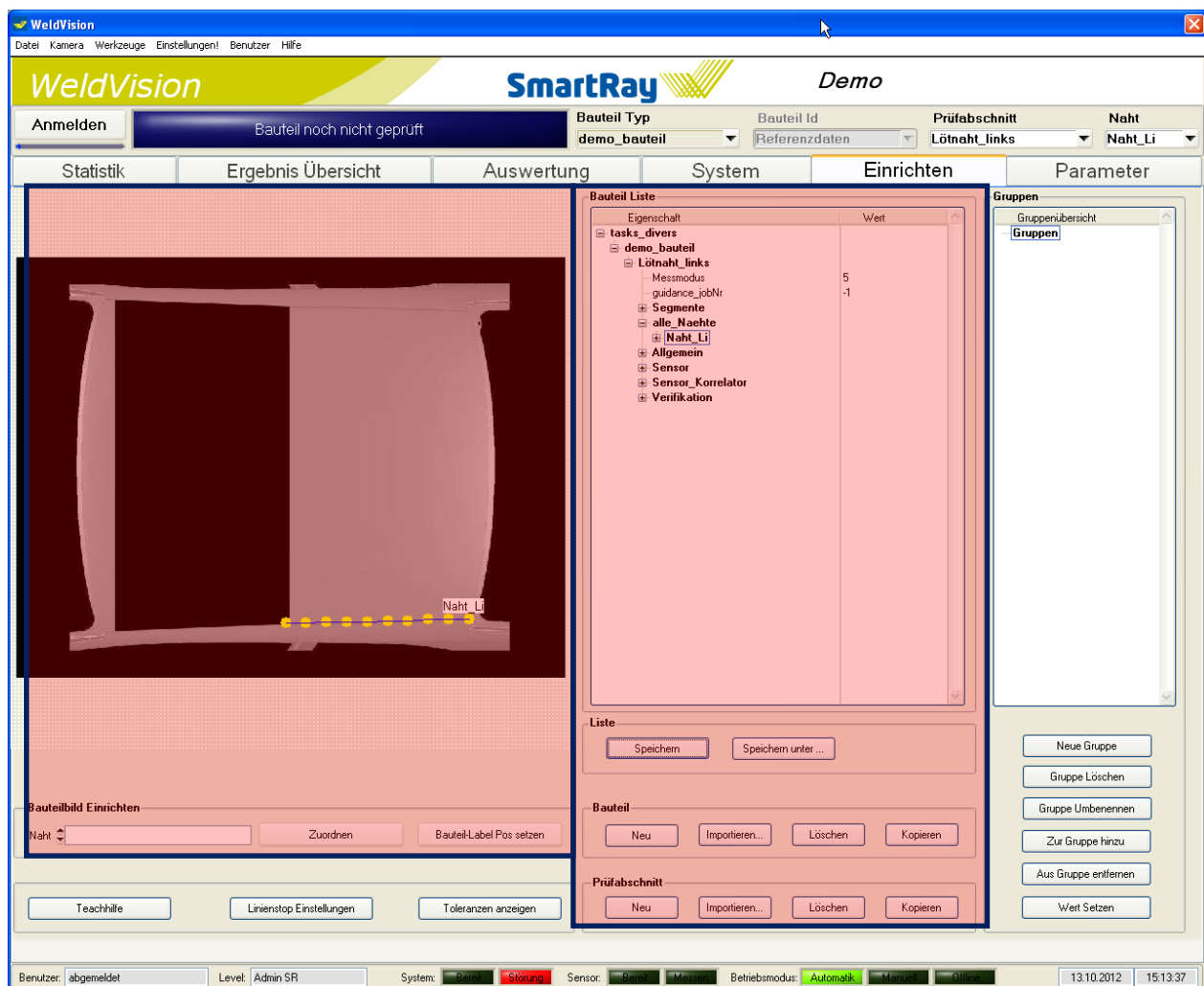
A newly selected image is only displayed when the software is restarted. More information about this can be found in the general WeldVision manual.

Attention! Tasks (component types) and jobs (testing stages) must be selected via the SPS or robot. IDs need to be assigned which can then be used for allocation purposes. It is also necessary to specify to each type the last job after the testing of which the component can be regarded as fully tested.
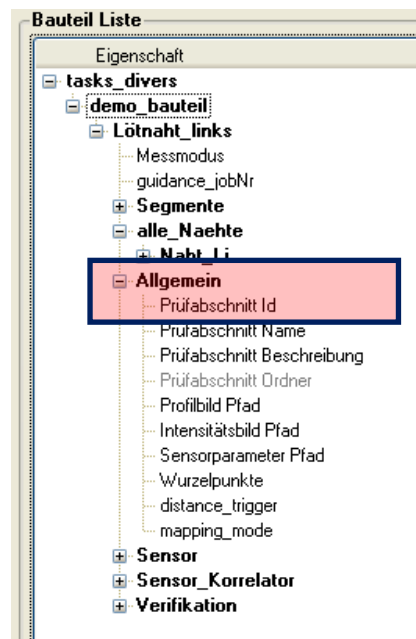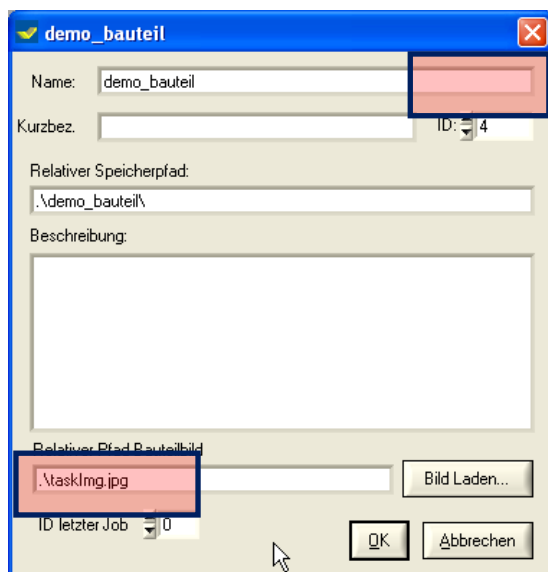
Further information on this topic can be found in the project-related field bus interface descriptions or must be agreed directly with the project manager.

2.1   Creating seams

Seams are created in the Parameters tab, since they are always part of a job. To add seams, simply select the "New seam" button and give it a name.

Attention! The name can subsequently only be changed in the Parameters field 'Seam name'. Updates are only made once the job is reloaded. It represents the seam in the visualisations and should therefore be chosen carefully.
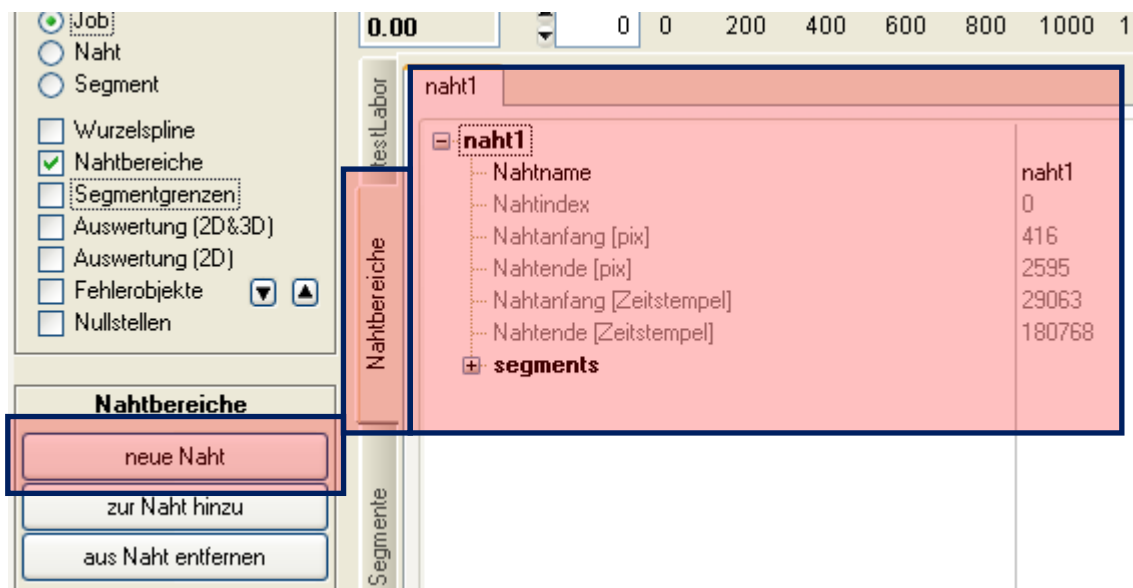
2.2   Planning the testing sequence

The type, job and seam name should be clarified and known before the setup phase begins. Changes are possible at any later point, although experience has shown that they can cause confusion.

Attention! The IDs must be defined from the start and should not be changed subsequently, since database entries, among others, use these numbers as reference points. Older data records may no longer be available for viewing after a change.

Attention! In order to significantly shorten the setup phase, template jobs or even tasks can and should be used wherever possible that can then be imported and renamed or copied.

The entire testing sequence should be clarified in advance in order to ensure clarity during the job division process.

Of note when dividing up jobs:

- Long sections (jobs) lead to very large images which, from 10,000 - 20,000 image lines upwards, become unwieldy when it comes to visualising the data later.
- Short sections, e.g. when each individual seam is given its own job, lead to unnecessary dead times as a result of a certain overhead during job changes, thereby jeopardising the cycle time. Depending on the tasks in hand, a time of 1-2 seconds per job is a perfectly reasonable assumption. With short jobs, this time is significantly less than 1 second, however the volume of changes can increase the amount of time taken.
- Too many jobs muddle the structure of the task list.
- Collate seam groups on the component using a sensible system into one job.
- The seams within a job are captured with the same sensor settings. Very different seams that may require different sensor parameters should therefore not be grouped into a single job.
- Large gaps between 2 seams are the ideal indicator for a job change.
- Larger gaps between 2 seams can be suppressed in the image capture by switching the laser. This allows a larger gap to be part of a job too without having to enlarge the image capture unnecessarily. If it is possible, however, a job change should always take place in the case of a very large gap.
- Is it possible to use tried-and-tested template jobs for known tasks? SmartRay is able to provide prepared jobs for some applications.

Attention! If the jobs are set up and the robot lane taught, compliance with the required cycle time must be checked and ensured with test drives. If problems arise at this stage, the job division may need to be reconfigured. Consequently, this step must be completed without errors and frozen before any further steps. You must also take note of the dead times for job changes caused by possibly longer evaluation times at the end of a job. Since evaluation is usually not yet activated in this phase, these may not even occur. If possible, a dummy evaluation should be drafted that reflects the evaluation time to be expected as realistically as possible. Plan time reserves of a few seconds, since under Windows and where the computer is carrying out a range of other tasks, fluctuations can be expected in terms of time.

3   Principles of sensor setting and positioning

This chapter explains to you the principles behind setting and positioning the sensor.

The orientation of the sensor towards the seam or component surface is of crucial importance for the quality of the subsequent evaluation and assessment of the seam. The quality of the robot lane is therefore also particularly important. As well as using mechanical teaching aids for rough pre-programming of the lane, WeldVision also offers setup assistance that makes the precise alignment of the sensors easier. This is based on the sensors' live image function, i.e. the current image of the laser line on the sensor is displayed. The engageable crosshairs indicate the centre point of the measuring area. The sensor must be positioned so that the laser line moves in the area of the crosshairs.

Attention! When working with the setup assistant, the system should be in setup mode. To do this, switch to Setup mode in the System tab.
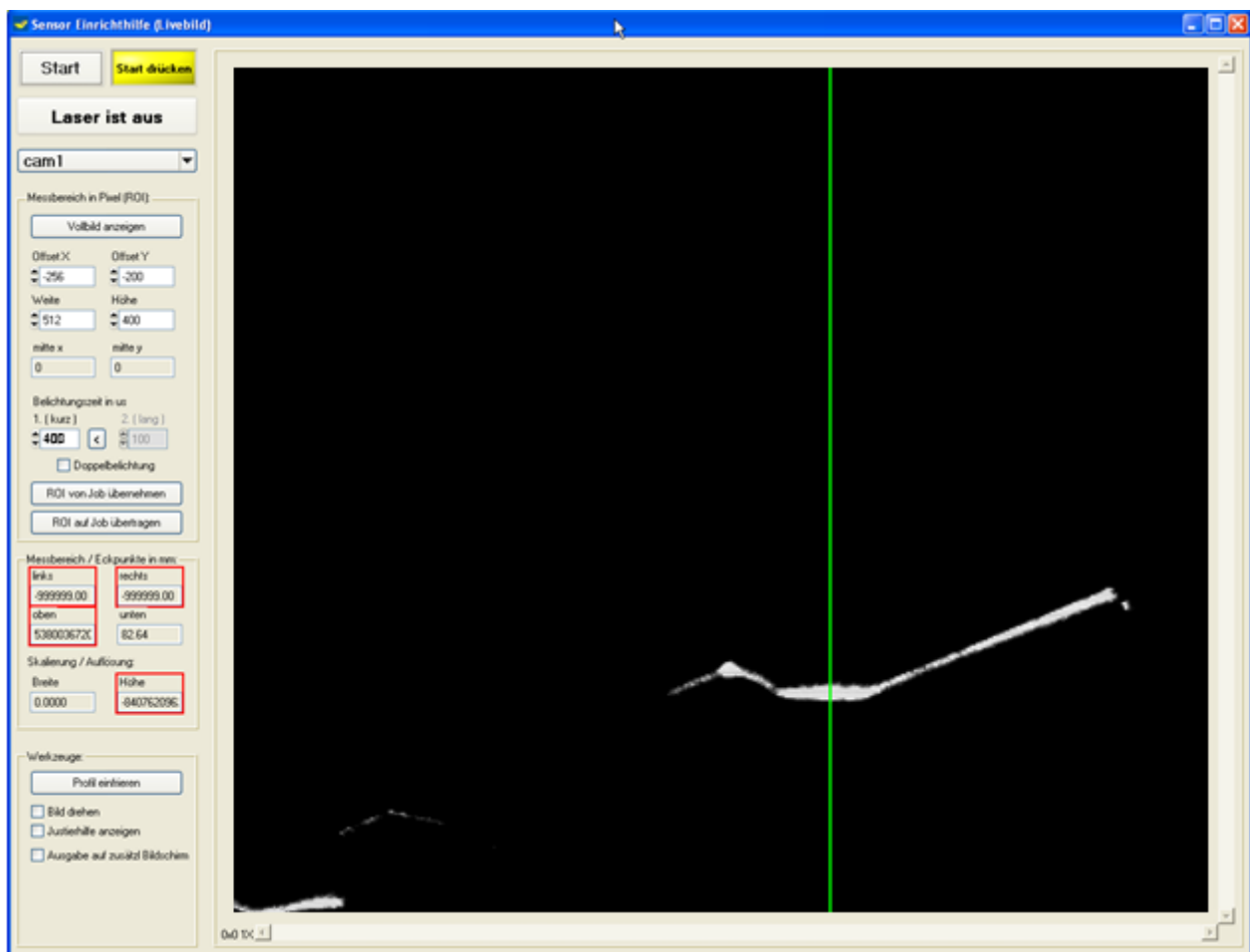
3.1   ROI setting (sensor reading range)

ROI stands for Region of Interest and describes the ideal size and position of a rectangular section on the image sensor that is to be viewed. The digital image sensor, like any conventional digital camera, is comprised of many image points or pixels which, arranged next to and below each other, span a rectangular area. Depending on the sensor used, this rectangle can be made up of 1280 x 1024 or 640 x 480 pixels, for example. The ROI parameters now describe a rectangle within this pixel array. The size and position of the rectangle determine the sensor's ideal visual and measuring range.

The coordinates origin of the ROI is not, as would normally be the case, at the bottom left-hand edge of the image, but rather at the centre of the sensor's full measuring range. This point is described by the coordinates Centre X/Y. As a result of production tolerances in the sensors, this may vary from sensor to sensor by max. 10% of the overall sensor size. The point is set during the calibration of the sensor at the factory and serves as a reference point for each ROI setting.

The centre point can be visualised by selecting **Show cross-hairs.** A set of crosshairs appears in the image.

OffsetX and OffsetY coordinates are therefore typically negative.

This dependence ensures that, in the event of the sensor being changed, the desired measuring range remains virtually identical and that no parameter adaptations are required either to the sensors or in the assessment stage.

Offset X	Start point in x of the ROI
Offset Y	Start point in y
Width	ROI: Width
Height	ROI: Height
Centre X	Centre point of the actual measuring range
Centre Y	Centre point of the actual measuring range

The start point of the ROI on the sensor is therefore calculated as follows:

SensorStartX = CentreX + OffsetX

SensorStartY = CentreY + OffsetY

The end point of the ROI is accordingly:

SensorEndX = CentreX + OffsetX + Width

SensorEndY = CentreY + OffsetY + Height

During setting operations, care must be taken to ensure that the ROI (the corner points) are not outside the sensor.

Attention! The parameters OffsetX and Width must be checked for divisibility by 8, 24 or 32, since this is specified by the architecture of the various sensors.

WeldVision will display invalid settings.

Setting rules:
- The ROI should not be positioned completely up to the edge of the sensor. A minimum distance of approx. 10% of the full size of the sensor should be observed, e.g. for a 480 pixel sensor width or height, SensorStartX or Y should start at no earlier than 48 pixels and end at 480-48 = 432.
- The sensor's profile rate / scan rate, e.g. 1000 profiles / second, depends not only on the exposure time, but also very much on the size of the ROI selected (width and height). The ROI must be chosen so that the desired scan rate is achieved and the requisite measuring range is also covered at the same time. See also 'Requirements on the scan rate'.
- Since the greatest accuracy of the sensor can be expected in the centre point of its measuring range, it makes obvious sense to arrange the ROI around this centre point. Exceptions to this may arise depending on the application's requirements.
- When making settings, deactivate **Rotate image** since otherwise the X and Y axes will be inverted in the image.

The measuring range set with the ROI is displayed as additional information in mm. In the event of implausible values, the conversion table for the sensor being used does not appear. The function of the setup assistant is not affected by this, however.

3.2 Requirements on the scan rate

Depending on the task in hand, the system must be able to find errors with a certain minimum size. As well as the pre-specified resolution (= points per mm) of the sensor in width and height, which can still be changed within limits by varying the measuring distance, there is also the resolution in the direction of travel, the 3rd dimension. This depends on the travel speed and the scan rate of the sensor, also known as the profile rate or refresh rate. The scan rate itself depends, as already described above, on the size of the ROI. It determines, as a function of the robot's feed rate, the resolution in the direction of travel. In ideal cases, the resolution in the direction of travel should be exactly as small as the resolution in width (lateral resolution).

Example:
A robot travels at 100 mm/s. With a scan rate of 1000 Hz, this yields 1 profile every 0.1 mm. If a sensor is used with a lateral resolution of also 0.1 mm per pixel (profile point), this yields an ideal ratio of 1:1. Sensors with a higher resolution, e.g. 0.05 mm per pixel, should therefore also have a higher scan rate, or the travel speed must be lower in order to re-approximate the 1:1 ratio.

Attention! The system's detection accuracy depends not only on the resolution of the sensor, but also on the resolution in the feed direction.

The ideal ratio is one of 1:1. Experience has shown that a ratio of up to 1.4:1 still yields good results. Based on the above example, this corresponds to a scan rate of 750 Hz.

The following rule of thumb applies to fault detection:
The smallest detectable characteristic should be at least five times the resolution.

With this sample setup, it is therefore possible to detect errors with a diameter of 0.5 mm. Better resolution in all dimensions also leads to better detection. Systems with a resolution of 0.025 mm can detect errors down to 0.1 mm. At this order of magnitude, however, other factors come into play that make detection much more difficult, such as the surface properties of the material being tested. The detectability then shifts upwards in certain circumstances.

The scan rate can be read off in the System tab under the sensor status information. It is updated as soon as a recording has been started with the current parameters.
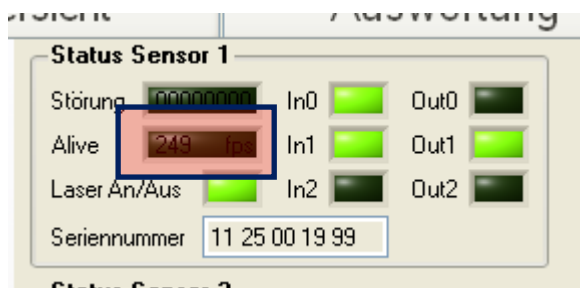
3.3 Setting the exposure time

The choice of optimum exposure time is extremely important for the quality of the profile generation.

Profile sections that are too dark or too light should be avoided, particularly in the relevant seam area. Experience has shown that the line thickness is 4-12 pixels, but this is ultimately very dependent on the sensor.

Generally speaking, as bright an illumination as possible should be aimed for without over-exposing the seam area.

Reflections can be reduced by reducing the exposure time. At the same time, however, there is a risk that parts of the surface will not be measured if too little light is captured from them.

One problem can be that there are both very bright and very dark points, such as smoke spots and silicates on the surface that can appear very dark. In this case, HDR mode should be used since otherwise the quality of the recorded profile may be too poor for the detection of small defects.

With the HDR approach, 2 exposure times are used. Experience has shown that the 2nd exposure time should be selected 3 to maximum 10 times longer than the 1st. The shorter exposure time is crucial for optimum illumination of the seam area.
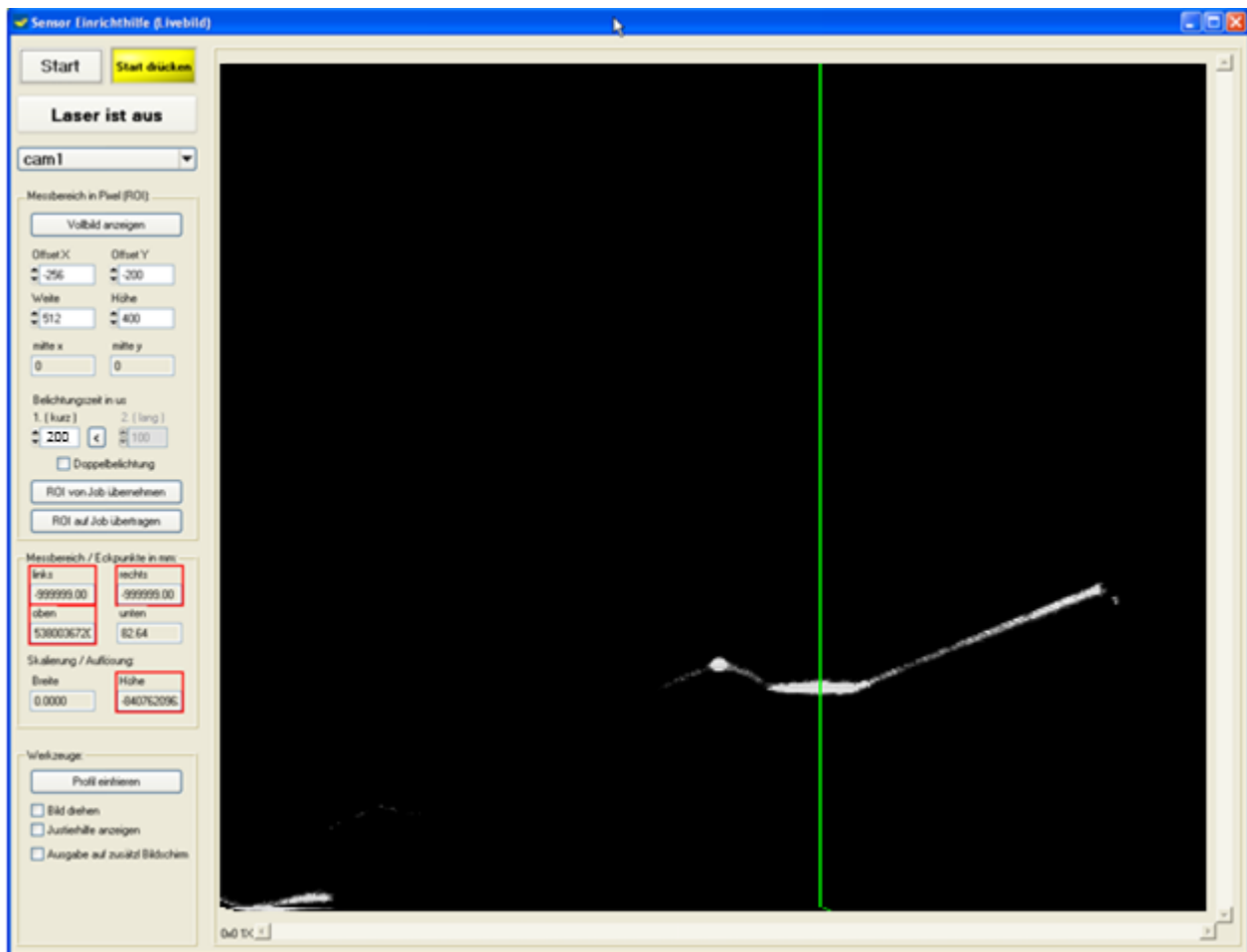
Optimum illumination (exposure time: 400 us)
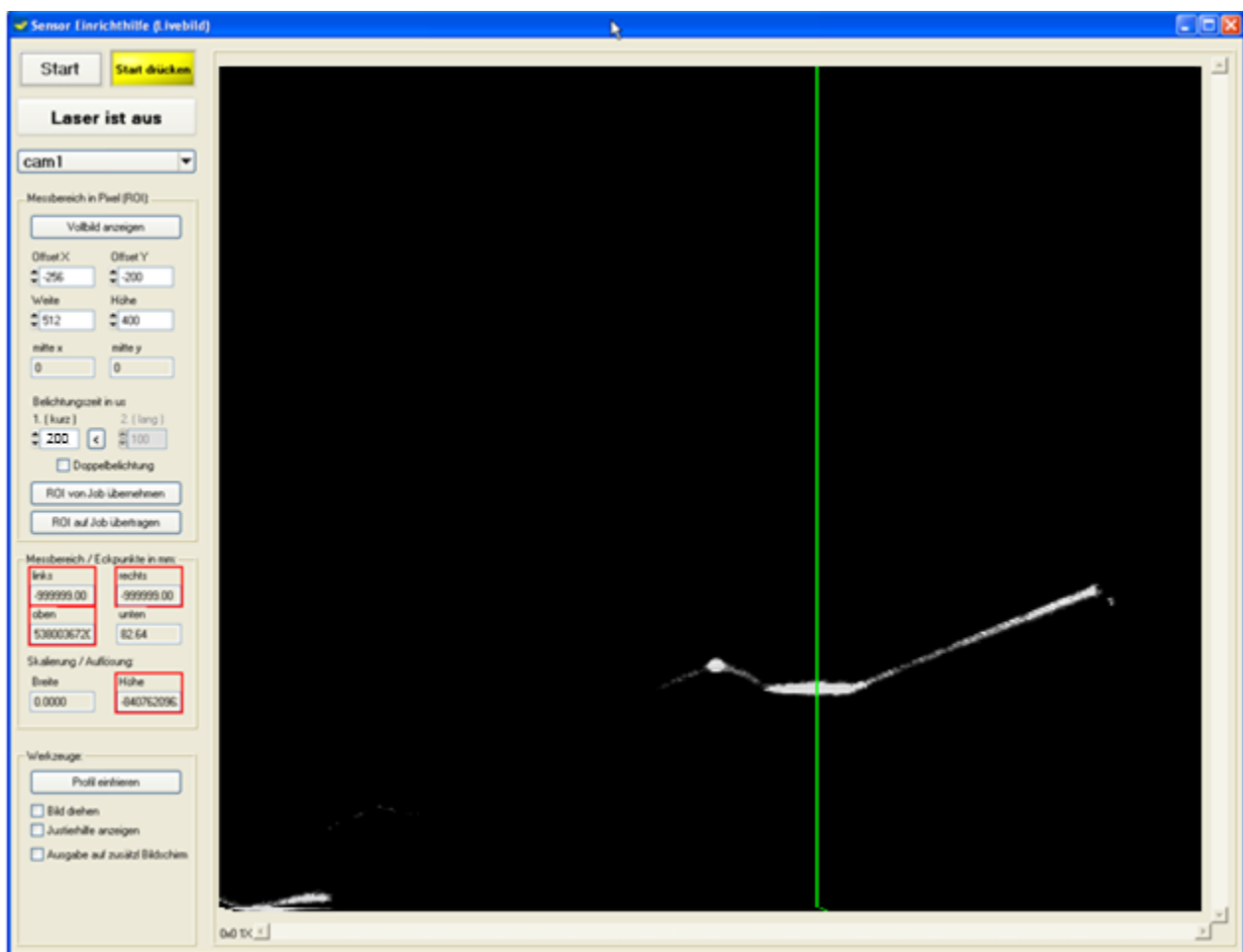
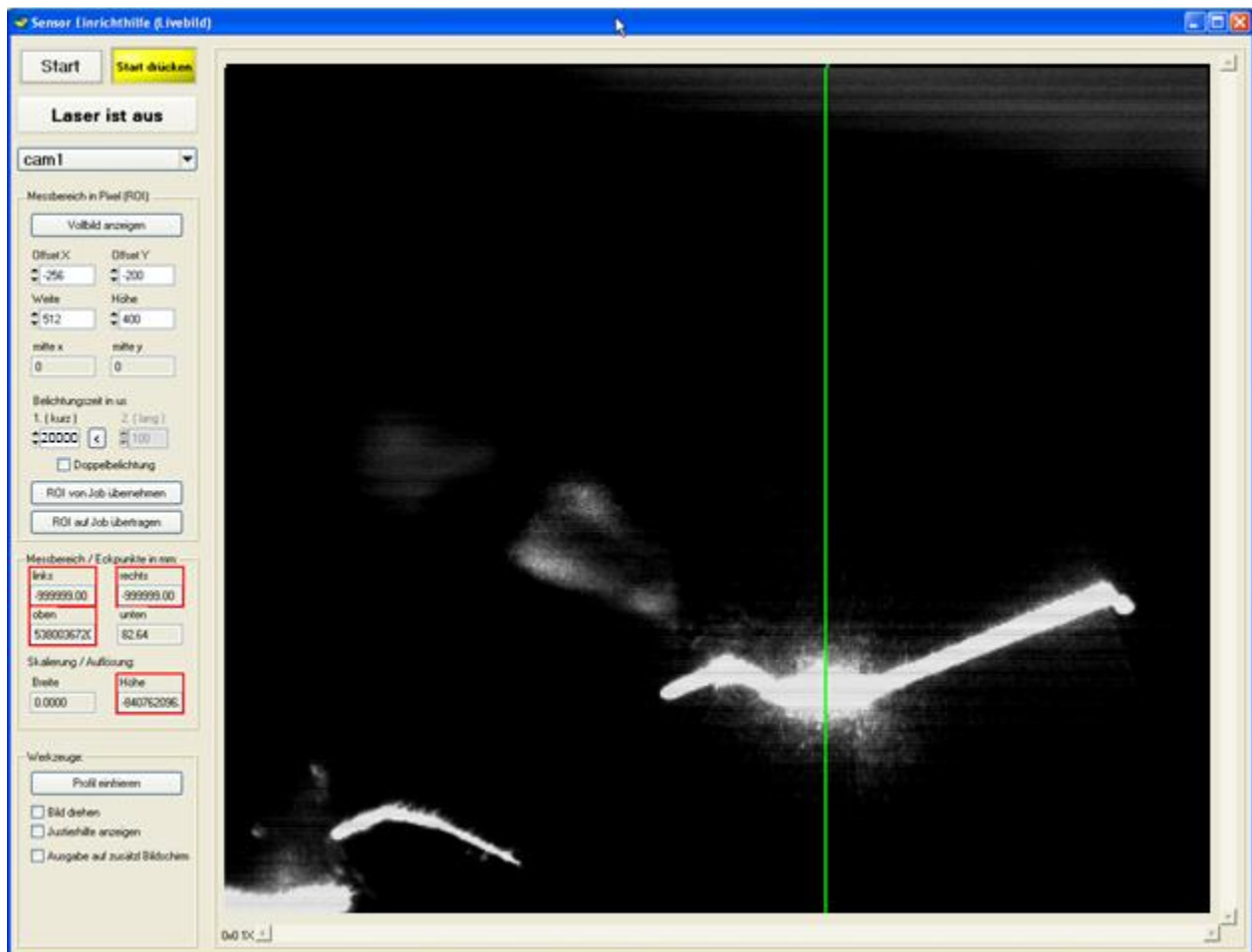Too bright illumination (exposure time: 2000 us)
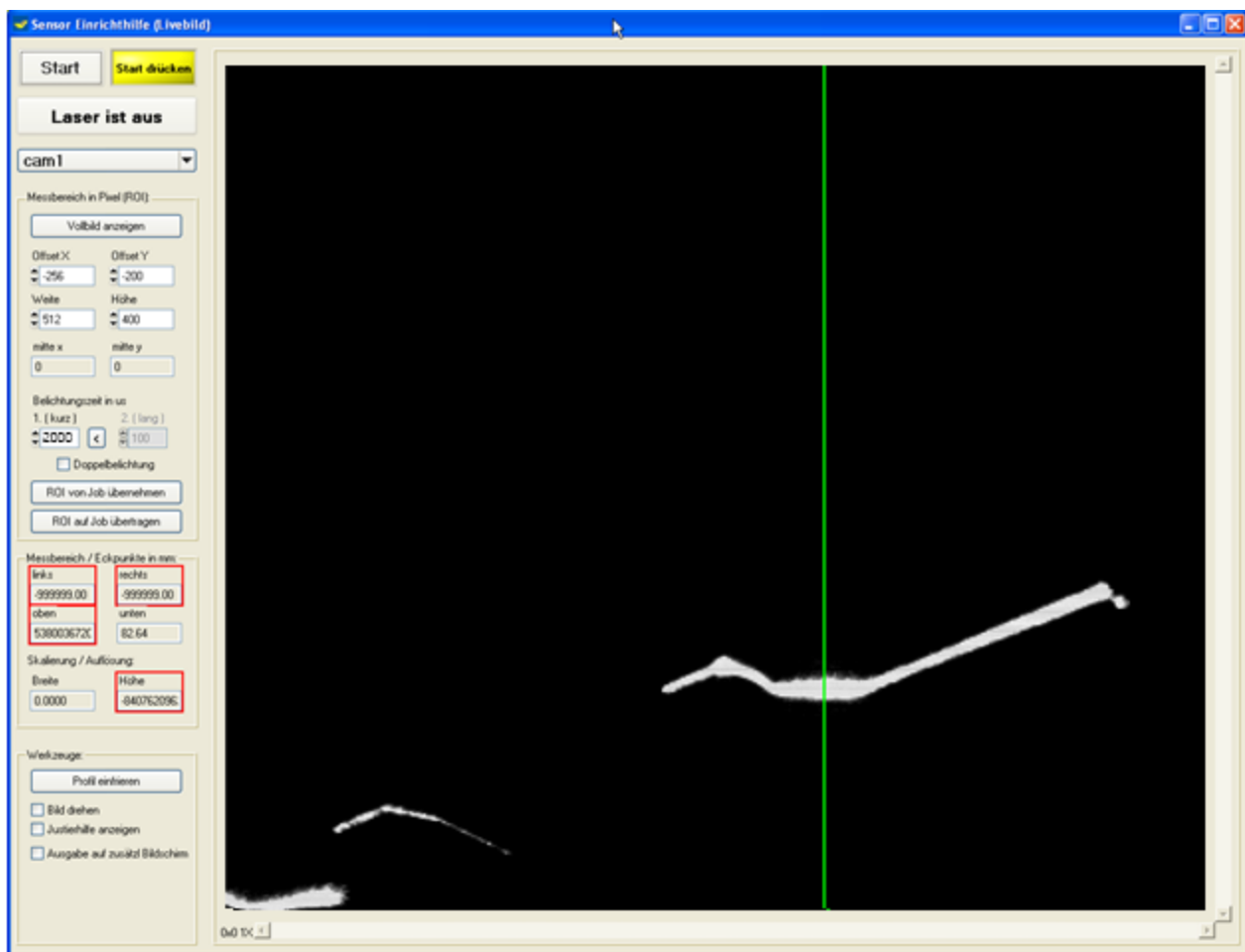
Illumination initially too weak, since parts of the laser line are visibly too dark (exposure time 200 us)

Far too bright illumination (exposure time: 20000 us)

The actually fine laser line is almost no longer appreciable as such. Reflections appear.

3.4 Units

The height and width or positional values are specified in the software in mm, but in some cases during the parameterisation stage also as points or pixels.

Height: 1/16 pixel = 1 height unit = depending on the sensor resolution (scaleZ) e.g. 0.009 mm.

Width: 1 profile point = 1 pixel = depending on the sensor resolution (scaleX) e.g. 0.100 mm.

3.5 Coordinates systems

The coordinates systems of the sensor and robot are arranged differently. It is therefore worth comparing the two.

Direction	Robot coordinates system	Sensor coordinates system
Feed / direction of travel (e.g. along the seam)	Y	Y
Direction of impact / height to the component	X	Z
Side / along laser line	Z	X
Yaw angle	A (rotate around x)	B (rotate around y)
Roll angle	B (rotate around y)	C (rotate around z)
Pitch angle	C (rotate around z)	A (rotate around x)

4   Setting up the robot lane

This section goes hand in hand with the previous sections. Before programming (teaching) the robot lane, planning and a few sensor settings first have to be carried out. After teaching, the first tests are performed to check that everything is running within the required framework. One of the most important points, for example, is adherence to the required cycle time.

4.1   Setting up TCP

The TCP can be set up using a mechanical aid, the sensor's CAD data or using the setup assistant in the WeldVision software.

The following steps describe the setting up of TCP using the WeldVision setup assistant:

1. Open the setup assistant, launch it and activate the crosshairs
2. Select the 4-point method on the robot
3. Now position the sensor from four different directions over a small hole, an Edding point or another point-like object on a surface (the verification panel offers holes of various diameters), so that the object lies in the desired position in the image, e.g. in the crosshairs.
4. Done

4.2   Requirements on the robot lane

When programming the lane, the following points must be noted:

- The WeldVision setup tool should always be used, since only this enables the quality of the lane and the profile quality to be expected as a result to be tested.
- To begin with, ideally only a few points should be programmed across the entire lane.
- A test run and a look at the setup tool indicate the fluctuations in the laser line in the image and therefore the fluctuations in the measuring distance and the position relative to the seam. Under no circumstances should the laser line drift out of the ROI. Generally speaking, the greater the deviations the broader the ROI may need to be set and therefore the slower the sensor will become. Countless further disadvantages can also arise later in the evaluation stage. The height of the fluctuations should therefore be reduced to a minimum.
- Points may need to be corrected and/or interim points set.
- Vibrations should where possible be avoided or minimised.
- Changes in the direction (angle) of the sensor relative to the seam from point to point should ideally be avoided in order to ensure even movement.
- The lane speed should be kept as constant as possible if the speed compensation feature is not used.
- Adherence to the cycle time or compliance with the target lane speed must be checked. Since WeldVision requires a little time between 2 jobs (e.g. sub-programs, follow-ons, etc.) for evaluations or the sequence handshake, sufficient reserve should be planned into the cycle time review.
- Essentially, a late possible change in the robot program once the system has been set up usually leads to a large amount of duplicated setup work and should therefore be avoided at all costs. Despite the broad leeway and options provided by the WeldVision software and the SmartRay sensors, particular care should be taken when programming the lane. The more accurately work is carried out (taught) at the beginning, the less work will be needed later.

- Avoid unnecessarily fast accelerations (home position) in order to prevent subjecting the sensor to avoidable mechanical stress in the long term.

## 4.3 The setup process using the live image function

The following procedure serves as a guideline when setting up the robot lane using the live image function in the setup tool.

1. Set up the TCP in the focus or optimum middle measuring range of the sensor (see Setting up TCP). Roughly pre-position the sensor with respect to the component using the mechanical teaching aids, taking account of the measuring range applicable to the sensor and its centre.
2. Check in the System tab whether the sensor(s) is/are connected. The alive signal must slowly flash green. If there is no connection, the fuse circuit / emergency stop might be the cause since in some systems the sensors are supplied with power via these.
3. Open the setup tool via Menu / Camera / 2D/3D recording or use the Setup assistant button in the Setup tab.
4. Start live image view by clicking on the Start button.
5. If necessary, set the reading range of the sensor to maximum in order to make it easier to find the image of the laser line (see explanation on setting the ROI) or, if there are already parameters available, click **Get from job** to use the ROI settings from the job currently selected.
6. Switch the laser on. To do this, click **Laser on / off**.
7. If the environment, orientation and laser line are still unknown and invisible in the image, set the **exposure time** to a very high value, e.g. 10000 us. As soon as the laser line appears in the image, set the exposure time to a realistic value (see Setting the exposure time).
8. Now carefully position the sensor with respect to the component so that the area to be measured / tested is ideally within the crosshairs or is located within the desired ROI. For this 1st setup process, the sensors should be positioned over the seam, even if the start point of the image capture will later be before the seam.
9. In most cases, it is useful to select the ROI width a little wider than the seam being inspected in order to gather information for calculating the sheet model as well as the seam.
10. The WeldVision software allows you to subsequently compensate any lateral fluctuations of the lane within a certain framework. This is however only possible if additional edges that run parallel to the seam in the image (i.e. within the ROI) are visible. This may lead in certain circumstances to the ROI needing to be set wider than it would need to be for the seam inspection, and therefore to a lower scan rate.
11. If necessary, activate **Rotate image** since the laser line may appear vertically or horizontally in the image, depending on the sensor type. We recommend setting the image so that the laser line is shown horizontally in the image.
    a. The live image shows:
        i. Change in the measuring distance -> the laser line drifts upwards or downwards in the image, and can be controlled very effectively in the live image.
        ii. Lateral displacement along the laser line -> the contour in the image drifts to the side, and can be controlled very effectively in the live image.
        iii. Displacement in the direction of travel -> the contour changes only in the context of the new measuring position, and therefore cannot be controlled in the live image.
        iv. Change in the roll angle-> the laser line tilts, appears skewed in the image, and can be controlled very effectively in the live image.
        v. Change in the pitch angle -> the laser line becomes brighter or darker; the contour changes only in the context of the new measuring position (depending on the quality of the TCP setup), and therefore cannot be controlled in the live image.

vi. Change in the yaw angle -> the contour changes only in the context of the new measuring position, and therefore cannot be controlled in the live image.
b. Of note when aligning angles:
i. Set the pitch angle so that the laser is not reflected directly back into the receiving lens. Ideally set a slight angle of incidence, ideally one that reflects the laser away from the sensor. Deviate from this only in exceptional cases, e.g. if there is poor light or accessibility problems.
ii. Set the yaw angle so that the laser is ideally at 90° lateral to the direction of travel and therefore to the seam.
iii. Set the roll angle so that the sensor views the seam as much from the front as possible, e.g. in the case of fillet welds (T-joint) in the direction of the angle bisecting lines.
iv. In the event of reflections near the laser line, try optimising all of the angles to minimise the reflection or remove it from the laser line.
12. Now set the exposure time if necessary (see Setting the exposure time)
13. Once the 1st position has been found and set up, click ***Freeze profile***. The current image of the laser line is frozen as a profile and can now be used as an orientation aid for setting up the next points along the lane / seam. The start point before the seam can now also be programmed. If necessary, freeze the current profile repeatedly if the contour changes markedly along the lane (see robot lane planning).
14. The sensor parameters should now be adopted into the job. See below.
15. Once all points are set up, a test drive needs to be carried out and the live image checked. The laser line should not drift out of the ROI even between the lane support points. Try to achieve deviations in the position of the laser line in the image that are as small as possible. Now also look at the laser switching points, i.e. is the laser switched on a few mm before the seam and then switched off again a few mm after it? Once all the conditions are met, the setup tool can be closed and you can begin recording the first reference data records.
16. Once the quality of the recorded data has been checked, it may be necessary to make a few optimisations to the lane in order to minimise reflections, for example, or to correct excessive fluctuations. This procedure needs to be repeated until the reference data records are 100% OK. The criteria for assessing the data records will be described separately.

4.4 Sensor parameters

The sensor settings found using the setup tool must be adopted into the job(s). For the ROI and exposure time, there is the 'Transfer ROI to job' button, which makes the task simpler.
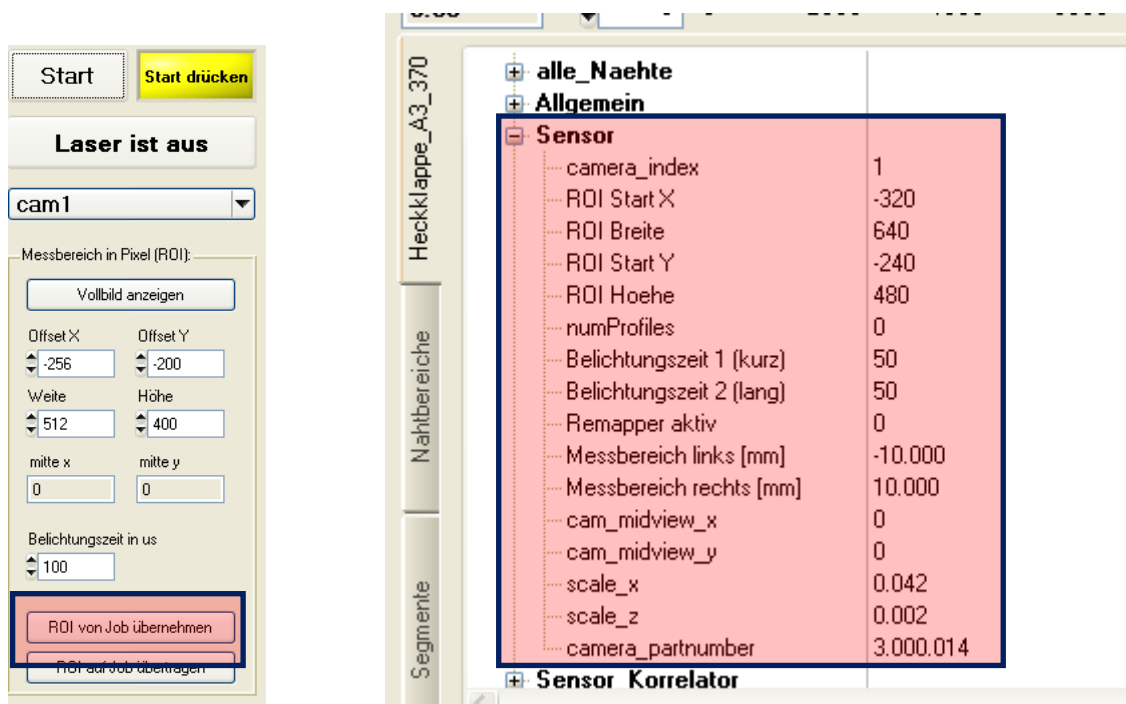
For the sensor, however, there are still a few other parameters that are not adopted automatically and which may need to be entered manually in the job, but which must at least be checked.

These are:

Camera index	When using more than one sensor, this parameter specifies which sensor is connected to the job.
ROI	Region of Interest reading range, determined using the setup tool.
Max. Number of Profiles	Determines the maximum number of profiles that the sensor can include for the job. 0 = unlimited.
1st exposure time	Exposure time, determined using the setup tool.
2nd exposure time	If HDR mode is used, a 2nd exposure time must be set.
Linearisation (Remapper)	The linearisation (remapping) can be engaged in order to convert the raw sensor data using the sensor's conversion table ([SensorName].lut) into equidistant pixels. The resulting image can then be used to directly measure very accurately via the scaling factors. This function is optional and only necessary if very high, absolute accuracy is required, or if there is a risk after changing sensors that the image will shift such that the previous evaluation no longer functions correctly.
Measuring Range Left	Determines the left-hand edge of the measuring range in mm relative to the sensor's fixed measuring range centre point (midview). The value can be read off directly in the setup tool and should be adopted during commissioning after the first-time setting of the ROI.
Measuring Range Right	Determines the right-hand edge of the measuring range in mm relative to the sensor's fixed measuring range centre point (midview). The value can be read off directly in the setup tool and should be adopted during commissioning after the first-time setting of the ROI.
Sensor centre x Sensor centre y	When calibrated at the factory, the sensor is given the coordinates of its measuring range centre point in pixel coordinates. The ROI is generated relative to this and ensures that even if the sensor is changed, the actual

|	measuring range always remains in virtually the same place despite the production tolerances in the sensor itself. The coordinates can be read off directly in the setup tool.
Scaling x	Scaling factor for the conversion of profile point indices into mm.
Scaling z	Scaling factor for the conversion of height units into mm.
Sensor part number	The specification of the sensor's 3.000.xxx number tells the system what type of sensor it is.

5   Recording reference image(s)

This chapter explains how the first reference images can be recorded, checked and stored.

Provided that the component information and test run have been set up in full, there is communication with the bus and the robot lanes and the sensor are set up as described above, the first reference recordings can now be made.

It is very probable that some recordings have already been made in order to check the robot lane and the sensor settings.

5.1   Setup mode and the first image capture

Recordings can of course be selected and started very easily in automatic mode or, if you prefer to first take snapshots of individual jobs, in manual mode. To do this, switch to Setup mode in the System tab. In order to suppress influences from the field bus, the field bus should also be deactivated by ticking the relevant option. Then select the desired job in the component list simply by clicking it and start the measurement manually by pressing the Start button.
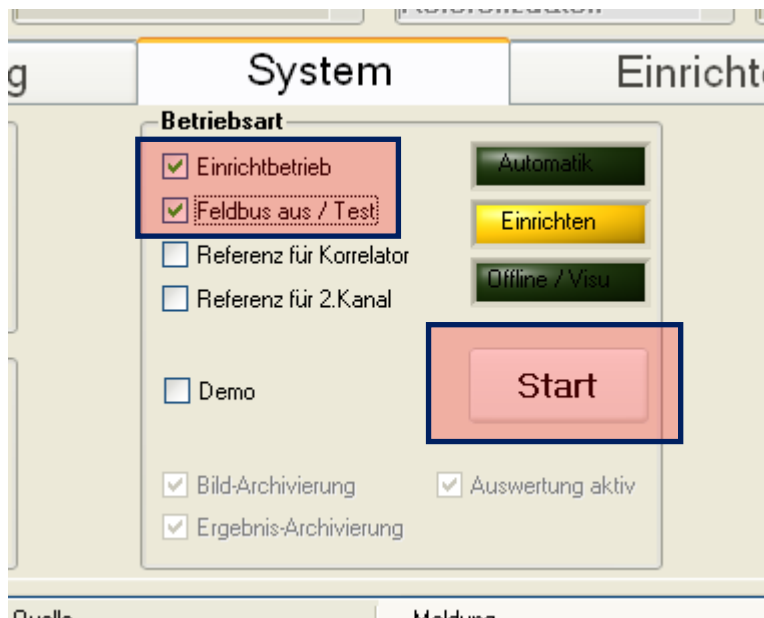
If the robot now travels down the lane, it controls the sensors via the signals 'Laser and image capture' and 'Start measurement'. The signals should be present at the inputs of Sensor In0 (laser) and In1 (image capture). This can also be checked in the System tab.
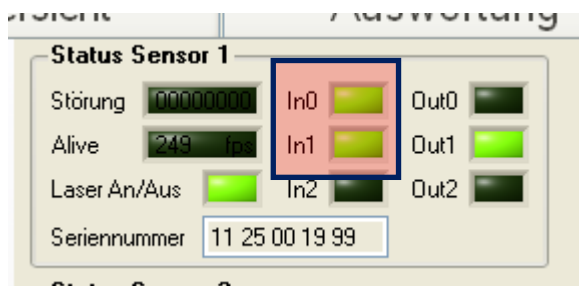
The 'Laser' and 'Image capture' (= measurement) signals are switched by the robot and sent via the field bus to an IO module. From there, they are transferred as 24V signals to the sensors. This measure is needed to respond in real time and therefore minimise fluctuations in the image capture process. To start image capture,

the 'Image capture' signal must be set and remain active until the entire job, i.e. the entire image capture, has ended. Meanwhile, 'Laser' switches the laser on at every seam and then, in the event of larger gaps between 2 seams, switched off again. The sensors generate data only when the laser is switched on. See also the 'Field bus' section.

The sensors begin sending data to WeldVision as soon as the robot starts moving. Meanwhile, in the System tab, the data blocks that are currently being transferred should appear as images of varying sizes.

5.2 Displaying and loading sensor image data

The sensor data can either be viewed and processed directly in the System tab at the end or also in the Parameters tab.

Attention! If it has not been done automatically, set the image source switch in the Parameters tab to 'Current' in order to see the current recording.
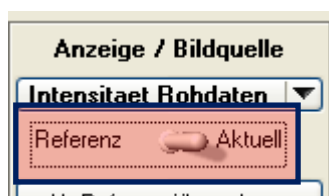
Depending on the settings in the configuration file, recorded sensor data is stored in the archive folder. The menu function 'Tools/Load Job (or Task) Archive Data' gives you access to the archived data records.
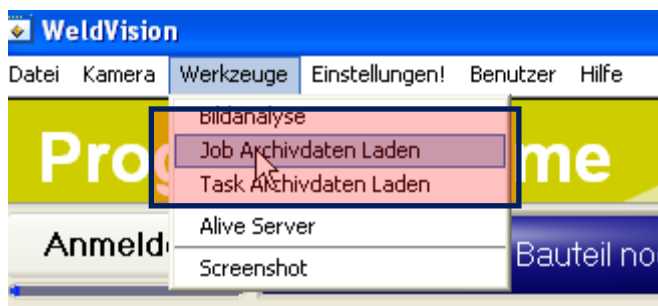
The most convenient and recommended method is to use the Statistics area. Even if no evaluation has been set up or carried out yet, the data records can be selected for viewing using filtering without database via the archive folders. This allows you to very easily jump between different data records.

See the chapter entitled 'Viewing, equilibrating and optimising results' below.

## 5.3 Adopting a recording as a reference

Each job requires a reference recording in order to firstly test the evaluation without having to load other data specially and secondly as a reference for the various actual evaluation methods. Details of this can be found in the chapter entitled 'Setting up / parameterising seam evaluation'. It is also easy to check with this method whether significant differences have occurred between the time of the reference data capture and the current data which would indicate that framework conditions may have changed.

If the viewing of the data records shows that all of the criteria for a good capture are met, e.g. visual range OK, exposure time OK, no disruptive reflections, etc., then this type of capture can be adopted as a reference. To do this, display this image in the Parameters tab and click the 'Adopt as reference' button.

Attention! Ensure that the image data also matches the job currently selected. It is usually selected correctly by the system. There are special cases, however, where the context is not automatically provided.
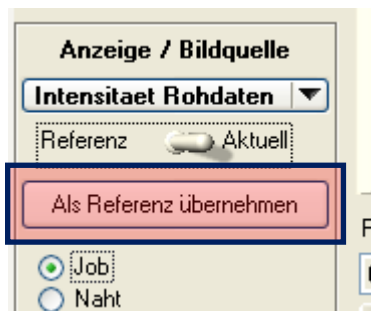
First select the image for both versions, i.e. for the contour model and for correlation.
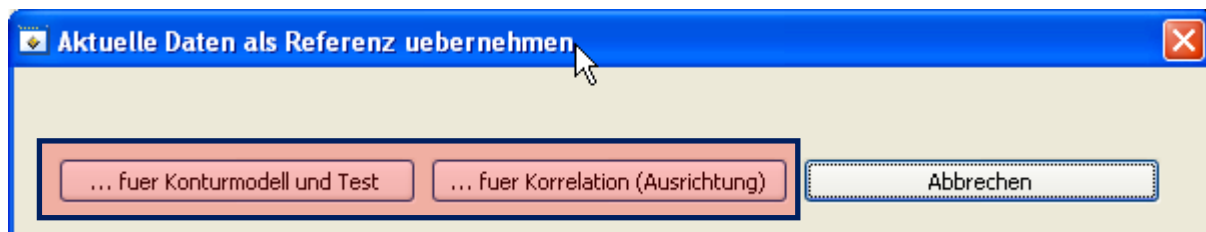
Attention! Now save the job in order to permanently store the reference.

# 6 Setting up / parameterising the seam evaluation

This chapter explains the terms that occur and the parameters available, as well as any steps required for the evaluation of the seam.

As soon as the reference image is available, parameterisation can begin. If it has not yet been done, select the desired job and switch to the Parameters tab.

Attention! You should at first only work on the reference image. To do this, set the image source switch to 'Reference'.

Attention! Sometimes, a change - for example of a parameter - is not immediately displayed in the image; in this case, simply re-evaluate it.

Attention! Virtually all parameters can be very easily copied and therefore transferred in order to save duplicating work, especially where there are many segments or seams, etc. To do this, simply click the right-hand mouse button 1 to 2 times on the parameter (group, seam, node) and select 'Transfer value' in the menu that appears. In the parameter tree structure, select the area into which you wish to copy the value(s). When copying across jobs, do not forget to save the entire component list.
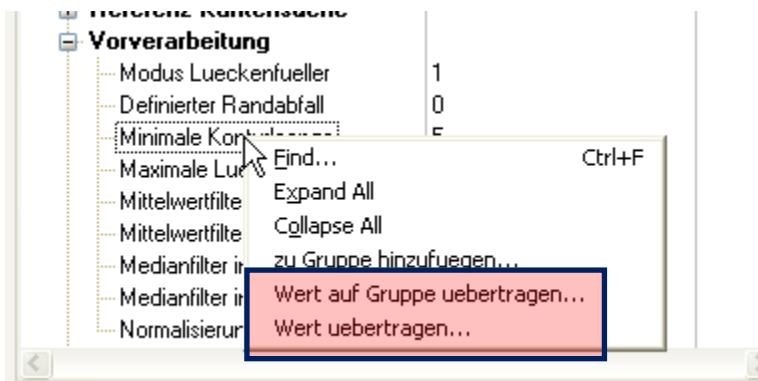
6.1   Segmentation

The next steps first involve dividing the image into segments and assigning the segments to the seams.

Why have segments?
- Since a job and therefore an image capture can contain more than just one seam, or image areas before and/or after the seam are simply uninteresting, the image is divided up into segments.
- The segments can also be processed during image capture as soon as they are available. This in turn dramatically shortens the evaluation time at the end of the capture and therefore also the waiting time between 2 jobs, and subsequently the cycle time.
- Various segments may require other methods and parameters for evaluation. Each segment can be set individually.

6.1.1   Splitting segments

To carry out segmentation, select the 'Split segment' tool and click the desired point in the image. A green line indicates the segment borders. The active segment appears normal, while the others appear greyed out. For this view, 'Segment borders' needs to be selected in the 'View' section.

Attention! Selecting the tool automatically takes you back to 'Select' in order to prevent any unwanted segmentations.

Segment borders can be moved using the 'Move start' and 'Move end' tools. Borders can also be moved by holding the Shift or CTRL button down and clicking directly with the mouse on the start / end of the currently-selected segment.

Segments are deleted by choosing 'Merge segments'. Alternatively, the segment can be selected in the 'Selection' area and deliberately deleted by clicking on the red x. The parameters of the merged or deleted segment are then lost.

'Select' and a click on the image selects the segment.

The 'Auto-split' function facilitates rapid, simple splitting of a segment into as many evenly-sized segments as you wish.
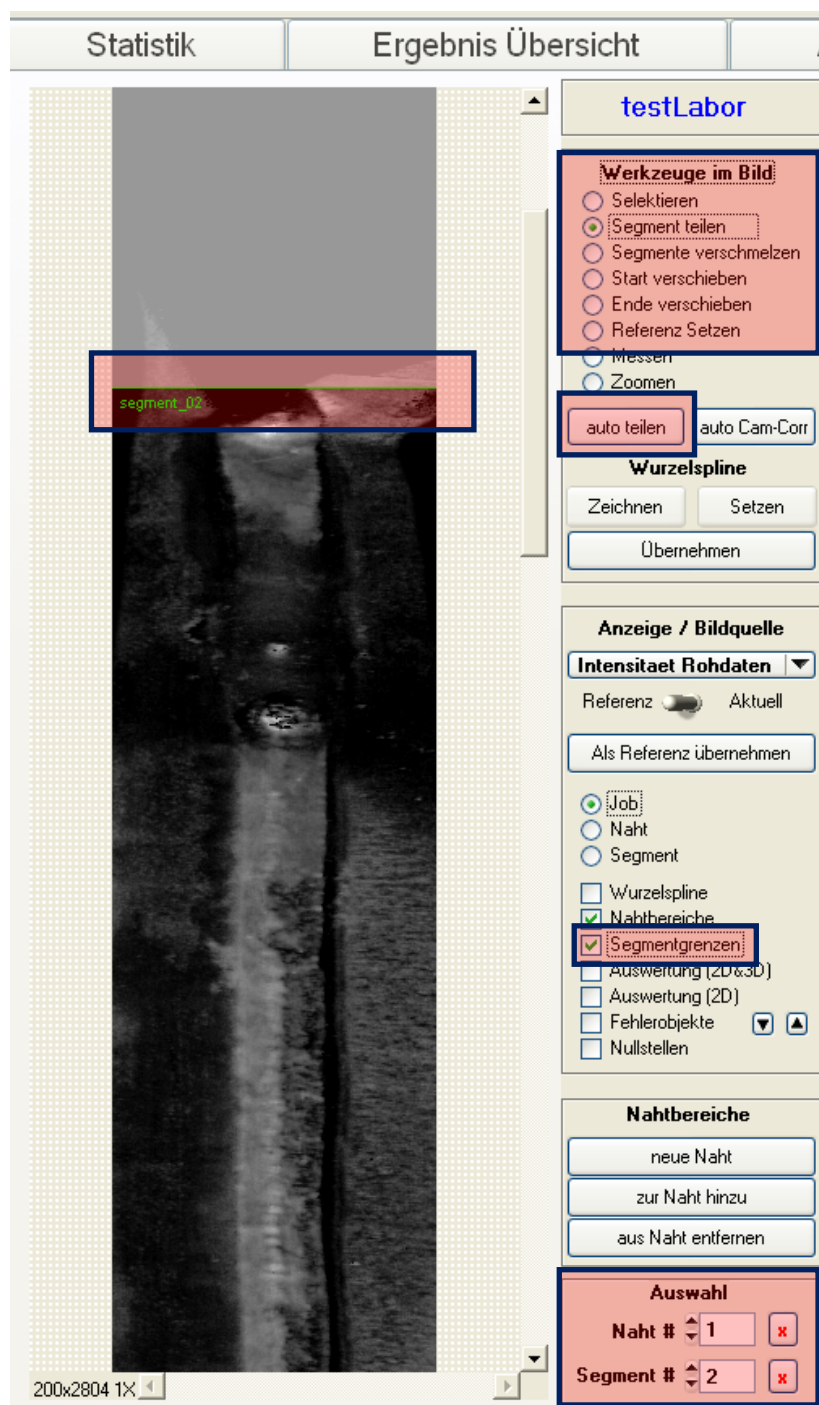
Each created segment generates a new entry in the Segments tab. Each segment has the same parameters.
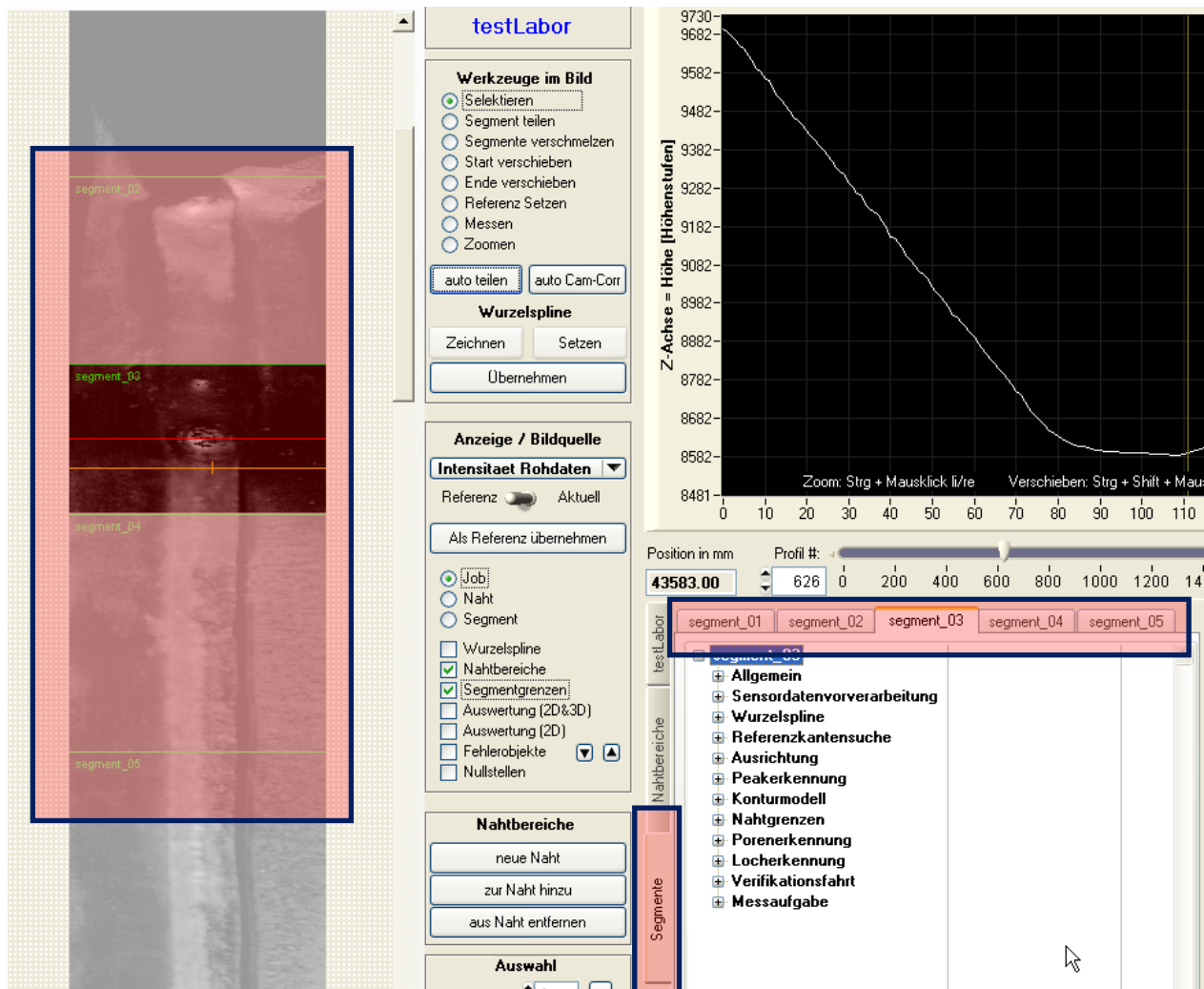
6.1.2 Assigning segments to a seam

The segments now need to be assigned to the seams.

To do this, switch to the 'Seam areas' tab, select a seam, select a segment in the image or in the bottom selection and click the 'Add to seam' button.

If a series of consecutive segments are to be assigned to the same seam, you simply need to assign the first and last segment to this seam and any segments inbetween will be assigned to the seam automatically.
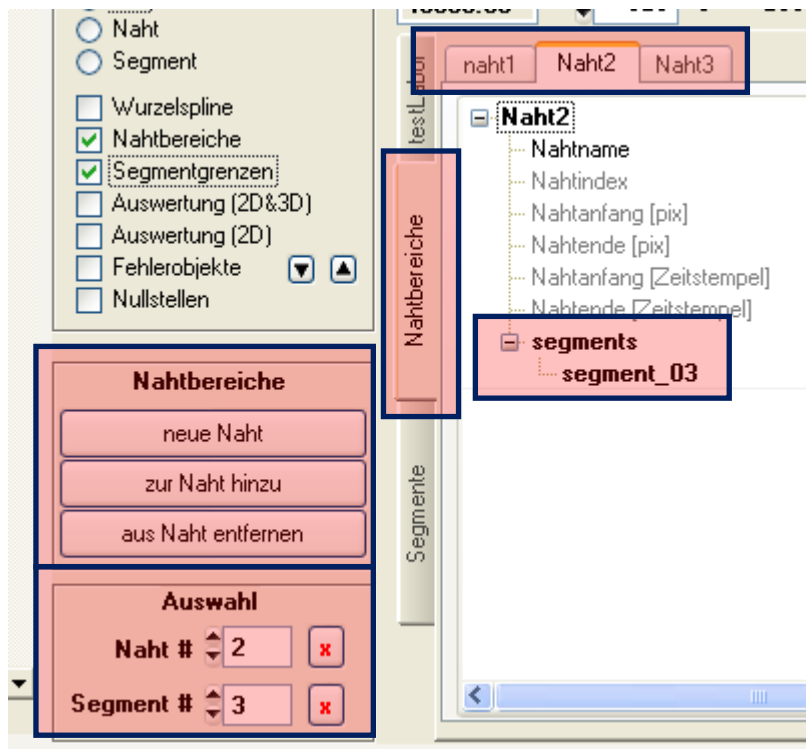
Once the segments are assigned to the seams, the seams in the component overview image can now also be positioned for the results display, for example for a reworking station. A bead is drawn along the illustrated line for each segment.

More information about segmentation and 'Drawing the seam in the component overview image' can be found in the general WeldVision manual.

6.1.3   Time stamp

What is the time stamp, and what is it used for?

The time stamp is only used internally and therefore is of no relevance to operators. Since it appears in some places, however, it is explained below:

The sensor provides a time marker for each profile (= 1 image line) that begins counting with the start of image capture. Items in the image data are determined using this time stamp and not using the image line number. The big advantage of this is that subsequent changes to the sensor settings, for example to the exposure time, can produce a longer or shorter image. If you wished to define the segment borders on the image line, for example, then the entire segmentation process and very likely the parameterisation process too would need to be carried out all over again. The time stamp method does away with this disadvantage.

Later versions calculate the current robot lane speed using time markers. This produces an almost identical image even if the lane speed changes.

6.2 Image data filtering (pre-processing)

6.2.1 Media and mean value filter

The sensor's raw data is initially not smoothed and therefore exhibits varying degrees of interference, depending on the surface captured. The sensor's resolution (= number of pixels per mm) is typically better than the characteristics being detected or, in other words, the resolution forcibly downgrades the detection level. The filtering and smoothing of data now produces clearer contours with less interference, however in certain circumstances it can also filter out small characteristics that are of the same magnitude of size as the filter. This means that the filter size determines the minimum detectable characteristic size. Filters should therefore be selected so that they generate low-interference data but do not at the same time swallow up the fault characteristic.

Median filter: This filter does not change any values, but instead sorts the values and then takes the value that lies in the middle of the range. This means that small outliers can be completely rejected without the adjacent data being changed by its neighbours. The big advantage of this, for example, is that edges remain edges and are not rounded.

Mean value filter: This filter smoothes by replacing the original value with the mean value from its environment. This filter softens the data.
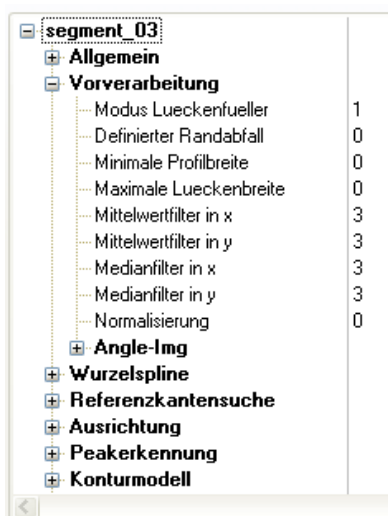
6.2.2 Gap fillers

Raw data can contain gaps. These are points at which the sensor has not seen anything, e.g. the laser disappears behind a step or into a hole and is no longer visible to the camera. Or the surface is very dark or extremely shiny / reflective. In this case, too little light returns to the camera and the exposure time is not sufficient to make the location visible. If there are too many points like this, the exposure time should be rechecked.

These areas, seen in the profile image as black points, also known as zero points, need to be filled intelligently with artificial values so as not to impair the evaluation mechanisms and in order to make representation of the profile easier. Smaller gaps can be interpolated, i.e. the adjacent profile progression is simply continued. In the event of larger gaps, interpolation becomes increasingly more dangerous, since this progression then deviates more and more from reality. These gaps are simply filled with the lowest neighbouring point. Shadows on steps, for example, are literally always lower by their very nature.

6.2.3 Parameters in Preprocessing

The parameters are found in the Preprocessing node.

Name	Default value	Description
Mode Gapfiller	1=interpolate	If several modes were available, this could be set here.
Defined Trimming	12 [height units]	Defined artificial continuation of the profile at an edge at the perimeter of the image. Especially necessary if edge detection is active. The profile progression should ideally progress with the same inclination as the end of the edge. The value specifies the height change compared to the previous height. The mechanism is limited to 200 height units.
Min. Profile Width	5 [profile points]	Contours (contiguous profile points, e.g. between 2 gaps / zero points) smaller than the minimum contour length are rejected.
Max. Gap Width	10 [profile points]	Gaps up to the maximum gap length are filled through interpolation. Larger gaps are topped up with the lower of the neighbouring values.
Meanfilter x	3 [pixels]	Filter size for smoothing of profile data. Only odd numbers are permitted. 0 = filter off. (seam-based)
Meanfilter y	3 [pixels]	Filter size for smoothing of profile data. Only odd numbers are permitted. 0 = filter off. (seam-based)
Medianfilter x	3 [pixels]	Filter size for cleaning the profile data of outliers. Only odd numbers are permitted. 0 = filter off. (seam-based)
Medianfilter y	3 [pixels]	Filter size for cleaning the profile data of outliers. Only odd numbers are permitted. 0 = filter off. (seam-based)

6.3 Orientation / position correction (alignment)

All of the components to be tested are typically subjected to a position tolerance of a greater or lesser magnitude, e.g.: play in the component holder, trimming and component tolerances, vibrations, imprecise robot lane, etc. If a component is always positioned slightly differently under the sensor, however, this will also be visible as a shift or rotation in the image. To ensure that the evaluation is as good as possible and can be carried out with as consistent a quality as possible, ideally few fluctuations should occur in the image data. For this reason, depending on the size of the position tolerances to be anticipated, the image should be orientated using a known reference before the actual evaluation. The technical term for this is alignment. Depending on the situation and the geometry of the component, various methods can be selected.

- **Alignment using correlation**
- **Alignment using correlation in the sensor**
- **Alignment with a component edge**
- **Alignment with the lowest or highest point**

Attention! For each segment, the right method can and must be set in the 'General' node and therefore activated.

6.3.1   Alignment using correlation

'Correlation' in this context means the evaluatory comparison of two contours. This yields a measure of the quality of the similarity. So if you take a profile section (reference profile) and move it over the profile (current profile), the place with the greatest match will also be the place with the highest quality value, and the system can then calculate the profile shift. The current profile is then moved so that it is again congruent with the reference profile. This produces the 'aligned image' which, relative to the position, should ideally look identical to the reference image. The position is compensated and therefore no longer influences the subsequent stages of the evaluation process.

Attention! The correlation approach is purely profile-related here and not image-related, i.e. each individual profile is corrected. This makes it possible to correct any cause of positional variation, such as vibrations, shifts and slight rotations in a single step. When compensating rotation, a small error occurs since you are not rotating, but rather shifting, causing a shear effect, however this effect is negligible for small angles and the advantages of this practice outweigh the disadvantages.

Setup process:

The reference profile is obtained from a recording that is regarded as successful and permanently adopted using the 'Adopt as reference image' button. Reference images for correlation must be adopted as a correlator reference.
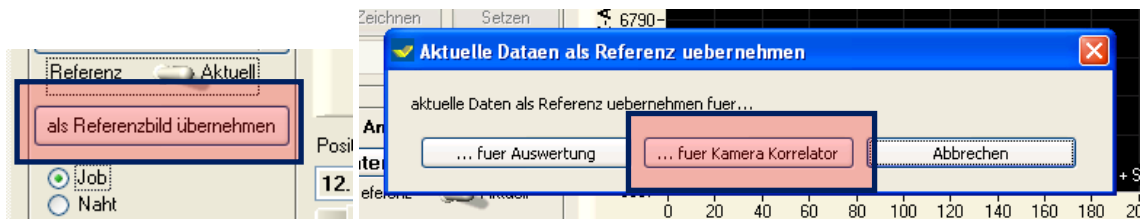
The drop-down choice of image source can be used to display the adopted reference image for correlation.
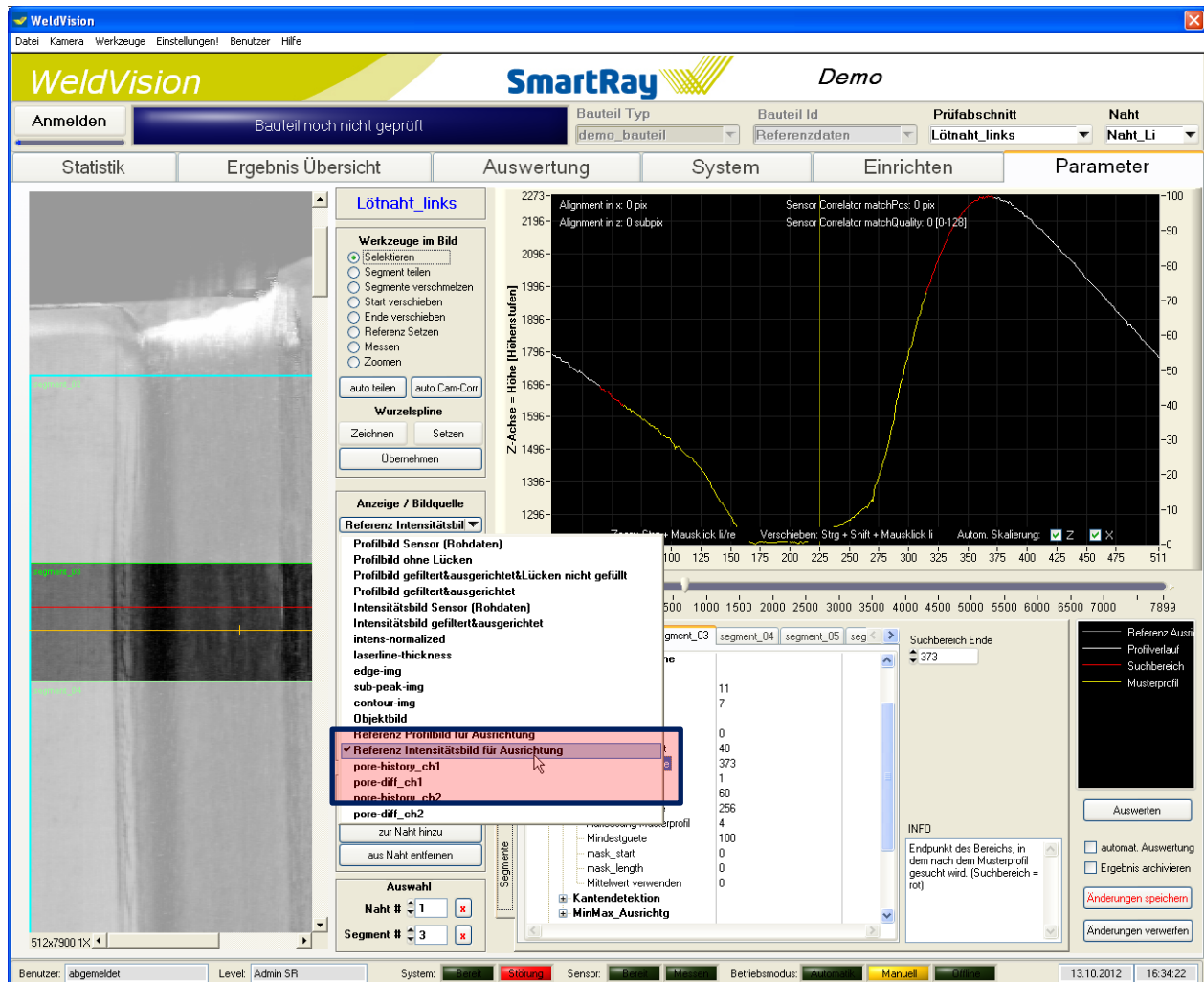
Parameterisation:

The choice of reference profile section and search or correlation area is performed by setting the correlator parameters appropriately and this is represented in the profile display with colour markings. (Search area = red; reference profile section - yellow).
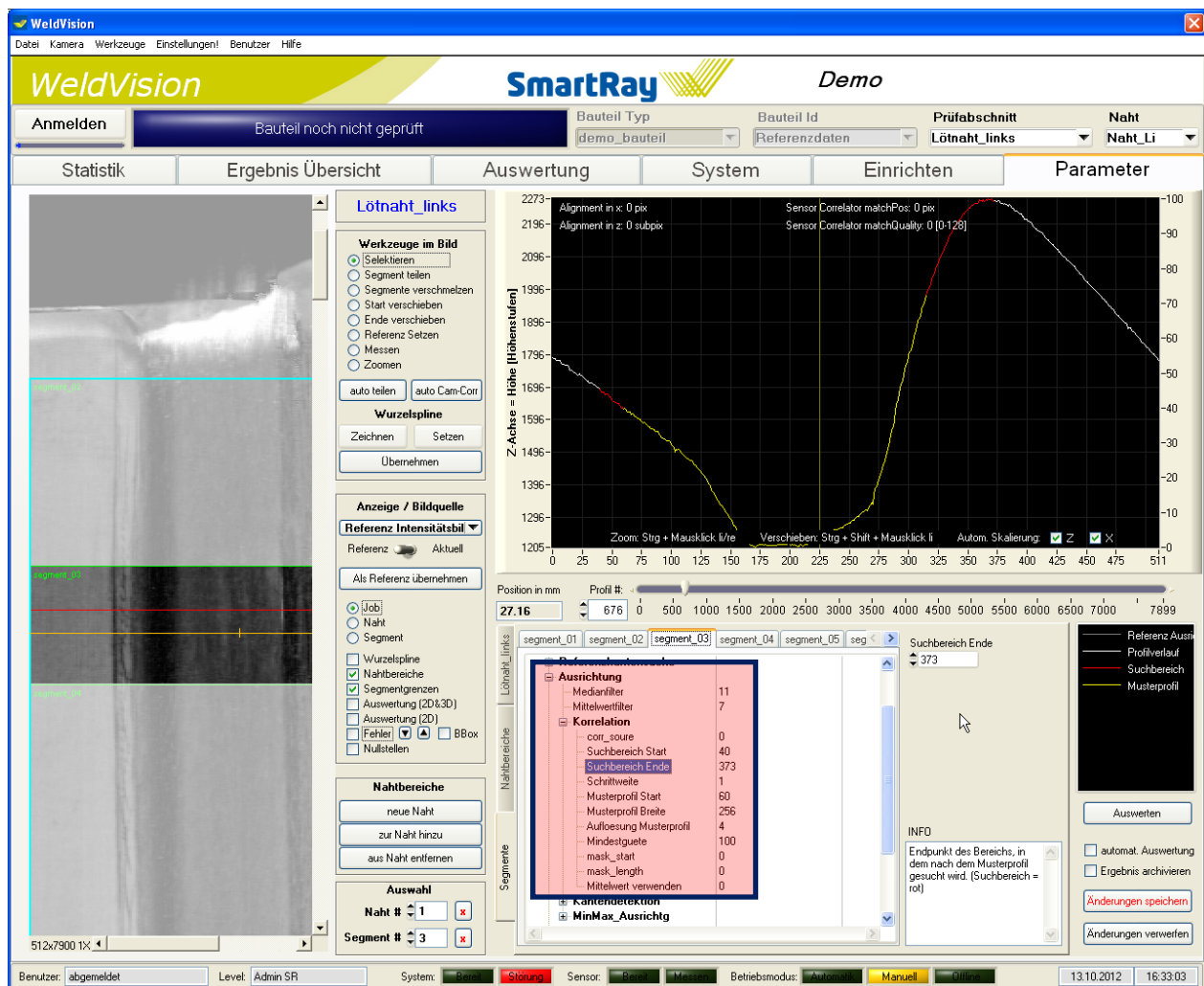
Name	Default value	Description
Data Source	0 = profile data	Correlation with profile data or intensity data. Currently only profile data is supported.
Searcharea Start	0 [profile points]	Starting point of the range in which the search for the comparison profile is carried out. (Search area = red)
Searcharea End	300 [profile points]	End point of the range in which the search for the comparison profile is carried out. (Search area = red)
Stepsize	1 [profile points]	Accuracy of the correlation. The coarser the grid, the faster the evaluation at the expense of the accuracy of the position determination. Provided the evaluation time presents no problem, the value should be set to 1.
Model Profile Start	80 [profile points]	Start point of the comparison profile that is to be correlated with current profiles. (Comparison profile = yellow)
Model Profile Width	128 [profile points]	Length of the comparison profile that is to be correlated with current profiles. The value must be from the 2^n series if correlation in the sensor is used. (Comparison profile = yellow)
Resolution Reference Data	4 [profile points]	Reduction in the resolution of the comparison

		profile by a chosen factor. The coarser it is, the faster the evaluation. The accuracy only suffers depending on the characteristics of the profile. The value must be from the 2^n series if correlation in the sensor is used.
Min. Matchquality	100 (0 - 127)	Only active with correlation in the sensor. Only found positions at which the max. quality is better than the minimum quality are adopted, otherwise the old value is retained. (max. 127; a good value is 100-120)
Mask Start	n/a	Hides an area from the centre of the comparison profile. For example if a highly variant seam form is not to be correlated too.
Mask Width	n/a	Hides an area from the centre of the comparison profile, e.g. if a possibly highly variant seam form is not to be correlated too.
Use Mean Value	0 = No 1 = Yes	The average value of all profile lines is applied to the segment for orientation. This is a good method if constant shifting over the entire segment is expected.

Attention! The selected reference profile must have a characteristic form. A straight line, for example, is not uniquely defined in terms of its position. Correlation would not work. This condition needs to be met across the whole active segment, otherwise this method is unsuitable and a different solution must be selected.

To check the quality of the alignment, the reference profile is simultaneously represented with the current profile in Correlator view. The size of the shift (alignment) in x can also be read off in the graph above.

The results of the correlation can and should always be cleaned and smoothed with median and mean value filters. Individual outliers disappear and the orientation per image line is smoothed.

6.3.2   Alignment using correlation in the sensor
Correlation in the sensor is set up in a similar manner with the same parameters as normal correlation. The function is only available in 'Pore detection'. Limitations, described in the parameter declarations and in the separate document on pore detection, should be noted.

6.3.3   Alignment with a component edge
The alignment is performed with a component edge that is visible in every recording. A special reference image like the one used for correlation is not required. To also ensure that the correct edge is found, a search area, the direction and nature, i.e. whether it is a rising or falling step, need to be set up.

The edge search itself is applied in a line-based manner and takes into consideration the 2nd derivation of the data progression. The 2nd derivation corresponds to the magnitude of the change in the data. At one component edge, the profile progression changes markedly, and consequently the 2nd derivation at this point is large. The correct local maximum is then found using a threshold. The method can be applied to profile data, intensity data and soon also to angles. The consideration of angle change has the tremendous advantage that the determined changes, i.e. the 1st and 2nd derivation, are not dependent on rotation.

The result may look as follows:

The illustration shows the raw data on the left without alignment. The component geometry does not look like this in real life, but as a result of imprecise positioning of the sensor with respect to the component during the scan, this produces a distorted image of a weld seam. Through alignment with a step on the left next to the seam, the image can be nicely straightened up. All further procedural steps are now somewhat easier to set up.

Before   After

Parameterisation:

The search area is shown in turquoise (but changes to red as with the correlator). The 1st derivation is blue. The 2nd derivation, and therefore the important curve to which the threshold value is applied, is green.
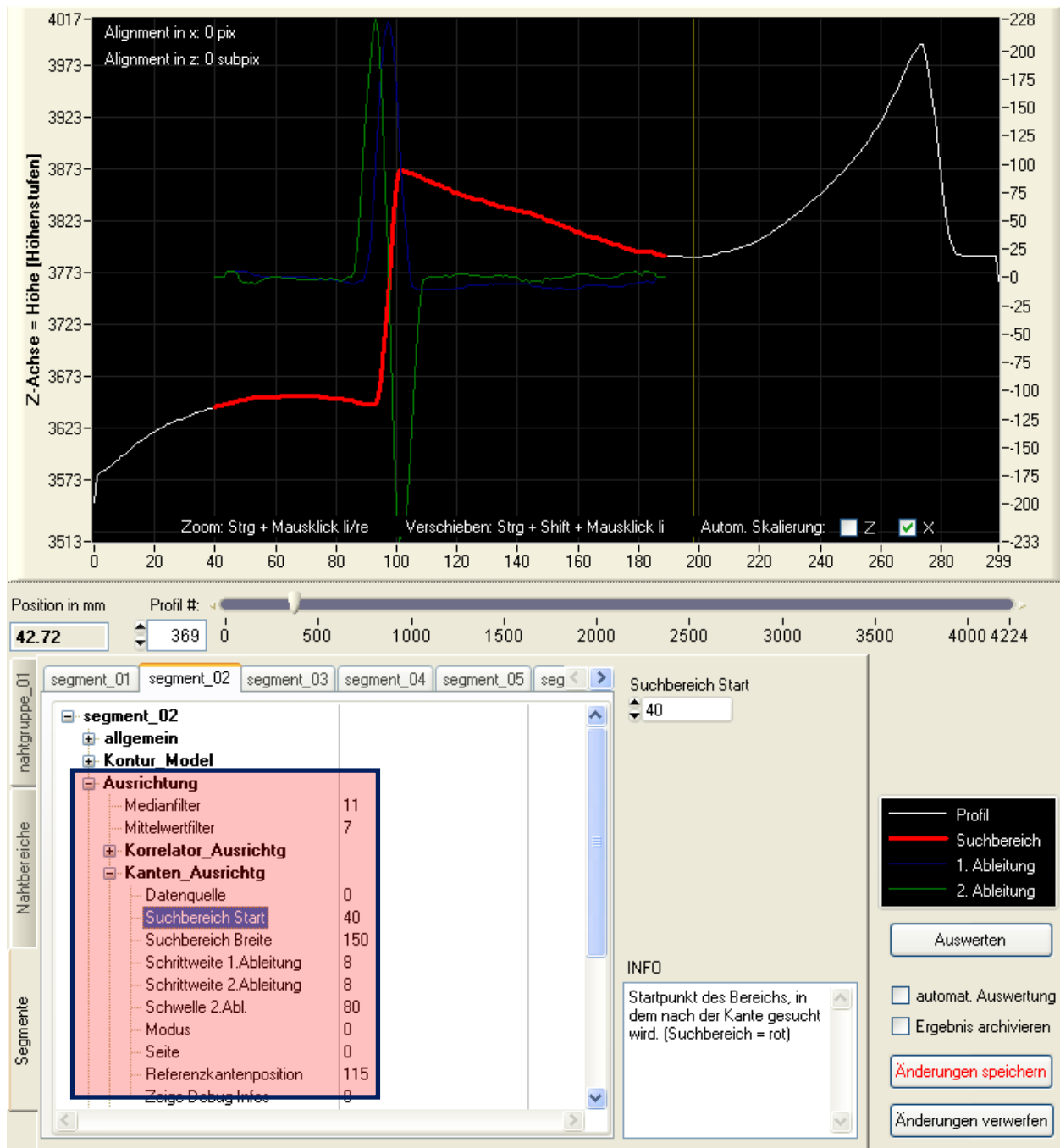
Name	Default value	Description
Data source	0 = profile data	Edge finding in profile data, intensity data or angle data (recommended).Currently only profile data is supported.
Searcharea Start	0 [profile points]	Starting point of the range in which the search for the edge is carried out. (Search area = red)
Searcharea Width	150 [profile points]	Length of the range in which the search for the edge is carried out. (Search area = red)

Stepsize 1st Derivative	8 [profile points]	The 1st derivation corresponds to the incline and is the difference from one point to the next. The point distance is the step width.
Stepsize 2nd Derivative	8 [profile points]	The 2nd derivation corresponds to the incline of the 1st derivation and is the difference from one point to the next. The point distance is the step width. It is therefore a measure of the change in incline. The larger the edge, the larger the 2nd derivation.
Thresh 2nd Derivative	100	If the 2nd derivation is above the threshold value, the associated local maximum is counted as an edge.
Mode	0: rising flank 1: falling flank	(will not in future be used, since the preceding sign of the threshold makes it clear) rising edge or falling edge.
Direction of counting	0: 1st edge from the left 1: 1st edge from the right	Specifies from which side the edge is searched for. From the left or from the right.
Reference edge position	50 [profile points]	Defines which position (profile points from the left) the edge is laid at in the aligned image.
Show Debug Info	0	Internal parameter. Do not change!

The size of the shift (alignment) in x can also be read off in the graph above.

The results of the edge search can and should always be cleaned and smoothed with median and mean value filters. Individual outliers disappear and the orientation per image line is smoothed.

6.3.4   Alignment with the lowest or highest point

With this type of alignment, either the lowest or the highest point within the search area is searched for and the profile shifted accordingly. This method can in future also be combined with the edge search in order to also find edges close to an extreme value.

This method is currently still in development and is therefore not documented in more detail at the moment.

6.4   Setting up root point progression

Once the image has been filtered and aligned, the actual seam detection can now begin. The seam search area must be very flexible yet very simple to set up. As well as the component alignment, the anticipated seam position or anticipated root point position can vary, for example the component edge to be welded over fluctuates independently of the component's outer edge in the case of an overlap seam. In this instance, despite the image alignment, the seam search area must be included accordingly. In order to handle the many requirements, the root point progression (or root, for short) can be set up using a wide variety of different types. It represents a type of anchor, i.e. reference for the seam search area.

The methods are:

- Root via reference spline (draw)
- Root via edge
- Root via edge and reference spline
- Root via edge at seam start / seam end
- Root via edge at seam start / seam end and reference spline

6.4.1   Root via reference spline

In the case of complex progressions or missing marks in the image, the root can perfectly easily be drawn. The position is then permanently linked with the aligned image. If a recording without seam is available, it would now be useful to use it, since it will be easy to draw along the edge. If only the seam is visible, the root should be drawn as precisely and as evenly as possible at the presumed root point position (e.g. over-welded edge). The root can be redrawn and adopted at any time. All other position-dependent parameters are referenced to the root and shift with it. So if it should turn out at the end that a seam search area is not ideal at one particular point, simply create a new drawing.

Attention! A new drawing currently means a new drawing for the entire image, not just the affected point or seam. There are plans to optimise this function.

Setup process:

Activate the 'Draw' button and then set grid points by clicking on the image. A green line is drawn between each pair of grid points. Double-click to exit. A zigzag course has been drawn here to make it easier to follow. With 'Adopt', the grid points are used to calculate a spline (a gentle curve), which is shown in yellow. In the display section, however, the root spline must be ticked for this to happen. If only one vertical is drawn, click 'Set', select the position in the image and adopt it.
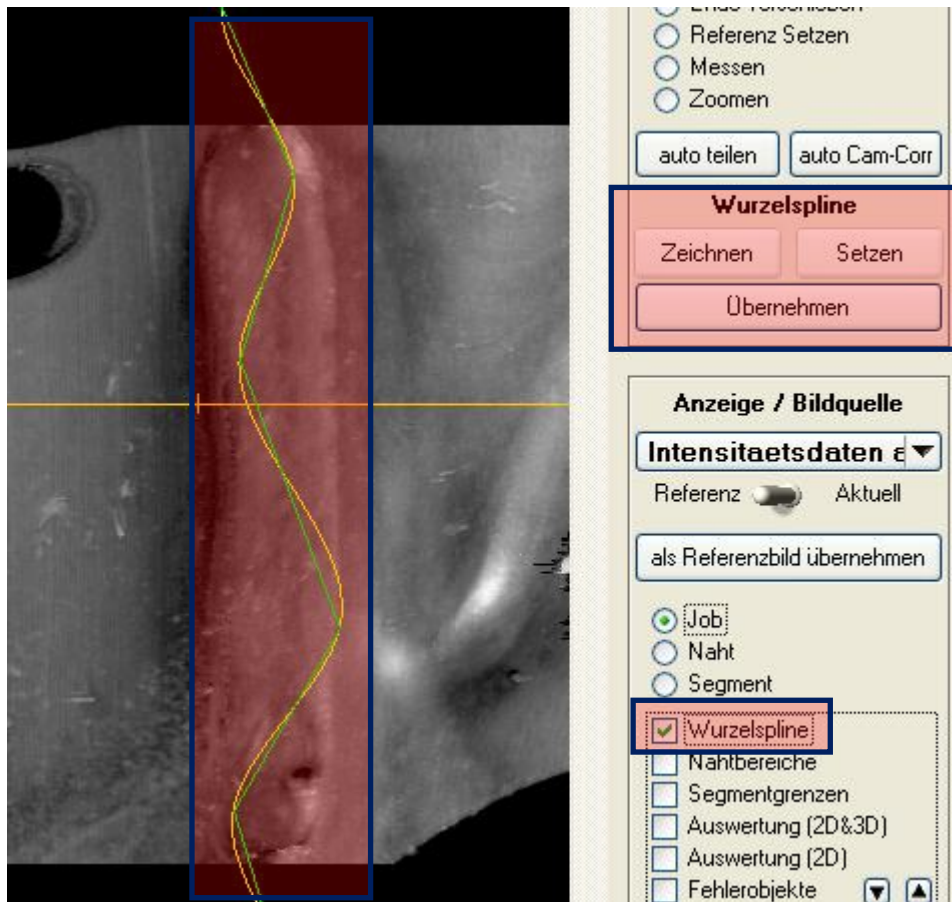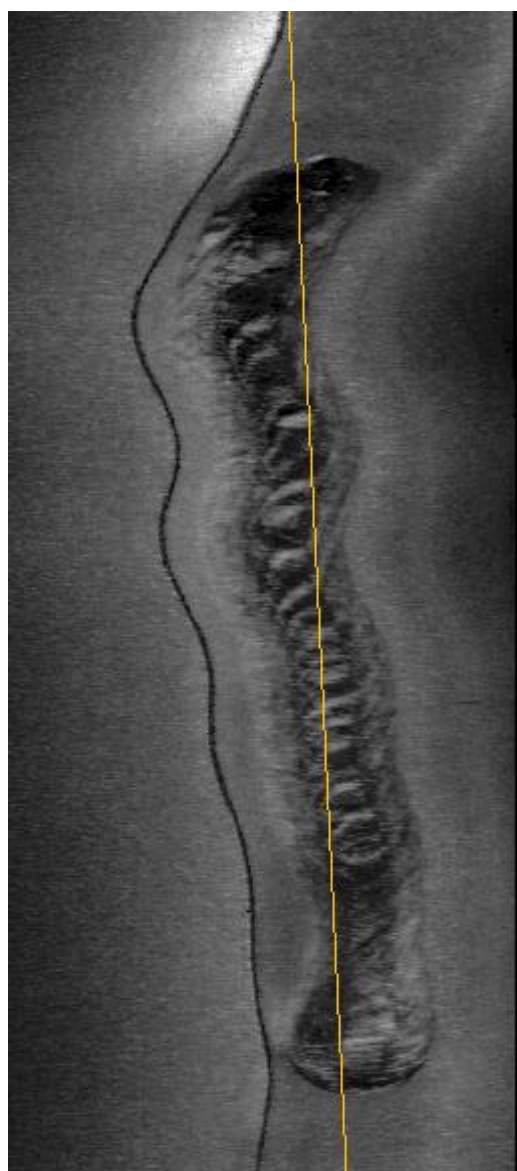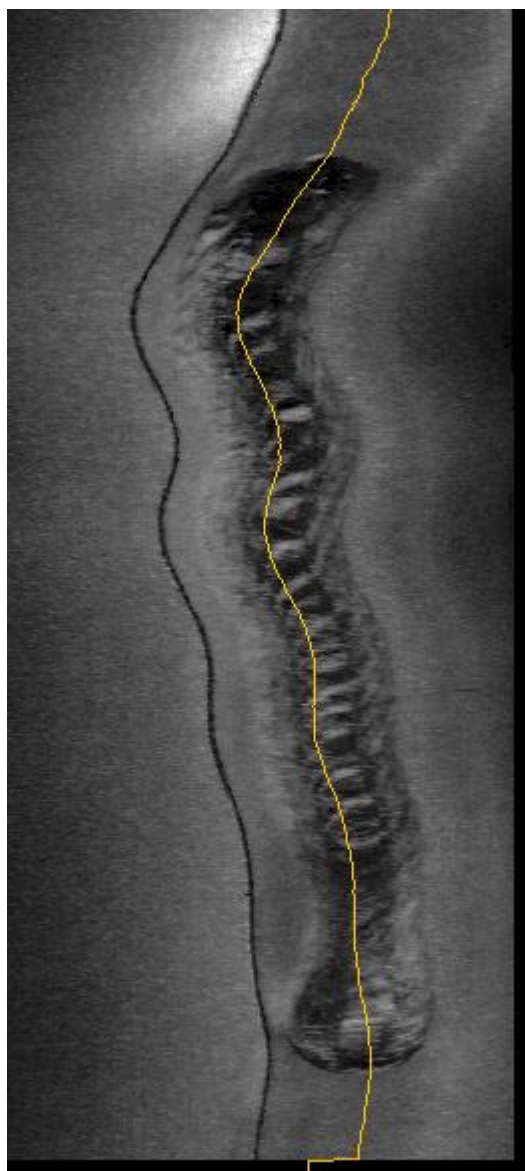
6.4.2 Root via edge

The root is always recalculated on in a line-based way by an edge search and can be deliberately shifted to the side by setting an offset. If a straight line is expected for the progression, a straight line can also be fitted into the calculated progression. The edge search method is identical to the one from the chapter entitled 'Alignment with component edge'.

The result may look as follows:

The step to the left of the seam has been searched for and the root shifted to the right by a given offset.		The 'Apply regression' option has been activated. A straight line is laid through the contour.

6.4.3 Root via edge and reference spline

The root is again calculated via the familiar edge search. The positional value is then however added to the drawn root spline. By setting the offset, the resulting curve can then be created at any desired position. This means that a contour obtained from the image can be specifically rotated and even distorted to any degree.
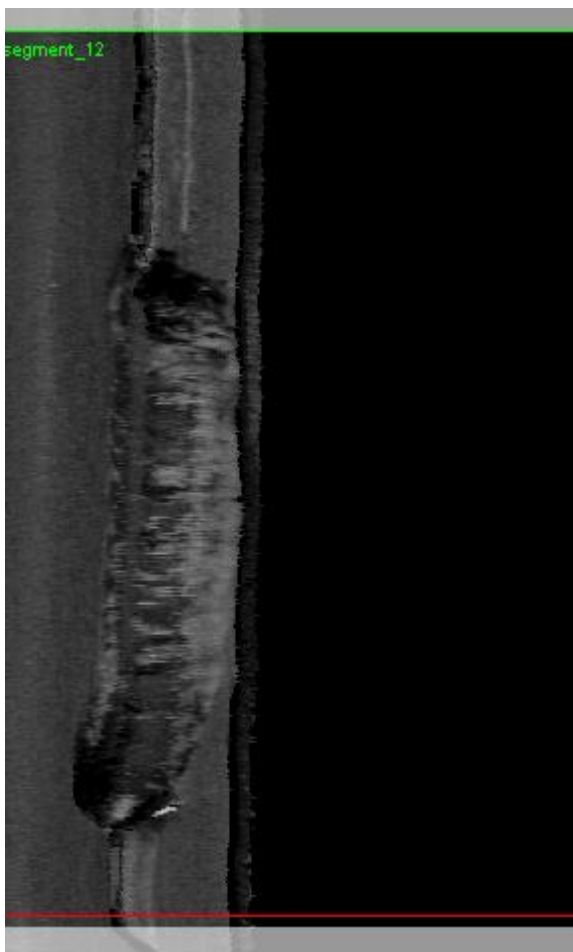
6.4.4   Root via edge at seam start / seam end

If the edge lies below the seam and is only visible at the start and / or at the end of the seam, this method is the one to use. Based on the segment borders, the search for the edge is only carried out at the start and / or end of the segment and then either a vertical line placed at the edge position or, where both grid points are used, a straight line is placed through both points.

The result may look as follows:
Firstly, the component was aligned with the right-hand outer edge of the component. Then, the search was carried out at the segment borders for the still-visible but not over-welded edge in order to determine the root point progression. A slightly skewed straight line is seen that closely follows the current edge progression.
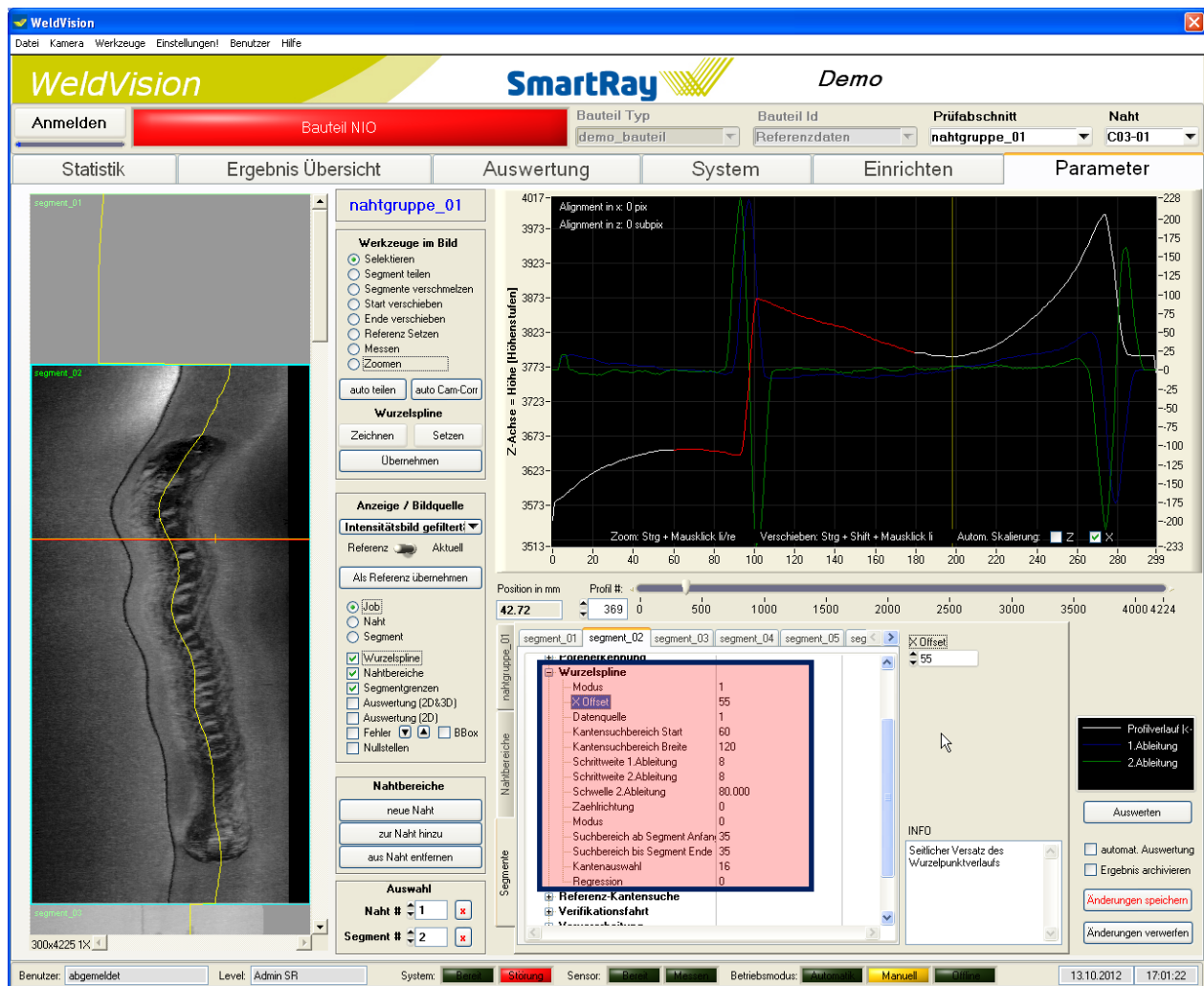
Before: After:
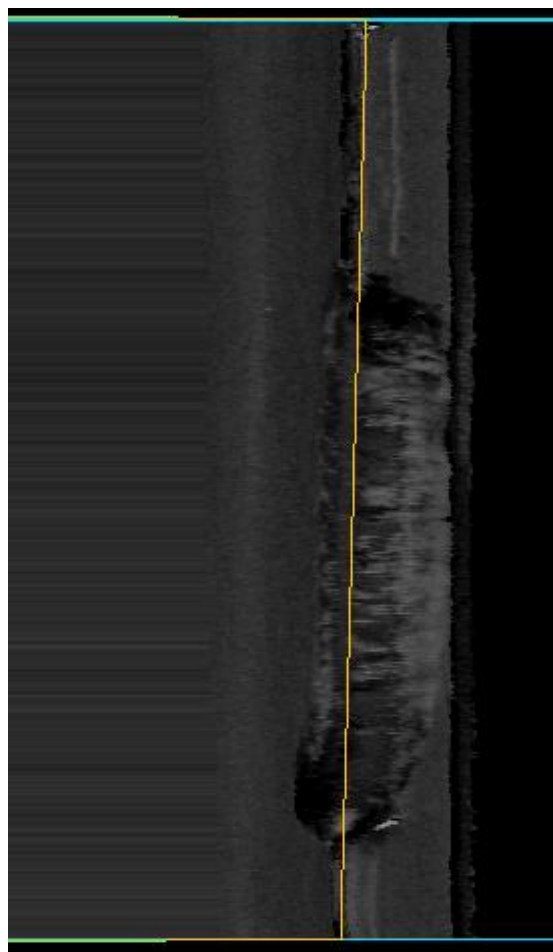
6.4.5   Root via edge at seam start / seam end and reference spline

The grid point(s) is / are again calculated via the edge search at the segment ends. The result is then added to a drawn progression. See also the methods described above.

Parameterisation:

| Name	Default value	Description
Mode	0: Draw spline 1: Edge 2: Edge and spline 4: Edge start segment 8: Edge end segment 16: Edge start / end 32: Edge start and spline 64: Edge end and spline 128: Edge start / end and spline	Mode for root point progression. Draw, set at edge or even a combination of edge finding and drawn progression.
X Offset	0 [profile points]	Lateral offset of the root point progression
Data Source	1: filtered profile data	Selected data source during calculation or correction of the position of the root spline using an edge
Edge Search Area Start	0 [profile points]	Starting point of the area in which the search for an edge is carried out
Edge Search Area Width	100 [profile points]	Length of the area in which the search for an edge is carried out
Stepsize 1st Derivative	8 [profile points]	The 1st derivation corresponds to the incline and is the difference from one point to the next. The point distance is the step width.
Stepsize 2nd Derivative	8 [profile points]	The 2nd derivation corresponds to the incline of the 1st derivation and is the difference from one point

		to the next. The point distance is the step width. It is therefore a measure of the change in incline. The larger the edge, the larger the 2nd derivation.
Thresh 2nd Derivative	100	If the 2nd derivation is above the threshold value, the associated local maximum is counted as an edge.
Mode	0: rising flank 1: falling flank	(will not in future be used) rising edge or falling edge.
Side	0: 1st edge from the left 1: 1st edge from the right	Specifies from which side the edge is searched for. From the left or from the right.
Search Area from Segment Start	10 [profiles]	Number of profiles starting from the segment start in which an edge is searched for. Only active in modes that contain the edge start and / or end segment.
Search Area to Segment End	10 [profiles]	Number of profiles ending with the segment end in which an edge is searched for. Only active in modes that contain the edge start and / or end segment.
Edge Selection	0: Median 1: Mean value 2: Left 4: Right 8: Left quantile 16: Right quantile 32: Bar chart	Method according to which the position resulting from all of the found edges is calculated.
Regression	0: Off 1: Active	Calculates a compensating straight line using all of the edge positions or grid points

6.5 Setting up the contour model

To ensure that geometric seam border finding can function reliably, it requires the progression of the component surface without the seam and needs this information to be as accurate as possible. This is because deviations in the profile compared to the expected component surface may possibly be interpreted as a seam. There are several ways to achieve the required objective. Depending on the prevailing edge conditions, a reference recording without seam can simply be created or, if this is not possible, a model will need to be generated artificially since it is not possible to look under the seam.

The model will be generated using compensating straight lines that are attached to the current profile via anchor points. There is precisely one anchor point next to the seam for each seam side, and therefore a straight line which should lie so that it recreates the component surface in the seam area as closely as possible.

To achieve this, the incline can be set manually or calculated automatically based on the current progression in the anchor point. A combination of the above is also possible. The point of rotation around which the straight line revolves can also be shifted. In normal cases, this is located at the inner end of an anchor and can, if need be, moved along the extension of the small anchor contour piece. The advantage of this is that it is now possible to also respond to roundings and yet still place the anchor far enough away from the seam area. See the illustration below in the red box. You will see that the straight line does not run directly through the anchor.
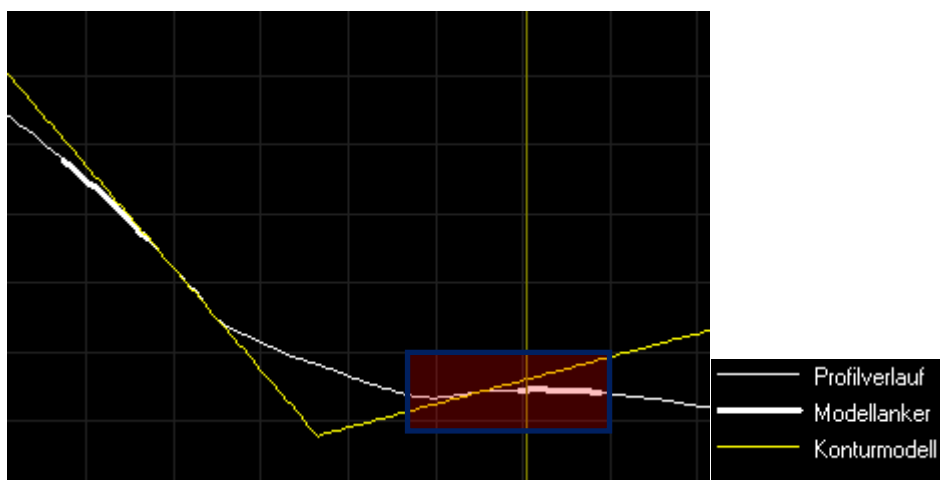

The following methods can be used to generate models:

- Regression intersection point
- Regression rising step
- Regression falling step
- Reference profile from segment start
- Straight line from 2 grid points
- Reference profile from segment end
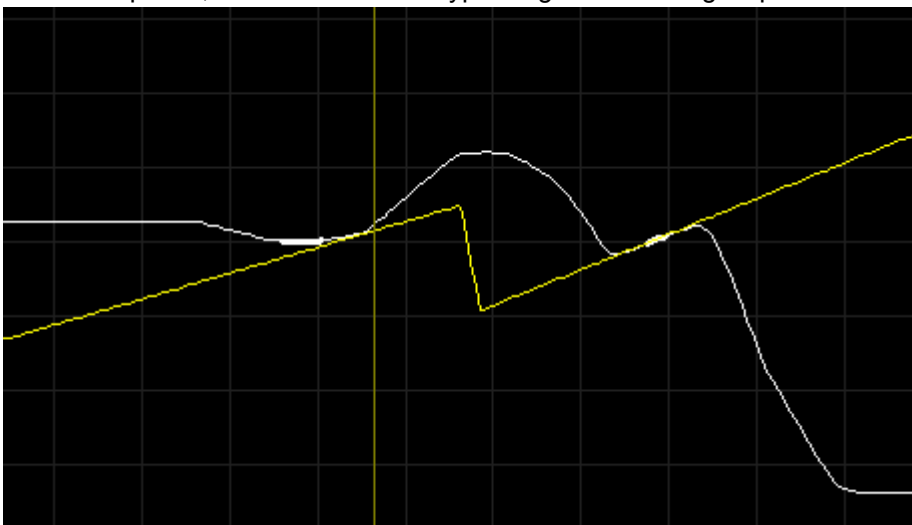- Reference profile from segment start and end

Example of the model type 'Regression intersection point'
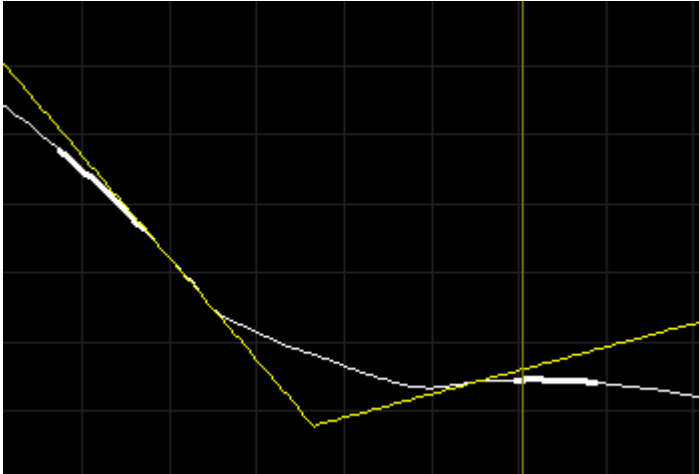
Example of the model type 'Reference profile from segment start and/or end'
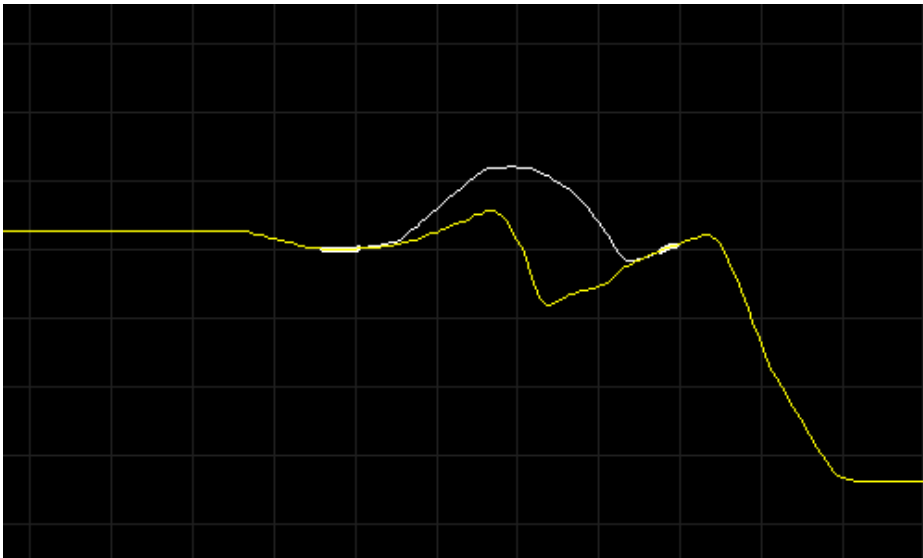
The same profile, but with the model type 'Regression falling step'

Parameterisation:

The anchors are set first. They are anchored at the root and can be shifted laterally on the profile. The appropriate model type is then chosen and the incline set or adjusted manually, including the point of rotation, until the desired result is achieved. The model must effectively recreate the background everywhere in the segment. If not, interim segments will need to be generated in which separate settings can be made. The illustration below shows that, in this case, for example, 3 segments were needed in order to achieve good modelling across the entire seam area. In the area of segment _03, the component surface on the right-hand side changes quite markedly. This then increases the amount of modelling work required. If it is possible in practice to generate a recording without seam at this point, this would then of course be the better solution.
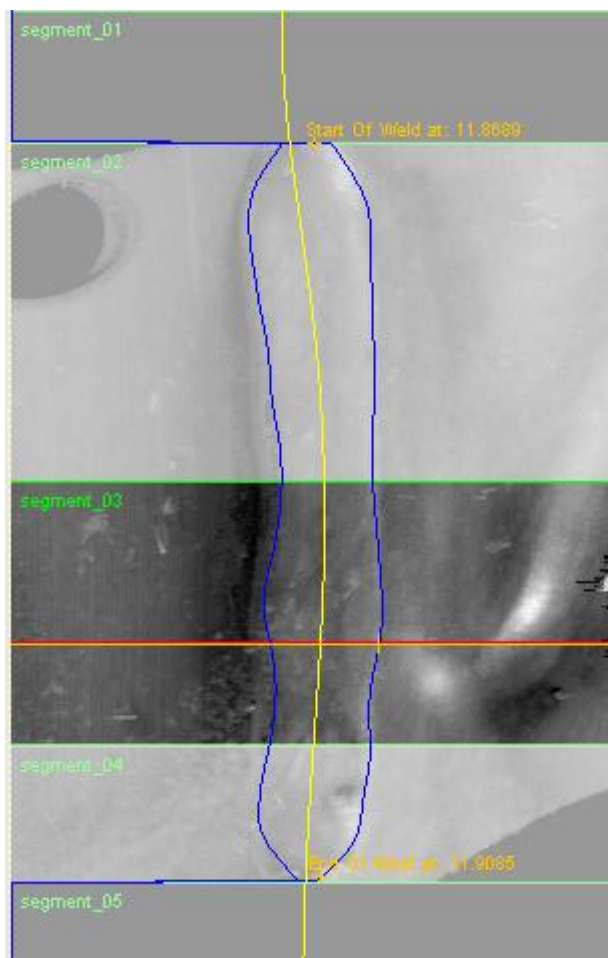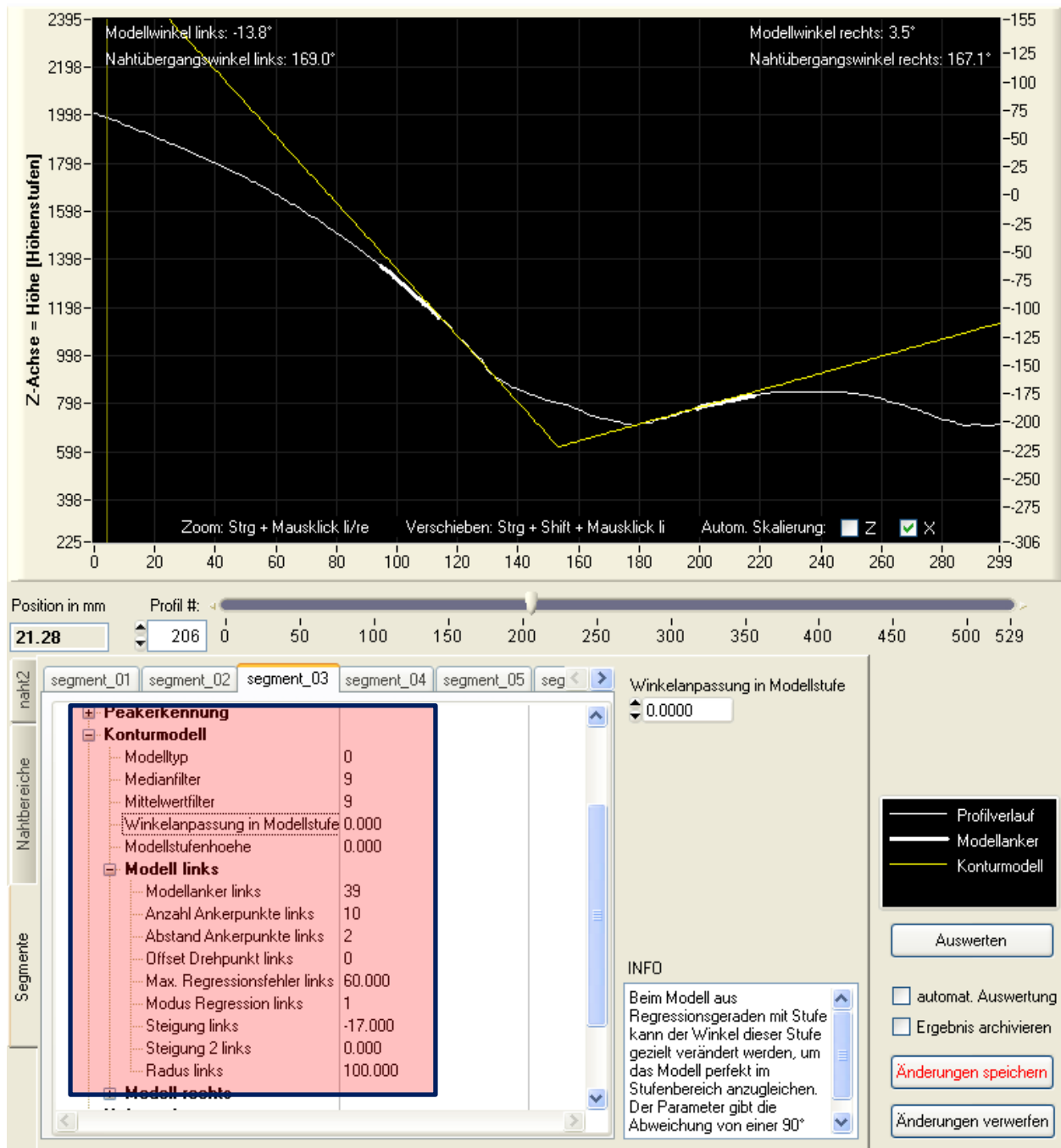
If the automatic calculation of the straight line incline is used, or in the event of a change of segment that causes sudden changes in the model, we recommend activating the cleaning and smoothing mechanisms (median and mean value filters).

The parameters are divided in the software into the left and right-hand side. In the table, no distinction is made between the side-dependent parameters.

Name	Default value	Description
Model Type	0: Regression intersection point 1: Regression rising step 2: Regression falling step	Defines which reference model type is to be used. (Regression = compensating straight line)

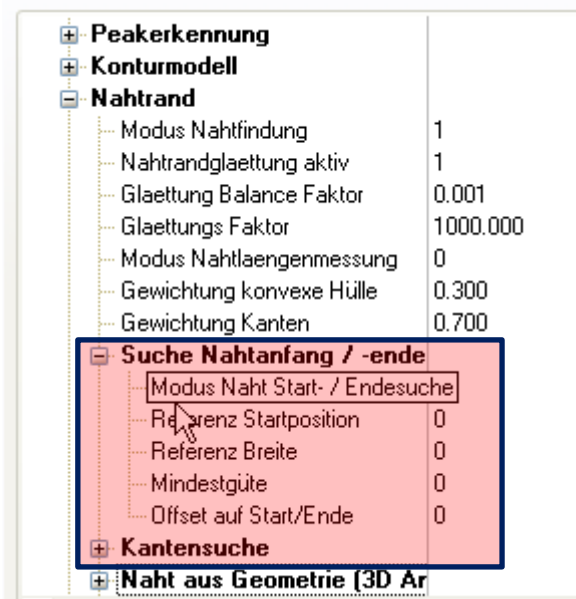|	3: Reference profile before the seam 4: Line from 2 points left + right	
Medianfilter	11 [profiles]	Cleans the model's incline values, if for example outliers occur in the automatic calculation of the incline that would markedly distort the model from one profile to the next.
Meanfilter	7 [profiles]	Smoothes the model's incline values in order to facilitate a gentle model progression or the transition from profile to profile.
Angle Adjustment in Model Step	0 [°]	With the model from regression straight lines with step, the angle of this step can be specifically altered in order to perfectly approximate the model in the step area. The parameter specifies the deviation from a 90° step to the straight line.
Model Step Height	0 [height units]	If not equal to 0, then the value determines the step height and not the level found in the anchor. In other words, if the model level in the anchor cannot be used on the lower model straight line, for example because the component ends simultaneously with the seam, then this method can help.
Model Anchor	30 [profile points]	The anchor determines where the model merges with the profile and how far the seam search area extends. The distance is specified relative to the root point position.
Number of Anchor Points	10 [profile points]	The number of grid points along the profile which the anchor is to be made up of. These points create a compensating straight line which then forms the basis for the model. The more grid points, the more accurate the calculation of the compensation straight line (e.g. 20 points).
Distance of Anchor Points	1 [profile points]	The distance between grid points along the profile. Helpful for optimising the calculating time if a longer section needs to be defined as an anchor without increasing the number of grid points.
Offset Pivot Point	0 [profile points]	Shifts the model's point of rotation along the regression straight line through the anchor in order to adapt the model more closely to the background in the seam area, for example in the case of non-linear progressions such as a rounding.
Max. Regression Error Right	100000.0	Will not be used in future. Set to 100000.0.
Regression Mode	0: Manual 1: Automatic 2: Automatic from reference	This mode specifies whether the incline of the model straight line is set manually, or determined automatically through the anchor points. In the case of automatic calculation from the reference, the incline is calculated once from the reference image and applied to all current recordings.
Slope	10 [°]	Specifies the incline of the model straight lines. In the case of automatic setting, this parameter can be used for fine adjustment, i.e. this value is added to the automatically determined incline.
Slope 2	0 [°]	If not equal to 0, then the model incline progresses linearly from incline 1 to incline 2 within the current segment, i.e. the model has incline 1 at the start of the segment and incline 2 at the end.
Radius	0 [mm]	New feature; not yet official; the model would be a circle.

6.6 Setting up characteristics

6.6.1   Seam borders

Attention! The seam borders section of the program is currently being completely redesigned. At the time of printing, there was no information available about the new structure.

As soon as the contour model has been set up, the system can determine the seam borders. In normal cases, the seam borders are found entirely using geometric characteristics. In special cases, it is also possible to find the seam using the intensity image. A combination of the two worlds is also possible. In most cases, the default settings should yield good results.

The seam border node is divided up into the following areas:

6.6.1.1 General parameters

Name	Default value	Description
border fusion mode	0: Automatic 1: 3D only 2: 2D only	Decides which method is used to determine the seam border. Information from intensity data (2D) and profile data (3D) is combined in automatic mode.
border smooth active	Active	Activates smoothing of the seam border progression through a spline function.
border smooth balance	0.010	Spline parameters
border smooth factor	100.000	Spline parameters
weld length mode	0: First to the last profile in which minimum width is reached 1: Total number of profiles in which minimum width is reached	Mode determines how the seam length is measured. 0: First to the last profile in which minimum width is reached. 1: Total number of profiles in which minimum width is reached
Weighting of convex envelope	0.3	A convex envelope can be created around the found border seams. Weakly characterised seam areas can therefore be interpolated.
Edge weighting	0.7	Found edges can be interpreted as seam borders.

6.6.1.2 Start-end search

This method searches for the start or end of the seam using correlation. It represents another alternative to edge detection as a method for searching for seams. Its use is entirely optional and is only practical in certain applications.
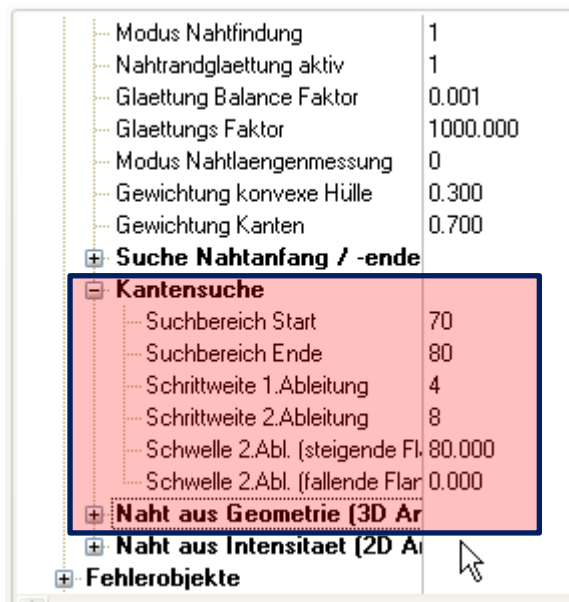

Name	Default value	Description
Mode Weld Start/End Search	0: Search mode off 1: Camera correlator search mode active 2: Correlation calculation active	Seam start and end search via the correlation method. As soon as the anticipated and actual profile match even only slightly, the seam end or seam start has been reached. 0: Search mode off 1: Camera correlator search mode active 2: Correlation calculation active
Reference start position		Starting position from which the calculation of correlation values takes place
Reference length		Length of the section for correlation calculation

Minimum quality threshold		Minimum match quality for adopting the found position as valid, otherwise the previous position is used (max. 127); a good value is 100-120
Offset to start / end		Offset value for found start or end point (with respect to the profile line)

6.6.1.3   Edge detection

As additional security for seam detection, the profile progression can first be tested with the aid of edge detection. If it is not smooth, i.e. if the profile contains edge or step-like contours, the system assumes that there cannot be any valid seam there. The seam borders are then set on the root point, i.e. the seam width is 0. This method is optional and only recommended if significant edges are anticipated in the case of faulty or missing seams.

This variant of edge searching supports the combination of rising and falling flanks, since for example a typical plate step in both cases should exhibit a powerful bend. A search is therefore performed for 2 edges. Otherwise, this procedure is comparable with the edge detection already described in other methods.

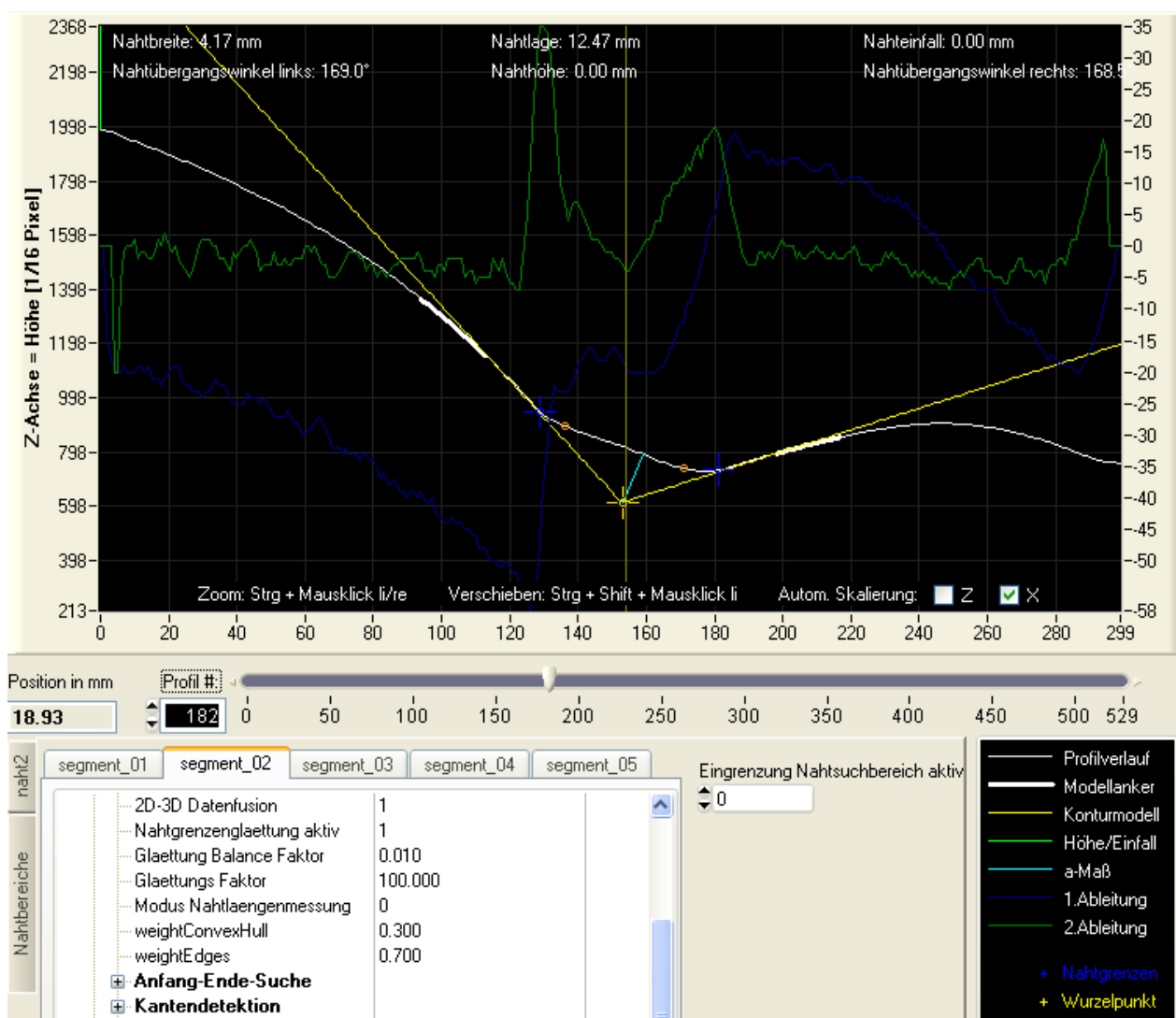| Name	Default value	Description
Searcharea Start	0 [profile points]	Starting point of the area in which the search for an edge is carried out
Searcharea End	100 [profile points]	End point of the area in which the search for an edge is carried out
Stepsize 1st Derivative	8 [profile points]	The 1st derivation corresponds to the incline and is the difference from one point to the next. The point distance is the step width.
Stepsize 2nd Derivative	8 [profile points]	The 2nd derivation corresponds to the incline of the 1st derivation and is the difference from one point to the next. The point distance is the step width. It is therefore a measure of the change in incline. The larger the edge, the larger the 2nd derivation.
Thresh 2nd Derivative (Rising Edge)	100	If the 2nd derivation is above the threshold value from an absolute perspective, the associated local maximum is counted as an edge.
Thresh 2nd Derivative (Falling Edge)	100	If the 2nd derivation is above the threshold value from an absolute perspective, the associated local maximum is counted as an edge.

6.6.1.4   Seam border_Geo

This section contains all the parameters that are responsible for geometric seam border detection based on the contour model.
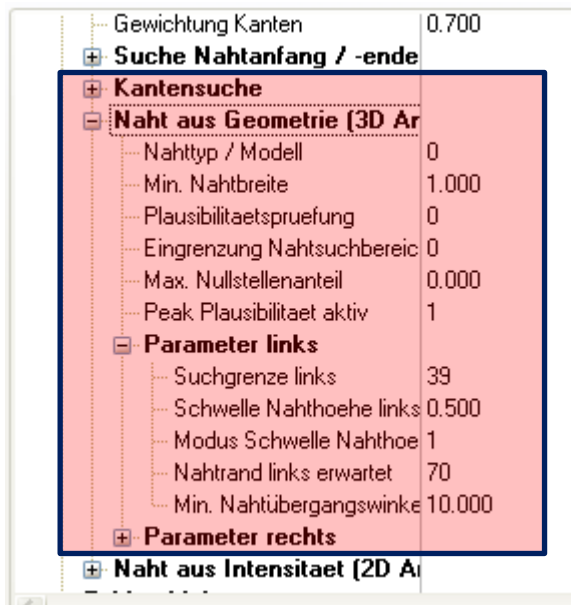
The geometric seam border search works in a multi-stage way. The deviation from the model is determined first. From a certain threshold value, the deviation is classed as so large that a seam must be present there. In the graph, this point is marked with 2 small orange circles.

This is not, however, the point of the actual border seam. You are actually in the seam at this point. Consequently, the virtual intersection point with the model is now calculated from this point outwards.

Once reached, the seam transition angle is now considered. This is the angle between the background (= model) and the seam progression (= current profile). If the angle is larger than a minimum dimension, the system moves outwards towards the anchor until the minimum angle is reached.

The final border seam is then displayed in the graph as a blue cross or as a blue contour in the image.

The parameters are divided in the software into the left and right-hand side. In the table, no distinction is made between the side-dependent parameters.

Name	Default value	Description
Seam type	0	Not used
Min. Weld Width	2.0 [mm]	Minimum width of the seam to determine the start and end of the seam.
Plausibility check	0	Not used or so far without function
Limitation of seam search area	0	Pre-selection processes automatically determine or limit the seam area.
Max. Zero point proportion	0.0 [1.0 = 100%]	Checks within each profile whether there are too many zero points within the seam borders. If there are, the seam borders are set to the root point (seam width = 0). Value range 0.0-1.0
Peak plausibility active	0: Off 1: Active	In areas of disruption, such as weld beads, the model and therefore the seam border may not be determined correctly in certain circumstances. The peak detection finds the disruptions that are then taken into account in the activation of seam detection.
Search Offset	40 [profile points]	Distance to the root point position = limit of the seam search area.
Threshold Weld Height	0.4 [mm]	Minimum deviation of the profile from the contour model. The found position is indicated in the graph as a small orange circle.
Threshold Mode	0: Absolute 1: Superelevation 2: Descent	A superelevation, descent or both are searched for as deviations.
Expected Weldborder	0 [profile points]	If no clear seam border is found, this position is used. Good seam borders can quite easily not have any geometric characteristics, so if necessary a seam border needs to be found in a good scenario. The value specifies the distance from the root point position.
Min. Weld Transition Angle	10.0 [°]	Minimum angle between the model and the profile for determining or optimising the seam border. (0.0=function deactivated)

6.6.1.5   SeamObj_Intens

These parameters are responsible for seam border finding from the intensity image. The methods are relatively complex and are only activated in special cases. In view of the revision of this section that is currently underway, no detailed description will be provided at this point.
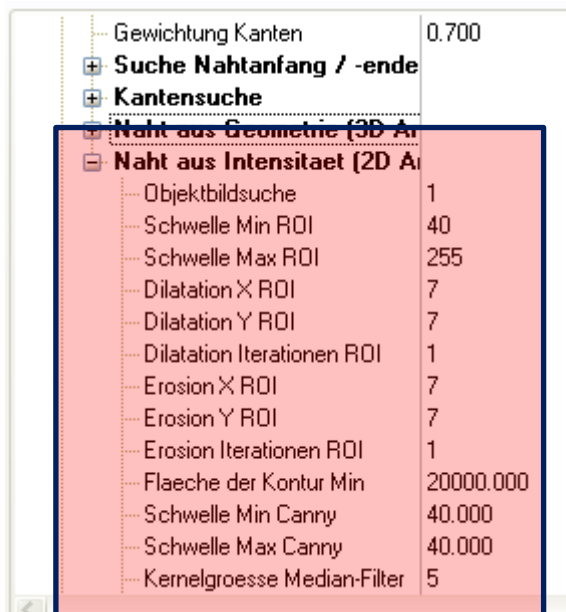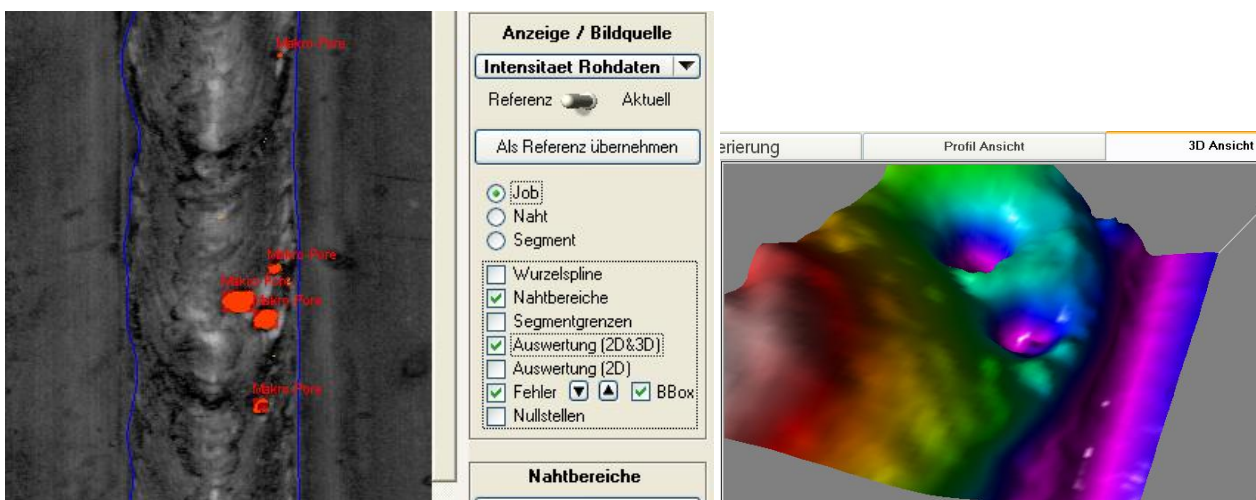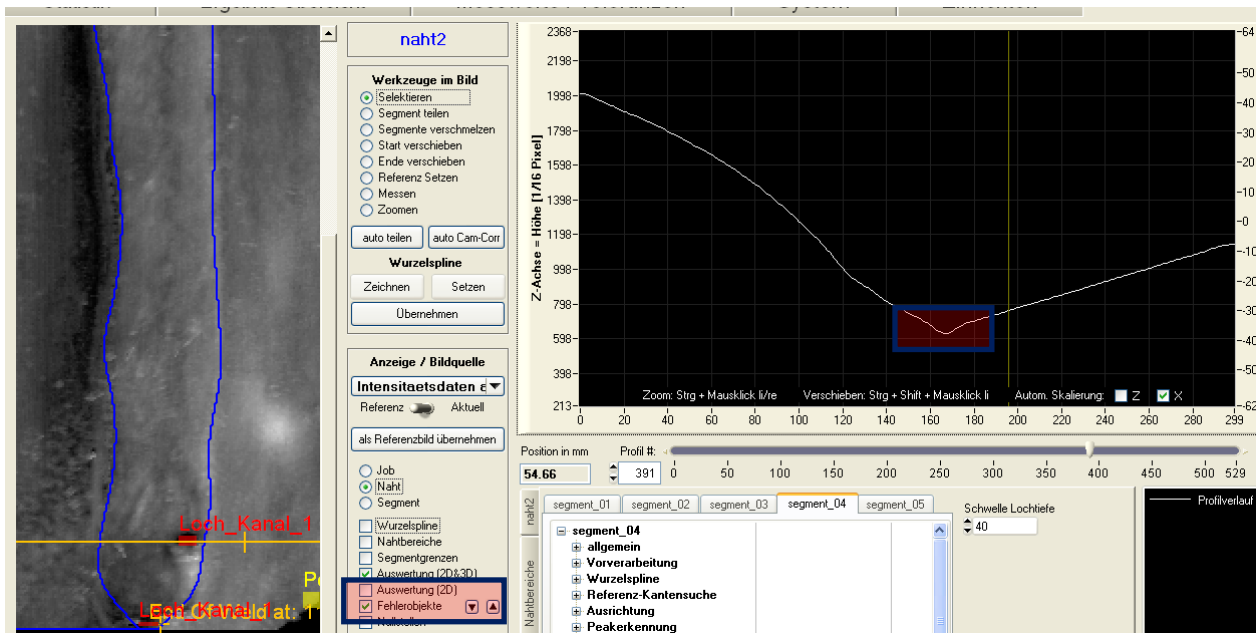

6.6.2   Error objects

These parameters are responsible for searching for error objects such as holes, pores, edge notches or spatter.

Pores:

Depressions such as pores are only searched for within the previously found seam borders. The area can also be limited in order to avoid incorrectly classifying small irregularities at the perimeter as errors. There are 2 channels in order to respond with greater flexibility to small and large errors. Each channel offers the same options. However each channel can evaluate a different area, particularly the seam edges, with different settings. This means it is possible, for example, to search for very small errors only in the centre of the seam, while the search for larger errors can be carried out up to the edge of the seam. Standards also require, in certain circumstances, a different evaluation of large and small pores or holes.

The search for very small defects naturally also increases the risk of pseudo-errors, i.e. errors being detected where there are none. Since very small defects do not necessarily render the entire seam unusable, the number of permitted errors over a given trajectory is usually higher than 0 in the tolerance, in contrast to the occurrence of a single larger error.

The error objects can be displayed in the image by placing a tick for the error objects and boundary box (BBox) in the display area. Using the arrows, you can jump from error to error through the image. In the representation graph, the hole is very clearly recognisable in the profile. The 'Evaluation' tab also contains a 3D representation of the error.

A hole or pore typically possesses one geometric characteristic, however depending on the seam material it can also have a significant effect in the intensity image. Consequently, the information from both image sources may also need to be combined.

Geometric detection takes place by subtracting a highly smoothed variant of the profile image from the original. Smoothing either partly or completely eliminates defects depending on the filter size and error size and replaces them with the surroundings. By subtracting this image from the original, the errors are then worked out in the differential image. The remaining differences are segmented using a threshold and then put together to form objects. The objects can then be evaluated based on side ratio (shape) and area before the tolerance is finally applied.
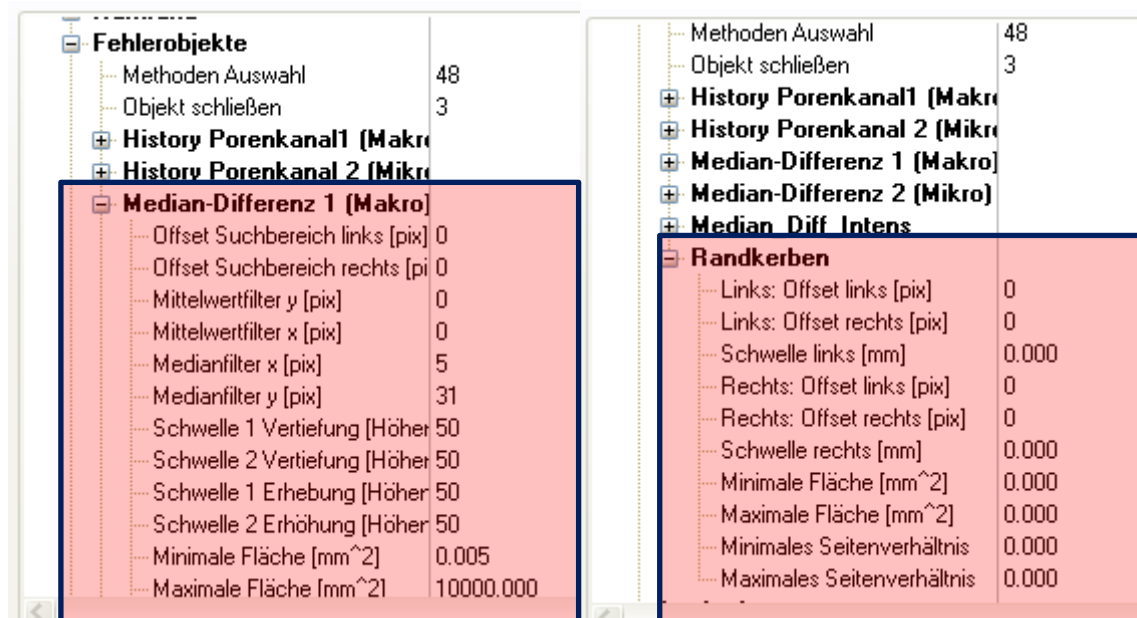
Edge notches:

Edge notches are notch-like depressions at the seam edge, i.e. in the vicinity of the seam borders. Depending on the seam type, the notch may lie inside or outside the seam border. Affected areas are drawn in purple in the error representation. The depression is calculated using the Euclidian distance between the profile and the model.
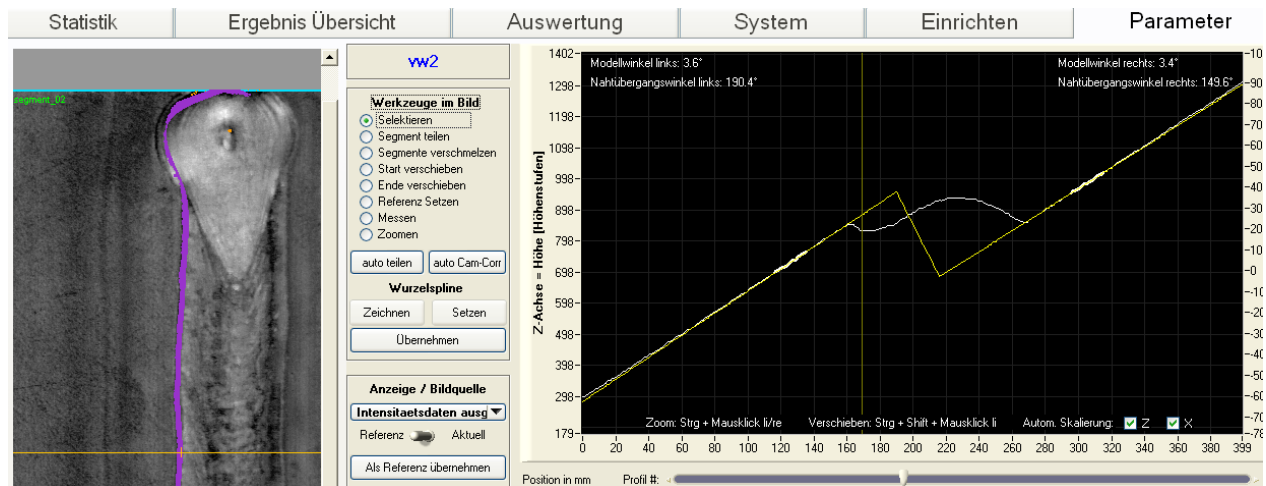
Parameters:

The parameters for the pores and hole search are found in the node 'Error objects'. The parameters of the median filter-based evaluation described above are found in the sub-node 'Median difference 1/2'.

Name	Default value	Description
Method Selection	16: Median difference 256: Edge notches	Activates the method(s) for error detection.
Close Objects	3 [pix]	Performs a close operation on the found object.

		This makes weak objects clearer.
Median difference		
Offset search area depression left / right	0 [pix]	Offset to the seam border for the search for depressions (pores). A positive value restricts the area inwards. A negative value extends the search beyond the seam borders.
Mean value filter x/y	0 [pix]	Optional mean value filter for generating the 'error-cleaned' filtered image.
Median filter x/y	0 [pix]	Median filter size for generating the 'error-cleaned' filtered image. This image is then subtracted from the original.
Threshold 1 Cavity [height values]	16 [height units]	Threshold value for the search for depressions (pores) in the differential image.
Threshold 2 Cavity [height values]	16 [height units]	2nd threshold value for the search for depressions. If the 1st threshold is exceeded, the search continues from there outwards to the point below the 2nd threshold. This optional variant can optimise the size of the error object.
Threshold 1 Bump [height values]	50 [height units]	Threshold value for the search for elevations (pits, spatter) in the differential image.
Threshold 2 Bump [height values]	50 [height units]	2nd threshold value for the search for elevations. If the 1st threshold is exceeded, the search continues from there outwards to the point below the 2nd threshold. This optional variant can optimise the size of the error object.
Minimum area	0.0 [mm^2]	Minimum area from which an object is marked as a potential error.
Maximum area	1000000.0 [mm^2]	Maximum area up to which an object is marked as a potential error.
Minimum aspect ratio	0.0	Minimum aspect ratio of the circumferential rectangle from which an object is marked as a potential error.
Maximum aspect ratio	1.0	Maximum aspect ratio of the circumferential rectangle up to which an object is marked as a potential error.
Undercuts		
Offset Searcharea Left [pix]	10 [profile points]	Search area for edge notches around the left-hand seam border.
Left threshold	0.2 [mm]	Threshold value at the maximum depth of the left-hand notch measured in the search area.
Offset Searcharea Right [pix]	10 [profile points]	Search area for edge notches around the right-hand seam border.
Right threshold	0.2 [mm]	Threshold value at the maximum depth of the right-hand notch measured in the search area.
Min. Area [mm^2]	0.0 [mm^2]	Minimum area from which an object is marked as a potential error.
Max. Area [mm^2]	1000000.0 [mm^2]	Maximum area up to which an object is marked as a potential error.
Min. Aspect Ratio	0.0	Minimum aspect ratio of the circumferential rectangle from which an object is marked as a potential error.
Max. Aspect Ratio	1.0	Maximum aspect ratio of the circumferential rectangle up to which an object is marked as a potential error.

7 Tolerance of measuring results

To ensure that the system operator does not lose an overview of the variety of parameters, the results display with the tolerance parameters has been separated from all other parameters. Following successful basic parameterisation, the tolerances should also be set which will then ultimately lead to a good or bad seam - and therefore component - result. The tolerance is therefore carried out in the Evaluation tab, with the measuring values of each characteristic also being displayed.

Attention!
Virtually all characteristics are only calculated if the seam length has been determined successfully, i.e. if any seam has been detected at all, regardless of whether the measured seam length is being evaluated. The seam length is determined from the area of the seam that falls short of the set minimum width (see Seam border parameters > Minimum width).

Essential for ensuring that the measuring values can be calculated correctly in global coordinates [mm]is that the job parameters ScaleX and ScaleY are set correctly according to the sensor used (see job parameters).

The available characteristics are:

- Length or part length (segment length)
- Width
- Superelevation
- Descent
- Position
- Thickness (a-dimension)
- Cross-sectional area
- Asymmetry
- Left / right seam transition
- Holes / pores
- Spatter
- Volume
- Zero point proportion
- Width / height ratio
- Edge notches

The mechanisms for tolerance are the same for all characteristics with measuring value progressions as with the width measurement, for example. With length measurement, only the length dimension is tolerated, i.e. a few parameters are missed out here. The parameters for pore and hole searching are of course also slightly different.

Procedure for selecting a seam and characteristic:
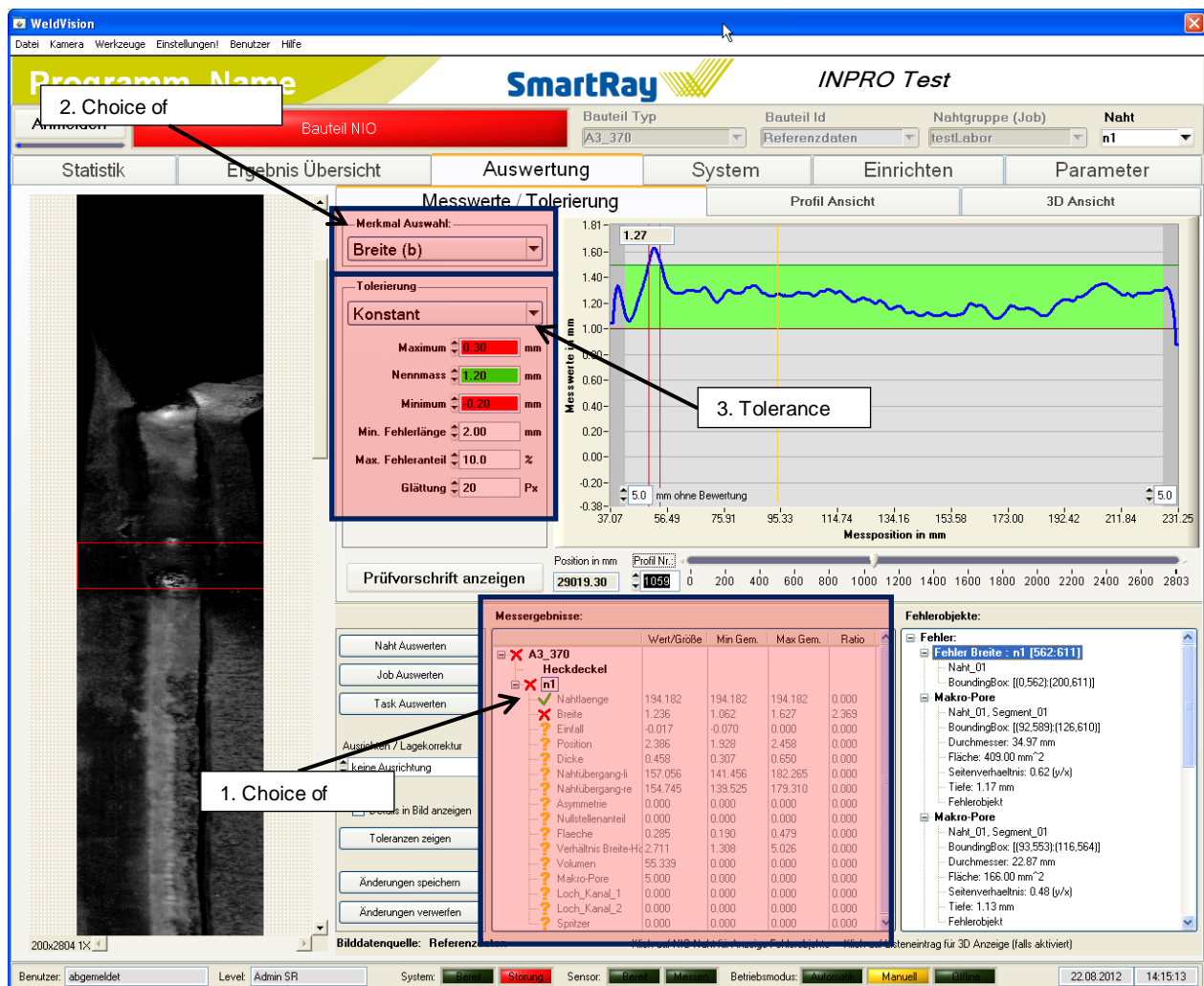
Types of tolerance:

Deactivated	The characteristic is deactivated, is therefore not evaluated and is not factored into the seam result.
Constant	fixed limits are defined along the seam's entire measuring value progression In this mode, the tolerances must be entered via the tolerance parameters.
Flexible	In the graph, freely definable contours can be drawn in for the upper and lower limits. The values in the tolerance parameters 'Maximum' and 'Minimum' then specify an offset to the drawn progression. Tip! To begin with, set these parameters to zero.
Statistical	The test run function in the Statistics area allows a given number of data records to be used to determine the tolerances statistically. The tolerance ranges thus determined can then be reused just as well as ones that have been drawn in. Here too, the choice must therefore be in favour of 'flexible'.

Tolerance parameters for characteristics with measuring value progressions, e.g. width:

Nominal dimension	The nominal dimension is the characteristic's mean ideal value.
Minimum	Offset to the nominal dimension downwards.
Maximum	Offset to the nominal dimension upwards.
Min. error length	Only if the tolerance overrun continues for longer than this length will the overrun be evaluated as a true error.
Max. error proportion	Only if all of the characteristic's individual tolerance overruns relative to the seam length across the entire seam are greater than this value will the characteristic be evaluated as

	bad.
Tolerance parameters for pores and hole detection:	
Min. diam.	Only objects larger than the minimum diameter are evaluated as errors.
Max. diam.	Only objects smaller than the minimum diameter are evaluated as errors.
Search area	The search area determines the radius of the circle around an object in which a search is carried out for further objects that are then counted as an associated group. This enables groups of pores or pore chains to be detected.
Max. number	The max. number of objects is relativised to the groups found via the search area. If, therefore, there are more than the permitted number of objects within a group, the characteristic is only then evaluated as an error.

7.1 Exclusion of seam ends from the evaluation

Offsets can be set for each characteristic in order to exclude seam ends from the evaluation. Seam ends are often not clearly defined, or are subject to major fluctuations in the process. As a result, it is perfectly possible for pseudo-errors to occur, i.e. an error is detected even though there is no such error there, or it is irrelevant.
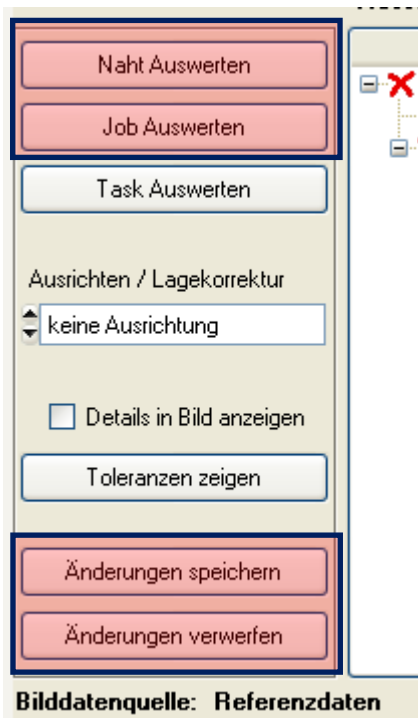
To begin with, the parameters should be set to zero in order to capture all error objects. Then, during optimisation, the seam ends should be sequentially excluded until the result satisfies the requirements.
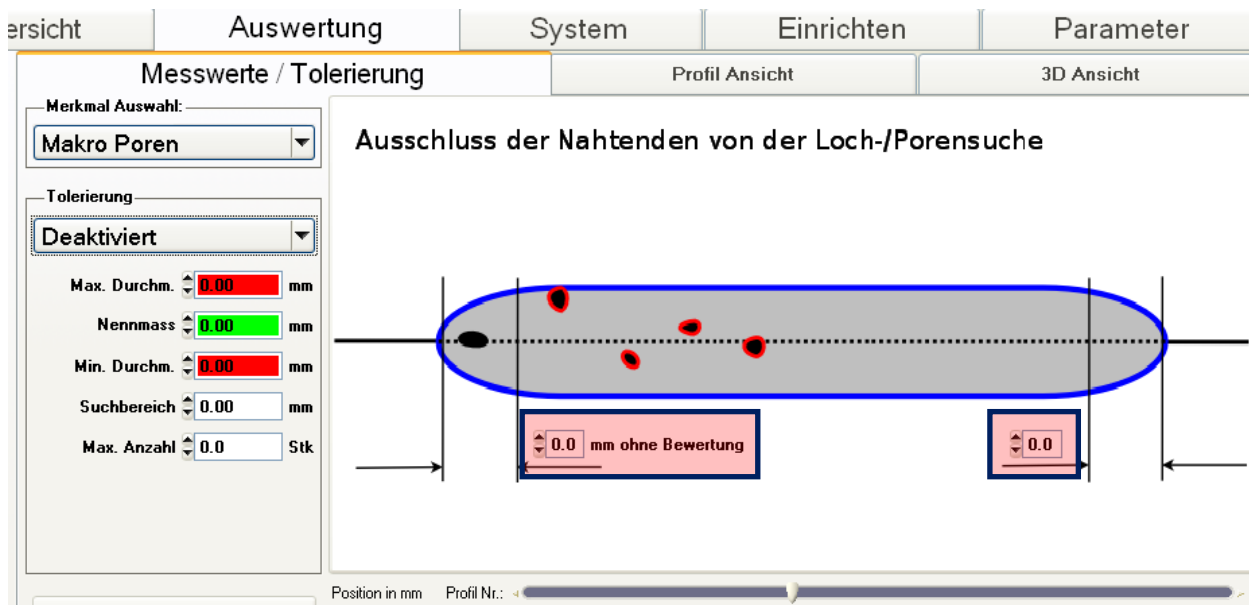
Attention! All tolerance parameters (but not the flexible, drawn progressions) can be transferred to other seams just like the parameters in the Parameters tab. To do this, click on a parameter with the right-hand mouse button.

Attention! Measuring value progressions are only available with data records that are currently being evaluated, or in the case of newer versions if they have also been archived. If the graph should not show any results, simply click on Evaluate seam or job.

Attention! Don't forget to save your work!!!

Congratulations!!! You've successfully set up seam testing.

Data records from a large number of parts can now be collated and the optimisation and validation begins in order to adapt the system as effectively as possible to the process fluctuations.

8   Viewing, equilibrating and optimising results

Of course, the system must be able to provide reliable information regarding the quality of a component's seams. The quality of the evaluation depends on the quality of parameterisation and tolerance. As a result, these need to be checked meticulously, particularly in the run-in phase, and optimised as necessary. This can only be done if a large number of data records are inspected and the results checked.

In order to enable this comparison between humans and machines to be carried out as conveniently as possible, WeldVision offers a number of options that include the manual evaluation of seams. In this case, the user can provide details of the quality of a seam and these details are then stored in the database for the component in question. Statistics can then be used to specifically filter according to deviations between the human and machine results.

It is also possible to evaluate any desired number of seams or components automatically as many times as you wish offline with adapted parameters if necessary. The results can then in turn be compared with the manual evaluations already saved.

If there are virtually no discrepancies from an adequately large number of representative data records, you can assume a very high degree of system reliability and go online with the parameters. The acceptance procedure for our WeldVision systems is carried out using these tools. This equilibration and optimisation process is also called validation.

8.1   Exporting / importing data

If there is no direct connection to the database or archive data, for example on a local system that is quite remote from the WeldVision system, the database must first be exported from the original system and the archive data copied. The archive data has a normal archive folder that functions like a ring memory by virtue of the WeldVision tool's automatic deletion of old data records and which copies the reference archive folder into the data records that have only been evaluated manually. Data records in this folder are not deleted automatically. This ensures that the reference data that has been evaluated manually is not lost. This database is then always available, in order to carry out a verification of the system's evaluation quality at any time, for example if changes have been made to parameters, tolerances or even methods.
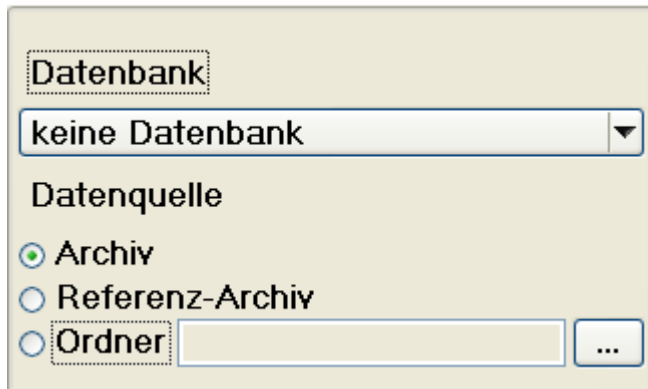
The database, but also the archive image data, is exported via WeldVision's functions into a file.

The archive folders, however, can also be copied using Windows Explorer, for example. The paths to the archive folder are set in the WeldVision configuration file config.xml. See General system settings.

The database and folders now need to be imported or copied into the local system. Ensure that the path specifications match in the WeldVision configuration file config.xml of the local instance.
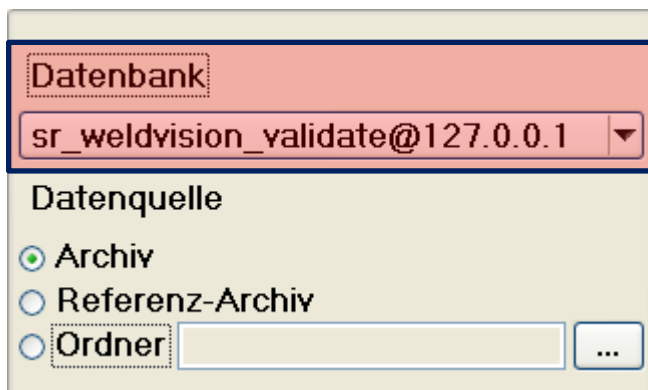
8.2 Filtering data and displaying hit lists

The normal route is now for the desired data records to be filtered for viewing via the imported original database. Alternatively, however, the folders only can also be imported without the database if the original database is not available. In this case, however, the required folder needs to be selected. You can also choose not to use the original database if, for example, no manual evaluation has been carried out on the system and the evaluation is also not yet usable due to incomplete parameterisation.

The data can be filtered in a variety of different ways. Time or shift, component type or group, results incl. manual evaluation. For more on the filtering options, see the chapter on Statistics.

If there is no original database available, a separate database should be generated at a later point and the manual evaluation of the seams also carried out in it. This is the validation database. It is needed for the human / machine equilibration. Results of test runs with new parameter settings are written in here and can then be evaluated statistically. They of course need to be set up on the system. See General system settings for more information.

8.3 The validation or reference database

Database entries in this database are only achieved by re-evaluating selected data records using the test run / validation function. Mark the required data records in the hit list (typically mark all if the filter has already supplied the correct selection) and activate the field marked 'Results -> Reference database' (if still available). This stores the results in the reference database. Click start.
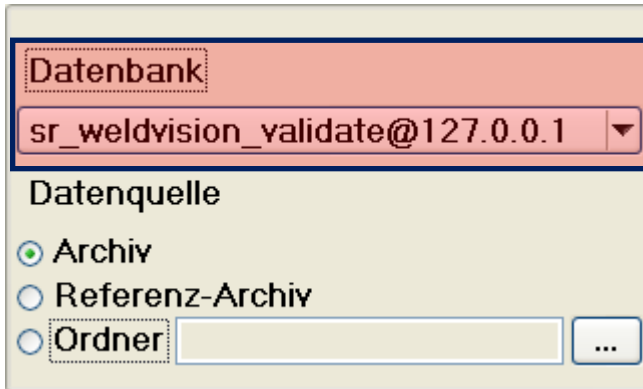
Results from new components are added to the database; results from existing components are deleted in order to avoid duplicated entries for the same component. Existing manual evaluations are adopted so that this important information is not lost. A test can therefore be carried out as many times as you wish. Manual evaluations are retained, however the old results of the evaluation are overwritten with the new results.

The results of a test run are therefore now found in the validation database.

Attention: The validation database contains selected data records for the purposes of targeted parameterisation and approval of the system. Adopted or individual manual evaluations of seams are possible.
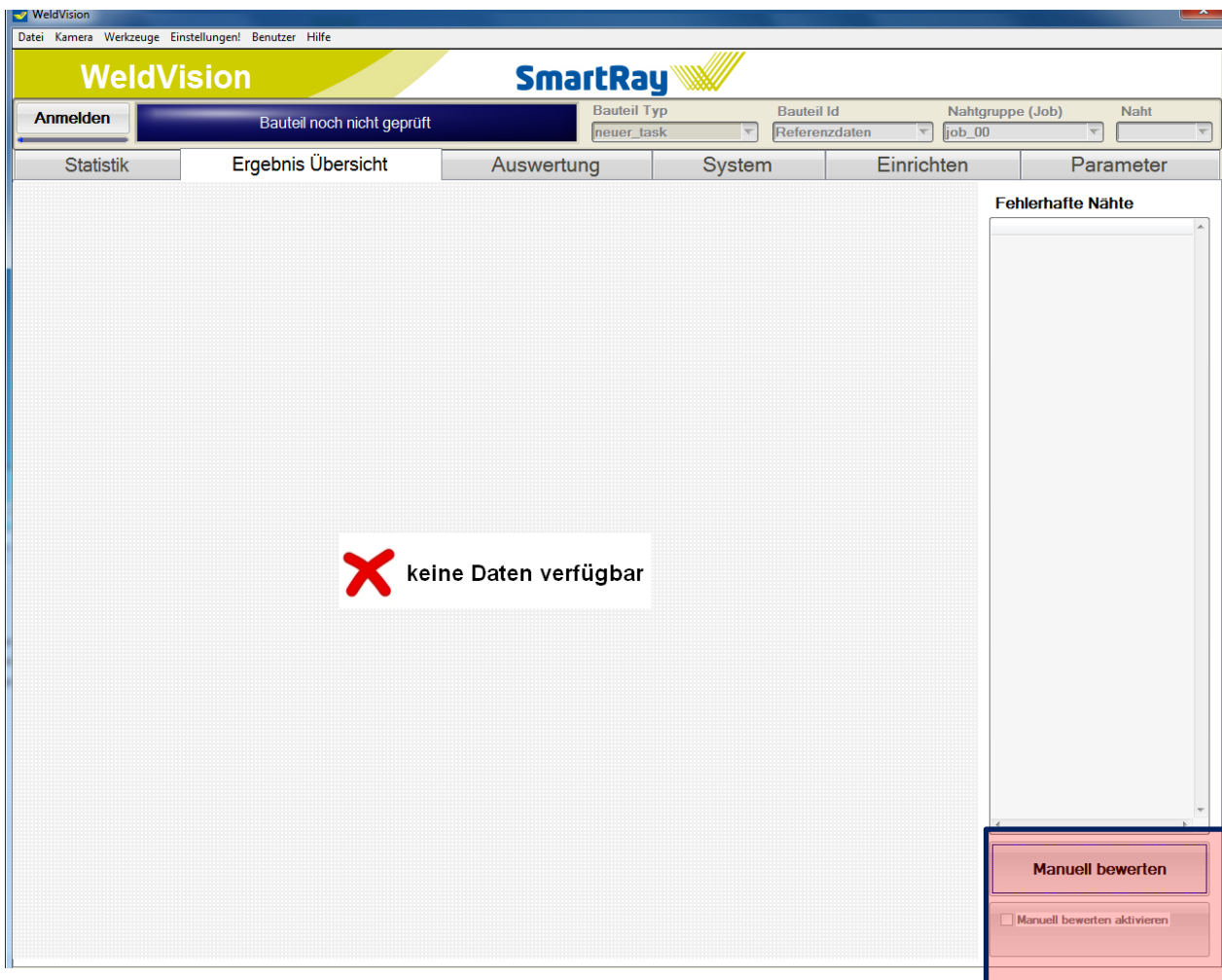
Attention: Emptying the validation database deletes all the manual evaluations generated in it.

Attention: The results can be filtered, displayed and evaluated as usual using the statistical tools. The database selection must however be switched to sr_weldvision_validate. Repeated test runs, however, are possible at any time with this setting to the same database.

8.4 Manual evaluation of a component

Double-clicking a component in the hit list switches to the 'Results overview' tab. The component can be evaluated manually here.

Clicking on 'Evaluate manually' opens the seam list and displays the current evaluation. The component can now either be evaluated in its entirety as Good (OK) or Bad (NOK), or each individual seam is evaluated. A black tick means Good (OK). Unfortunately there is no more aesthetically pleasing graphical input mask available at the moment.

A manually evaluated component is displayed with a background colour appropriate to the evaluation.

The manual evaluation can be corrected at any time with a new evaluation.

In this example, the manual evaluation is poor, however the assessment is good, which can be recognised from the green tick. This therefore represents a discrepancy, i.e. a deviation between human and machine.

8.5 Equilibrating data

In practical terms, a manageable volume, for example 50 representative data records, should be stored in the validation database and evaluated manually. The filters can then be used to search specifically for discrepancies, i.e. only those data records are displayed in which deviations between humans and machines occur, or only true NOK components are searched for, for instance. This filtering helps at a later stage of the parameterisation process to quickly locate and optimise the relevant data records.

The data records in the hit list can also be found in the drop-down menu on the right, at the top in the main view. This means that the data records can easily be scrolled through in all views.

The equilibration can now begin. Each data record is selected in turn and the evaluation checked step by step in the Measuring values / Tolerances tab or the Parameters tab.

1. Check the image data and decide whether the manual evaluation can match or not. It may be that the evaluation has simply been entered incorrectly, or that an error is being queried that is not detectable in the image. Errors that must necessarily be visible in the intensity image data (image display on the left) are typically all kinds of local defects, such as pores, holes, imperfections, etc. Even errors in the geometric characteristics, such as length, width, height, etc. are easily recognisable at a glance if they are locally limited or differ markedly from the normal dimensions. If the measuring values are borderline, i.e. too close to the tolerances, then this naturally becomes all the more difficult. In this case, the measuring value progressions need to be looked at. Characteristics such as the a dimension or seam transition angle or undercuts cannot be recognised in the intensity image, or can only be recognised with a great deal of experience. Here too, only looking at the characteristic's measuring data can help. If, therefore, neither the image data nor the measuring values reveal anything, then no attempt should be made to achieve the desired result any which way, but rather the individual who evaluated the component manually should be consulted to determine which type of error is supposed to have taken place here. It may be that the error is outside the recording and is therefore not visible. The fact is that the system cannot then find this supposed error and this data record is then not suitable for equilibration, or after clarification, it needs to be evaluated manually in a different way.

2. If, particularly during the early parameterisation phase, you need to assume that the basic settings such as image pre-processing, positional correction, root point progression, particularly the contour model, etc., have not yet definitely been set correctly, these settings should always also be checked. Most results depend very greatly on the quality of the contour model. Particular attention therefore needs to be paid to this. After a certain quantity of checked data, it will become apparent that the parameters are OK and this step can be skipped from this point forward. However you should always consider, in the event of unusual measuring results, that the error might not be due to an incorrect tolerance, but rather due to incorrect parameterisation and therefore measurement of the characteristic.

3. If you can assume that the parameters are OK, then the measuring values will also be OK. Only now can the tolerance for all desired and activated characteristics be checked and optimised. The setting of tolerances is typically the task of the system's operator. For an initial equilibration for the system acceptance, however, it is useful to work with your own tolerances. Since the tolerances can now be taught statistically, the amount of work involved is much less extensive.
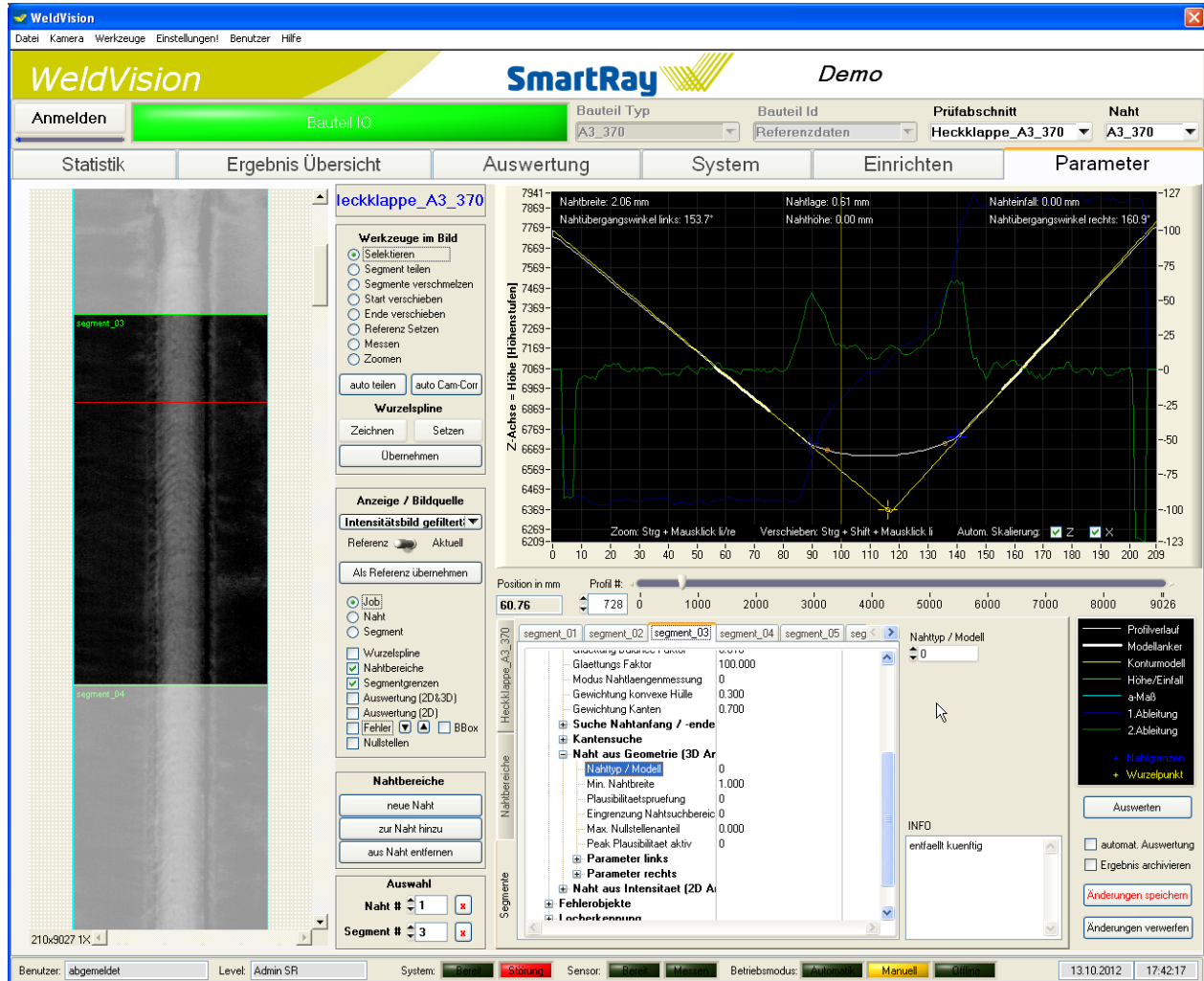
Attention: Often, detailed measuring results such as the seam width progression are not available upon visualisation of the data. In view of the large volumes of data, the database stores only the final results such as Good / Bad for each seam, the error objects, i.e. error locations and individual results such as the seam length. You only get the details if a new evaluation is carried out, i.e. after a data record is selected, the evaluation must first be carried out. This also makes sense, since you will want and need to test the modified parameters in order to visualise their effect. Newer versions will have the option of automatic evaluation, so that as soon as a data record is selected it is evaluated.

Depending on the version of WeldVision, it may be that results from the original evaluation have been stored with the archive data and can then also be displayed by selecting the display option 'From archive'.

SmartRay WeldVision
Seam inspection system

Measuring values / Tolerances tab view

SmartRay WeldVision
Seam inspection system
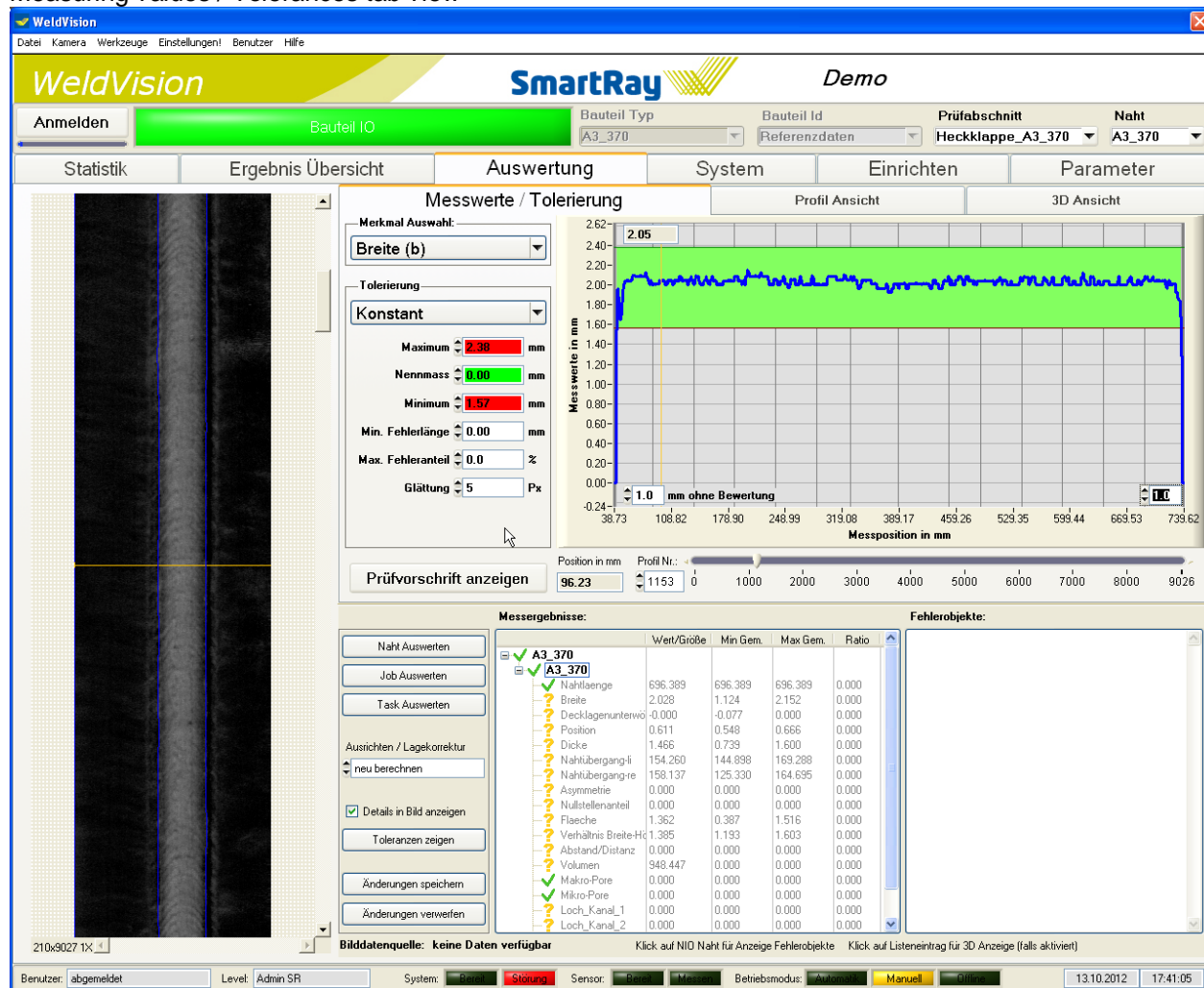
Parameters tab view

9 **Statistics**

Once the evaluation has been fully set up, statistical evaluations of the results can be used to obtain rapid statements regarding the quality and changes in the process can be detected. The options for statistics range from a simple OK/NOK distribution of the component to trend illustrations or documentation of the frequencies of certain error types.
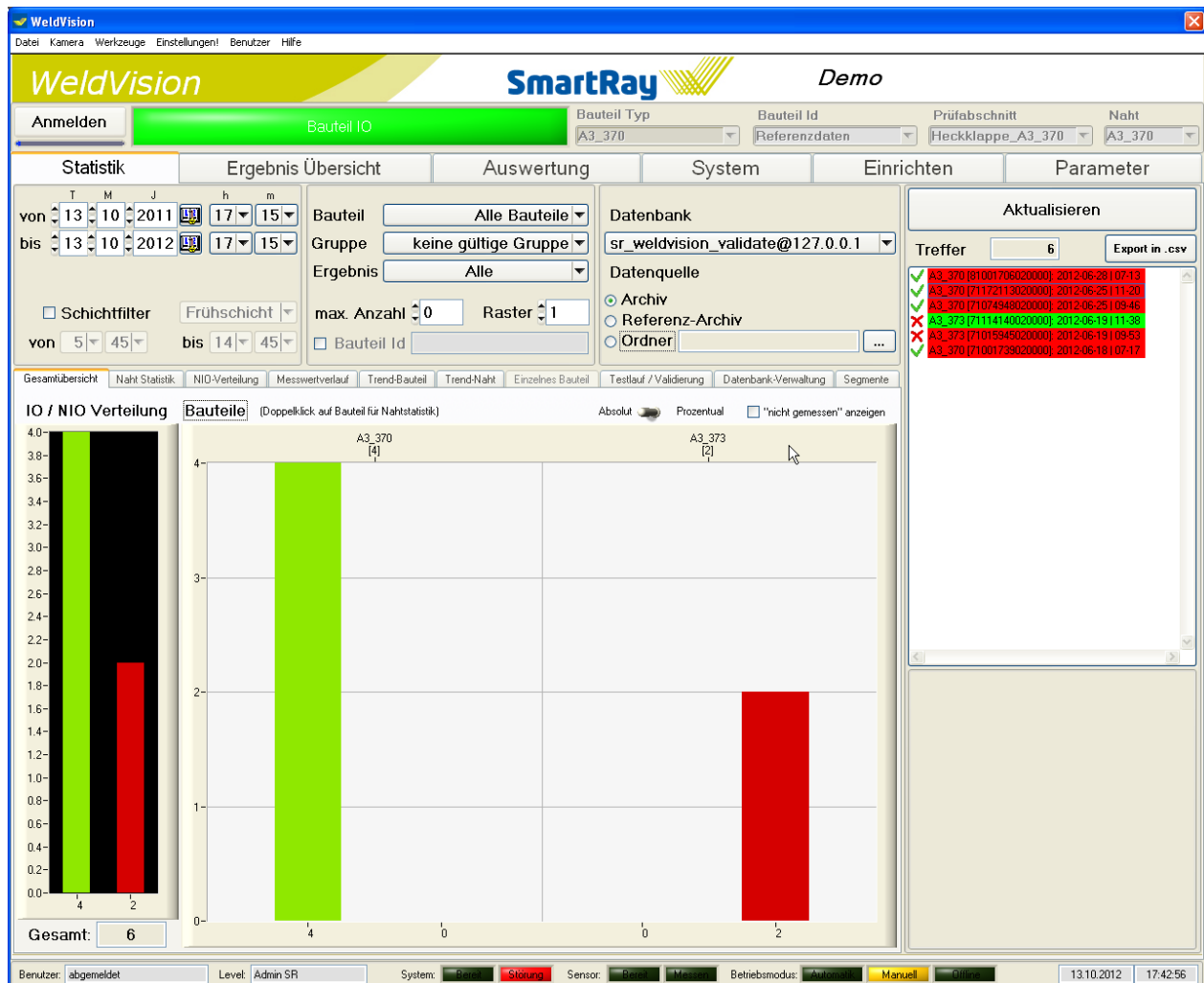
9.1 Filter area

To begin with, the filter is always set first. To do this, the period, the component types, the results and the data source, i.e. the database and / or archive folders are selected.

Attention: The hit list is not updated automatically. If you make changes to the filter, you will need to click on Refresh.

Attention: Right-clicking on the date or time will set the current time.

After pressing the Refresh button, the hit list appears.

The measuring results are identified using the following icons:

✔	Component tested -> Measuring result OK
✖	Component tested -> Measuring result NOK (error found)
❓	Result not available, e.g. because the component was not tested or no / the incorrect database was selected.

For hits shown in blue, data records have been found in the specified archive folder. This therefore means that detailed views of the results and offline optimisation / parameterisation are possible. For hits shown in black, only the result from the database is available, but no image data.

Data records highlighted red or green indicate that they were evaluated manually.

9.2 **Comprehensive overview**
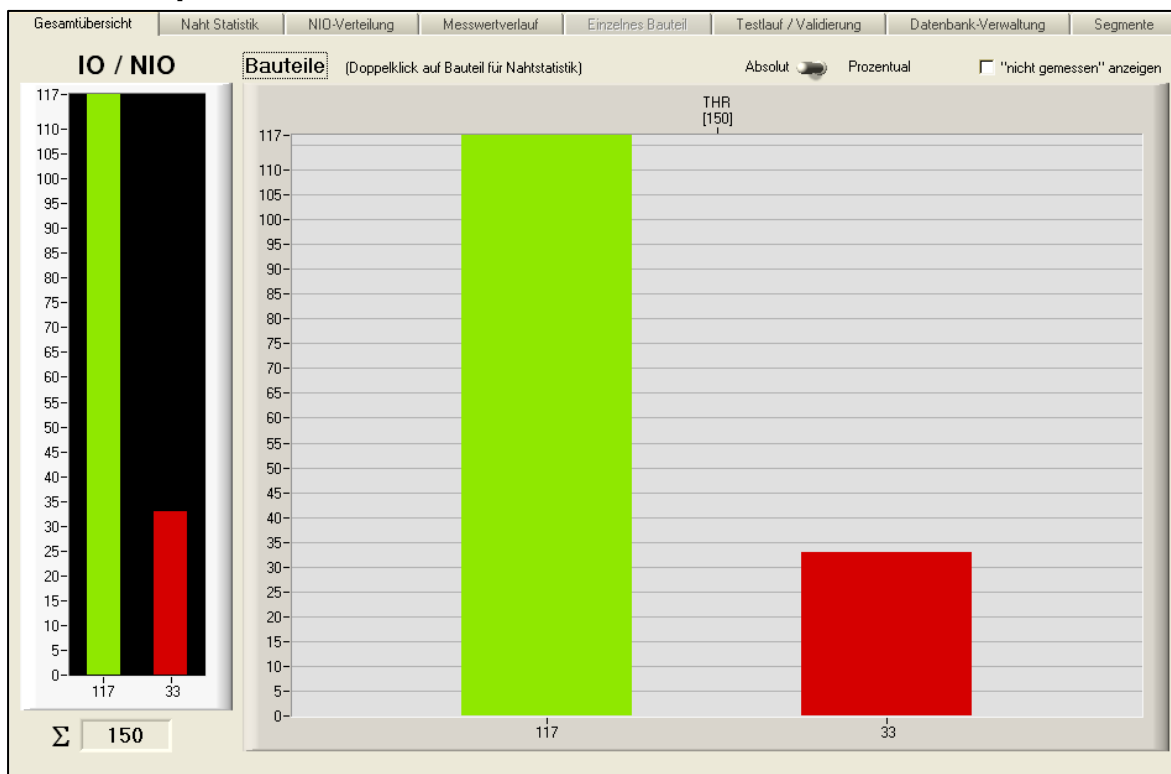
The Overview tab displays all of the tested components along with their measuring results.

>   Green: Measuring result OK

>   Red: Measuring result NOK

>   Yellow: Component not tested

The percentage share of the measuring results is displayed, along with the quantity of component tested.

The total of all measuring results from the selection is displayed in the area on the left. The bars in the area on the right show the number of parts tested as Good or Bad. More detailed evaluations of seams and characteristics can be performed using the other tabs, such as Seam statistics.

9.3 Seam statistics
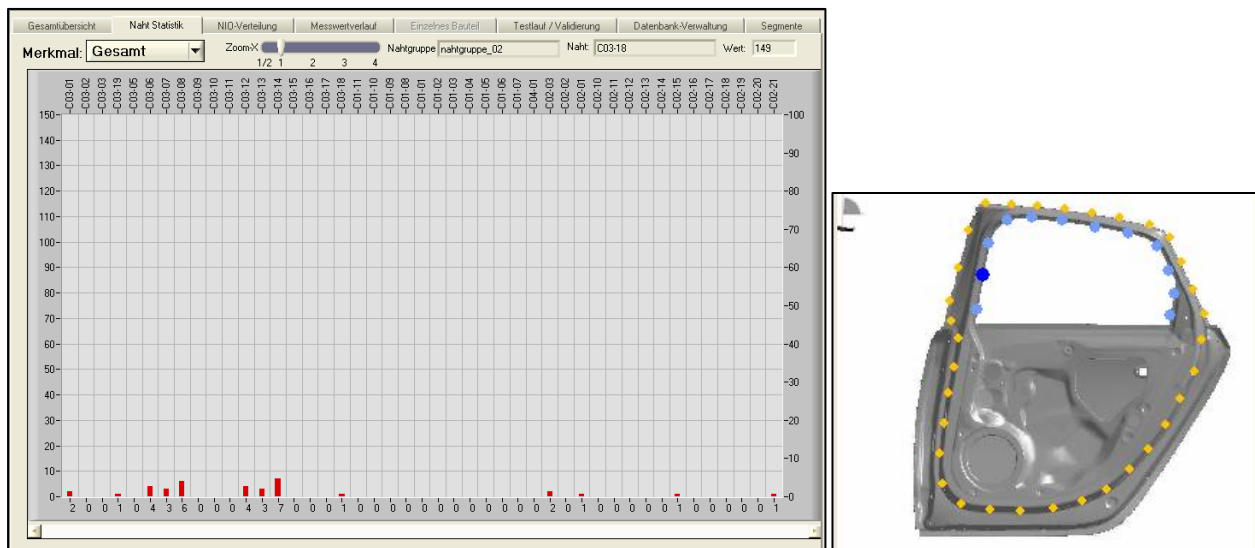
In this view, all of the seams of a component are shown with reference to the number of errors they contain.
A drop-down menu allows the display to be limited to individual characteristics.
If you move the mouse over the individual seams, their position in the component image is displayed (bottom right).
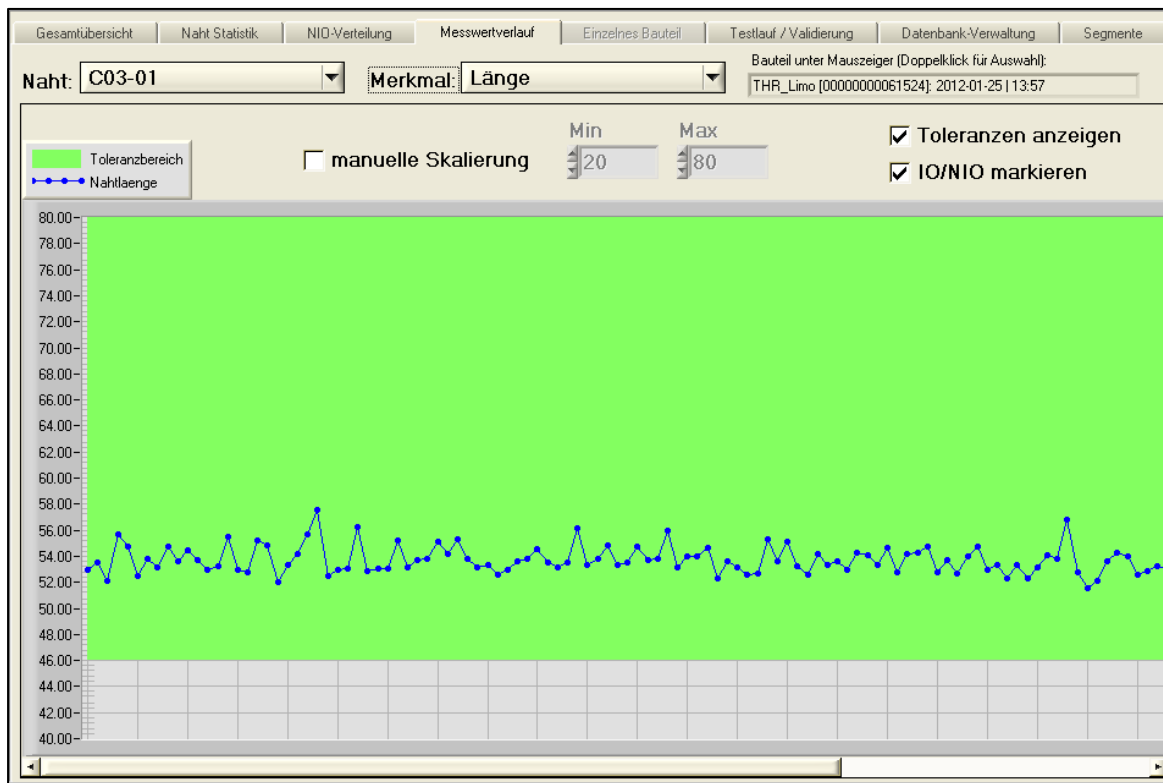
9.4 NOK distribution
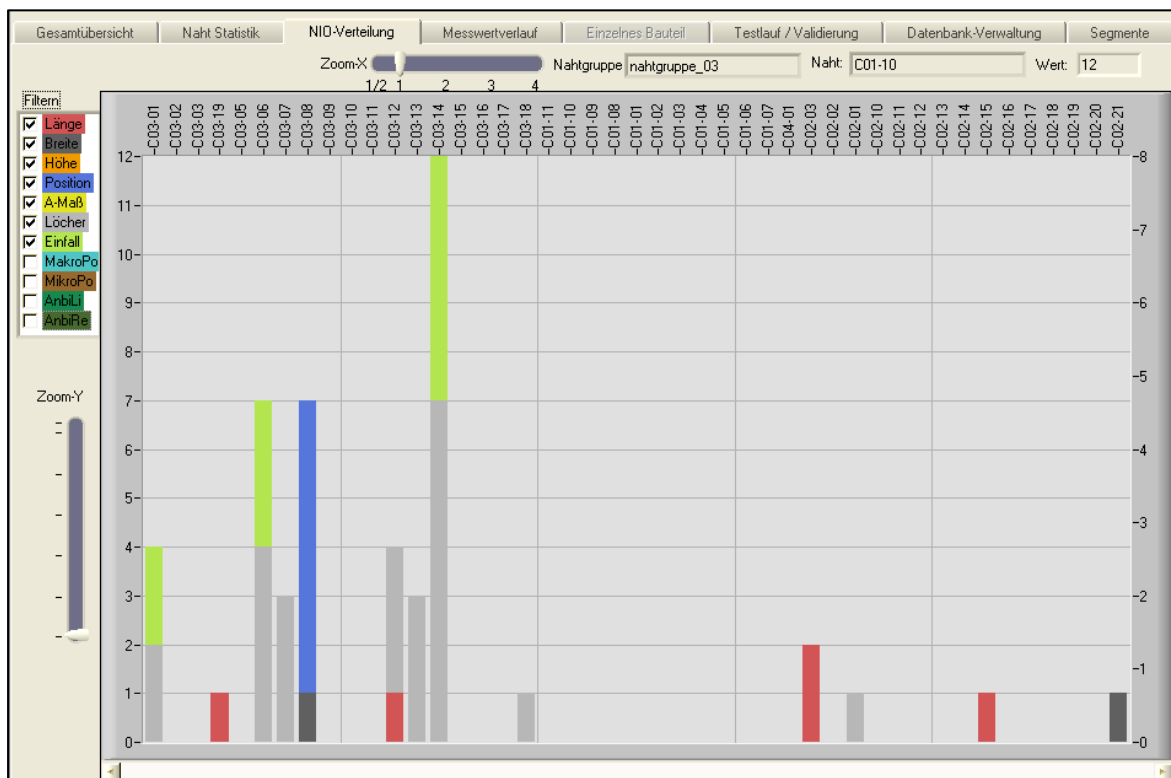
The "NOK distribution" tab provides are representation of the correspondingly selected error characteristics for each seam.

Double-clicking on the seam result takes you to the "Measuring value progression" tab.
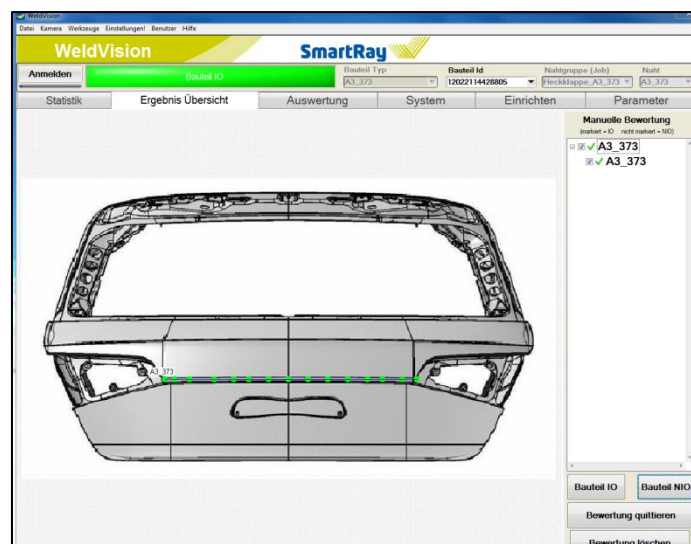
9.5 Measuring value progression

The "Measuring value progression" tab displays the corresponding progression of the characteristic in question for each measured component.

A drop-down menu allows the individual seams to be selected.

Double-clicking on the measuring point shown takes you to the associated component image in the "Results overview".

9.6 **Test run / validation**

This function is described in detail in the chapter entitled 'Viewing, equilibrating and optimising results'.

The test run offers the opportunity to test new parameter settings using stored data records.

The parameter settings that are currently saved are used for the test run (Parameters tab).

Before a test run can be started, the required component must be selected. This can also be filtered using a seam and results selection.

The results filter offers various options.
Filtering can be performed according to the following measuring results:

WeldVision — SmartRay — Demo

Anmelden | Bauteil IO

| Statistik | Ergebnis Übersicht | Auswertung | System | Einrichten | Parameter |

von 13 10 2011 17 15 Bauteil A3_370 Datenbank
bis 13 10 2012 17 15 Gruppe keine gültige Gruppe sr_weldvision_validate@127.0.0.1

Ergebnis: Alle Datenquelle

- Alle
- Nicht getestet
- IO
- NIO
- Werker_IO
- Werker_NIO
- IO/Werker_IO
- NIO/Werker_IO
- IO/Werker_NIO
- Diskrepanz
- mit Werkerbewertung

○ Archiv
○ Referenz-Archiv
○ Ordner

Aktualisieren

Treffer 4 Export in .csv

A3_370 [810017060200001 2012-06-28 | 07-13
A3_370 [711721130200001 2012-06-25 | 11-20
A3_370 [710743490200001 2012-06-25 | 09-46
A3_370 [710017390200001 2012-06-18 | 07-17

☑ Schichtfilter Frühschicht
von 5 45 bis 14 45
☐ Bauteil

max. Anz

Gesamtübersicht | Naht Statistik | NIO-Verteilung | Messwertverlauf | Testlauf / Validierung | Datenbank-Verwaltung | Segmente

Bauteile in Trefferliste wählen oder alle markieren

Alle Bauteile markieren | Markierung aufheben | Anzahl markiert:

Nahtfilter

alle Nähte

☐ Archivdaten neu speichern
Pfad ...

☑ Ergebnisse in Validierungsdatenbank schreiben

Datenbank zurücksetzen

Testlauf starten

☐ Toleranzen Lernen | Durchläufe 1

Ergebnis Details sind nur über die Validierungsdatenbank verfügbar.
Für Ansicht Einträge in weldvision_validate Datenbank suchen.
Dann in Trefferliste Eintrag zur Ansicht wählen.

Benutzer: abgemeldet | Level: Admin SR | System: Bereit Störung | Sensor: Bereit Messen | Betriebsmodus: Automatik Manuell Offline | 13.10.2012 17:49:15