
Operating & Processing Software
RiSCAN PRO
for RIEGL 3D Laser Scanners
VZ-400
RIEGL
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Version 2.0.3

RiSCAN PRO

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Table of Contents

Part I

Introduction

1 Introduction

RiSCAN PRO is the accompanying software package for the RIEGL 3D laser imaging scanners of the LMS-Z series. It allows the operator of the 3D imaging scanner to perform a large number of tasks including sensor configuration, data acquisition, data visualization, data manipulation, and data archiving using a well documented structure.

RiSCAN PRO is project oriented. The entire data of a project is stored within a single directory structure containing all scan data, calibrated photographs, registration information, additional descriptors and processing outputs.

We publish our project structure to allow our software partners to directly access all useful data gained within a scan project. The structure of the project is stored in a text based and documented project file making use of the XML language (see "Data exchange: Fileformats: RSP 327"). The name of the project file is "project.rsp". Within RiSCAN PRO all data is organized in a tree structure for comfortable access and clarity.

Part II

Installation

2 Installation

2.1 System requirements

Before you install RiSCAN PRO on your PC please make sure that the system meets the following requirements:

Operating system:

- Windows XP Professional
- Windows Vista Professional
- Windows 7 Professional
- Windows 8 Professional
- Windows 8.1 Professional
- 32 or 64 bit operating system

Note:

- In case of Windows Vista/7/8, please ensure that you have up-to-date device drivers installed (especially for the graphic card).
- RiSCAN PRO has no special extensions for multiprocessor or multicore computers. One function (triangulation, texturing or something else) will only load one processor. On the other hand you can start two (or even more) functions in parallel.

Memory requirements:

2 GB RAM minimum,
8 GB or more RAM **recommended**

Note:

On 32 bit operating systems, RiSCAN PRO 32 bit can use up to 3 GB RAM.
On 64 bit operating systems, RiSCAN PRO 32 bit can use up to 4 GB RAM.
On 64 bit operating systems, RiSCAN PRO 64 bit can use practically unlimited RAM.

Disk space requirements:

Approximately 200 MB for the program and plugins.
Approximately 700 MB for the example project (only included in the CD version of RiSCAN PRO).
At least 100 GB **recommended** for your own projects.

Hint:

The performance (in terms of speed) is often limited by the hard-disk(s). With increasing (scan-) file size the performance gets worse. So it is strongly recommended to use high speed hard-disks with a big cache memory. To further increase the speed, you can either use Solid State Drives (**SSD**s) or use more than one hard-disks combined in a Redundant Array of Independent Disks (RAID). RAID 10 for example gives good read/write-speed and high data security.

Interface for scanner communication:

Ethernet (LAN / WLAN 2.5 or 5 GHz, WPA) interface
Serial and ECP parallel interface

Graphics requirements:

1024 x 850 pixels minimum
1920 x 1080 pixels **recommended**
3840 × 2160 pixels **Ultra-High Definition (UHD) Displays supported**

OpenGL accelerated NVIDIA graphics card (NVIDIA GeForce series **recommended,** GeForce-7 or higher) with minimum OpenGL Version 2.0

See also: System configuration for NVIDIA graphics cards 5.

Note:
Some Laptops use hybrid graphic cards, i.e. a graphics processing unit ("GPU") combined with an integrated graphics processor ("IGP"). The aim is to provide fluent 3D graphics display and save battery by automatically switching between GPU and IGP on demand.
On Laptops using NVIDIA's Optimus technology, we have observed that sometimes only the IPG is used which may give bad 3D graphics performance or even display errors. So we recommend to configure the graphic card driver to use GPU instead (you can do this in the NVIDIA Control Panel).

Peripherals:
3 button mouse, optical wheel mouse **recommended**

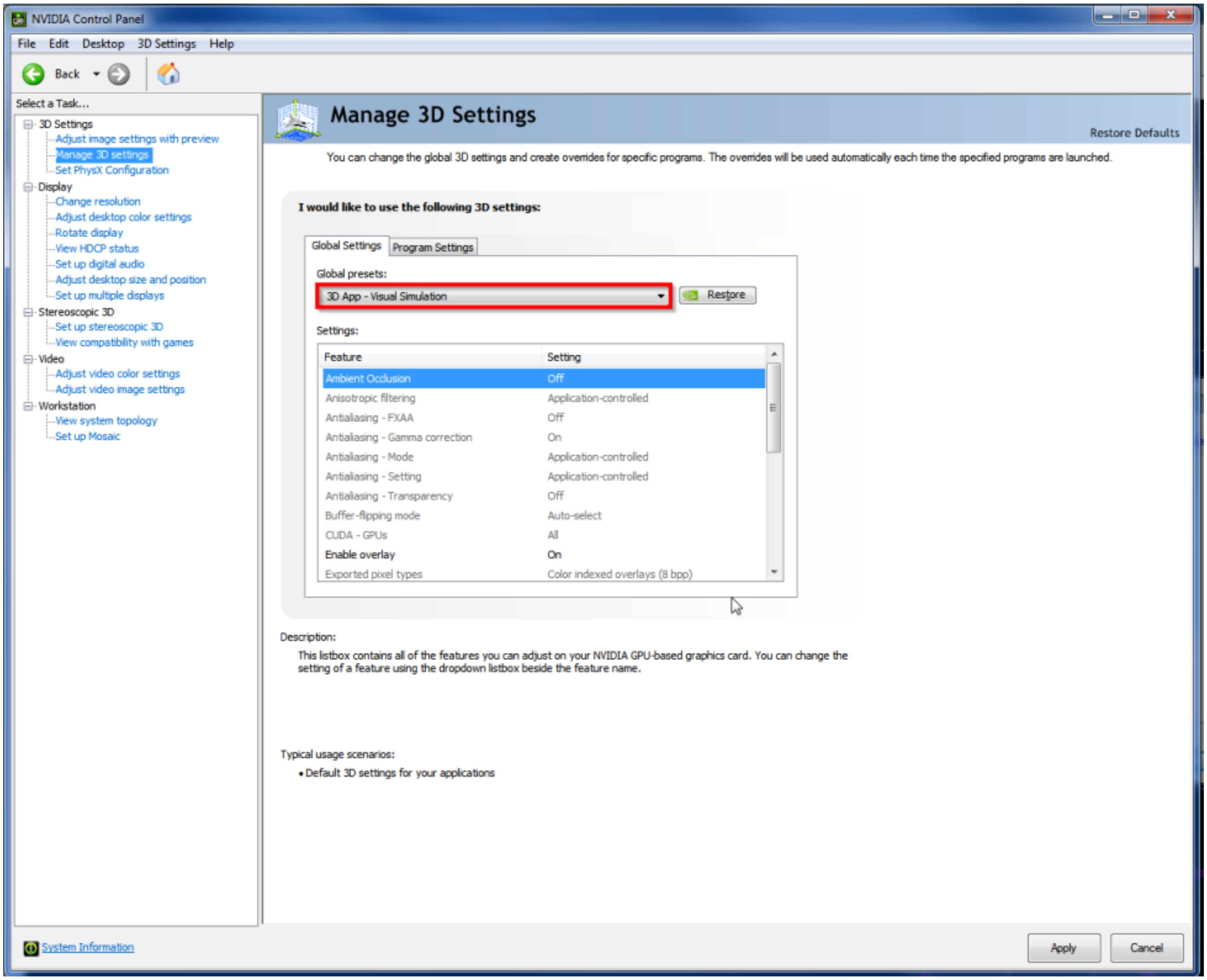
2.2 System configuration for NVIDIA graphics cards

Depending on which NVIDIA graphics card model is used some additional system configuration is required to further improve the graphics performance of RiSCAN PRO.

NVIDIA Quadro graphics card configuration

In order to fully utilize NVIDIA Quadro driven graphics cards it is recommended to switch to "3D App - Visual Simulation" in the NVIDIA Control Panel.

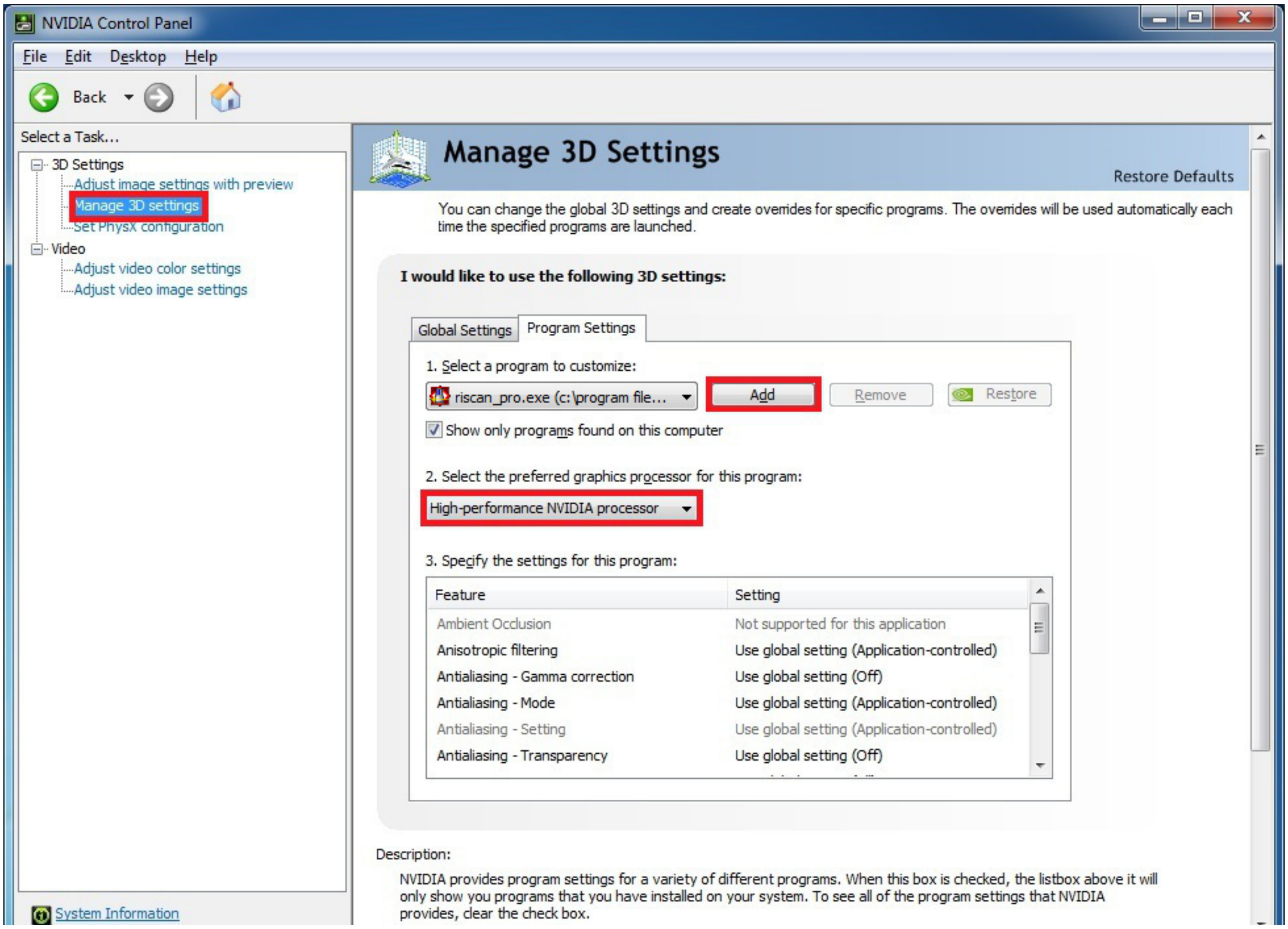
1. Open the "NVIDIA Control Panel"
2. Go to "3D Settings" -> "Manage 3D settings"
3. Go to tab "Global Settings"
4. Select "3D App - Visual Simulation" for "Global presets:" and click "Apply".



NVIDIA Optimus Technology

Some Notebooks use hybrid graphic cards, i.e. a graphics processing unit ("GPU") combined with an integrated graphics processor ("IGP"). The aim is to provide fluent 3D graphics display and save battery by automatically switching between GPU and IGP on demand. On Notebooks using NVIDIA's Optimus Technology, we have observed that sometimes only the IPG is used which may give bad 3D graphics performance or even display errors. So we recommend to configure the graphic card driver to use GPU instead.

1. Open the "NVIDIA Control Panel"
2. Go to "3D Settings" -> "Manage 3D settings"
3. Go to tab "Program Settings"
4. Under "1. Select a program to customize:" Click the "Add" Button and add RiSCAN PRO to the list.
5. Under "2. Select the preferred graphics processor for this program:" select "High-performance NVIDIA processor" and click "Apply".



2.3 Program installation

To install RiSCAN PRO on your system just run "SetupRiSCAN_PRO.exe".
This program will guide you through all parts of the installation process.

Note: Make sure that you have **administrator privileges** before you install RiSCAN PRO. For proper usage of RiSCAN PRO it's necessary that the current user is at least member of the user group "**Power user**" (in German versions of MS Windows: "Hauptbenutzer"). Otherwise RiSCAN PRO will be unable to save program parameters or might not even start. Please contact your system administrator to set the access rights properly.

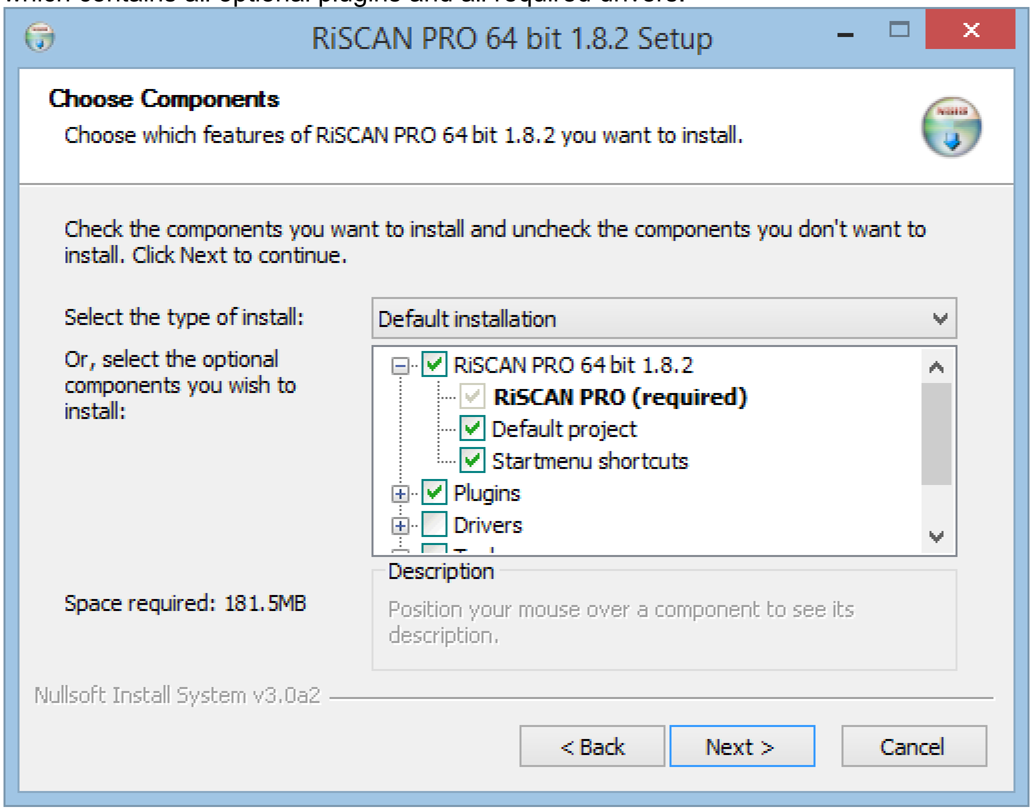
Note: If you're installing RiSCAN PRO for the first time and you've received an USB dongle for software protection please do not attach the dongle until the installation procedure is completed. After installation close all RIEGL programs and attach the dongle. Now you can start RiSCAN PRO.

Steps of installation:

- **License agreement:**
  First of all you will be prompted to accept the license agreement.
  Please read the license agreement carefully and press the button "I agree" in order to accept the license agreement and continue the setup.
  Otherwise the setup will be aborted without installing RiSCAN PRO.

• Component selection:

The setup of RiSCAN PRO is available in different versions: small, medium and full. The components which are actually included in the setup may differ. The following description is based on the full setup which contains all optional plugins and all required drivers.



In this dialog it is recommended to select the "Full Install" option to make sure that all components are installed.

Component description:

- **RiSCAN PRO (required)**
  The application itself
- **Default project**
  Contains a RiSCAN PRO project with default camera calibrations and camera mountings.
  The default project will be copied to the selected project folder which will be defined on the next page.
- **Startmenu shortcuts**
  Add shortcuts (links) for RiSCAN PRO to your startmenu.
- **Plugins**
  This section contains the optional plugins for RiSCAN PRO (such as Camera, Hybrid Multistation Adjustment)
- **Drivers**
  This section contains the drivers available for RiSCAN PRO

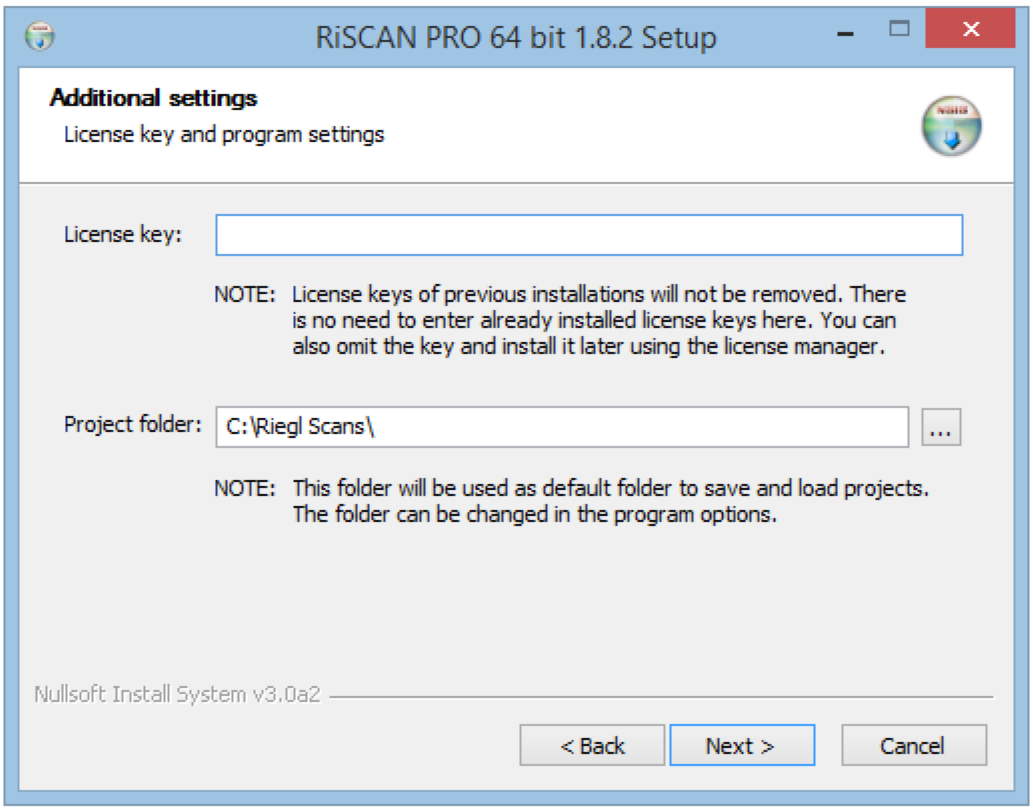
- **RiPort**
  This installs the RiPort driver on your system.
  Note: RiPort is **not** needed on PCs with MS Windows95/98 or if you do not intend to use the parallel port for data acquisition.

  If the setup detects that RiPort is already installed, you will be asked whether the installed driver or the driver of the RiSCAN PRO package should be used.

  If you decide to use the driver of the package, the old driver is uninstalled and the new driver is installed.
  Note: The system will have to be rebooted twice.

  More information about "RiPort" 349

- ## Additional settings:



- **License key:**
  Enter the license key here.
  The license key can be entered with or without the dashes ("-") between the numbers.
  Also the characters can be uppercase or lowercase ("A" or "a").

  If you do not enter a license key you can use the license manager 10 of RiSCAN PRO to manage your licenses later.
  If you do not enter a license key a default viewer license key will be installed which allows you to run RiSCAN PRO but you are not able to acquire data.

  Note:

If you update RiSCAN PRO to a newer version you do not have to enter a license key because the "old" one(s) are used.
The license keys of RiSCAN PRO are saved in both a per-user and a global manner.

- **Project folder:**
  Enter the folder where the projects and the default project (if selected) should be saved. The default folder is "Riegl Scans", located directly on the C:\ drive. You can also modify this folder in the Program settings 32.

- ### Installation Directory

  On this page you can choose the folder where RiSCAN PRO will be installed to.
  The default folder is "Riegl_LMS\RiSCAN_PRO\" in your applications folder.

- ### Complete installation

  By clicking "Install" on the "Installation Directory" page the installation is completed.
  Now all required files are copied to your system.

  Note:
  For each selected plugin and driver (except "RiSCAN LIB") the corresponding setup is started during the installation of RiSCAN PRO.

2.4 License manager

To run RiSCAN PRO it is necessary to enter a valid license key once. This can be done during the installation 9 or anytime while RiSCAN PRO is running.
The license keys for RiSCAN PRO are saved in both a per-user and a global manner. While the per-user licenses are only valid on the user account where the key was entered, the global license keys are valid for all user accounts.

Generally a key has two criteria:

- **Time**

  - *unlimited*
    This key has no expiry date.

  - *limited*
    This key is only valid until a certain date. After this date (and if no other valid license key is available) you can not work with RiSCAN PRO. (The license manager appears on startup.)

- **Device**

  - *HDD-Lock*
    The key is only valid on a PC with a certain hard-disk-ID. In this case RiSCAN PRO works with all RIEGL LMS-scanners.

  - *Device-Lock*
    This key in only valid in combination with a certain scan device. In this case you can start the program, but you can only work with the scanner determined by the key. Connections to other scanners will be refused.

  - *Dongle-Lock*
    Alternatively a USB dongle is available. The advantage of the dongle is that you can work on any PC equipped with a USB port with just one license key and all instruments.

Since RiSCAN PRO version 1.3.0 three different categories of licenses are available:

- **Viewer license** (V)
  This license is automatically installed with RiSCAN PRO and enables you to open and view projects. You can not modify or create data within the projects.

- **Acquisition license** (A)
  This license is bound to the serial number of an instrument and enables you to perform basic data acquisition and processing tasks.

- **Processing license** (P)
  This license is bound to a HDD-ID or a USB Dongle and can be used for advanced processing functions.

A complete list of which license is used for which function can be found in RiSCAN PRO in the menu "**Help ? > License table...**" (functions that are not mentioned there can be used without a license key).

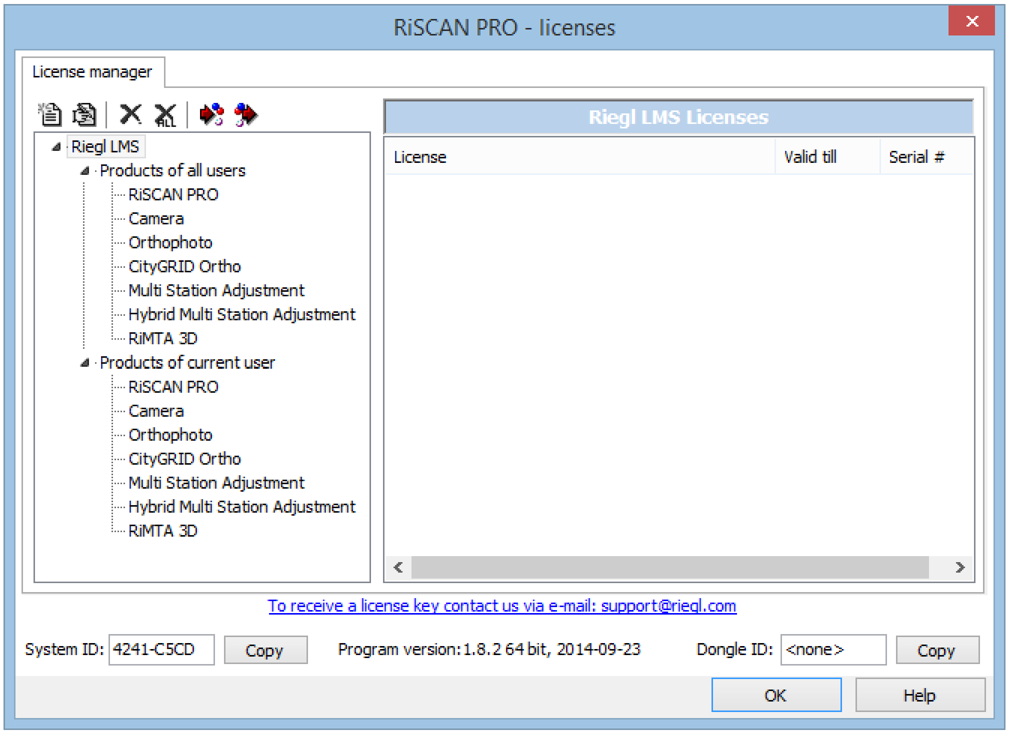
Since RiSCAN PRO version 1.4.2b7 licenses can have a maintenance contract limitation date. These licenses are only valid for program versions created before the end of the contract. So you can use the software as it is without time limitation, but the licenses may become invalid after a software update because of an expired maintenance contract.

For extended information about a license key (such as type, time limitation, maintenance contract end,...) hover your cursor over the license key for a moment until a small hint window appears.

Per default, all licenses are stored on the local computer. For **acquisition licenses** and **plugin licenses** you can also use remote licenses. In that case the license keys are saved on a central **license server**. Each client that needs a license must be connected to the same network as the license server. More information about remote licenses can be found below.

Manage local licenses:

With the built-in license manager of RiSCAN PRO you can add, edit and delete licenses for RiSCAN PRO and its plugins. To show the license manager click "**Tool > Licenses > Local licenses...**".
The license list shows currently existing license keys for RiSCAN PRO.



On the left side you can see a treeview showing the products of the current user and of all users. Click on a product to see the installed license keys. The license keys will be displayed in the list on the right side. The icon near the license key shows the state of the license key:

.... the key is valid
.... the key is NOT valid

Hint: To determine the type (Viewer, Acquisition, Processing) of a license key, hover the cursor over the license key and wait until the small hint window appears.

- ## Adding a license key:

By clicking on "Add new license key" a new dialog appears, where the new license key can be inserted.

Note:
It doesn't matter if you enter the license key with or without the dashes ("-") and blanks (" ").
Also the case of the characters isn't important.

- ## Editing a license key:

Select the license key by clicking on it.
Click "Edit license key".
A dialog appears, where the license key can be edited (see format notes at "Adding a license key" 12).

- ## Removing a license key:

Select the license key(s) you want to delete.
Click "Delete license key".

The selected license key(s) will be deleted without confirmation.

- **Removing all license keys:**

  Click "Delete all license keys".

  Note:
  There is no confirmation ("Do you really want to...")! The keys will be deleted and can not be restored.

- **How to get the HDD-ID:**

  In the bottom left corner of the license manager you can find a box showing the HDD-ID of your PC. By clicking the button "Copy" the HDD-ID is copied to the clipboard in order to be used in an e-mail to support@riegl.com.
  (The HDD-ID is also shown in the "about-box" of RiSCAN PRO.)

- **How to get the Dongle-ID:**

  In the bottom right corner of the license manager you can find a box showing the Dongle-ID (if a Riegl USB-Dongle is attached). By clicking the button "Copy" the Dongle-ID is copied to the clipboard in order to be used in an e-mail to support@riegl.com (The Dongle-ID is also shown in the "about-box" of RiSCAN PRO.)

Manage remote licenses:

To manage the remote licenses, select "**Tool > Licenses > Remote licenses...**" from the menu. The license manager for remote licenses is displayed. For a detailed description of this window please refer to the documentation bundled with the **LicenseServer** program.

You can find the **LicenseServer** program on the download page 338 of RiSCAN PRO in the section "**Tools**".

Read licenses from instrument:

During production of the laser scanner, license keys for data acquisition are saved in its internal memory. To read and save these licenses you can use the function "**Tool > Licenses > Read licenses from instrument...**". After definition of the communication port, RiSCAN PRO connects to the instrument and reads all saved license keys. All license keys that are valid for RiSCAN PRO or a plugin (e.g. camera plugin) are saved on the computer as licenses of the current user.

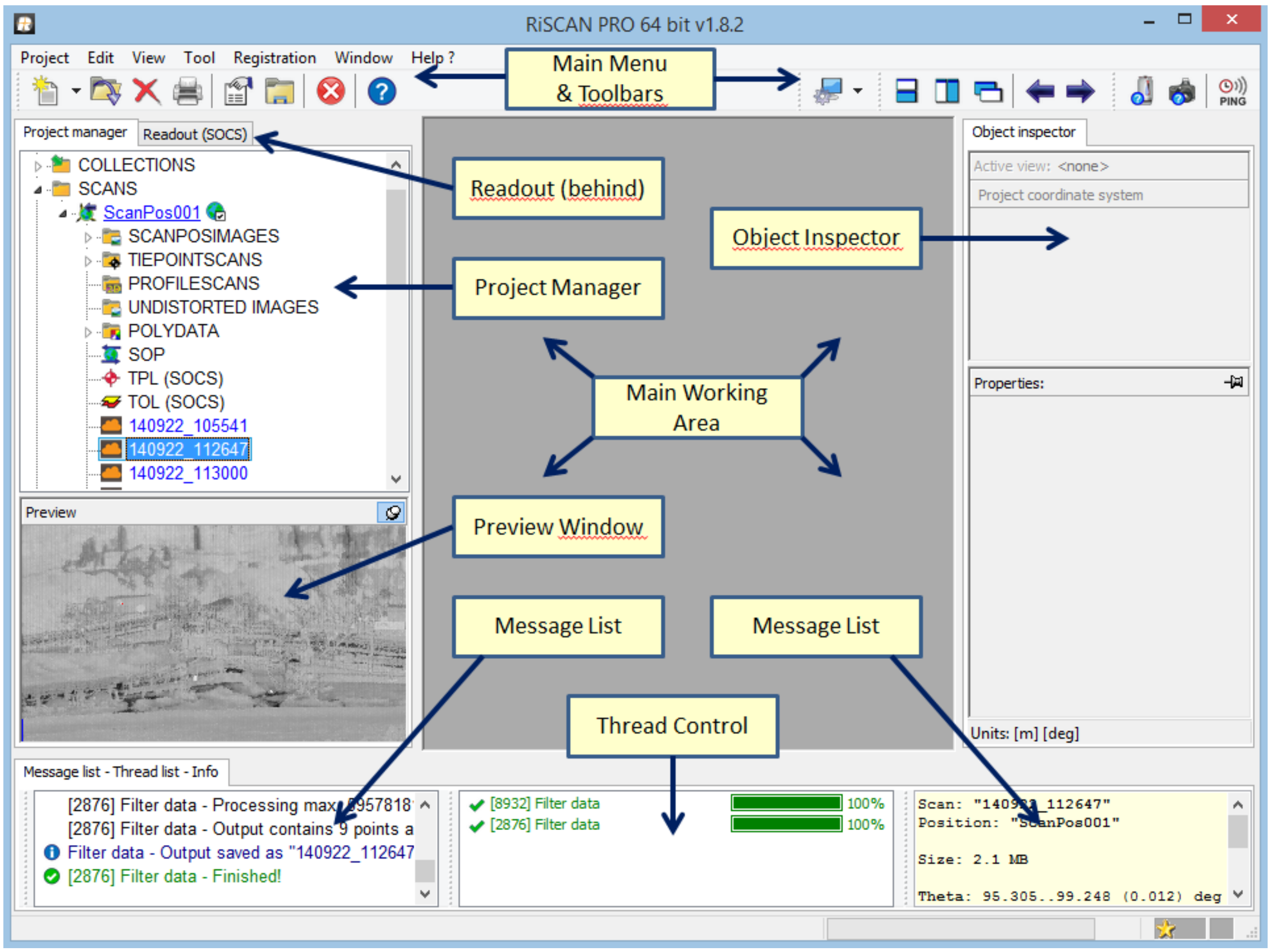
Part III

Getting started

3 Getting started

3.1 Main program window

The main window of RiSCAN PRO is modular. You can decide which tool windows should be displayed and where they should be placed. The configuration (visibility and position) will be saved at shutdown and restored the next time you start RiSCAN PRO. The following screenshot shows RiSCAN PRO with a default configuration:



Tool windows of RiSCAN PRO

- **Project manager**

  This window shows a so called "tree view" of the project structure. This tree view contains all items (scans, images, configurations, calibrations and so on) saved in the project. To modify an item click the item with the right mouse button and select your desired action from the menu.

  Shortcuts (within the project manager window):

Enter	perform default action (e.g. view a scan, open the tiepointlist,...)
ALT + Enter	shows the file attributes of selected object (the standard Windows dialog will be displayed)

CTRL + Enter	open selected object in Windows explorer (file path)
F2	rename 341 selected object

- **Preview window**

  This window is positioned at the bottom of the project manager and shows a thumbnail of the currently selected scan or image. You can open and close the preview window by clicking the pin next to "Preview:".

- **Message list window**

  This window shows all messages created by several functions of RiSCAN PRO. These messages are saved with the project, thus you have a complete summary of all actions performed in this project.

  Message examples:
  Project loaded, Project loaded (read only)
  Project saved
  Data acquisition started
  Data acquisition finished
  ...
  and also information, warnings and errors.

  Note:
  The number of messages in the message list is limited to 5000. Everytime this limit is reached the first (=oldest) 1000 messages are deleted.

- **Thread control window**

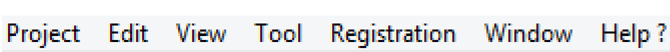
  This window shows a list of all running threads. A thread is a process which may last very long such as data acquisition or image acquisition. These threads are running in the "background" so you may continue working with RiSCAN PRO, although in a restricted manner. Note that a running thread can lock items of the project tree in order to avoid errors caused by changing values during the process.

  Note: You can not save or close the project or quit the program as long as threads are running and items are locked.

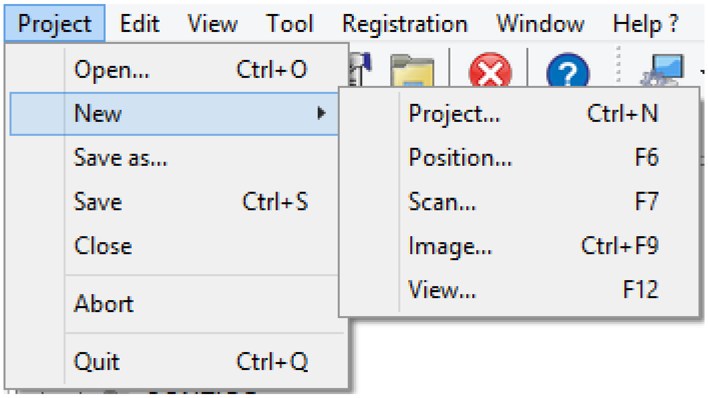
- **Info window**

  This window shows some information on the currently selected object such as number of points, file size and so on.

The main menu of RiSCAN PRO:



- **Project menu:**



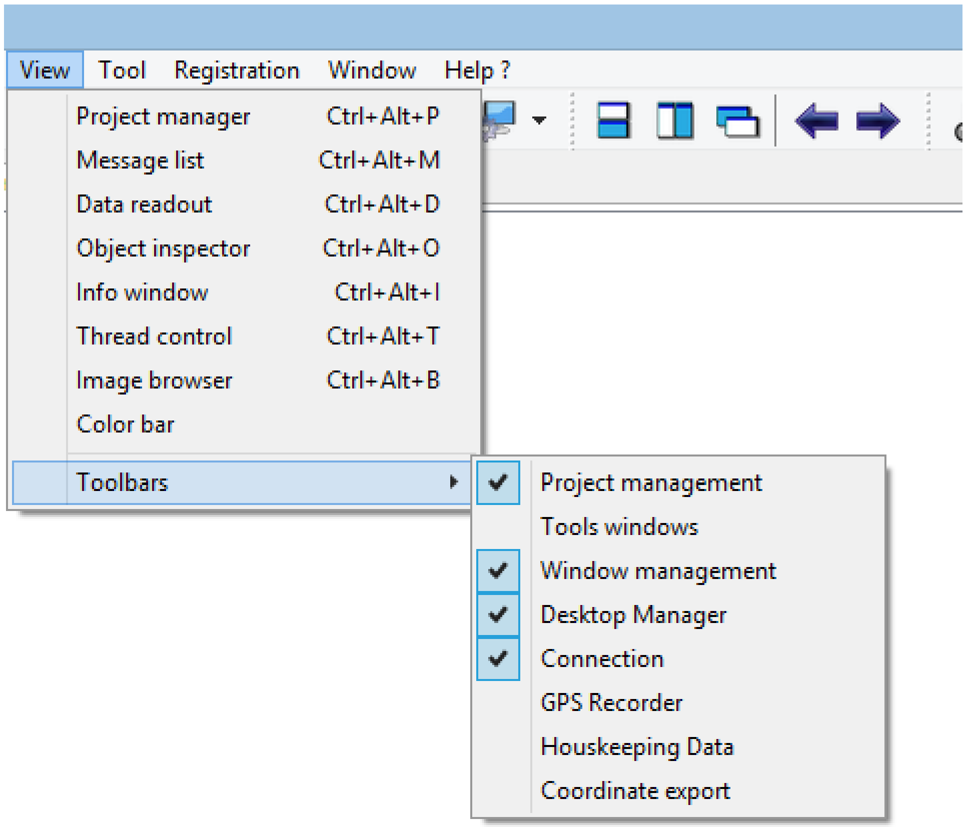
In this menu you can load, save or close a project.
The menu item "Abort" will quit all currently running threads like data or image acquisition.
With the submenu "New" you can either create a new project or create new items (scans, views, scan positions, images) in the project.

Note: You can not save a project while a thread is running (see also Thread control 16).

- **Edit menu**

This menu offers actions like edit, rename 341, show attributes, delete, and so on, that can be performed on the currently selected item of the project-window. The number and type of actions offered depends on the selected item. This menu is identical with the menu that appears when you right-click an item of the project manager.

- **View menu:**



With this menu you can open the following windows (if they are not already opened):

- Project manager 15
- Message list 16
- Data readout 178 (can be opened more than once)
- Object inspector 156
- Info window 16
- Thread control 16
- Image browser 182
- Tiepoint display 182

and the following toolbars:

- Project management 26
- Tool windows 15
- Window management 27
- 3D - Select 221
- 3D - Control 166
- 3D - Modify 226
- 3D - New object 270
- 3D - Measure 297
- Connection 27

- Housekeeping Data 27
- Coordinate export 318

- **Tool menu:**

Scanner search

You can use this tool to search for an instrument connected to the same network as the PC or even if the instrument is directly connected with the PC via a cross over network cable. This function might be useful if you don't know the IP address of the instrument.

All instruments found on the network will be displayed on the list in the center of the window. The columns of the list show the IP address, the serial number and the name (type) of the instrument. To apply the IP address to the communication settings of the currently opened project, select the instrument from the list and click the button "Apply".

Note:
The search time depends on the network speed, network load and the number of network instruments connected.
To read the instrument's serial number this tool needs to connect to the instrument. If this is not possible (e.g. because another user is connected) the instrument is not added to the result list.

Scanner configuration

Shows the configuration dialog to configure the scanner without acquiring a new scan (see "Scan acquisition 84").

Scanner orientation

With this tool it's possible to use the optional inclination sensors of the instrument to align the instrument (see Inclination sensors (optional) 92).

Scanner control

Shows a dialog to manually move the scanner.

- *Move*

  use the buttons with the arrow to move the scanner in the resembled direction. Pressing the button "Halt" (center) will stop the movement. Alternatively, use the following shortcuts:

  "A" -> turn left
  "D" -> turn right
  "W" -> turn up
  "S" -> turn down

- *Angles*

  provides information about the current alignment of the scanner. Press the button "Get position" to refresh the information.

- *Align*

Enter an angle for Theta (vertical alignment) and Phi (horizontal alignment) and press the button "Align" to manually set a position for the scanner.
The button "Set park position" will reset the scanner to a defined position (Theta: 0°, Phi: 180°).

GPS Time Synchronisation (RiSYNC)

Start the program "RiSYNC" (if installed) to synchronize the scanner's internal clock do the clock of a GPS receiver (please refer to the manual of RiSYNC for details).

V-Line File Browser

Open a file browser showing the contents of the scanner's internal memory (V-Line instruments only)

V-Line Web Interface

Open a web browser showing the web interface of teh V-Line scanner.

V-Line Remote Control

A tiny tool to show the contents of the V-Line scanner display and to do some remote control like park, restart or shutdown the laser scanner.

Navigation: You can press any of the arrow keys, the [ESC] key and the [ENTER] key on your keyboard. They will be sent to the scanner and have the same meaning as if you press the buttons on the scanner directly. Press [HOME] to start a scan and [END] to stop a scan. Click with the left mouse button into the image to simulate a [ENTER] keystroke, click with the right mouse button to simulate a [ESC] keystroke.

Note:
This tool just displays the contents of the scanner's display as an image. This means that you can not click into the image to select menu items, buttons or edit fields! You can only click on the four soft keys on the bottom of the image.
The remote control window must be activated in order to send the keystrokes to the scanner (you can click on the window caption to activate it).

V-Line Atmosphere Settings...

Tool to configure the current atmosphere parameters (like temperature, humidity, air pressure) in the V-Line scanner (see also Atmospheric correction and geometric scaling correction 346 and laser scanner's manual).

V-Line HDR Image Settings...

Tool to configure add-on image acquisition in addition to traditional image acquisition in the V-Line scanner in order to acquire multiple LDR images for HDR image generation. RiSCAN PRO will not combine the acquired LDR images into a HDR image. In order to do so please use third party image processing software. For further information on how to configure add-on image acquisition in the scanner please refer to the scanner's manual.

Camera configuration

With this tool you can remote configure some parameters of your digital camera. This tool is only available if the camera plugin is installed.
You can adjust following parameters:

- Av (aperture)

- Tv (exposure time)

To acquire an image click the "Capture image" button. The resulting image will be displayed in the preview window.

Miscellaneous

Multiple rename tool

With this tool you can rename 341 a set of objects (positions, scans, images, polydata,...) in one step. This tool offers three modes:

Remove blanks
This removes all blanks (space) of the object name

Replace blanks
This replaces all blanks (space) of the object name with a user defined character (default is "_").

Enumerate
All objects will be named like "ScanXYZ" whereas XYZ is an unique number and the prefix "Scan" depends on the type of object

Include sub objects:
This tool renames the currently selected objects in the project manager. Activate this option in order to also rename objects contained in the selected objects. In this case you can also set a filter defining which objects should be renamed.

Example:
To rename all distorted images of all scan positions proceed as follows:

- open the multiple rename tool
- select the project object in the project manager
- define a mode (remove or replace blanks, enumerate)
- activate the option "Include sub objects"
- Select "Scan position images (distorted)"
- Unselect all other object types
- Click the button "Rename"

Calculator

The calculator is a tiny tool which enables you to quickly calculate the sum or difference between two or more values such as surface areas or volumes 300. To add a value to the calculator just drag the value from the project manager and drop it onto the list. To change the sign of a value, select the value from the calculator's list and click the button "+" or "-". The result of the calculation is displayed at the bottom of the calculator window.
If you want to save the result click the button with a small floppy disk on it.

Example: You want to calculate ValueA - ValueB. Proceed as follows:

- Open the calculator
- Drag ValueA and drop it onto the calculator (it automatically has a "+" added in front of it).
- Drag ValueB and drop it onto the calculator
- Select ValueB in the calculator
- Click the button "-"
- The result is displayed at the bottom of the calculator window

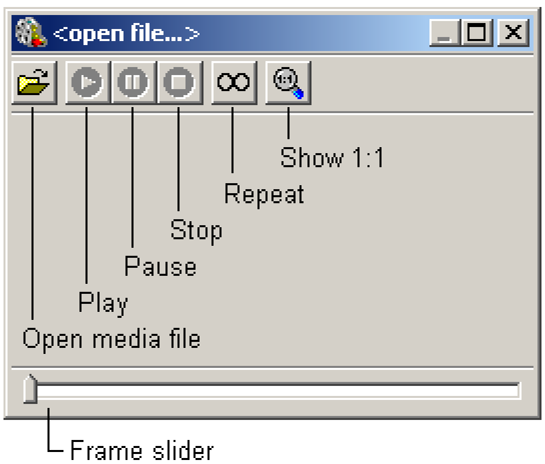
To copy the result to the clipboard (e.g. in order to use it in MS Excel) click the second button from the

right.
To force a recalculation of the result click the third button from the right.
To remove a value from the list select the value first and click the third button from the left (with the red X on it).

Note:
You can only add values of the same unit to the calculator. That means, if the first value added to the calculator represents a surface area you can only add further values of the type "surface area" and so on.

Media player

The built-in media player of RiSCAN PRO is able to play the following media file formats: AVI, WAV, MP3



If the playback of an video file is running (AVI) the video will be stretched/shrunk according to the size of the window. To show the video 1:1 (100%) click the button "Show 1:1".

Note:
Whether the media player is able to play a certain sub type of the AVI format depends on the installed video codecs. Please contact the distributor of the video file in order to get the correct video codec.

Repair 3DD header

To get higher accuracy some corrections are applied to the raw data measured by the instrument. These corrections are described by a lot of parameters that are adjusted in the factory and saved in the data file gained from the instrument (the 3DD file). In the case of any misadjustment of the instrument, the point data is not correct due to wrong correction parameters. To solve this problem it's necessary to recalibrate the instrument in the factory. The data files already acquired by the instrument (while it was misadjusted) can possibly be repaired by this tool. After recalibration in the factory a template 3DD file is generated containing a new set of calibration parameters. This template file can be applied to the faulty scan files. To do so please proceed as follows:

- Open the project containing the faulty scan(s).
- Start the "**Repair 3DD header**" tool from the "**Tool > Miscellaneous**" menu.
- Select the "SOURCE SCAN". This is the template scan file provided after recalibration in the factory.
- Select the faulty scan files to repair.
- Click the button "OK" to start the repair.

Note:
This function is only applicable to acquired scans (not colored or resampled) with the same type of header (preferably the same instrument)! Furthermore it depends on the kind of misadjustment whether you can use this tool or not.

Terminal (RiTERM)

This tool is a terminal program for testing a connection (it can be also reached via Start -> Programs -> Riegl LMS -> Support -> RiTERM).

Licenses

License manager

Shows the license manager (see "License manager 10")

Remote licenses

Tool to manage the licenses received from a License Server (see "License manager 10").

Read licenses from instrument

Tool to import all licenses stored in a connected laser scanner (see "License manager 10").

Options...

Shows the dialog "RiSCAN PRO Settings" (see "Program settings 28")

- **Registration menu:**

Coarse registration

Tool to generate a basic registration of two scans by manually defining matching points in both scans (see Interactive coarse registration 197).

Multi Station Adjustment

Tool for improving the registration of two or more scan positions based on surface data (see Multi Station Adjustment 212).

Image registration

This tool helps you to register one image by defining matching points in the image and a scan (see Image registration tool 205).

Matrix comparison

With this tool you can compare two matrices. The difference will be displayed as an offset in X, Y and Z direction and as a rotation around the X, Y and Z axis. To load a matrix into the tool just drag a COP, SOP or POP matrix 338 from the project manager and drag it onto one of the two matrix grids. As an alternative you can also right-click into the matrix grid and select "load" from the menu. When two matrices have been loaded click the button "Calculate" in order to calculate the differences.

Multiple SOP export

You can use this tool to export all orientation and position matrices (SOPs) of all scan positions of the current project in one step (e.g. for analysis in MS Excel). On the left side of the window ("TARGET FOLDER") you can select the destination folder (this is where all exported files will be saved). On the right side ("scan positionS") you can select the scan positions of which the SOPs should be exported. To control which files should be generated you can use the three boxes in the bottom right corner ("EXPORT SETTINGS"). Possible file formats are: .SOP 325, .DAT 326 and .ROT 326. To start the export click the button "OK". For each selected scan position the files will be saved to the target folder whereas the filename corresponds to the name of the scan position.

Multiple COP export

You can use this tool to export all orientation and position information of multiple images of the current project in one step. On the page "**Images**" you can select the images to export. On the page "**Settings**" you can define the export coordinate system and the target folder for the generated files. Deactivate the option "Place all files into one folder" in order to save the files into the same folder as the corresponding images.
The exported files contain the data in standard INI file format (text files, please refer to the chapter "Data exchange > Fileformats > Image information 331" for details).

- **Window menu**

This menu offers functions to manage the windows and toolbars.

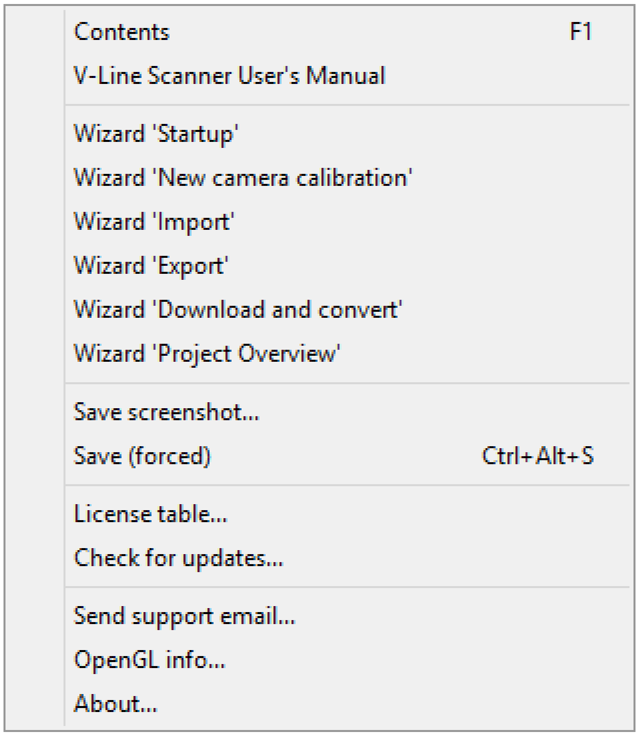
- *Desktop manager* - with the desktop manager you can save and load the desktop settings (i.e. position of visible toolbars, size and position of main window).

To **save** the current desktop settings click the button **new** and enter a name for the desktop settings (e.g. "Fullscreen", "Postprocessing", ...). To overwrite saved desktop settings select the name from the list "Desktops" and click the button **save.** To **load** saved desktop settings either select the name and click the button **load** or double click the name.

- *Horizontal* - the windows are aligned in a horizontal manner.
- *Vertical* - the windows are aligned vertically.
- *Cascade* - the windows are aligned behind each other.
- *Previous* - switch to previous window
- *Next* - switch to next window
- *Close all* - close all windows

- **?**

This menu will provide the help file and some wizards to guide you through the program.



- Contents

This will open the help file. It can also be reached by pressing the key "F1".

- Wizard "Startup"

This wizard will guide you through the steps for a basic configuration of RiSCAN PRO.

- Wizard "New camera calibration"

This wizard is used to create a base camera calibration used to start a new camera calibration task (see "Base camera calibration 54").

- Save screenshot

this will create a screenshot and save it to a specified directory and file.

- Send support email

Generates an email containing some information about your installation of RiSCAN PRO and your computer. The email will be sent to support@riegl.com.

Note: The email is not sent automatically. Your default email client program starts up and displays the email. Please add your own comments to the email before you send it.

- OpenGL info

Shows some information about graphic card and graphic driver.

- About

Provides basic information about the current version and RiDRIVERs installed.

The toolbars of RiSCAN PRO

To view the different toolbars, select View -> Toolbars from the main menu and select a toolbar from the list. The meaning of the different symbols and their usage will be explained in the specific documentation on the function it is used for.

Project management:

- *New*

  If a project is already open, clicking this symbol will show the "New Scan 84" dialog, otherwise the new project dialog will appear.
  clicking the arrow will show the menu "New..." 17.

- *Open*

  Shows the dialog to open a saved project.

- *Delete selected item*

  Deletes the currently selected item in the project manager (scan, image, scan position, and so on).

  Note:
  If the trash can is activated the object will not be deleted permanently, but moved to the trash can.
  To restore deleted objects, double click the item "TRASH" in the project manager, select an object and click the button "undelete".
  Please refer to the chapter "Program settings 30" to see how to activate the trash.

- *Print*

  You can print a report on the current project.

- *Edit properties of current object*

  Shows the attributes of the currently selected item of the project window (scan, image, scan position, tiepointlist and so on).

- *Cancel*

  Use this button to cancel the current process (data or image acquisition).

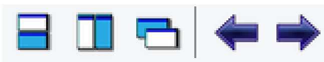
- *Help*

  Displays this help file.

Tool windows:

- *Show project manager* 15
- *Show object inspector* 156
- *Show tiepoint display* 182
- *Show data readout window* 178
- *Show thread list (a list of all running tasks)*
- *Show message list* 16

Window management:



- *Arrange windows*

  Use these buttons to arrange the windows horizontally, vertically or overlapping.

- *Previous/Next window*

  Use these buttons to quickly switch to the previous or next window.

Connection:

This tool can check the network (TCP/IP) connection of the scanner and the camera server (see "Creating a new project 41"). For that purpose RiSCAN PRO sends a ping to the specified network address and waits for the echo of the scanner or camera server. If an echo is received within a certain time it's assumed that the connection is OK and a small tick appears on the button. Otherwise a small "x" will be displayed to indicate that something is wrong. If the tool is deactivated or it's waiting for the first response a small question mark will appear on the button.

- *Network connection state of scanner*

  To activate the tool click the button with the scanner (the button will stay pressed).
  To deactivate it click the button again (a small question mark appears on the button).

- *Network connection state of camera*

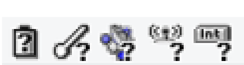
  To activate the tool click the button with the camera (the button will stay pressed).
  To deactivate it click the button again (a small question mark appears on the button).

- *Interval for network-connection-check*

  Click this button to set the interval for the connection checks.

Note:
This is just a simple tool to check the network connection. It only checks IF something responds to the ping but it doesn't care WHAT responds. That means if you enter the network address of another PC instead of the address of the scanner, the tool will pretend that everything is OK but communication with the scanner will not be possible unless you enter the correct address.

Housekeeping Data:



The tool "Housekeeping Data" allows to monitor the scanner's supply voltage and temperature. Housekeeping data will be updated as soon as a project is opened and you click the buttons of the tool or you start an online data acquisition. The tool will show the corresponding icons immediately after the data has been successfully retrieved. Furthermore a short hint informs you about the exact values of the supply voltage and the temperature if you hover the cursor over the buttons.

- *Button icon states*

  If the housekeeping data of the device is unknown an empty battery and thermometer with a small question mark will be displayed. If everything is OK the buttons will have blue icons, else they appear in red.

- *Configuring the limiting values*

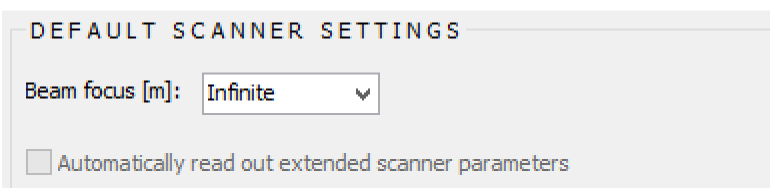
  To adjust the limiting values of the scanner supply voltage and temperature right-click one of the buttons and choose "Configure" from the context menu. A small dialog will appear that allows you to adjust the upper and lower limits.

Note:
The tool does not take any countermeasures to prevent the device from being damaged (e.g. if the temperature is too high).

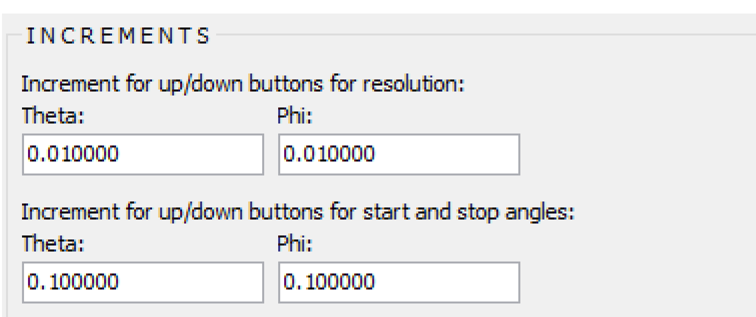
3.2 Program settings

In the RiSCAN PRO Settings dialog you can set several options.

- **General - Default scanner settings**

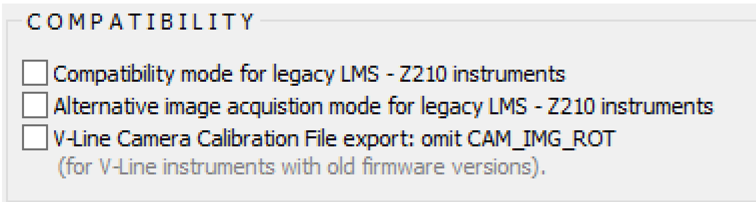


Beam focus:
This beam focus is used when you select a "Overview 90", "Panorama 91" scan.



Increment for up/down buttons for resolution:
The value for the resolution in degrees in the New Scan 84 window is increased/decreased by the amount set here each time the arrow is pressed ( ).

Increment for up/down buttons for start and stop angles:
The value for the start and stop angles in degrees in the New Scan 84 window is increased/decreased by the amount set here each time the arrow is pressed ( ).



Some older LMS Z210 instruments are not capable of high pulse-repetition-rates. Activate these options to reduce the rate (Too high rates result in a higher number of invalid measurements).

- ## General - Data acquisition

Save acquired scan data immediately to hard disk
If this option is checked the current project is saved automatically before data acquisition and the recorded data is immediately stored on the hard disk. This is very useful if you run your system from a mobile power supply and want to prevent data loss in case of running out of energy.
Acoustical feedback
This causes RiSCAN PRO to give an acoustical feedback everytime a data acquisition (scan or findescan) has finished. Possible options are:

deactived
no acoustical feedback at all.

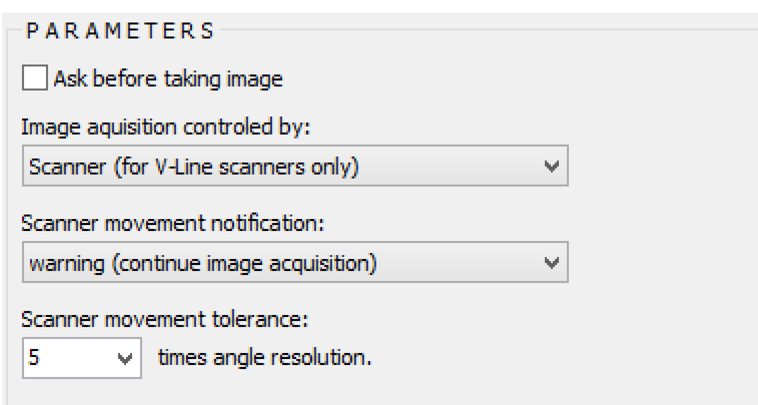
via PC speaker
uses the built-in speaker of the PC or laptop.

via soundcard
uses the standard sounds of the operating system which will be played by the sound card (if installed).

Maximum tilt angle

If your laser scanner is equipped with optional inclination sensors, RiSCAN PRO will analyse them during data acquisition. If the inclination angles sway more than this limit angle, a warning message is displayed. This should help you to recognize unstable instrument setups.

- ## General - Image acquisition



Ask before taking image
When this mode is activated, the instrument moves to the first/next snapshot position and displays a dialog box but no image is acquired. Confirm the dialog box to acquire the image. This can be used to wait until the area is cleared (i.e. target object is not covered by any other obstructive objects).

Image acquisition controled by:

- **Scanner (for V-Line scanners only)**
  If the image acquisition is controlled by the scanner it will use the mounted camera to acquire images. RiSCAN PRO will download the acquired images from the scanner. In this case the camera has to be connected to the scanner via USB.
- **Software**
  If the image acquisition is controlled by RiSCAN PRO it will directly control the scanner and trigger the mounted camera. In this case the camera has to be directly connected to the PC via USB or LAN.

Scanner movement notification
During image acquisition the position of the instrument will be read out twice for every image. Once before taking the image and once after the image was taken. The two positions will then be compared with each other.
You can choose from three options for what should happen if the deviation is larger than a specified amount (*Scanner movement tolerance*):

- deactivated ... nothing happens.
- warning (continue image acquisition) ... only a warning is printed into the message list.
- error (abort image acquisition) ... the current image acquisition is aborted.

• General - Optional

Some optional settings.

File associations:
If you enable these options RiSCAN PRO is started automatically when you open the project.rsp file or the project folder (e.g. by double clicking it in the Windows Explorer).

Note: Under Windows 2000 these options can not be deactivated properly.

• General - Tiepoint scan

See Reflector extraction (Scan) 93.

• General - Units

Specify physical units used throughout the whole program.

Angle:

- Degree (deg)
- Radian (rad)
- Gon (gon)

Range:

- Meters (m)
- Feet (ft) -> (1 ft = 0.3048 m)

- US-Feet (ft) -> (1 ft = 12/39.37 m)
- Yards (yd)

Amplitude scale unit
- 0...1
- 0...255

Color scale unit
- 0..1
- 0..255
- 0..65535

Pressure unit
- MILLIBAR (mbar)
- MILLIM. OF MERCURY (mmHg) -> (1 mmHg = 1.333 mbar)
- INCHES OF MERCURY (inHg) -> (1 inHg = 33.86389 mbar)

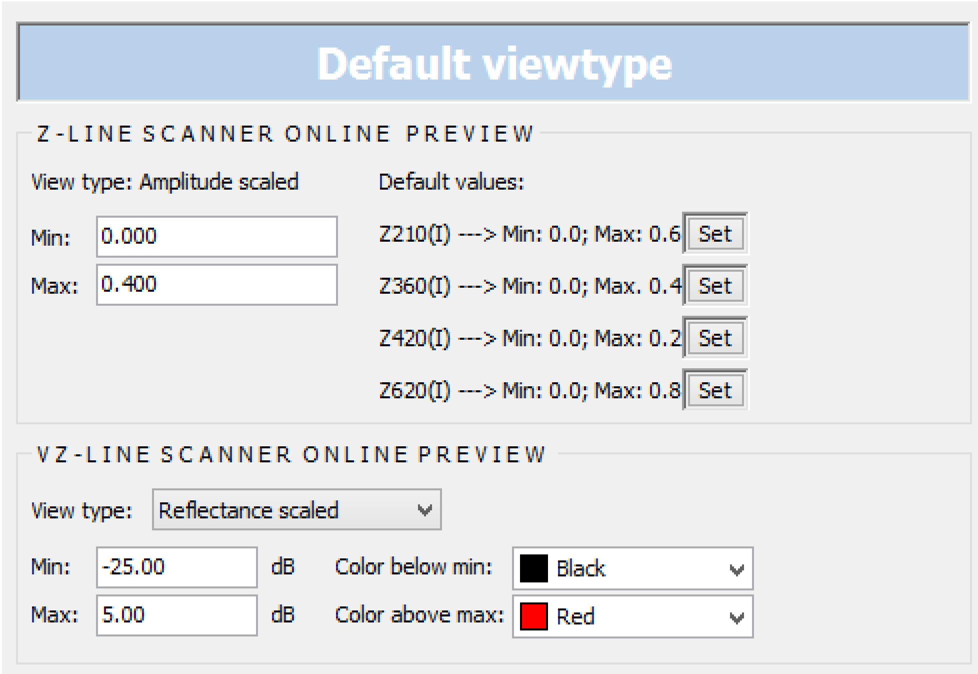
Temperature unit
- CELSIUS (°C)
- FAHRENHEIT (°F) -> ([°F] = [°C] G9/5 + 32)
- KELVIN (K) -> ([K] = [°C] + 273.15)

WARNING: Do not change the units while a project is open! This may compromise the integrity of coordinates or parameters saved in the project. It is recommended to restart RiSCAN PRO after changing the units.

- ## Additional - Default viewtype

Sets the default viewtype, which is used when opening an online 2D/3D view during data acquisition and for creating thumbnails of scans.
(See Visualisation of data 128)

Online preview:



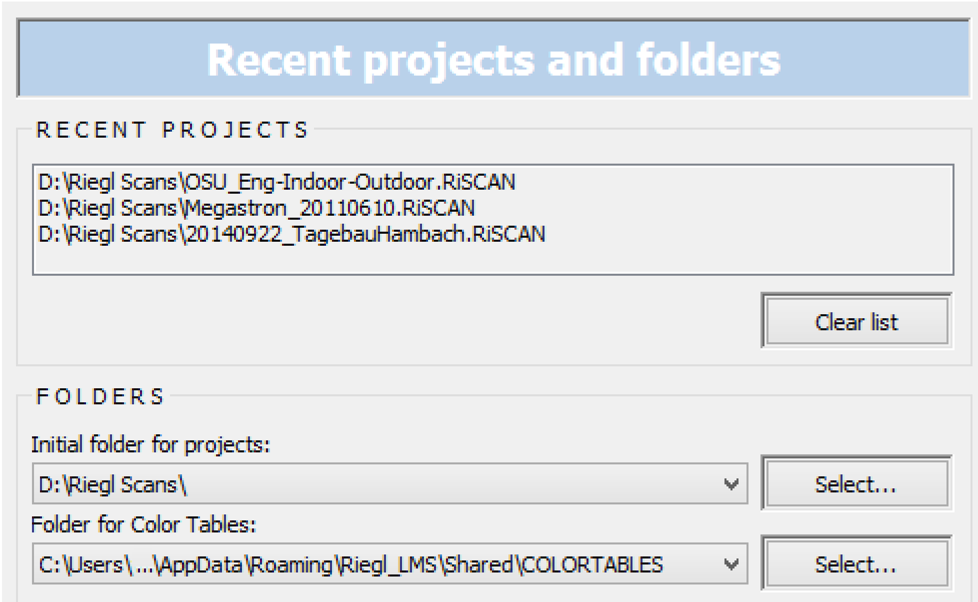
- **Additional - Naming conventions**

  You can define some default names which will be used when a new object is created.

- **Additional - Project manager**

  Sets several settings for the "Project window".
  (See Main menu 15)

- **Additional - Recent projects and folders**



Recent Projects
Shows a list of recently edited RiSCAN PRO projects. Press "Clear list" to remove all entries of the recently edited projects list.

Folders

Initial folder for projects:
This folder will be used as the preselected destination folder when creating a new project by choosing "Project" > "New" > "Project".

Folder for Color Tables:
User defined Color Tables 185 are read from this directory during program startup.

- **New project - Communication**

Sets the default communication settings for a new project.

- **New project - Default settings**

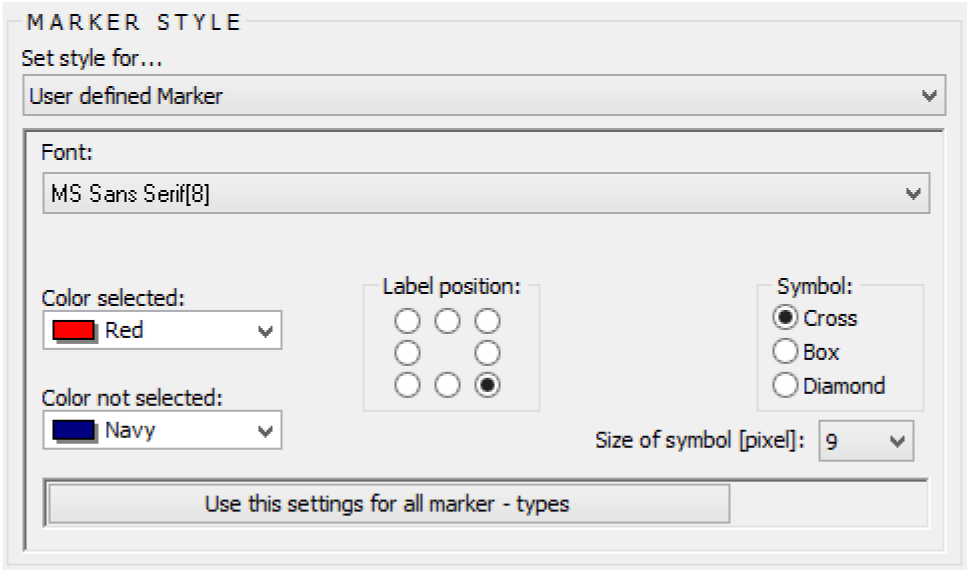
Set the default settings for a new project.
- L O G O I M P O R T - Allows you to specify a default logo that is automatically imported into new projects and used as the default view overlay.

- **Fullscreen settings**

These settings are used when you switch the 2D or 3D view to fullscreen mode.

- **2D Settings - Marker settings**

Sets the marker style(s) of the 2D - view window.



You can set the style for each tiepoint type. This is useful when e.g. TPL SOCS and TPL IMAGE are displayed in an image.

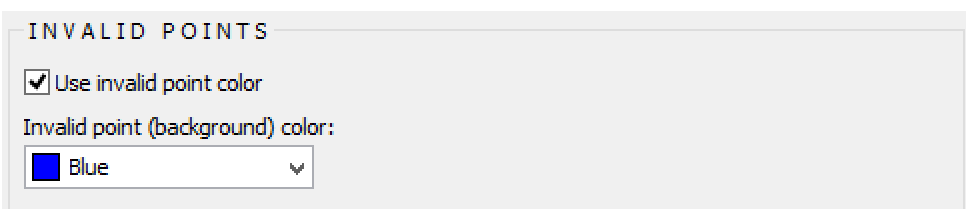
With "Label position:" you can select where the label (=name of the tiepoint) should be placed. This is useful, when two tiepoints of different type (e.g. a TP SOCS and a TP IMAGE) are at nearly the same position (Due to the fact that the labels are on different positions, you will be able to read the names of the tiepoints).

By clicking "Use these settings for all marker - types" all marker - types will have this style. So if you display different tiepoints in a 2D-View they will all look the same.

- **2D Settings - Selection settings**

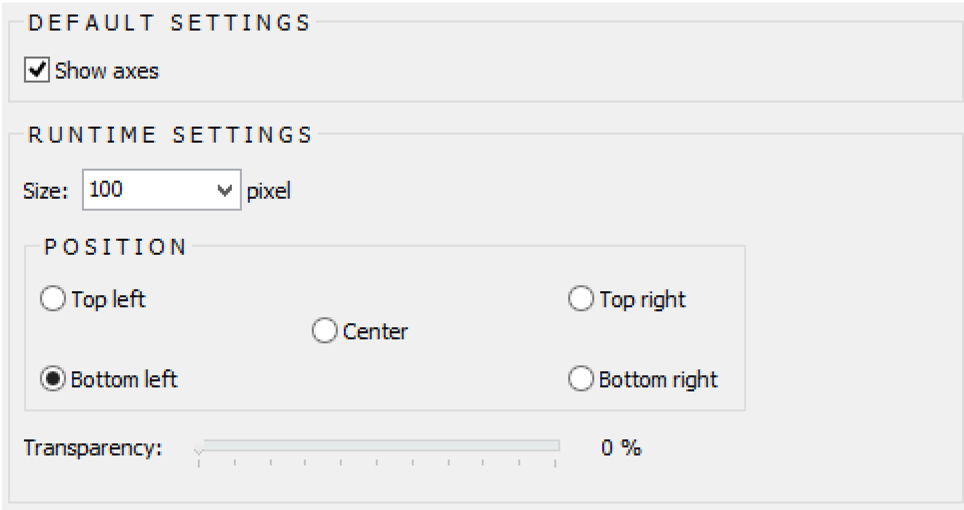
On this page you can defined the color and size for the lines and nodes of the point selection tools in a 2D view.

- **2D Settings - Other settings**



Use invalid point color
Activate this option, if you want to use a certain color (*Invalid point color*) for invalid measurements in a 2D view of a scan.

- **3D Settings - Axes settings**



Default settings

- **Show axes**
  Activate this option if you want to display the axes when a new object view [144] is created.

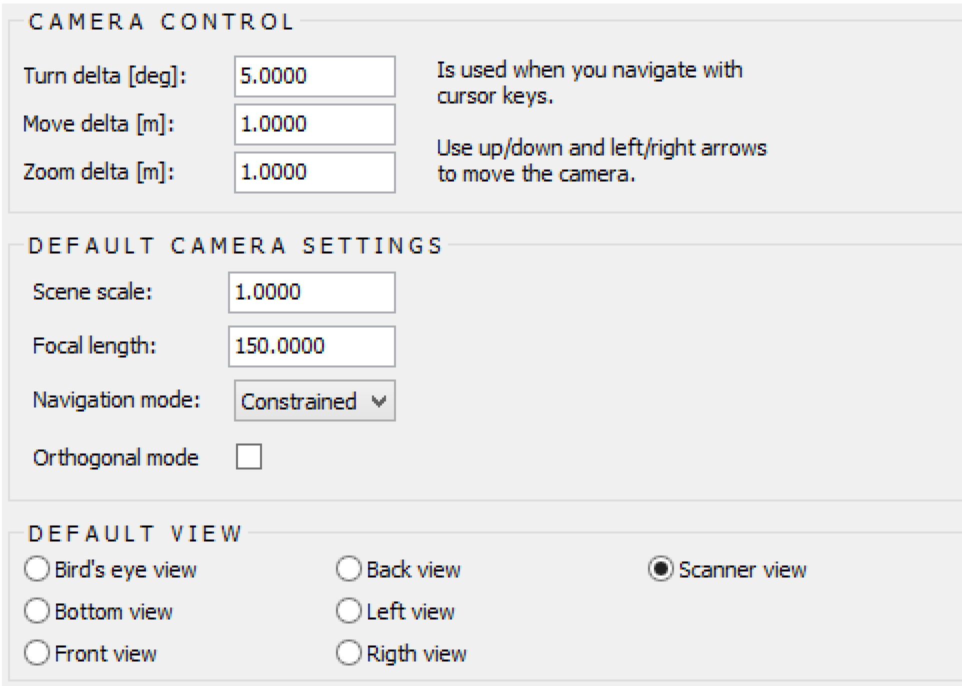
Runtime settings
These settings will influence the appearance of all object views.

- **Size**
  Define the size of the axes in pixels.

- **Position**
  Define the display position of the axes.

- **Transparency**
  Define the transparency of the axes.

- ## 3D Settings - Camera settings



Camera control
You can define the values for navigating the camera in an object view 144.

Default camera settings & Default view
These values are used when you create a new object view 144.

- ## 3D Settings - Color Settings

Default color
Default colors are used when you create a new object view 144 or when you display objects.

Runtime colors

Selection color ... This color is used when drawing selections in selection mode.
Selected color ... This color is used when you have select data.

Runtime colors influence the appearance of all object views.

- ## 3D Settings - Display settings

These settings are used when you create a new object view 144.
For detailed description of the these values see the object inspector 156 reference.

- ## 3D Settings - General settings

Antialiasing
Enable anti-aliasing for high quality 3D visualization. Disable anti-aliasing for high performance visualization.

Use hardware acceleration

Activate this option to use hardware accelerated graphic functions. **Note:** Your graphic card must be OpenGL compatible and support some extensions used by RiSCAN PRO. If one of these extensions is not available a warning is displayed and the rendering functions will fall back to (slower) software based functions.

Use texture compression

Activate this option to compress texture images before they are displayed. If this option is activated the images need less graphic card memory but loading will take more time and the quality might not be quite as good.

Note:

These options are only used once when an object view is opened. If you change these options you have to reload the object view for the changes to take effect.

3D Settings - Organized point cloud

Default settings - For detailed description of the these values see the object inspector 156 reference.

Runtime settings

Use vertex buffer objects (VBOs) - New graphic cards (OpenGL version >= 1.5) supports the ability to copy large data arrays to the graphic card memory. This will increase the rendering speed because the data transfer is only performed once.
Note: If you have problems with rendering organized point clouds, try to deactivate this option.

3D Settings - Orthophoto

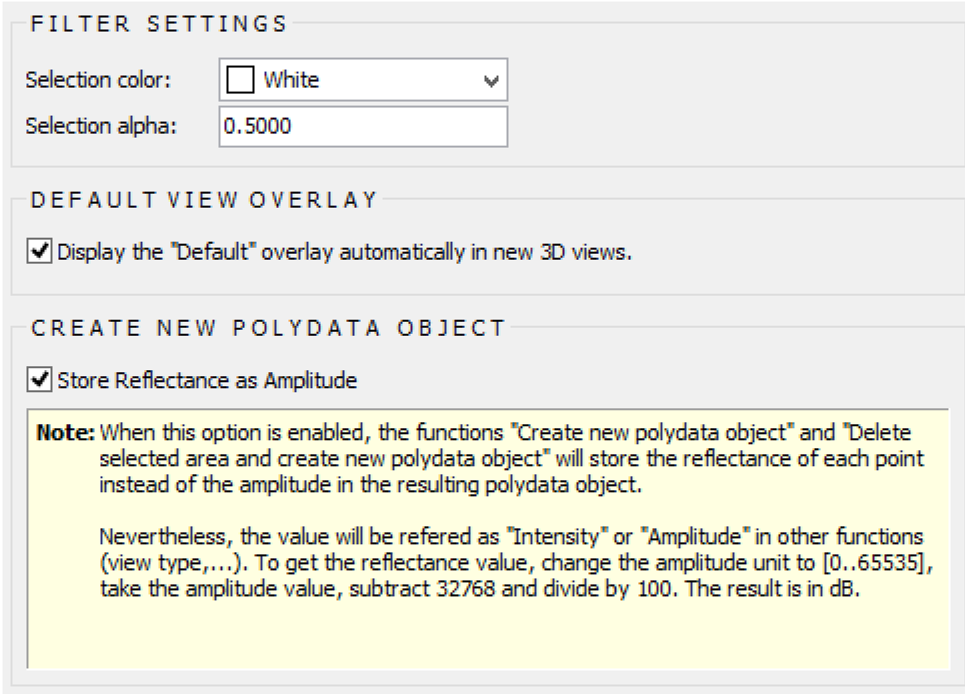
Runtime settings

Scale factor - The size of the orthophoto is scaled by this factor before it is rendered in the object view.
Load depth data - If this is activated the depth information of the "ZOP" file is loaded (if it exists).
Point divider - Only every n-th depth value is loaded from the "ZOP" file and used for rendering.

Note: It is recommend to use a scale factor of around 20% to avoid memory problems. Only load depth data if it is really necessary for visualization it in the object view.

3D Settings - Other settings

- Sets the default settings for a filter selection (create new orthophoto 264).



- Display the "Default" overlay automatically in new 3D views.

• Object view settings - Control settings

Mouse
Specifies the mouse sensitivity.

• Object view settings - Save settings

Define how an object view should be handled.

- never save ... the object view is only temporary
- always save ... the object view is added to the project structure
- ask user to save ... you will be asked before closing the object view

• Calculation parameters - Averaging / Resample

Set the default values for the averaging/resample-process 236 here.
If "Always ask for parameters" is checked you'll be prompted to enter the parameter each time you start the process. Otherwise the process will start with the default values.

• Calculation parameters - Find corresponding points

Sets the default settings for Finding corresponding points.
(See Registration of a scan position 187)

3.3 Coordinate systems

RiSCAN PRO uses different coordinates systems, the most important ones are described below:

Scanner's Own Coordinate System (SOCS) is the coordinate system in which the scanner delivers the raw data. Consult the scanner's user manual for the definition of the coordinate system. The data of every RIEGL 3D laser imaging scanner contains geometry information (Cartesian x, y, z coordinates or polar r, ϑ, φ coordinates) and additional descriptors (at least amplitude, optionally color information) for every laser measurement. Thus the output of a RIEGL 3D laser imaging scanner can be addressed as an (organized) point cloud with additional vertex descriptors in the scanner's own coordinate system.

Project Coordinate System (PRCS) is a coordinate system which is defined by the user. This could be an already existent coordinate system at the scan site, e.g., a facility coordinate system. RiSCAN PRO requires that all geometry data within this project coordinate system can be represented by single precision numbers (7 significant digits). For example, if mm accuracy is required, the maximum coordinates should be less than 10 km.

Global Coordinate System (GLCS) is the coordinate system into which the project coordinate system is embedded. Coordinates in the global system may contain very large numbers.

Camera Coordinate System (CMCS) is the coordinate system of the camera which is optionally mounted on top of the scanner to provide high resolution images.

In almost all applications, data acquisition is based on performing scans from different locations in order to get a complete data set of the object's surface without gaps or "scan shadows". The different scan locations are addressed as **scan positions**. When starting a new project, i.e. starting a new data acquisition campaign, you have to initialise a new scan position (by default ScanPos01) before acquiring data from the scanner. This scan position will hold all data acquired at that specific setup of the scanner.

A scan position is characterized by its own local coordinate system (SOCS), i.e. the position and orientation of the scanner within the project coordinate system. Position and orientation can generally be described by 6 parameters (3 for position, 3 for rotation) or by a transformation matrix. RiSCAN PRO makes use of a 4 x 4 matrix (MSOP) addressed as **SOP** information (SOP for sensor's orientation and position).

$$M_{SOP}=\begin{pmatrix} r_{11} & r_{12} & r_{13} & t_1 \\ r_{21} & r_{22} & r_{23} & t_2 \\ r_{31} & r_{32} & r_{33} & t_3 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

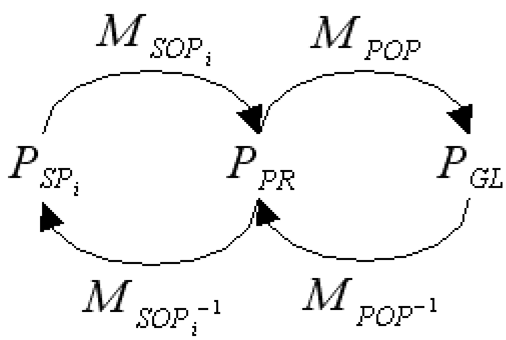
The matrix consists of 9 parameters reflecting the rotation (r11 to r33) and 3 parameters for the translation (t1 to t3). The use of homogeneous coordinates allows computation of rotation and translation in a single matrix multiplication. The translation vector is the scanners position and the column vectors (r1i r2i r3i)T are the directions of the local coordinate axes in PRCS. A 3D data point in homogeneous coordinates is represented by its 3D coordinates x, y, and z by

$$P_{hom}=(x\ y\ z\ 1)^T$$

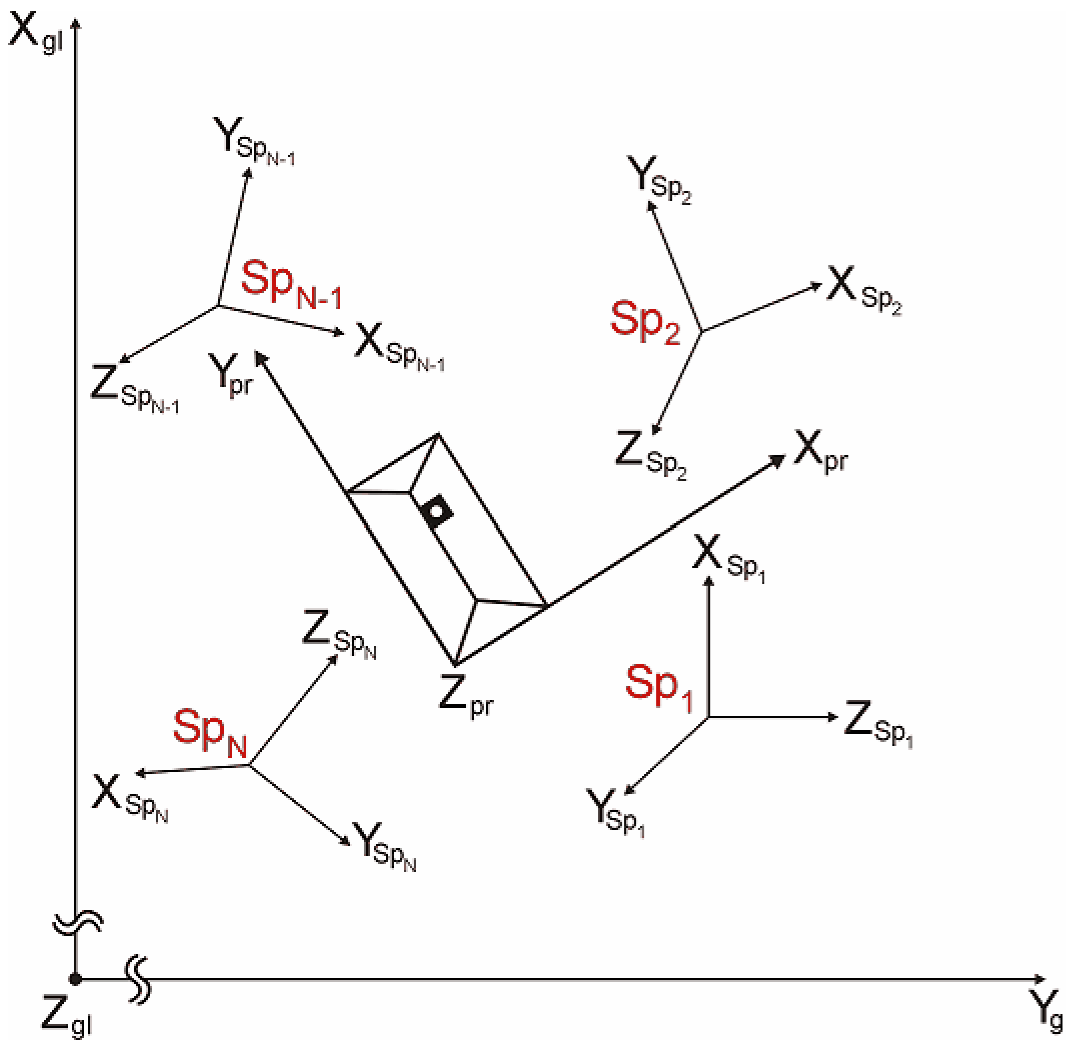
Note:
Changing the scanner's orientation at a specific location requires the use of a new scan position even if the scanner position was not changed.

Each scan position holds the scan data taken at this scan position, stored in the scanner's binary data format with the extension **.3DD**. Furthermore, each scan position holds its SOP information. In order to transform data from SOCS into the project coordinate system, data points are simply multiplied with the SOP matrix (**MSOP**) of the scan position.

In case a data point P has to be transformed from a specific scan position into the global coordinate system, first multiply with the MSOP matrix of the scan position to get into the project coordinate system and subsequently multiply with the MPOP matrix which transforms from the project coordinate system into the global coordinate system.



The sketch below shows an example for the coordinate systems GLCS, PRCS, and SOCS. The object is a building scene from a bird's view. A project coordinate system is defined with the Ypr – axis being parallel to the nave of the building and the origin of the PRCS coinciding with a corner of the building. The PRCS has to be a right-handed system. The GLCS is a left-handed system in the example, e.g, northing, easting and elevation. A number of scan positions are indicated by Spi, whereas the scanner has been set up for data acquisition (see the detailed description on scan positions below). Each scan position has its own local coordinate system (SOCS) resembled by the axes Xsp1, Ysp1, Zsp1.



3.4 Create new project

Generally you can create a new (empty) project by selecting Project -> New -> Project... from the menu.
You will be prompted for a filename and location for the new project.

It is recommended to use the default project 8 instead of creating a new project from scratch.
To do so, open (Project > Open...) the project and save it under another filename and/or folder (Project > Save as...).

Using this project as a template enables you to use the existing calibrations (Camera, Mounting, Reflectors,...).
You just have to delete items you don't need.

Note:
You need write permission for the target folder in order to create a new project.
The default project can not be changed because it is write-protected by default.

After you have created a new project continue with the steps described in the next chapter: "Project settings 42".

3.4.1 Project settings

The next step is to set the project attributes.

To set the project-attributes double-click the project-name (top-most entry of the Project-manager).
The dialog "Project..." appears. The dialog has the following pages:

Page "General"

On this page you can insert comments like name of operator, date, location, object description and so on.

Global project position:

The global (geographic) project position can be entered here. If automatic registration is activated (program options: "Tool > Options > General > Data acquisition") and you are using a V-Line scanner with enabled "Pose estimation" feature, then the global position is taken from the GPS data contained in the very first scan acquired or imported.

To show the project location on an online map, click on the button "Show on map" and select a map provider from the pull down menu. This will open up your Web browser software and navigate to the URL of the selected map provider.

To edit the map provider URLs, click on the button "Show on map" and select "Edit" from the pull down menu. A new dialog appears where you can modify or delete existing map providers as well as add new ones.

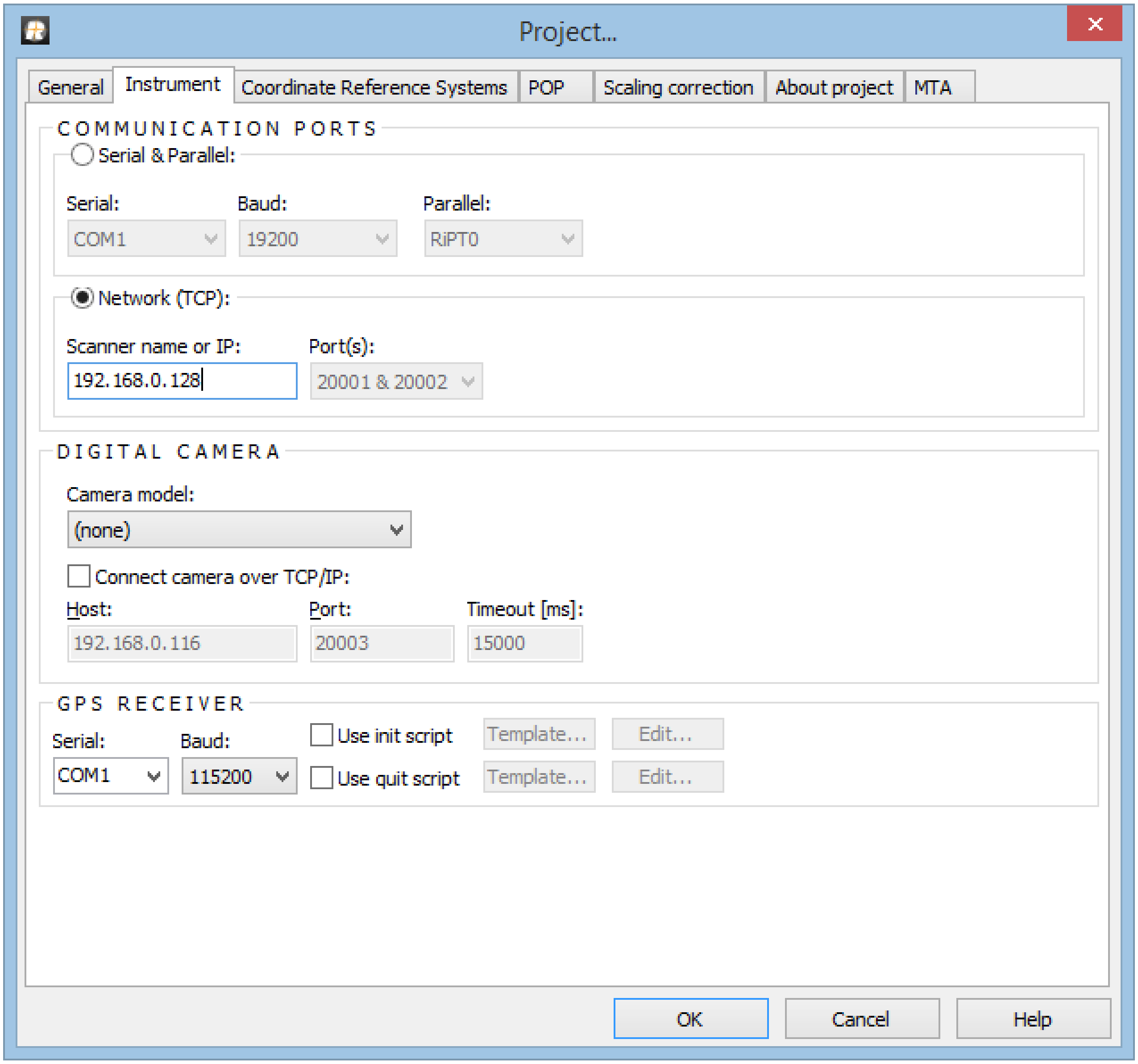
Time Synchronisation / Epoch:

This text represents a date and time used as base for the timestamp display in the data readout window 180.
By default this is the date and time of when the project was created but you can modify this value.
Note: When you enter a new date make sure that you use the following format:
YYYY-MM-DDTHH:MM:SS.ZZZ whereas

- **YYYY** is the year (4 digits),
- the first **MM** is the month (2 digits),
- **DD** is the day (2 digits),
- **T** is used as separator between date and time,
- **HH** is the hour (2 digits),
- the second **MM** is the minute (2 digits),
- **SS** are the seconds (2 digits),
- **ZZZ** are the milliseconds (3 digits)

Page "Instrument"

On this page you must set the *COMMUNICATION PORTS* to enable communication with the instrument.



First select "Serial & Parallel" or "Network" to determine the basic means of communication, corresponding to the type of cabling of your instrument.

Serial & Parallel:

If "Serial & Parallel" is selected you have to select the serial port (COMx), baud rate (default is 19200) and the parallel port (RiPTx) according to the settings in RiPORT 349.

Network (TCP):

If "Network (TCP)" is selected you have to enter the correct IP address of the device (192.168.0.234 by default). The ports can not be modified and are only displayed for your information. If you don't know the IP address of the instrument you can also use the tool "Scanner Search 19".

Note:
If you have problems while connecting to the instrument, please make sure that you used the correct cables.

If you use a firewall please make sure that bidirectional communication over the ports displayed on this page is allowed.

Note:
Please make sure that your PC has a valid IP address. To do so check the TCP/IP settings of the network connection. If "obtain IP address automatically" is selected it is necessary that a DHCP server is installed in your network. If no such server is installed (and of course when you connect the instrument directly to the PC via a cross over cable) you have to set a fixed IP address in the same logical network IP address range as the instrument (e.g. 192.168.0.233) and a proper subnet mask (e.g. 255.255.255.0).

Please refer to the help file of MS Windows or contact your network administrator.

Digital camera:

On this sheet you can also set the **camera type** in case your instrument is equipped with a camera. If you can not find your camera type in the list please check the RiSCAN PRO download page 338 for updates for the camera plugin or select "**Custom camera**". In the latter case RiSCAN PRO will not release the camera automatically but will ask you to do so manually when the instrument has reached the snapshot position. Capture the photo and confirm the message box. After the image acquisition has finished the scan position will contain the new image objects - with correct orientation information (COP matrix) - but the corresponding folder will not contain the required images. Thus you have to convert your image files into the JPEG format and save them to the SCANPOSIMAGES folder of the scan position. The files must be named like the corresponding image objects with the extension ".JPG".

If you notice problems when connecting to your camera directly through RiSCAN PRO, please check the "USB-protocol" setting of the camera. This value must be set to "PTP" for NIKON cameras and to "normal" for CANON cameras. To change this setting please refer to the product documentation of your camera (see also Appendix > Frequently asked questions > Data acquisition 335).

Select "**Connect camera over TCP/IP**" if the camera should be accessed via the network by using the camera server (default value of Port: 20003).
Note: The use of the camera server (which is not part of the RiSCAN PRO or camera plugin packages) is rather out of date. For remote use of the digital camera it is recommended to use our **Wireless Data Transmition Module WLAN-420** (or WLAN-420-CS respectively).

GPS Receiver:

In this section you can define to which serial port (COM port) the (optional) GPS receiver is connected and which baud rate should be used for communication. If the GPS receiver needs to be initialized after power up (e.g. to start data output or to connect to reference stations) then enable the option "**Use init script**". The init script is a standard text file, the contents of which will be sent to the GPS receiver during the connection set-up procedure. By clicking the button "**Template...**" you can select a template script file which is copied to the project folder. Click the button "**Edit...**" to edit the script file of the project (not the template). Enable the option "**Use quit script**" if you want to finalize your GPS receiver. The quit script is the counterpart of the init script and is sent to the GPS receiver right before the connection is closed (e.g. to disconnect from reference stations). Some template init and quit scripts are installed with RiSCAN PRO. They can be found in "<*RiSCAN PRO program folder*>\GPS\SCRIPTS\". Please have a look at the comments in these script files for details.

Note:
The contents of the init and quit scripts depends on the GPS receiver model. Thus RiSCAN PRO can neither interpret the scripts nor check the receiver's replies to the scripts.

Hint:
In the Program settings 28 you can specify default values for all these settings which will be applied to every new project.

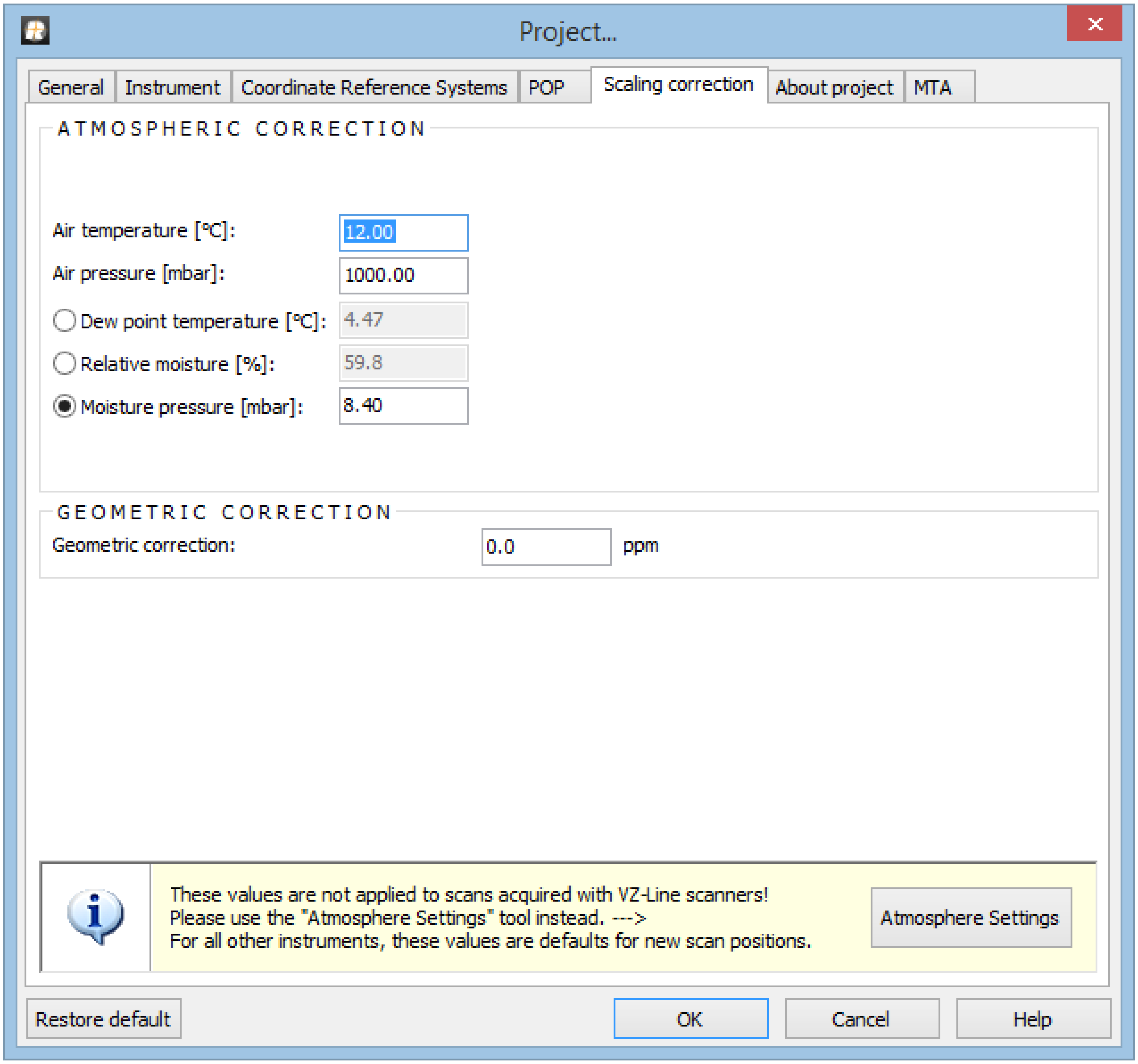
Page "POP"

This page displayes the POP matrix (see "Coordinate systems 38").
Additionally this page will show the rotation angles roll, pitch and yaw representing the orientation of the project coordinate system within the global coordinate system. These values are calculated from the current POP matrix and can not be modified. See chapter "Appendix / Angle definition / Definition of rotation angles 339" to learn about the meaning of the roll, pitch and yaw angles.

Page "Scaling correction"

To achieve maximum accuracy for the range measurement, set the atmospheric values to the actual values during data acquisition. The *GEOMETRIC CORRECTION* can be entered by the user and is applied to the range of the measurements (ppm = parts per million, for detailed description of the correction see chapter Atmospheric correction and geometric scaling correction 346 in the appendix).

Note: The values entered here will be the default settings for every new scan position.



Page "About project"

This page offers information about the project files such as location, number of files and total size of the project.

3.4.2 Create new scanposition

To create a new scan position just right-click the folder "SCANS" and select "New scan position". A dialog as shown in the section below is displayed which allows you to set the attributes of the scan position. The name of the new scan position will be set to "ScanPosXX", whereas "XX" is an unique number. You can rename 341 the scan position and give it a more meaningful name. To finally create the scan position click the button "OK" (the project will be saved automatically after the scan position was created).

scan position attributes

To modify the attributes of a scan position right-click the scan position and select "Attributes...". A dialog appears showing the following pages:

Page "General"

Enter comments or a basic description here.

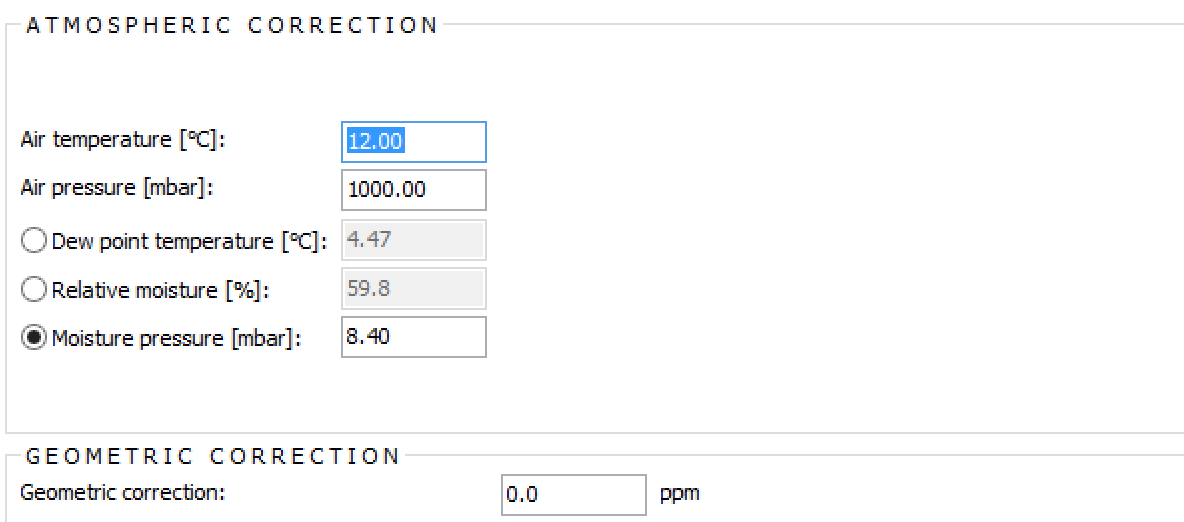
Page "Tilt mount"

see "Calibrations: Tiltmount 79"

Page "SOP"

This matrix will be used to align the scan position within the project coordinate system (see "Coordinate systems 38").
Additionally this page will show the rotation angles roll, pitch and yaw representing the orientation of the instrument within the project coordinate system. These values are calculated from the current SOP matrix and can not be modified. See chapter "Appendix / Angle definition / Definition of rotation angles 339" to learn about the meaning of the roll, pitch and yaw angles.

Page "Scaling correction"



Choose an instrument from the list and adapt the values for the *ATMOSPHERIC CORRECTION* to ensure exact measurements.
Note: These values are initialized with the project settings (see "Project settings 45").
For detailed description of the correction see chapter Atmospheric correction and geometric scaling correction 346 in the appendix.

Page "GPS"

On this page you can see a list of position records gained from an external (D)GPS receiver. To add new records check the **communication port configuration** in the project settings 42 and use the tool GPS Recorder 121. The records contain the fields timestamp (UTC), latitude, longitude, altitude, number of satellites and quality (also called "GPS mode"). Which fields are actually displayed depends on the data format used by the GPS receiver.

3.5 Calibrations

3.5.1 Camera

In order to make use of the image data acquired within RiSCAN PRO you need calibration data for the camera used. This calibration data includes data on the camera itself, e.g., dimensions of the images in pixels, the focal length of the lens and the center of the camera image. Furthermore, you need information about the position and orientation of the camera for every image to, e.g., apply the color of a pixel to a 3D surface. RiSCAN PRO provides the orientation and position information "automatically" in case the camera is mounted on top of the scanner. Up to this point the parameters describe an ideal "pin-hole" camera. However, in practice the lens introduces significant distortion. This lens distortion is modeled within RiSCAN PRO by up to 6 parameters. For more details see Camera model used 48.

The camera, when ordered with the scanner, is delivered with calibration information. This information is gained by using the calibration procedure integrated in RiSCAN PRO (usually Based on reflector column 55).

But please note the following:

The internal camera calibration parameters depend on

- the lens itself (even the same type of lens will lead to a different set of parameters)
- the setting of the focus
- the setting of the aperture.

Thus it is recommended to fix the camera's focus and aperture BEFORE doing the calibration. Setting the focus depends on the intended distance at which the camera will be used. Please note that you always have a finite depth of focus which increases with an increasing aperture number chosen.

If we tolerate blurring of 0.25 pixels we can set the focus to

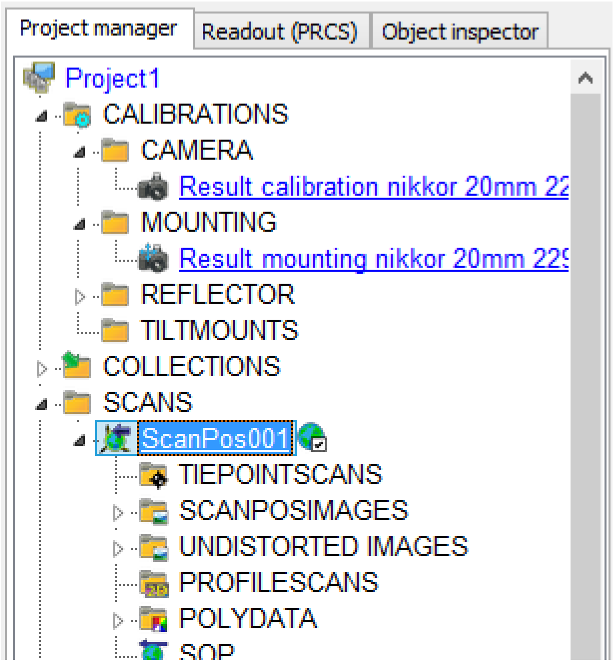
$$b = 4f^2/(dx\ a)$$

whereas f is the focal length of the lens in meters, dx is the pixel size in meters and a is the aperture number of the lens. In this case we get "unblured" images in the range from b/2 to infinity. For example, dx = 7.8 µm, f = 14 mm, a = 9 gives b = 11 m and an operational range from 5.5 m to infinity.

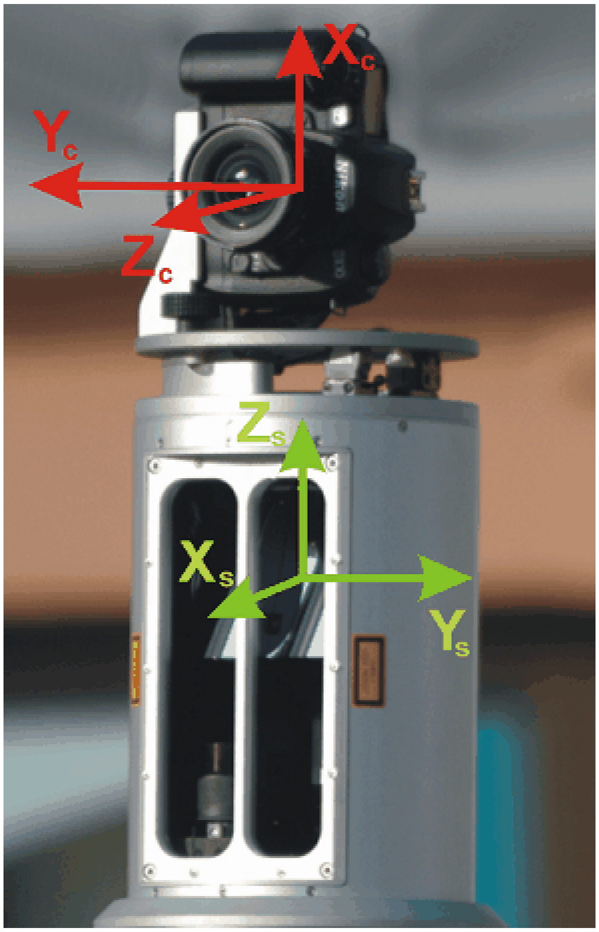
The external camera calibration parameters, especially the orientation of the camera when mounted on top of the scanner, will be changed after detaching and mounting. To account for these changes please refer to mounting calibrations 70.

3.5.1.1 Camera model

RiSCAN PRO uses a camera model similar to the one used in the "Open Source Computer Vision Library" maintained by Intel (see http://opencvlibrary.sourceforge.net/ and http://opencvlibrary.sourceforge.net/CvReference#cv_3d for details).
The calibration parameters defining the camera model (intrinsic and internal parameters) are stored within RiSCAN PRO in a tree node called CamCalib_OpenCV01 by default. A complete camera model usually also includes external calibrations parameters defining the orientation and position of the camera in 3D space. This information is held in the mounting calibration matrix, the COP matrix associated with each image at a scan position and the SOP information of the scan position in RiSCAN PRO.



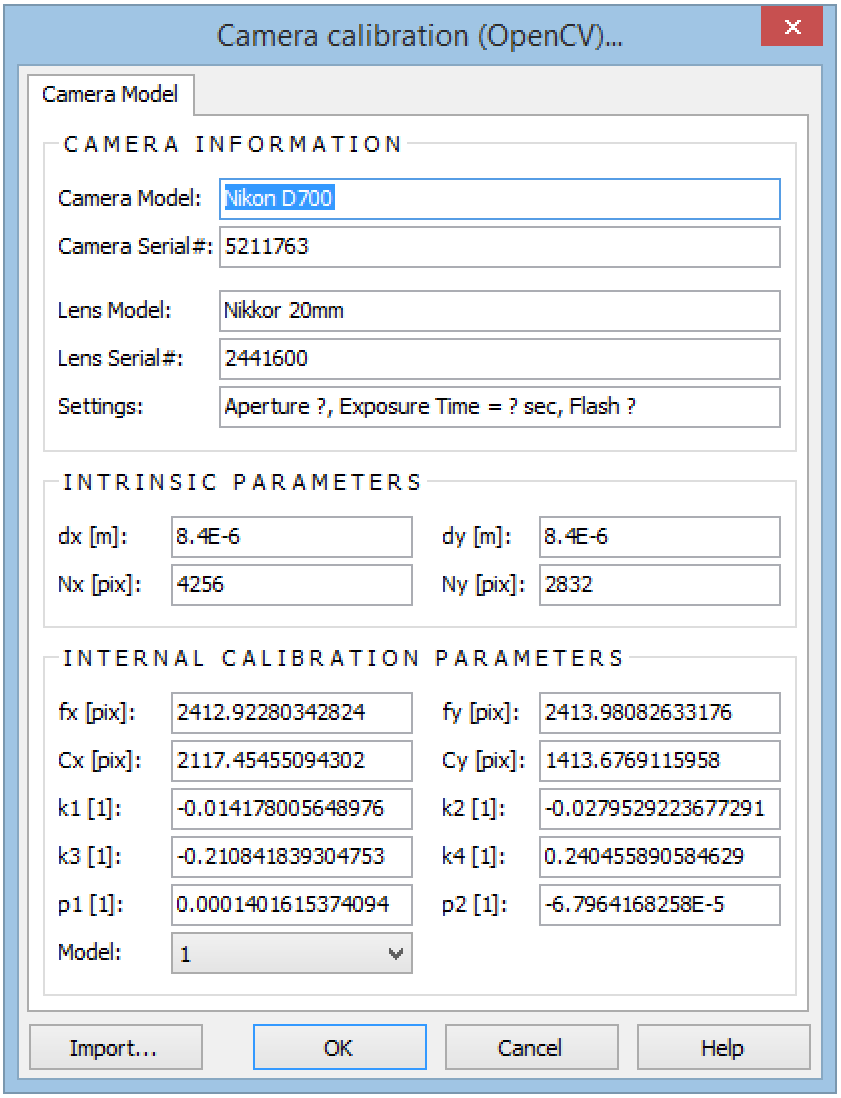
The camera model is based on a camera coordinate system (referred to as CMCS within RiSCAN PRO). The image below shows the Nikon D100 mounted on top of a LMS-Z360 with the axes of the SOCS and CMCS. The origin of the CMCS is the center of an equivalent pinhole camera. CMCS is a right-handed system with the x axis pointing from left to right in the image and the y axis from top to bottom. The z axis is identical to the center of the field of view of the camera.



The camera model is described by 4 intrinsic parameters and 8 internal calibration parameters. Additionally, descriptive information can be stored within RiSCAN PRO for documentation and data management in the field camera information.

Camera information is not used for any computation but as the internal calibration parameters are unique for every combination of camera and lens you should always make extensive use of the descriptive text.

Intrinsic parameters reflect basic parameters of the camera chip (CCD chip). Nx and Ny are simply the number of pixels in the horizontal direction (x direction) and the vertical direction (y direction), respectively. The parameters dx and dy are the dimensions of a single pixel of the CCD sensor. This parameter is commonly specified by the manufacturer, for the Nikon D100 the pixel size is 7.8 µm.



Internal calibration parameters can be divided into parameters describing (more or less) an ideal camera, i.e., a so-called pinhole camera. This is the focal length and the center of projection (the orthogonal projection of the pin-hole onto the chip surface). Two potentially different focal lengths (fx and fy) are used to account for the potentially different pixel size in x and y direction and to account for different focal length's of the lens (cylindrical lens error). The parameters fx and fy are normalized by the pixel size. The physical focal length is fx Gdx. In the example above, fx Gdx is 18.3 mm, pretty close to the nominal 20 mm of the lens. The center of the image is (Cx, Cy) in pixels. Usually, i.e., for low distortion lenses Cx ~ Nx/2 and Cy ~ Ny/2. Deviations account for a decentered lens and/or chip.

$$f_x = \frac{f}{d_x}$$

fx......[pix]
f........focal length [m]
dx.....[m]

Lens distortion is modelled by at least two radial and two tangential coefficients, k1, k2, p1, p2, respectively. In case k3 and k4 are both 0, the camera model is identical to the one described in OpenCV. The parameters k3 and k4 account for higher-order modelling of the radial distortion. The details on how the parameters are applied to transform from undistorted coordinates (i.e., ideal pinhole camera) to distorted coordinates are contained in the appendix describing the XML project file (the **calibration formulas** can be found in the file "project.dtd" which is located in the program folder of RiSCAN PRO).

3.5.1.2 Camera calibration

Prerequisite for calibrating a camera is one or more images showing identifiable objects with precisely known coordinates.
The first step to obtain a data set for calculating the model parameters is to

- determine the image coordinates of the object, i.e. find the image points, and to
- link the objects to the image points, i.e., to find the correspondences.

There are three different approaches that differ in the way the object coordinates in 3D are obtained and the way the correspondences are determined. All approaches are implemented in RiSCAN PRO and are described subsequently.

Based on reflector column

The basic idea is to set up a test field made up of a number of retroreflective targets positioned in a vertical column in a scene when viewed by the camera. The targets should (1) cover the vertical field of view of the camera and (2) should have a variation in depth. it is not required that the calibration field is long-term stable. The camera to be calibrated is mounted on top of the scanner and the test field is surveyed by the laser scanner by carrying out a number of tiepoint scans on the automatically detected targets. Then a series of images with flash is taken at different angular positions of the camera (automatically carried out by the calibration task). In every image the centers of the reflectors are automatically extracted and the extracted reflectors are automatically linked to the 3D coordinates of the targets. With this procedure, a virtual test field is generated covering the entire field of view of the camera.

The major advantage is that the test field can be put up easily, no total station is required, and the calibration task gives both the internal camera calibration parameters and the mounting calibration parameter.

Calibration based on flat check pattern images

Especially for wide-angle lenses (for the Nikon D100 up to about 40 mm) calibration based on flat check pattern images has been found to be useful. One example of an image is shown below, which shows a flat check pattern printed on white paper used to calibrate a camera with a 14 mm lens. The size of one square is 0.1 x 0.1 m. The check pattern is glued to a planar board to ensure the pattern is really flat.

For calibration the flat check pattern is captured by the camera to be calibrated several times. The whole image area should be covered, and in each image the complete pattern has to be visible. The inner check pattern corners are automatically detected by the calibration software and are automatically linked to the 3D coordinates of the flat check pattern corners (z is always 0).

The calibration software calculates best estimates for the 10 internal parameters and for the 6 external parameters of each image in order to minimize the deviation. The output of the calibration procedure is stored in a CamCalib_OpenCV node within the project for further use.

A calibration file for the camera is included in the scope of delivery every instrument. Thus, it is not necessary to recalibrate the camera as long as the lens parameters (focus, aperture, or specimen) are not changed.

Calibration based on reflector array

Especially for telephoto lenses, the calibration approach based on imaging flat check patterns is inconvenient as for a fixed focus of infinity the minimum range to the pattern would have to be quite large and thus the dimensions of the flat check pattern would be inconveniently large as well. This second approach is based on imaging a field of reflectors with known coordinates in 3D, henceforth referred to as reflector array. The reflectors must not lie in a single plane, but have to be distributed over a volume with sufficient depth. In the example below the reflectors have been fixed to a building to both sides of one corner and also to the roof. The reflector positions have been surveyed by means of a total station with mm accuracy.

Assign camera calibration to images

The camera calibration can be either assigned to each image one by one (image attributes 99) or you can assign the camera calibration to a couple of images in one step. To do so, please right-click the button "Camera calibration" and select "Assign to images..." from the menu. In this dialog you can define several filter settings. At the bottom of the dialog you'll see a summary of the filter settings explaining which images will be modified.

3.5.1.2.1 Base camera calibration

To start a new camera calibration task based on a reflector column 55 you need an initial camera calibration. You can either use the camera calibration of another camera of the same type and lens or you can use the new camera calibration wizard. This wizard allows you to create an initial camera calibration based on the information provided by the user such as camera type and type of lens. The created camera calibration doesn't contain distortion parameters of course.

To use the wizard proceed as follows:

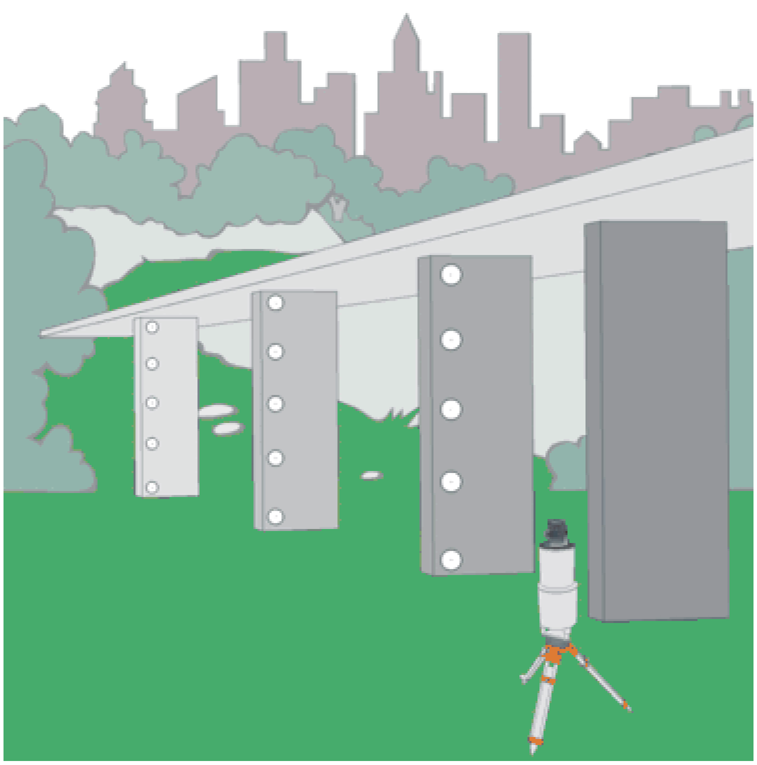
- Open or create a project.
- Right-click the folder "CALIBRATIONS / CAMERA" in the project manager.
- Select "New camera calibration (wizard)..." from the menu.
- **Step 1:** Define camera model
  In this step you can either select your camera type from the list or enter your own camera parameters. The parameters you have to enter are the camera model (just for your own information), the number of pixels and the size of one pixel of the image chip in both directions (vertical and horizontal).
- **Step 2:** Define lens model
  In this step you can either select your lens model from the list or enter your own lens parameters. The parameters you have to enter are the lens model (just for your own information) and the focus in millimeters.
- **Step 3:** Define additional data
  In this step you can enter additional information such as camera settings and serial numbers of camera and

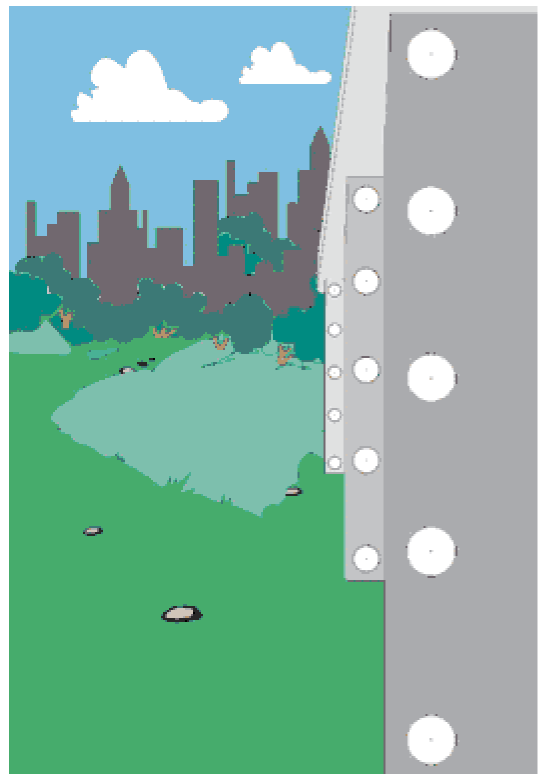
lens. Although it's not necessary to enter values in this step it is strongly recommended to do so. This makes it easer to keep track of which camera calibration belongs to which camera and lens.
Finally enter a name for the new camera calibration and click the button "OK" to create it.

3.5.1.2.2 Based on reflector column (recommended)

This task allows the user to either check an existing camera calibration or to perform the camera calibration using of an easy to set up calibration field.

The basic idea is to have a number of retroreflective targets positioned in a vertical column in a scene. The images below show an example of how the reflectors may be applied to existing structures, e.g., the supports of a bridge. The targets should (1) cover the vertical field of view of the camera and (2) should have a variation in depth, i.e., the targets should not be placed on a single plane perpendicular to the principle axis of the camera. The right image shows a camera image with the reflectors covering a vertical band of the field of view.





The image below shows an indoor scene with 9 reflectors attached to a column in about 3 m distance, 7 reflectors at a distance of about 8 m, and one reflector at a distance of about 13 m. The image is taken with a flash so the targets show up clearly in the image.

This calibration field alone is insufficient for accurately determining the calibration parameters of the camera. But as the camera is mounted on the rotating part of the scanner, a sequence of images can be recorded and all extracted targets of all images cover the complete field of view of the camera and thus give a very good calibration field.

Usually a calibration field is surveyed by means of a total station. As the laser scanner can provide the position of the targets in its own coordinate system very accurately by means of fine scans (tiepoint scans) no total station is required. By arranging the targets as described above only few targets were measured (in the example above 17 targets). By taking 20 images and extracting the reflectors from every one provides a virtual test field with about 340 targets.

So after setting up the test field by placing a number of targets as described above, the scanner with the camera mounted on top is set up in front of the test field.

Note:
For the image acquisition the scanner tries to turn left and right until the camera's total field-of-view is covered. Because the scanner can not turn across 0 degrees you have to arrange the scanner with the rear plate roughly pointing away from the reflectors.

The procedure to extract the calibration data based on a reflector column using the scanner and the camera mounted on the scanner is as follows:

Creating the new camera-calibration-task

1. Generate a new camera-calibration-task in an existing project or create a new project first. To do so right-click the CAMERA node and choose **New calibration (reflector column) …** from the menu.

2. You are prompted to select an initial camera-calibration and a initial mounting-calibration. You can either select a calibration from the list or import it from an other project (i.e. the default project - if copied during the setup of RiSCAN PRO). If you have no matching camera calibration you can also use the new camera calibration wizard 54. These calibrations are used for initializing the task. The better these calibrations are the easier the data-acquisition and thus the whole calibration task will be.

3. You are also prompted to select a scan position where the scan, the finescans and the images should be saved. Click on "create new" to create a new scan position.

4. Confirm the dialog by pressing the button "OK".

5. A small wizard will appear in the upper right corner of RiSCAN PRO. This wizard will guide you through the steps of the data acquisition needed for the camera-calibration-task (Once you have closed the wizard you can re-start it by right-clicking the camera-calibration-task and selecting "Acquire calibration data..." from the menu).

Calibration data acquisition step by step (with the wizard):

1. Acquire new single scan

The first step is to acquire a scan of your calibration field. This scan should contain all reflectors in your calibration field. Click the button "Start", configure the scan as usual 84 and start the scan.

2. Reflector extraction

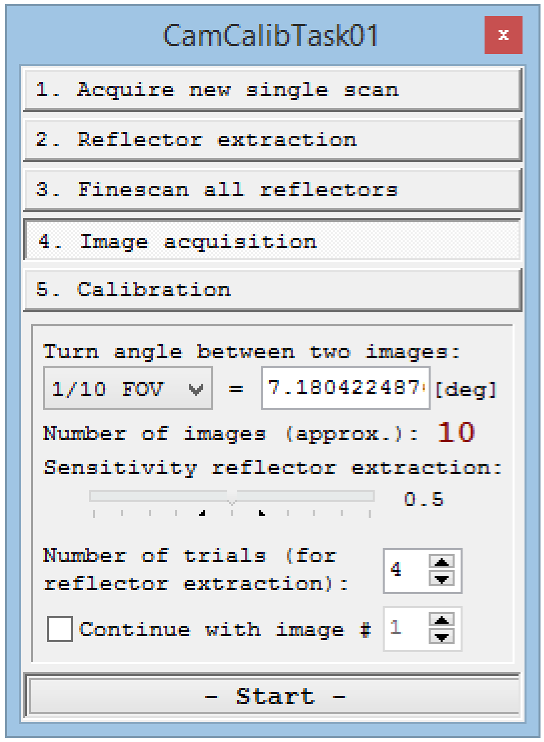
The second step is to extract the reflectors from the scan made in step 1. Select the scan from the list (should already be pre-selected) and click the button "Start". Configure the reflector extraction as usual 93. The TPL SOCS of the scan position will be displayed showing all extracted reflectors. Open the scan and display the TPL SOCS in order to check if all reflectors were extracted and delete all unnecessary reflectors (faulty detection or wrong targets).

3. Finescan all reflectors

The third step is to make tiepoint scans 117 of all reflectors extracted in step 2. By clicking the button "Start" all reflectors of the TPL SOCS will be fine scanned.

4. Image acquisition

The fourth step is to acquire images containing all reflectors. The first image will be acquired in order to have the reflectors in the center of the image. Before taking the second image, the scanner will turn to the next position (see "Turn angle between two images 58"). The image aqcuisition will be continued this way until no reflector can be extracted from the image. Configure the image acqusition (see "Description of the input fields 58" for more details) and start the image acquistion by clicking the button "Start".



Description of the input fields:

- Turn angle between two images
  Images will be taken at this angular interval. Either select one entry in the list on the left side or enter the angle on the right side. The list contains some default values expressed as fraction of the vertical field of view (FOV) of the camera (default is 1/10 FOV).

- Number of images (approx.)
  This shows the approximate number of images which will be taken (Note, that this value depends on the quality of the initial camera- and mounting-calibration and may differ from the actual number of images).

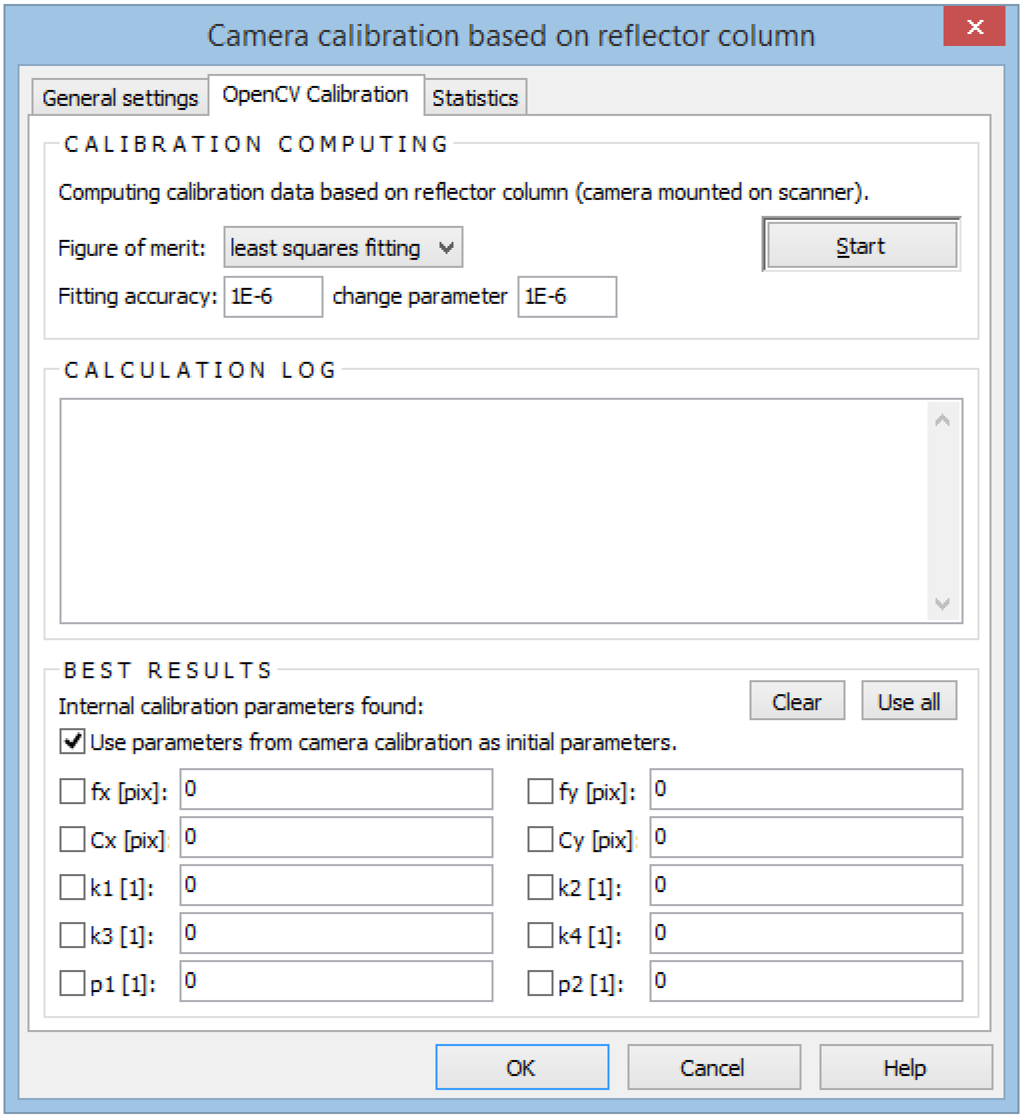
- Sensitivity reflector extraction
  With this slider you can set the sensitivity for the reflector extraction (from the images). The Range is from 0 to 1, default is 0.5. If the images are very bright try raising this value and vice versa.

- Number of trials (for reflector extraction)
  The algorithm will try to extract one single reflector from the image "Number of trials"-times before it fails (default is 4).

- Continue with image #
  If you are starting the image acquisition for the first time you can leave this setting as it is. If the image acquisition was interrupted (because i.e. something got wrong during the reflector extraction, power-loss of the camera or the reflectors where obstructed) you can restart it by clicking the checkbox and selecting the number of the image which should be next.

5. Calibration

After the image acquisition has finished you can calibrate the camera. To do so click the button "Start". The following dialog will appear:



On this page you can select which calculation method (*least squares fitting or robust* 74) should be used ("Figure of merit"). We recommend to use the default "robust" fitting which minimizes the sum of the absolute values.

The parameter "Fitting accuracy" defines the change in the residual error which stops the iterative optimization process. The default value is 1E-6. Values should range from 1E-4 to 1E-8.

The parameter "Change parameter" defines the absolute change of the ten calibration parameters. The default value is 1E-6. Values should range from 1E-4 to 1E-8.

Additionally you can select which of the parameters should be optimized. Select or deselect the parameter by means of the checkbox to the left of the parameter. The use of K3 and K4 may improve the accuracy of the calibration, especially for wide angle lenses.

The button "Clear" will reset the parameters and uncheck all parameters. The button "Use all" will check all parameters (all will be used for calibration.

If you select "Use parameters from camera calibration as initial parameters" the parameters are initialized with the parameters from the initial camera-calibration (Use this the first time you start the calibration).

Finally start the calibration by clicking the button "Start". The calibration will be started and you can watch the progress in the "CALCULATION LOG". After the calibration has finished you can switch to the third page "Statistics". On this page you will see a table showing all images and their mean, minimal and maximal pixel-distances (between tiepoints of the image and the tiepoints of the scan). At the current state an average pixel-distance about 0.5 can be considered as a good result.

To use the results in another project just import the camera- and mounting-calibration by right-clicking "CALIBRATIONS" and selecting "New OpenCV..." (to import a mounting: "New mounting...") from the menu. In the following dialog click the button "Import" to import the calibration.

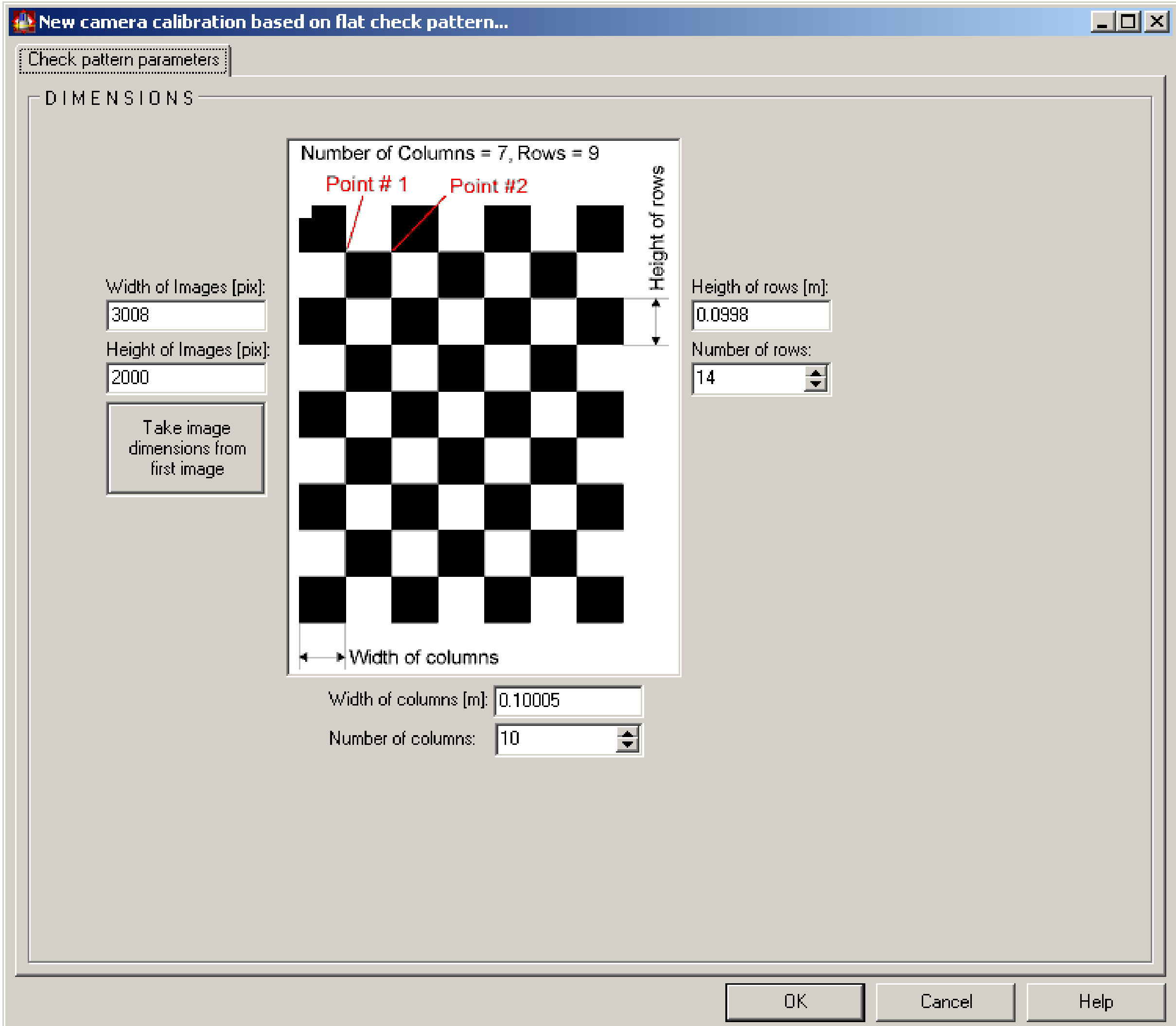
Hints:
Problems during camera calibration may be based on faultily assigned camera- / mounting calibrations. Please make sure that the correct camera- and mounting calibration is assigned to all images. Always assign the resulting calibrations located within the calibration task!

3.5.1.2.3 Based on flat check pattern

To do the calibration on your own you need a check pattern. The pattern has to be as flat as possible and as regular as possible with a high contrast. In the help directory you can find a pdf file (CheckboardScaled.pdf) showing a check pattern of 11 columns and 15 rows.

The procedure to extract the calibration data based on a flat check pattern is:

1. Generate a new node CamCalibTask in an existing project or make a new project first. To do so right-click on the CAMERA node and choose **New calibration (flat check pattern) …** from the menu. The following dialog will appear:



To initialize the camera calibration task set the values on the first page:

DIMENSIONS

- *Width and Height of Images in pixel*

  here you can either enter the dimensions of the images directly or you can click "Take image dimensions from first image" *after* importing the images of the check pattern (see step 2).

- *Height of rows*

  the height of one row in the check pattern in meters.

- *Number of rows*

  the number of rows in the check pattern .

- *Width of columns*

  width of one column in the check pattern in meters.

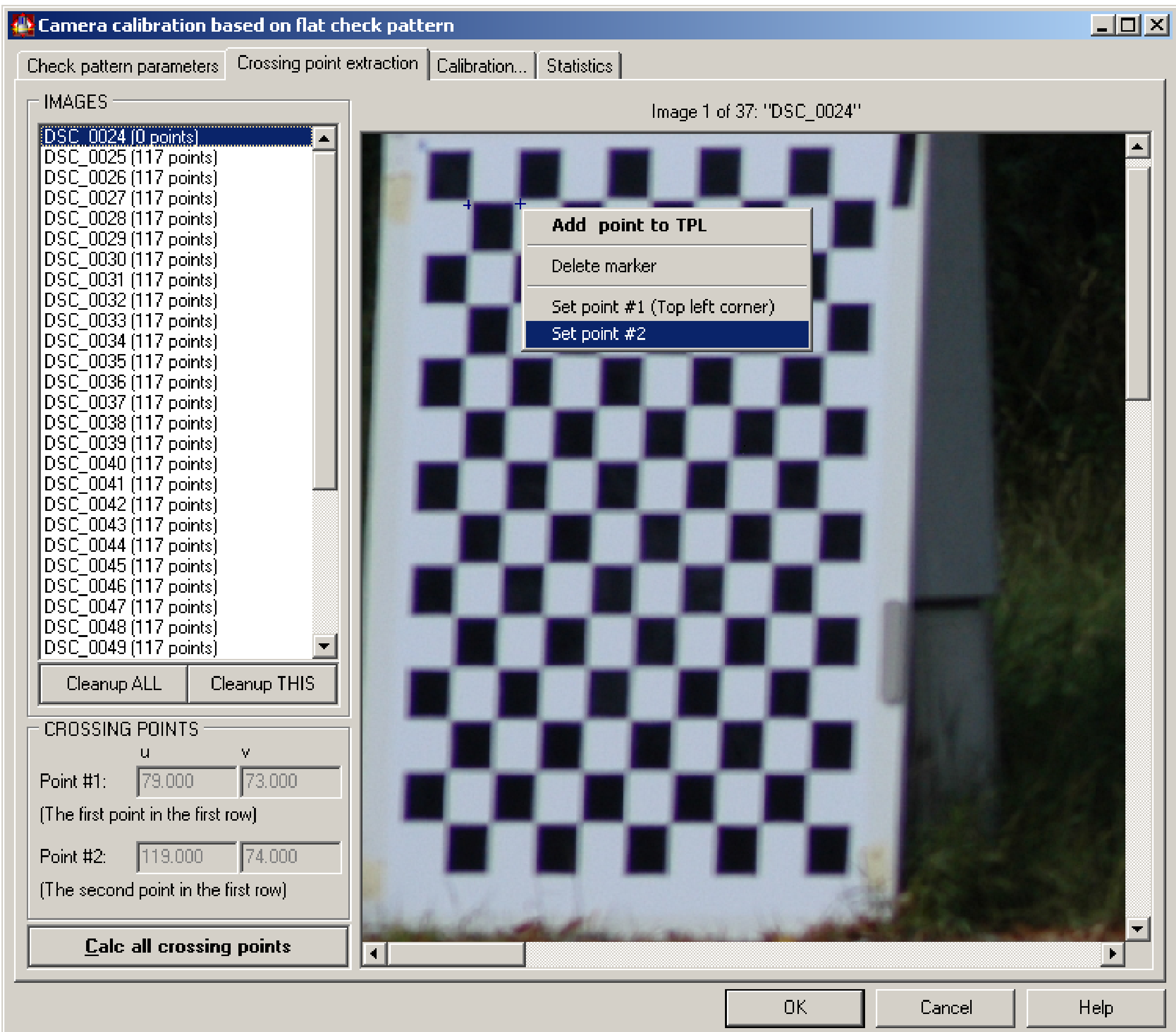
- *Number of columns*

  the number of columns in the check pattern.

Confirm with OK. The new node is named CamCalibTask01 (the number will be increased due to existing tasks) by default.

2. Right-click the node CamCalibTask01 and select **Add image(s) ...**. Add all images taken with the camera to be calibrated showing the flat check pattern from different view angles (take more images by tilting and panning the camera while taking shots).

3. The next step is to extract all crossing points (corner points of two neighbouring black fields) of the check pattern in all images.
Open the CamCalibTask01 (double-click, or right-click and select "Attributes").

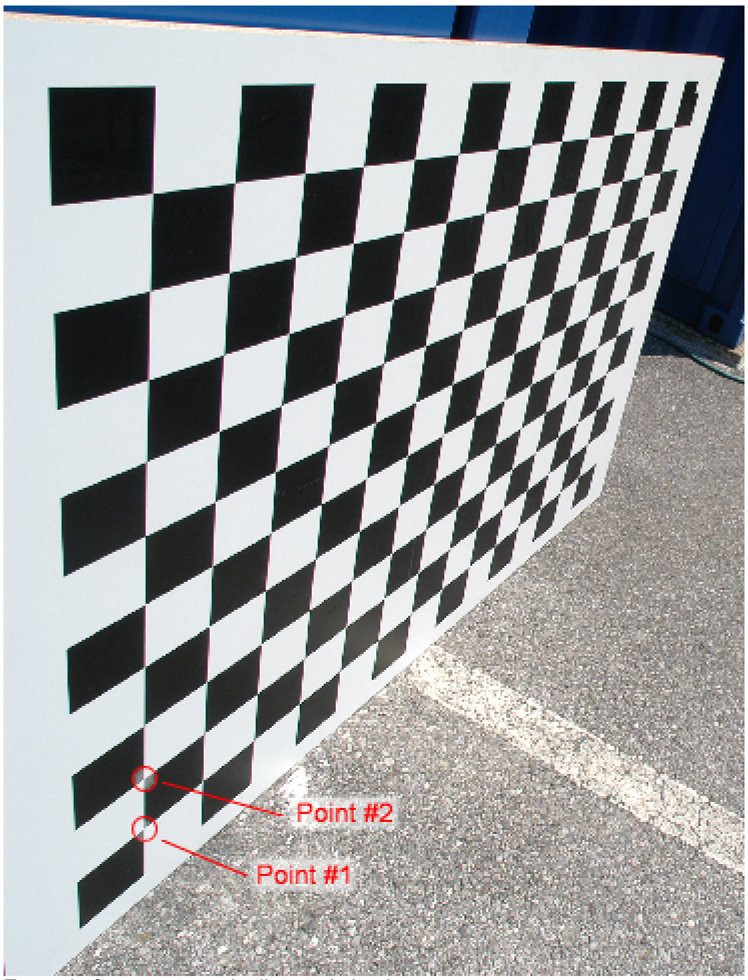


Select an image from the list on the left side. This will load the image into the window on the right side. Now set two markers at the first two crossings in the first row by left-clicking 134 (as in the image above). Now you have to identify the points by a single right-click on each marker and selecting its position from the menu (the order is not important). If you have done a faulty assignment you can simply overwrite it by

doing the assignment a second time as described above.
The button "Calc all crossing points" will cause RiSCAN PRO to calculate all other crossing points, which will take, depending on your computer configuration, more or less time. The result of the calculation will be displayed in the image by markers.

Distorted check pattern

In some cases automated detection of corner points fails. Especially if perspective distortion yields a ratio in width and height of the first square significantly different from 1 (compare the subsequent image). In this case try to define the square opposite to the first square. Use clockwise orientation again.

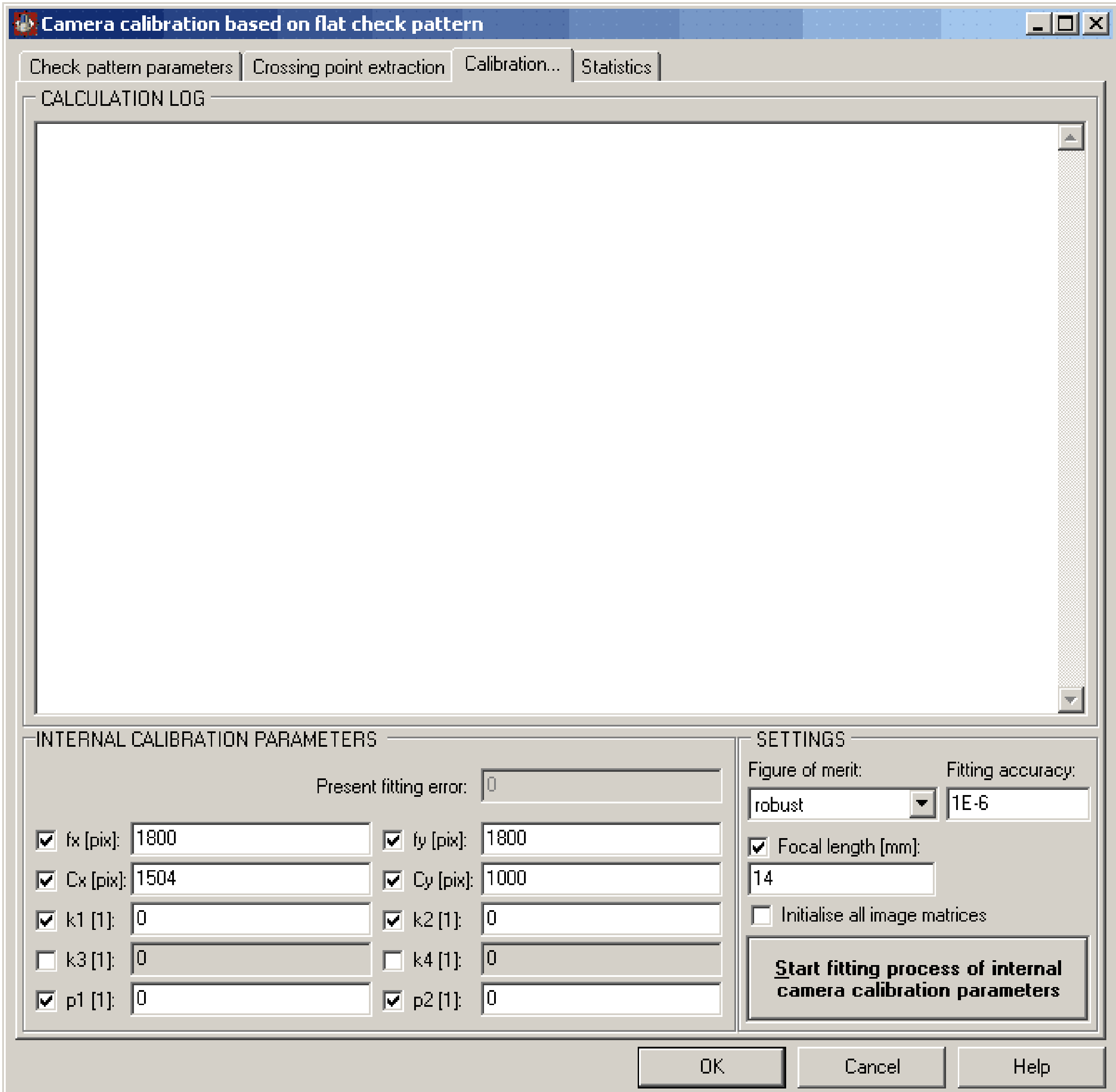


Example for an extremely distorted check pattern

Process all images sequentially in this way.

The buttons "Cleanup ALL" and "Cleanup THIS" will delete the found crossing points of all images or of the current image.

4. Now proceed by switching to the page "Calibration...". On this page you can select which calculation method (least squares fitting or robust 74) shell be used ("Figure of merit"). We recommend to use the default "robust" fitting which minimizes the sum of the absolute values.



Additionally you can select which of the parameters shall be optimized. Select or deselect the parameter with the checkbox to the left of the parameter. The use of K3 and K4 may improve the accuracy of the calibration, especially for wide angle lenses.

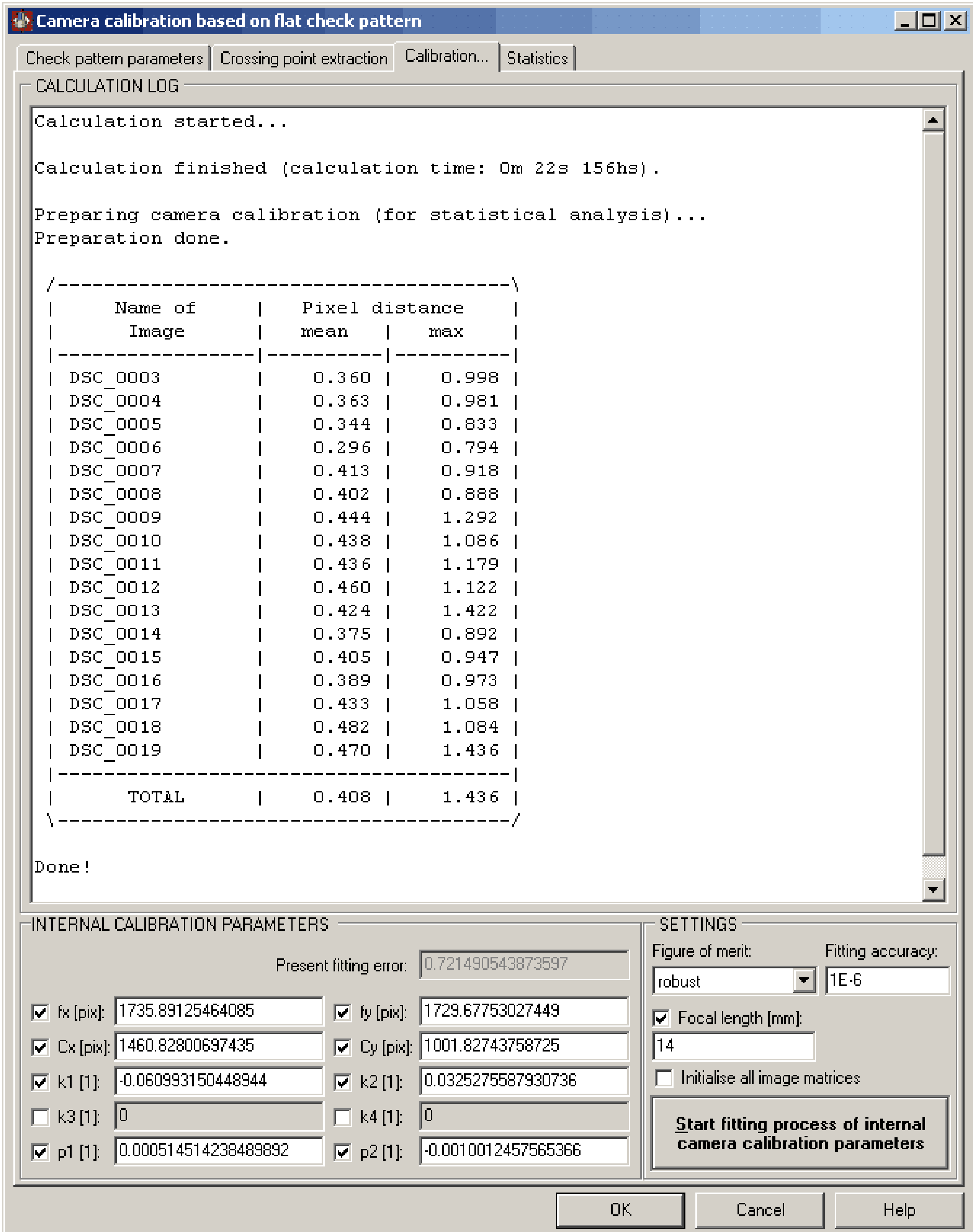
The parameter "Fitting accuracy" defines the change in the residual error which stops the iterative optimization process. The default value is 1E-6. Values should range from 1E-4 to 1E-8.

The parameter "Focal length [mm]" helps speed up the optimization process in case the focal length is known.

The checkbox "Initialise all image matrices" re-calculates the position and orientation of the camera for every image with respect to the check pattern every time you start a new fitting process. In case you have already run the fitting process successfully once and just want to see the impact of an additional parameter, e.g., k3, on the error, de-select this option and also deselect the "Focal length" option.

Start the fitting process by clicking the button in the lower right corner. You can keep track of the progress by looking at the "Present fitting error".

After the calculation was completed successfully, RiSCAN PRO displays a statistics section in the calculation log. The statistics contain the maximum and mean distances of the real crossing points (as specified by the check pattern parameters) transformed into image coordinates by means of the camera calibration data.



Furthermore, there is an additional page titled "Statistics". This page shows charts representing the pixel distances of the transformed 3D crossing points to the 2D crossing points in different ways to reveal dependencies on the radial distance (uncorrected radial distortion) or the angular dependence (uncorrected translational distortion) or the crossing index number to reveal incorrect 3D coordinates due to an imperfect check pattern.

5. Copy the **Result_CamCalib** the node CAMERA for further use to by right-clicking the camera calibration task and selecting "Copy Result...".

3.5.1.2.4 Based on reflector array

The procedure to extract the calibration data based on a reflector array is:

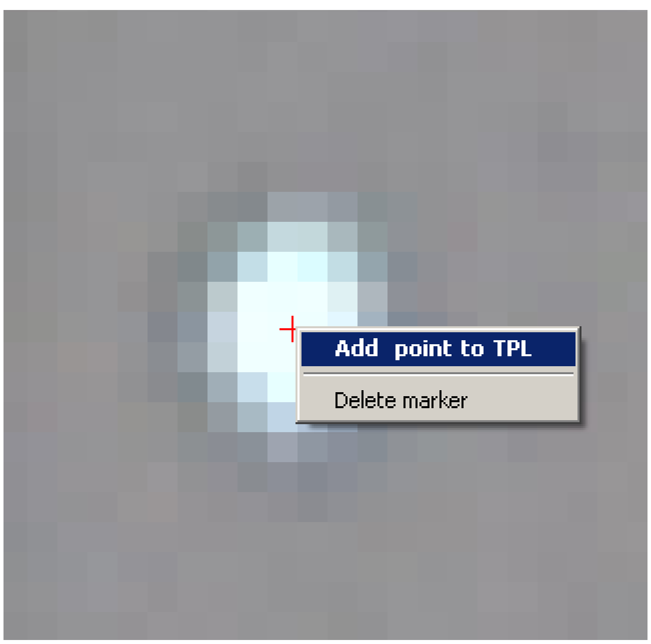
1. Generate a new node CamCalibTask in an existing project or create a new project first. To do so right-click the CAMERA node and choose **New calibration (3D Points) …** from the menu. Confirm with OK. The new node is named CamCalibTask01 by default.

2. Right-click the node CamCalibTask01 and select **Add image(s) ….** Add all images taken by the camera to be calibrated showing the reflector array. One image is sufficient if the reflectors cover the whole image area. Otherwise take more images by tilting and panning the camera while taking shots of the reflector array. At least 6 reflectors have to be visible in each image.

3. Import the tiepoints into the tiepoint list TPL (CALIB).

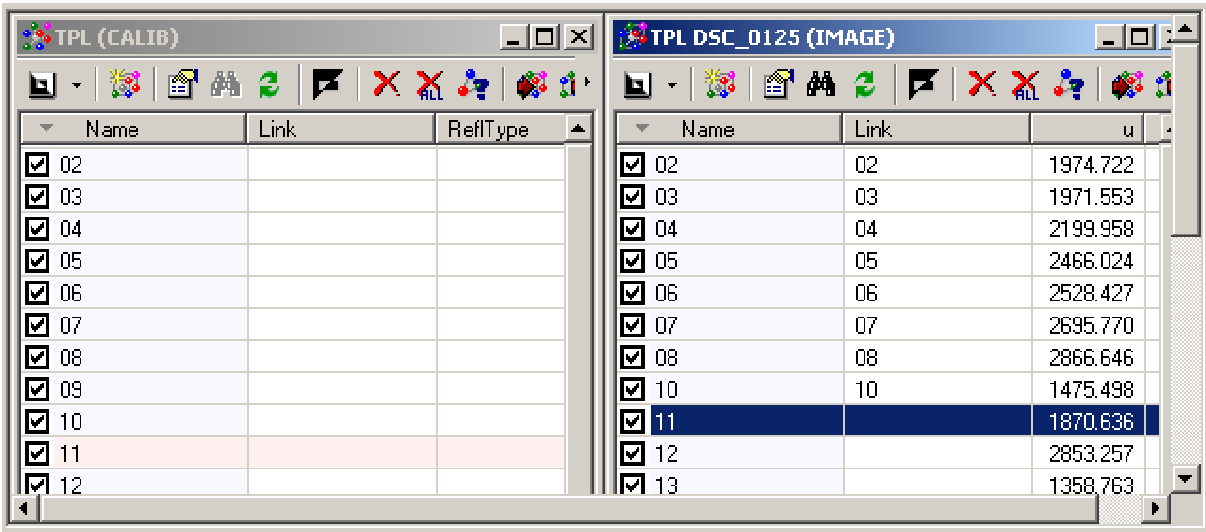
4. Process all images sequentially. For every image you have to identify the reflectors either manually or by automatic extraction (Find reflectors …). The automatic extraction works only in case the images were taken with flash and the reflectors clearly stand out from the background.

   For manual extraction using the flash when taking the images is also of advantage. Zoom into the image, set a marker with a left-click, open the menu with a right-click on the marker and add the point to the TPL (IMAGE) .

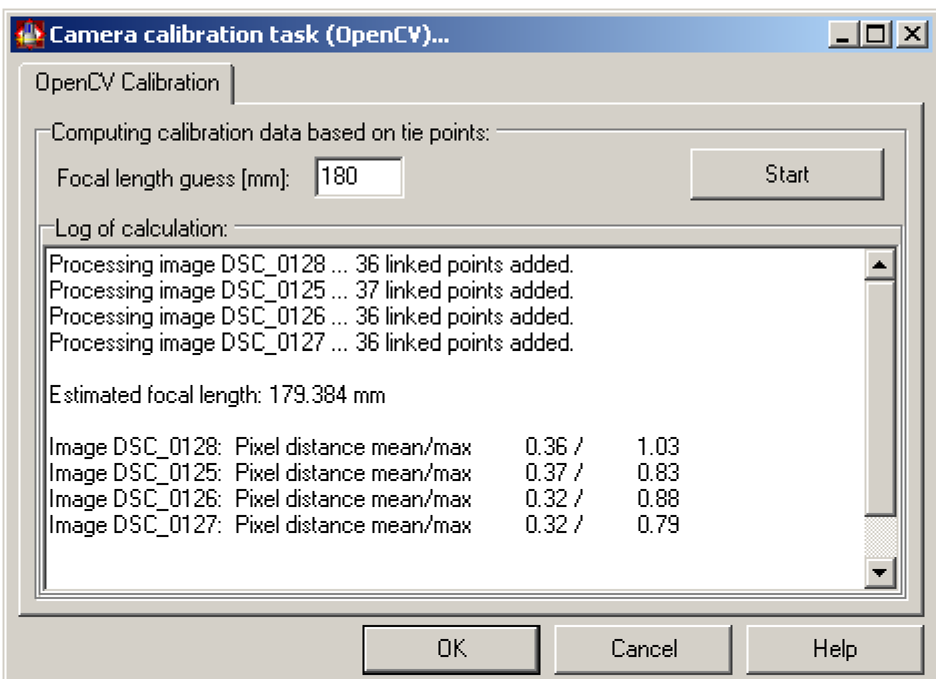


5. For every image set the correspondences between the TPL (IMAGE) tiepoints and the TPL (CALIB) tiepoints. This is done by simultaneously displaying both tiepoint lists as shown below. Establishing a link defining the correspondence is done with drag and drop . Left-click an item's name in the TPL (CALIB), drag it over the corresponding name in the TPL (IMAGE) and drop it. You see the link in the link column.

You are assisted by using the same numbering in the TPL (IMAGE), which is defined in the previous step.



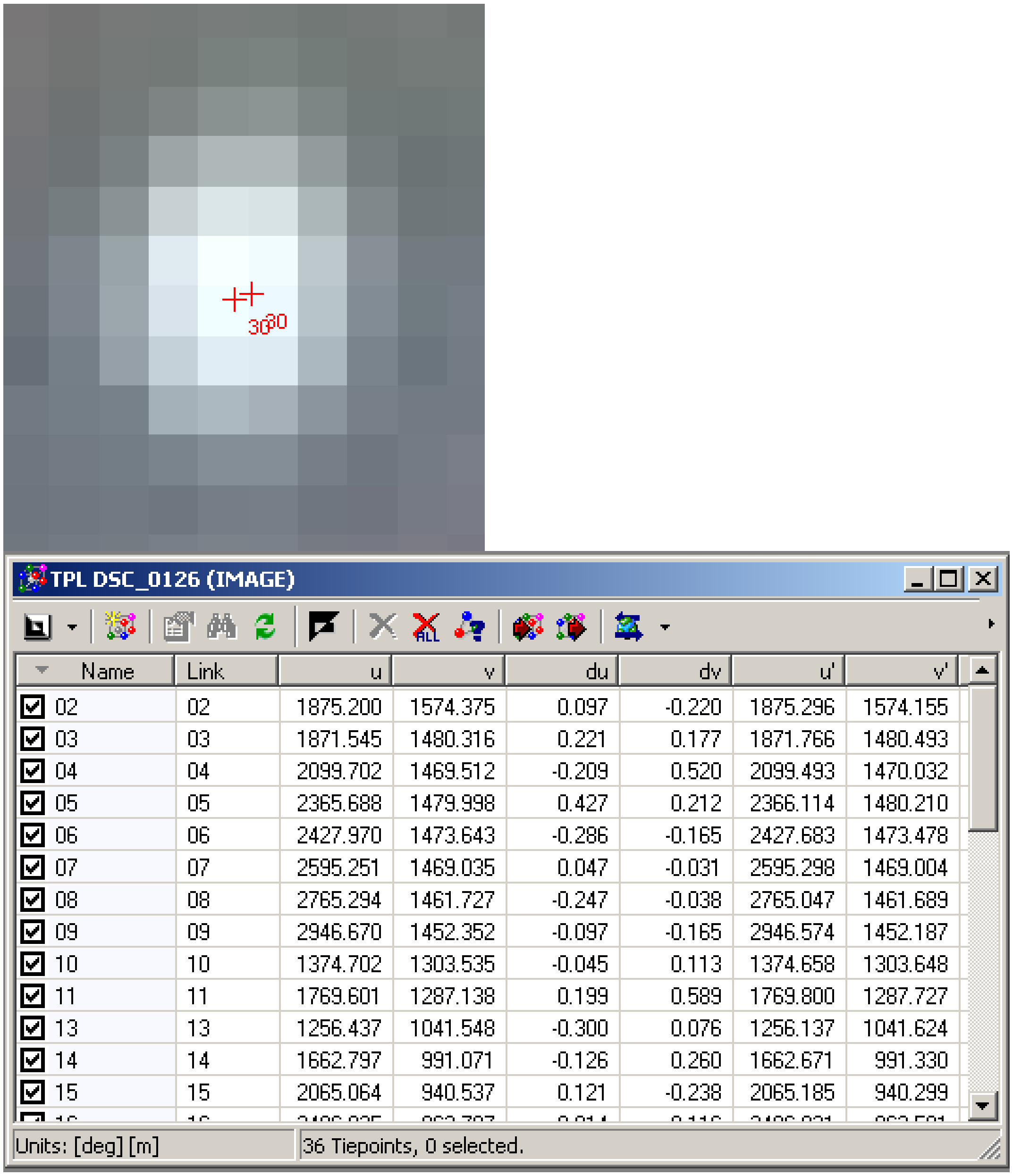
6. Open the attributes window of the node CamCalibTask01 by double-clicking, or right-clicking and choosing **Attributes…**. Enter the approximate focal length in mm into the edit field. Use the number printed on the lens. Initialise the computation of the calibration parameters by clicking **Start.** All linked points are extracted from the lists and calibration parameters are calculated.



After successful calibration RiSCAN PRO displays a statistical analysis for each image. The calibration data is entered in the **Result_CamCalib** node and for every image the estimated position and orientation of the camera in the coordinate system of the TPL (CALIB) are updated.

7. With the calibration results it is possible to check the accuracy of calibration by either displaying both the tiepoints of TPL (CALIB) and TPL (IMAGE) simultaneously in the images or by numerically comparing the

difference in pixels in the TPL (IMAGE).



Name	Link	u	v	du	dv	u'	v'
02	02	1875.200	1574.375	0.097	-0.220	1875.296	1574.155
03	03	1871.545	1480.316	0.221	0.177	1871.766	1480.493
04	04	2099.702	1469.512	-0.209	0.520	2099.493	1470.032
05	05	2365.688	1479.998	0.427	0.212	2366.114	1480.210
06	06	2427.970	1473.643	-0.286	-0.165	2427.683	1473.478
07	07	2595.251	1469.035	0.047	-0.031	2595.298	1469.004
08	08	2765.294	1461.727	-0.247	-0.038	2765.047	1461.689
09	09	2946.670	1452.352	-0.097	-0.165	2946.574	1452.187
10	10	1374.702	1303.535	-0.045	0.113	1374.658	1303.648
11	11	1769.601	1287.138	0.199	0.589	1769.800	1287.727
13	13	1256.437	1041.548	-0.300	0.076	1256.137	1041.624
14	14	1662.797	991.071	-0.126	0.260	1662.671	991.330
15	15	2065.064	940.537	0.121	-0.238	2065.185	940.299

8. Copy the **Result_CamCalib** to the node CAMERA for further use by right clicking the camera calibration task and selecting "Copy Result...".

3.5.1.3 Field of view

To estimate the field of view of the camera use the following formula:

$$\Theta = 2 \cdot \arctan\left(\frac{dx \cdot Nx}{2 \cdot f}\right)$$

Variable	Meaning	Value for Nikon D100
f	focal length [m]	depending on lens
d	dimension of chip [m]	23.7mm
Nx	number of pixel in x-direction	3008 pixel
dx	dimension of one pixel in x-direction[m]	0.000 007 8m = 7.8 µm

The following table shows Θ for several lenses on a Nikon D100:

focal length	Θ
180 mm	7.5 deg
50 mm	26.4 deg
20 mm	60.8 deg
14 mm	80.0 deg

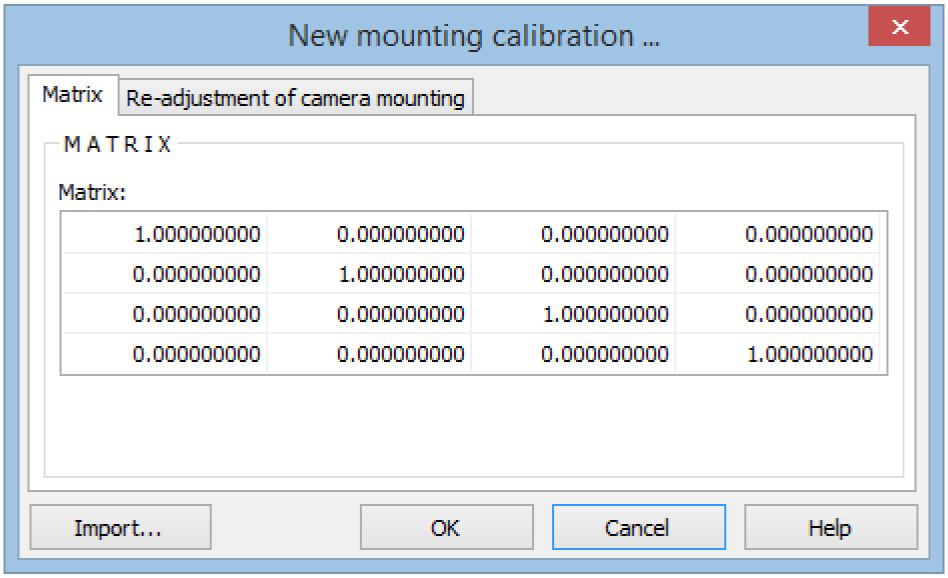
3.5.2 Mounting

The mounting matrix transforms from SOCS into CMCS at the reference orientation. The reference orientation is defined as the position at which the azimuth 339 angle is equal to 0 degrees. Data is transformed from the SOCS system into the reference system by COP-1.

The mounting matrix is also contained in the CALIBRATIONS section referred to as mounting calibration. Please note that the mounting calibration has to be updated after every mounting of the camera as the angles at which the camera will be mounted will slightly differ from the angles the camera has been mounted before detaching the camera.

Creating a new mounting - calibration:

To create a new mounting - calibration open the folder "CALIBRATIONS", right-click on the folder "MOUNTING" and select "New Mounting...". The following dialog will appear:

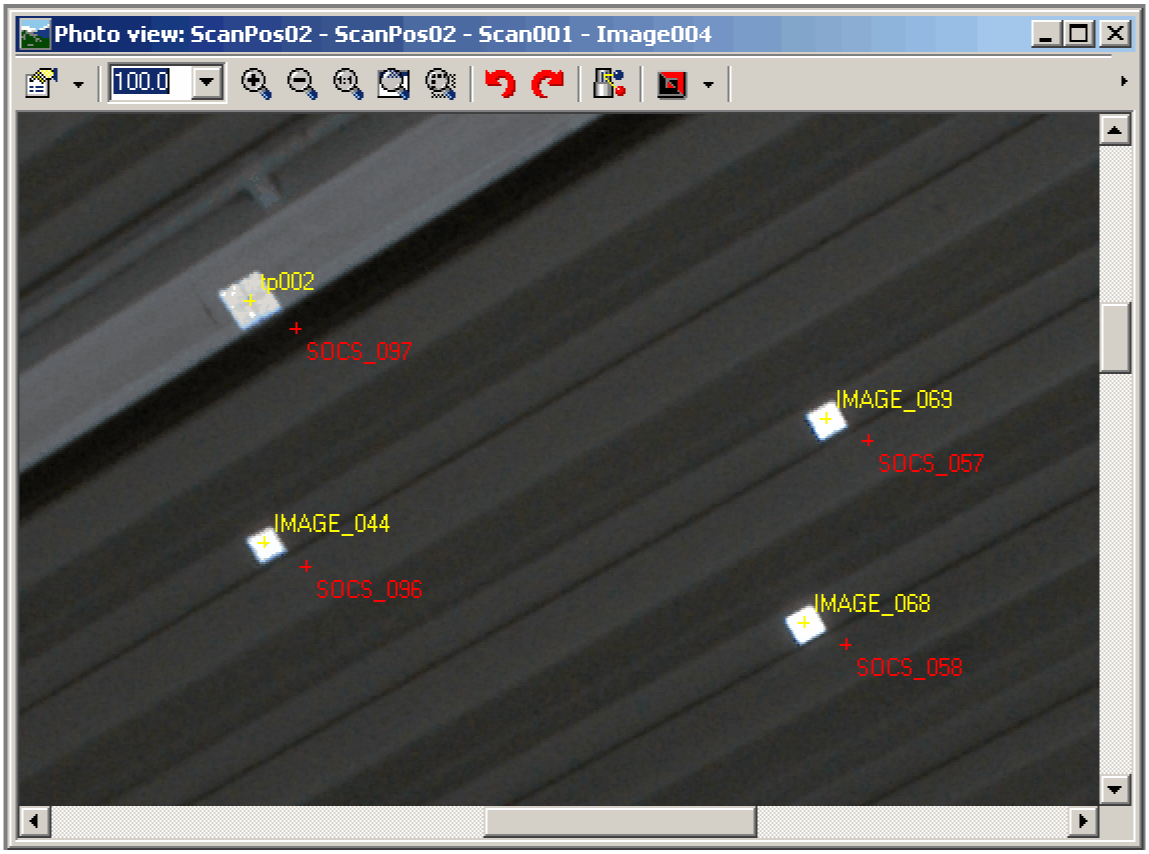


Use the button "Import" in the bottom left corner to import an already existing mounting-calibration from an other project (e.g., the default project installed on your platform).

Improving the mounting calibration

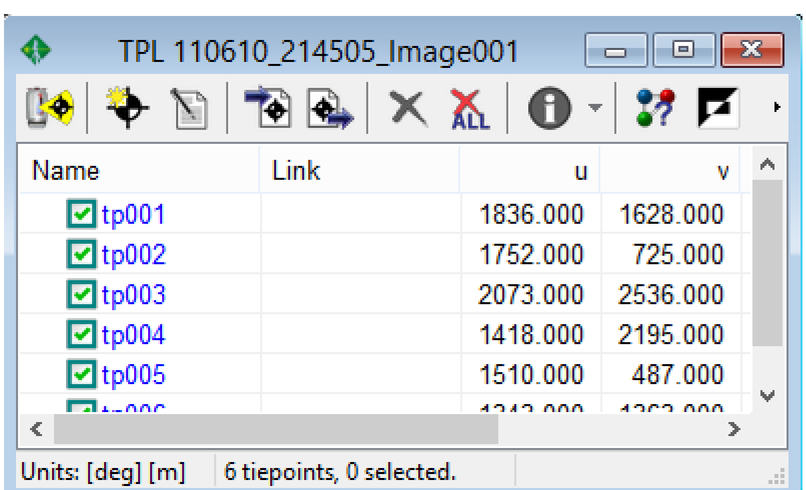
In order to check the quality of the mounting adjustment you need some objects with known coordinates you can clearly identify in at least one of the images acquired with the camera. In the example shown below we scanned an area with some signals (i.e., retro-reflectors) and we took some images with the flash switched on. Furthermore, we automatically extracted the reflectors in the image (see "Image acquisition: Reflector extraction 103") and we extracted the reflectors from a corresponding scan (Scan acquisition: Reflector extraction 93) to fill up the TPL (SOCS) with the coordinates of the reflectors in the SOCS system. To get the best accuracy we recommend to "finescan 117" the reflectors.

The image below shows a part of the image where we activated the display of the TPL Image (yellow) and TPL SOCS (red).



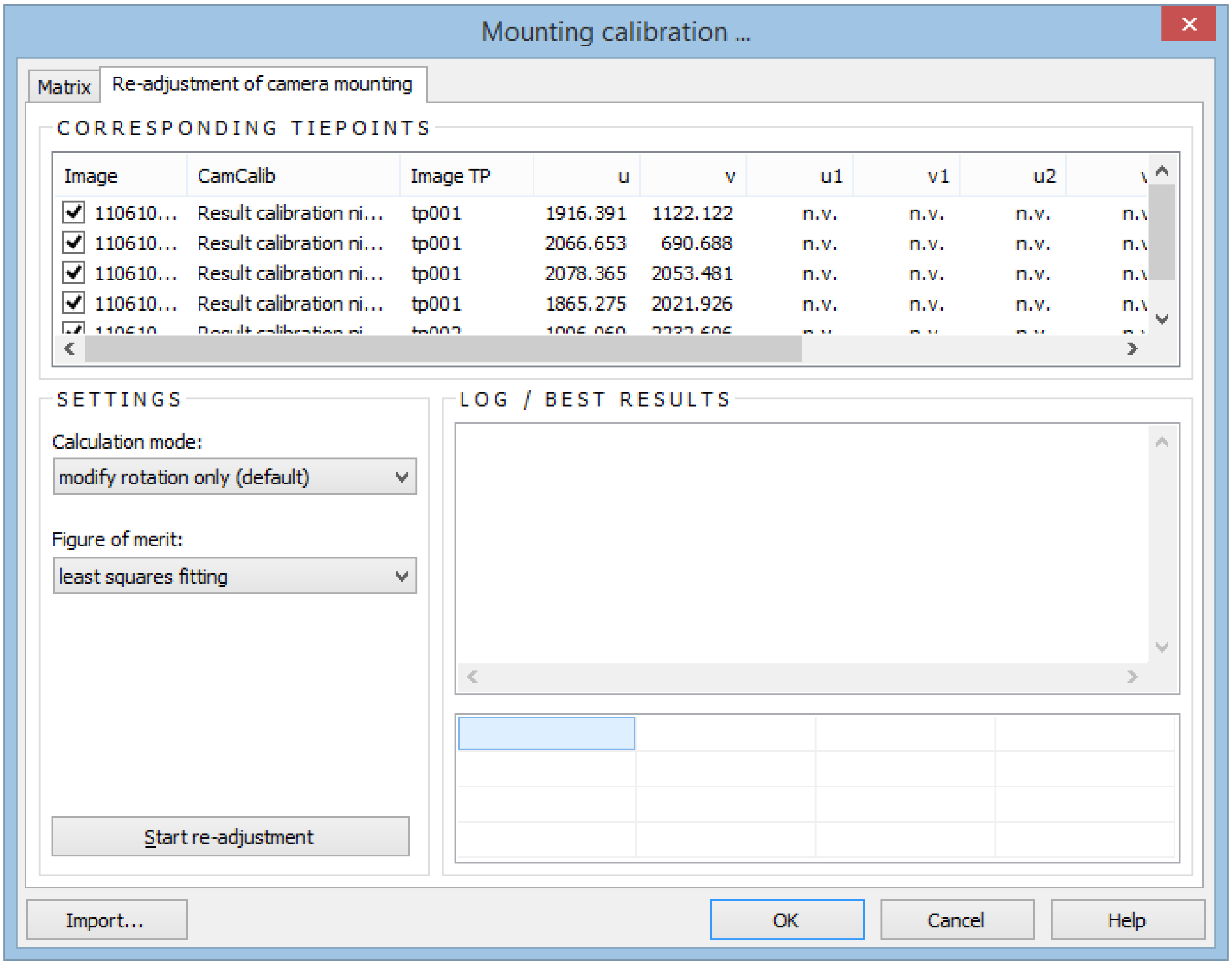
You can see the deviation in the pixel coordinates which is caused by a not perfectly calibrated mounting matrix.

In order to improve the alignment, first establish the correspondences between the image points (TPL IMAGE) and the points in 3D (TPL SOCS). This is done manually by drag and drop. Make TPL (IMAGE), TPL (SOCS) and the image itself visible. Zoom to the image region of interest. Read the name of the tiepoint in SOCS and select this tiepoint in the TPL (SOCS). Note that the color of the tiepoint changes from the unselected color to the selected color. Select the corresponding image point in the TPL (Image). Also note the change in color due to selection. Now establish the link by dragging the TPL (SOCS) point into the corresponding TPL (IMAGE) point (Drag and drop must be done in the TPL-Window, not in the Image-View!). The link is shown in the link column of TPL (IMAGE) (compare the screen shot below).



Important note: In order to improve the mounting calibration you have to use at least 3 corresponding points.

Once you have finished establishing the correspondences, start the optimization by displaying the "Re-Adjustment of camera mounting" page (right-click the mounting calibration in the directory "MOUNTING" in the "CALIBRATIONS" directory). RiSCAN PRO searches all scan positions for links you have established before and displays the links in the upper part.



For optimization the following options are available:

SETTINGS

- *Calculation mode:*

  Modify rotation only:
  Only the three rotation parameters out of the six parameters defining the mounting calibration are optimized. As the position of the camera is very well defined by the mounting support this default option should be used.

  Modify rotation and translation:
  All six parameters are optimized. This option should only be used with a sufficient number of well distributed signals (reflectors). Use this option with care!

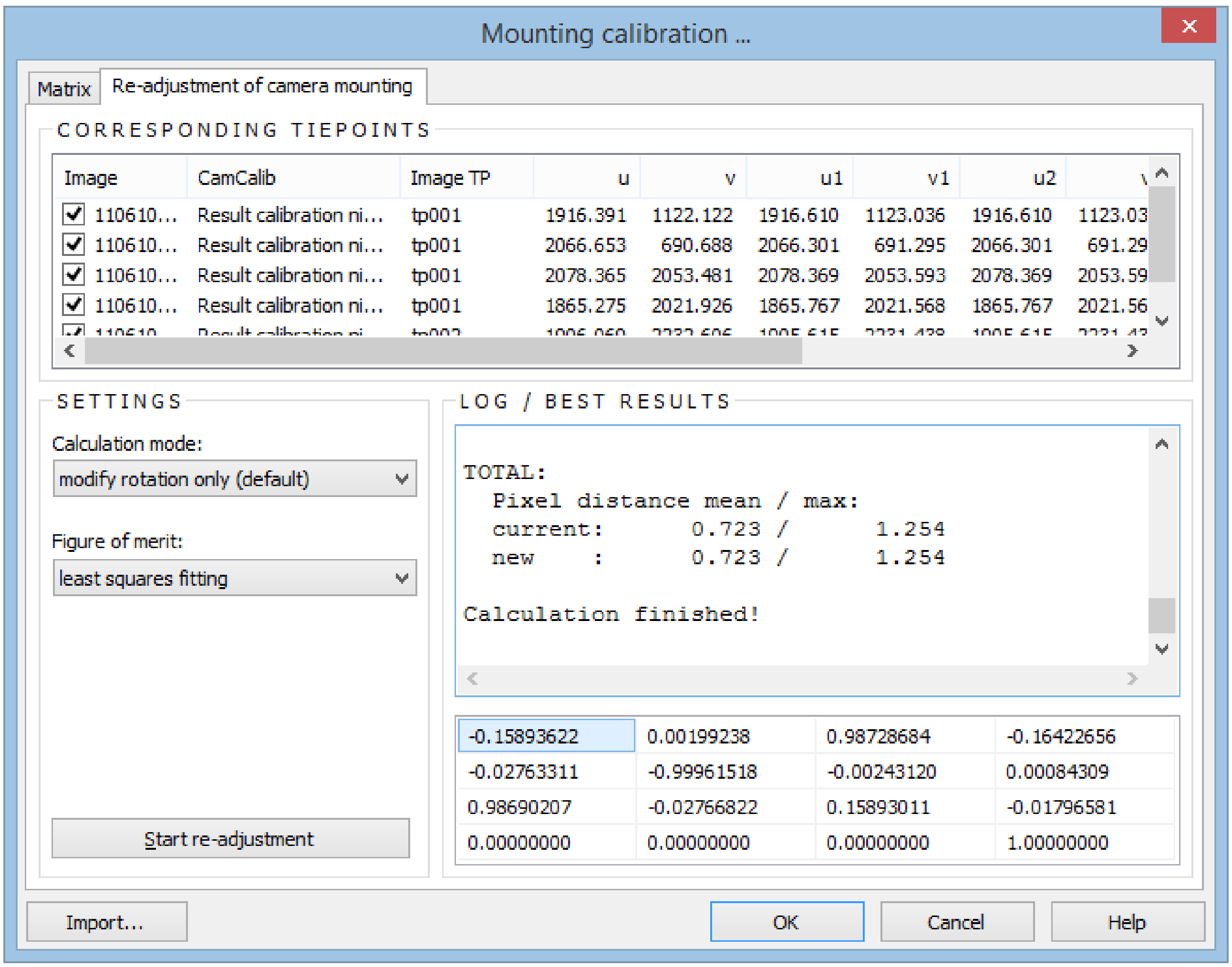
Modify translation only:
Do not use this option.

- ***Figure of merit:***

Least squares fitting:
Optimization is based on minimizing the sum of the squares of the residuals. This is the standard setting. Note that the result may be changed significantly even by a single outlier arising from establishing a wrong link.

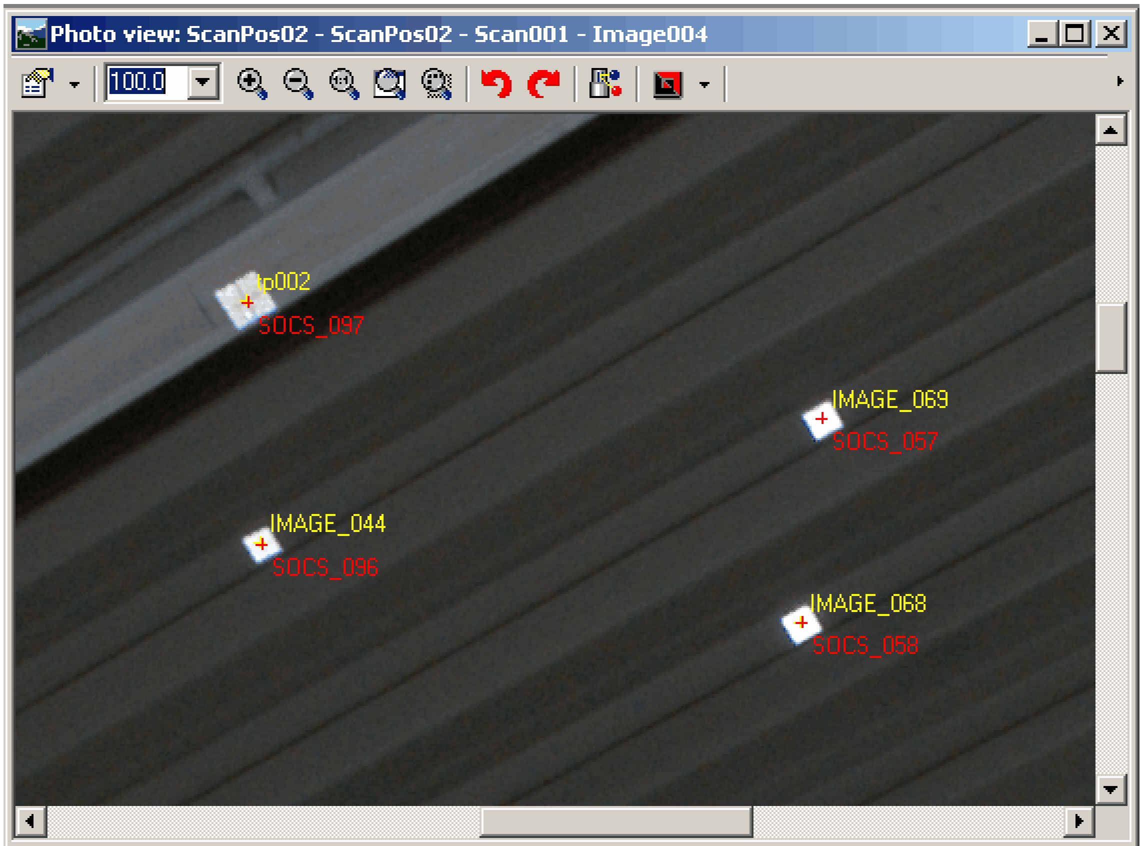
Robust fitting:
Optimization is based on minimizing the absolute value of the residuals. Note that this option reduces the sensitivity to outliers.

Start optimization by clicking the button "Start re-adjustment".
Note that this process may take some time if the camera-calibration has to be prepared.



The result for the optimization of the matrix is shown at the bottom. The LOG area displays the improvement in the residuals.

Check the quality of the mounting calibration by displaying the tiepoints again within the image (compare image below). Update the display by switching the display of the tiepoints off and on again.



Assign mounting calibration to images

The mounting calibration can either be assigned to every image on by one (image attributes 99) or you can assign the mounting calibration to a couple of images in one step. To do so, right-click the mounting calibration and select "Assign to images..." from the menu. In this dialog you can define several filter settings. At the bottom of the dialog you'll see a summary of the filter settings explaining which images will in fact be modified.

3.5.3 Reflector

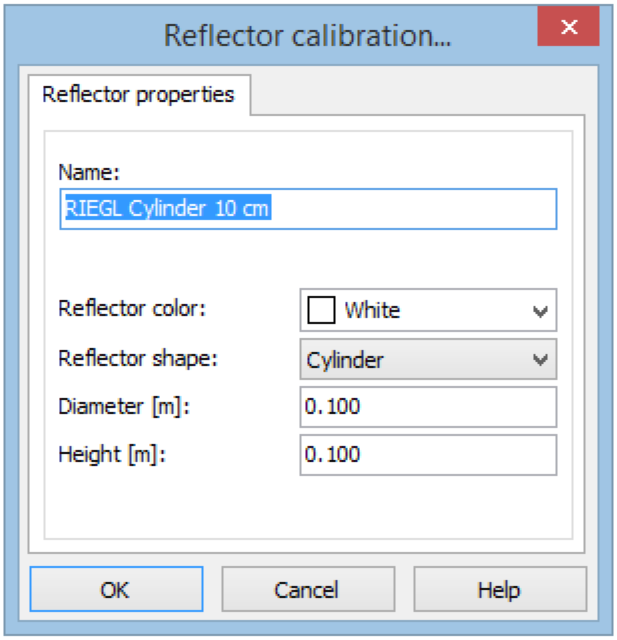
As you may use different reflector types during data acquisition you have to define a reflector calibration for each reflector type in the RiSCAN PRO-project.

Supported reflector-types are:

- Sphere
- Cylinder
- Disc (flat)

Define new reflector calibration

In order to define a new reflector-type open the folder "CALIBRATIONS", then right-click the folder "REFLECTOR" and select "New reflector...". This will show the "New reflector calibration..." dialog:



- Name:
  The name of the reflector calibration

- Reflector color
  All tiepoints with this reflector calibration will be displayed in this color within a 3D View

- Reflector shape
  All tiepoints with this reflector calibration will be displayed in this shape (sphere, cylinder, disc) within a 3D-View

- Diameter and Height
  - are dimension-information.

- Reflector constant
  This value is used only for the flat reflector type to correct the range measurement. The reflector constant will be added to the measured range as sketched for the type "sphere" below.

Note: Which input fields are displayed depends on the shape you have selected!

Modify (edit) existing reflector calibrations

In order to edit a reflector-type open the folder "CALIBRATIONS -> REFLECTOR", right-click a reflector and select "Attributes...". This will show the "Reflector calibration..." - dialog which is quite similar to the "New reflector calibration" - dialog (see the section above) 76.

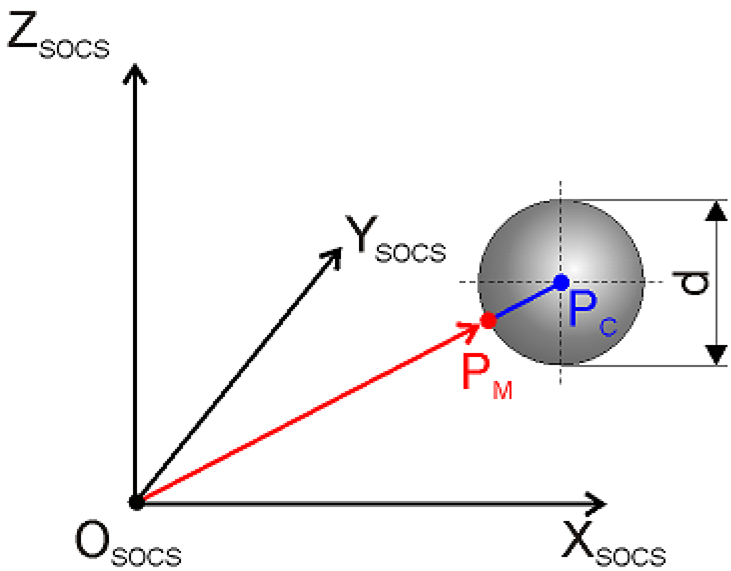
Note:
If tiepoints have already been assigned a certain reflector calibration, the reflector dimensions of this reflector calibration can not be changed. Define a new reflector calibration instead!

Assign reflector calibration to tiepoints

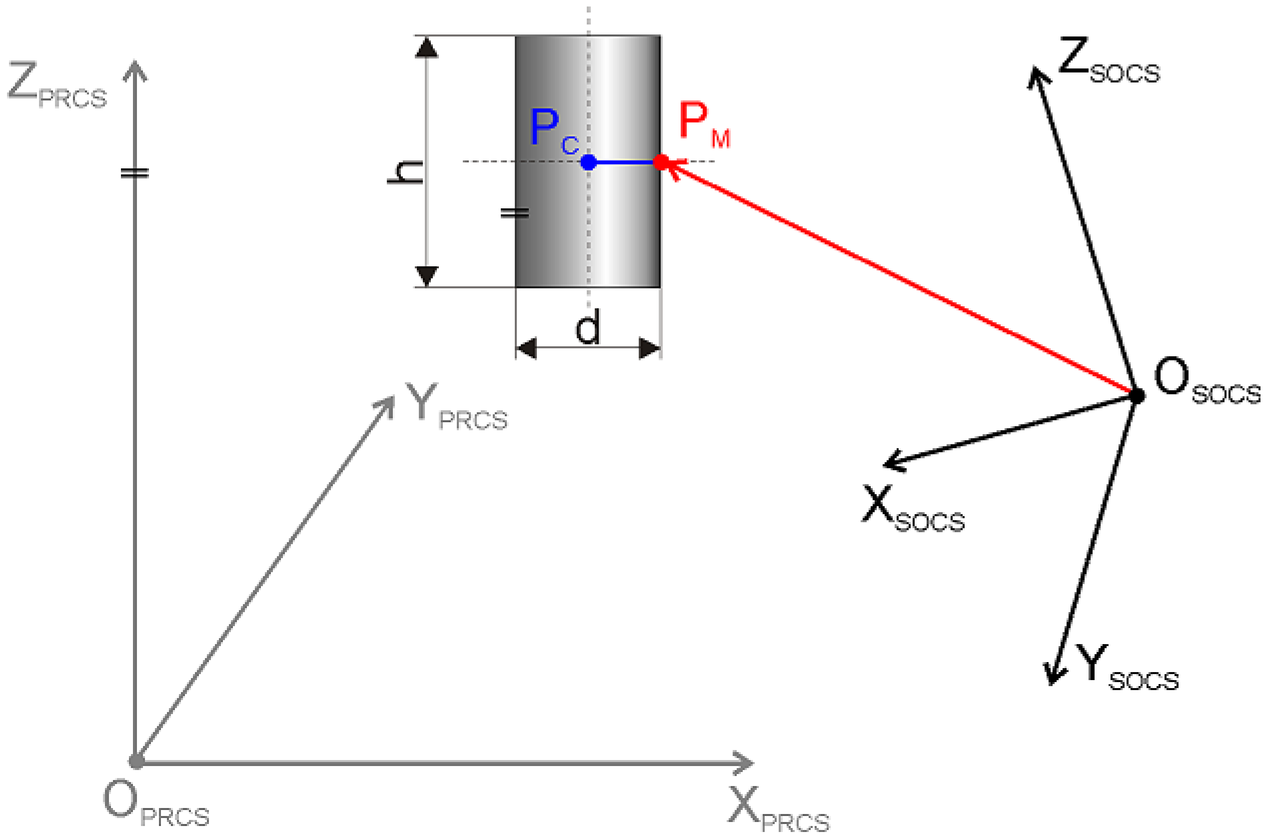
Please see section "Tiepointlist window104" to see how you can assign a reflector calibration to tiepoints.

Note:
When you assign a reflector calibration to a tiepoint this assignment is inherited by all linked tiepoints.
As soon as you assign a reflector calibration to a SOCS tiepoint (no matter if directly or inherited) the coordinates will be recalculated according to the reflector type and dimension. The calculation depends on the reflector shape and is done as follows:

Sphere:
The measured coordinates represent a point on the surface of the sphere (PM). To get the center of the sphere (PC) the vector of this point is enlarged by the radius (d/2) of the sphere as shown in the following sketch:



Cylinder:
RiSCAN PRO assumes that the cylinder is vertically aligned (the cylinder axis is parallel to the Z axis of the PRCS). Analog to the sphere the measured coordinates represent a point on the surface of the cylinder (PM). The center of the cylinder (PC) is calculated according to the radius (d/2) of the cylinder as shown in the following sketch:



Disk (flat):
No coordinate modification is done because the measured coordinates already represent the center of the disk.

3.5.4 Tiltmount

What is a tilt mount

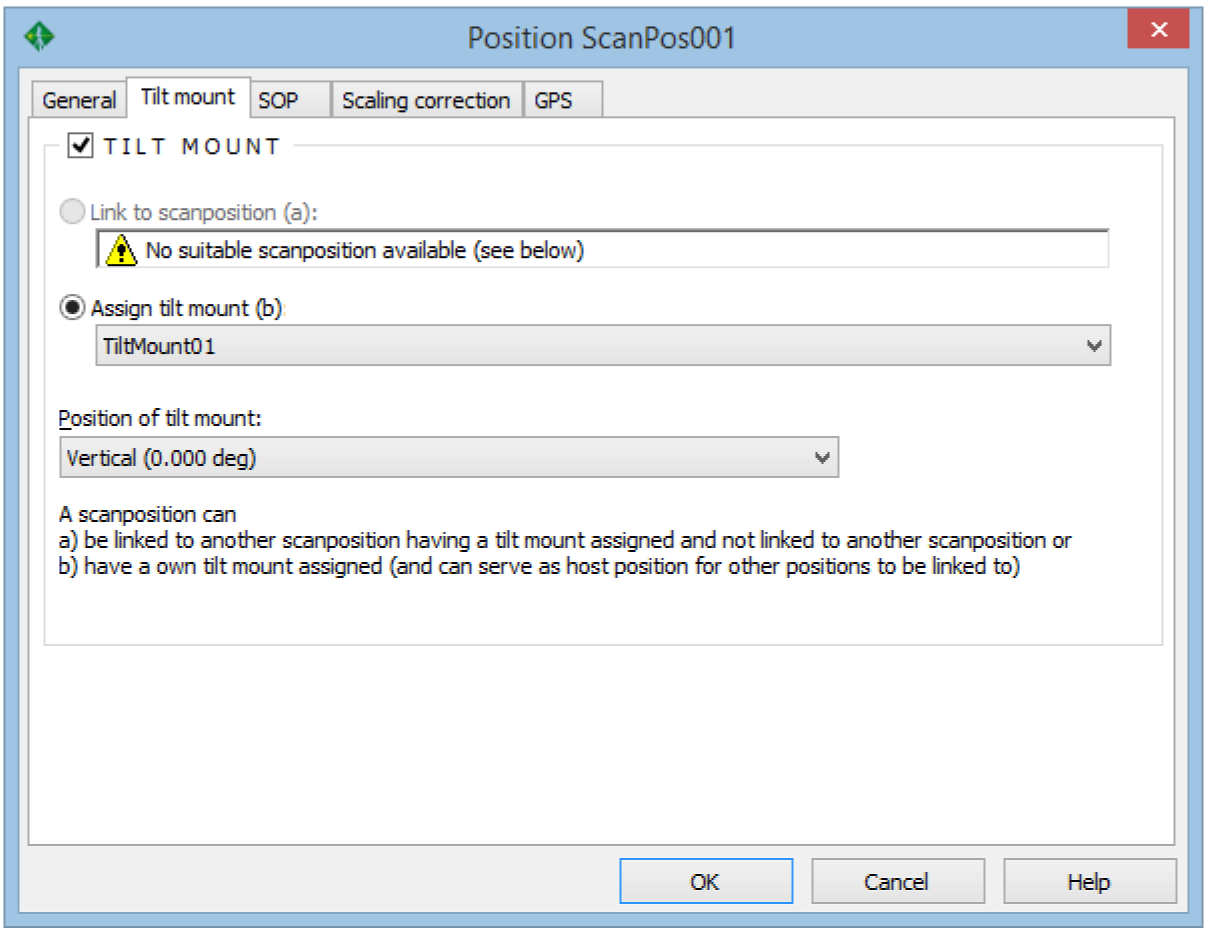
With a (physical) tilt mount you can tilt the scanner around the horizontal axis to predefined positions. The RIEGL tilt mount is able to tilt the scanner by 180 degrees (-90° to +90° against the vertical axis). The advantage of a tilt mount is the ability to enlarge the field of view of the scanner by scanning several times on the same position but with different tilt angles.

Z420 mounted on a tilt mount:

In RiSCAN PRO the scans are organized in scan positions. Every time you move or tilt the scanner you have to create and register a new scan position. When you use a tilt mount you can speed up the registration process by using a tilt mount calibration in RiSCAN PRO. This calibration contains a complete transformation matrix for each position you can tilt the scanner to. This allows you to automatically register all scan positions with the same setup position but different tilt angles together.

General workflow of how to use the tilt mount in RiSCAN PRO

1. Create a new RiSCAN PRO project
2. Import the tilt mount calibration from your default project (please refer to "How to calibrate a tilt mount 80"). To do so open the folder "CALIBRATIONS" from the Project manager window. Right-click the folder "TILTMOUNTS" and select "New tilt mount...". Click the button "Import" in the lower left corner to import a tilt mount from another project.
3. Setup the scanner (no matter what tilt angle) and create a scan position
4. To assign a tilt mount, right-click the scan position in the project manager window and select "Attributes...". The following dialog will appear:



TILT MOUNT

- *link to scan position (a)*

  select the link-target. That is the scan position which already has a tiltmount assigned (normally this would be the vertical position).

- *assign tilt mount (b)*

assign a tilt mount to a scan position (in order to make this scan position the "base"-scan position for others)

- *position of tilt mount*

  choose a position of the tilt mount (that is the tilt angle)

In case it is the first scan position you have to select option b and a proper tilt mount calibration from the list.

Hint: When you remove the option "TILT MOUNT" then the SOP matrix calculated from a former link to a scanposition (case "a") will be preserved. So the link is removed but the position and orientation of the scanposition will not change.

5. Perform the data acquisition.
6. If the tilt angle changes but the position remains unchanged, right-click the base-scan position (e.g. ScanPos01), click "New linked position..." and select the current tilt-angle (position) from the dialog. The relationship between the scan positions will be reflected in the project manager window in this way:

7. Repeat steps 5 and 6 as long as the position of the scanner isn't changed. Otherwise continue with step 3.
8. When the data acquisition is done you may have a project similar to this example:

Name of scanposition	Scanner		Link to	Used tilt mount calibration
	Position	Tilt angle		
ScanPos01	A	0.0°	TiltMount01	TiltMount01
ScanPos02	A	+45.0°	ScanPos01	TiltMount01
ScanPos03	A	-45.0°	ScanPos01	TiltMount01
ScanPos04	B	+90.0°	TiltMount01	TiltMount01
ScanPos05	B	+45.0°	ScanPos04	TiltMount01
ScanPos06	B	0.0°	ScanPos04	TiltMount01
...				

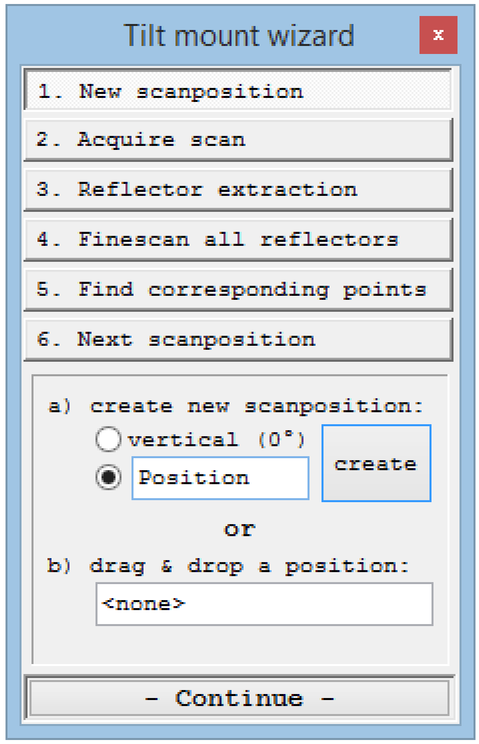
In this example the scanner was located at two different positions (A and B) with several tilt angles at each position. The tilt mount calibration "TiltMount01" was used. Base positions are "ScanPos01" and "ScanPos04". These positions have a link to the used tilt mount calibration. "ScanPos02" and "ScanPos03" are linked to "ScanPos01", so they inherit the tilt mount calibration "TiltMount01" from "ScanPos01". Due to this, "ScanPos02" as well as "ScanPos03" are already registered to "ScanPos01" (same for position B).

The final registration is done by registering "ScanPos01" and "ScanPos04" either to controlpoints of the project coordinate system or to each other (please refer to "Registration of a scan position 187").

How to calibrate a tilt mount

The calibration of a tilt mount is based on finescans of a reflector field at each tilt angle of the tilt mount. For each tilt position a new scan position is created and all scan positions are registered to the first (i.e. the vertical) scan position.

- Setup the scanner in the reflector field. It's recommended to use the vertical position (0°) as the first tilt position.
- Right-click the folder "TILTMOUNTS" in the project-manager window and select "Tilt mount calibration wizard..." from the menu and follow the steps of the wizard:



1. **New scan position**
   The first step is to create a new scan position. To create the scan position with a defined name (a) select either "vertical (0°)" or enter a name and click on the button [Create]. The new scan position will be created and the name is written at (b). Click the button [Continue].

2. **Acquire scan**
   Now you can acquire a scan (an "Overview scan 90"). This scan should contain all desired reflectors of the reflector field. By clicking the button [Start] the normal scan dialog is opened. Please choose the proper scan area and scan pattern and start the data acquisition.

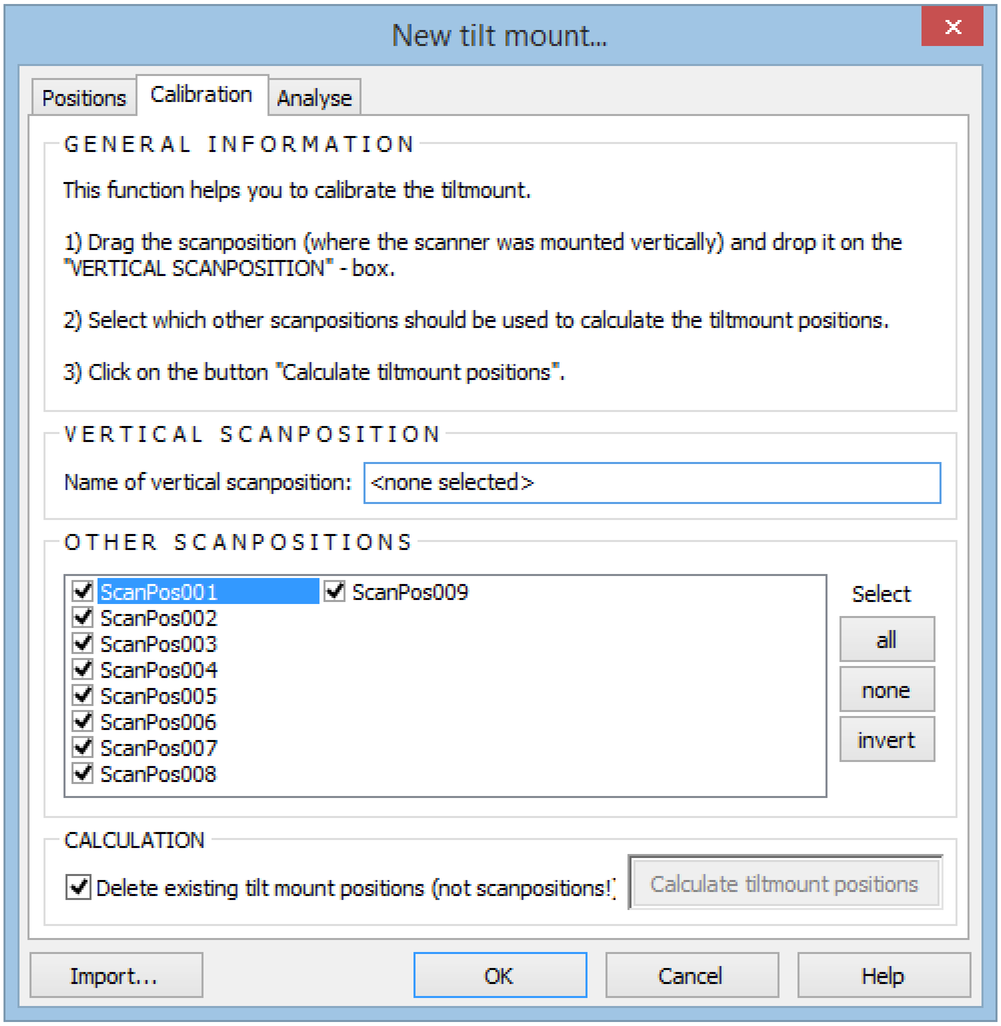
3. **Reflector extraction**
   Now the reflector extraction can be performed. On this page you can see/modify the scan used for the reflector extraction. To start the reflector extraction click the button [Start]. The extracted targets will be added to the TPL SOCS of the current scan position.

4. **Finescan all reflectors**
   in this step all reflectors of the TPL SOCS of the current scan position are fine-scanned. Of course you can modify the TPL SOCS before the finescans are started (e.g. to delete faulty detections, unnecessary targets...). Therefore the TPL SOCS is automatically opened in step 3. Clean up the TPL SOCS and click the button [Start] in order to start the data acquisition.

5. **Find corresponding points**
   If this is the first scan position of the calibration procedure you can skip this step (you will be asked by the wizard).
   Now the registration of the position onto the vertical (i.e. the first) scan position is done. On this page you can select the vertical scan position (already preselected by the wizard). Click the button [Start] to show the "Find corresponding points..." dialog. In the box "REFERENCE COORDINATE SYSTEMS" the vertical scan position is preselected. Click the button [OK] to start the procedure.

6. **Next scan position**
   The data acquisition of the current scan position is performed.

- If there are tilt positions left to be calibrated then click the button [Start]. The wizard continues with step 1.
- If the data acquisition of all tilt positions is finished, click the button [Acquisition finished,...]. The following dialog appears:



In this dialog you can see a summary of all acquired scan positions (box "OTHER scan positions"). You can decide which scan positions should be used for the calibration (by default all). You also have to define the vertical scan position. That is the scan position you have registered all other scan position to (by default the first scan position). If the pre selection of the vertical scan position is not correct please drag & drop another scan position from the list onto the box "VERTICAL scan position". To start the calibration (=calculation of the matrices for each tilt position) click the button [Calculate tiltmount positions]. The matrices will be calculated. You can see the result on the first page "Positions" of this dialog.

The calibration of the tiltmount is finished now. To save the result please click the button [OK] and save the project.

Part IV

Data acquisition

4 Data acquisition

4.1 Scan acquisition

General

Before acquiring a new scan make sure that the device is properly connected, switched on and the communication ports are set correctly (for more information about communication ports see also "Getting started: Create new project: Project settings 42").

Each acquired dataset is saved in a scan file (3DD, RXP) in the folder "SINGLESCANS", "SCANSEQUENCES" or "TIEPOINTSCANS" within the scan position. In which folder the scan is saved depends on the type of scan.

Scan type overview

Single scan:

Contains just one view (also called "frame") of the selected range. This represents a 3D snapshot of all targets within the field of view of the instrument at the time of acquisition.

Scan sequence:

Contains several views (frames) acquired immediately after each other. Scan sequences can be used for instance to scan a busy street. Because each frame is acquired at a different time it is likely that nearly all interfering targets (cars, pedestrians) can be filtered out by combining all frames. See "Data postprocessing: Resample 236".

Tiepoint scans:

Tiepoint scans are high resolution scans of points of interest (i.e. reflectors). See "Tiepoint scans 117".

Scan acquisition

In order to make a new scan click with the right mouse button on a scan position and select "New single scan..." or "New scansequence" from the menu. As an alternative you can also make a detail scan of an already acquired scan (just click on the scan instead of the scan position). A dialog window containing three pages appears:

- Scan acquisition dialog for Z-Line & LPM Scanner 84
- Scan acquisition dialog for VZ-Line Scanner 95

4.1.1 Z-Line & LPM Scanner

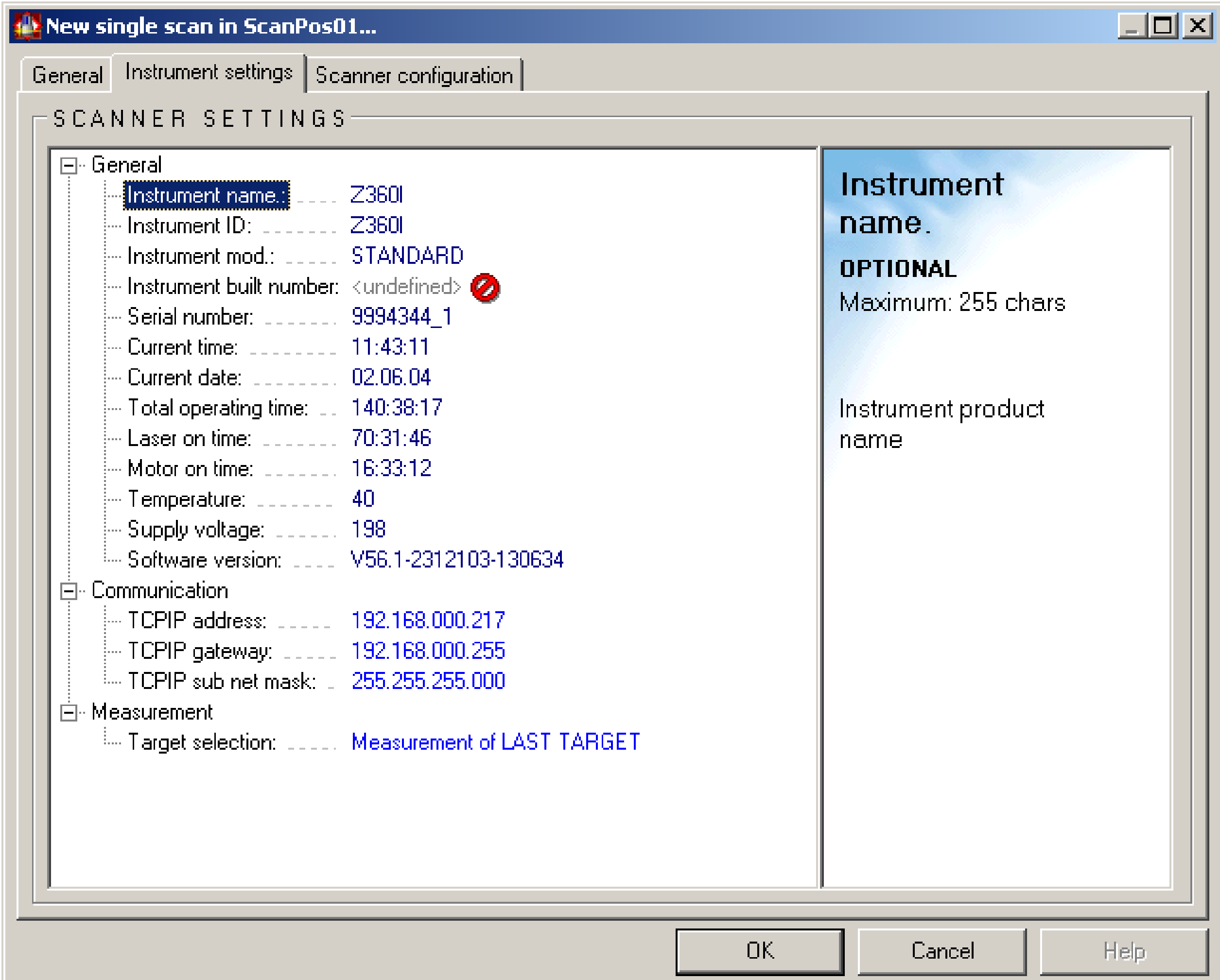
General

On this page you can insert comments like operator, date, location and so on.

Instrument settings

This page provides a tree-view with several extended settings and information about the instrument. Which and how many settings are available depends on the instrument you are using.

Example for Z360:



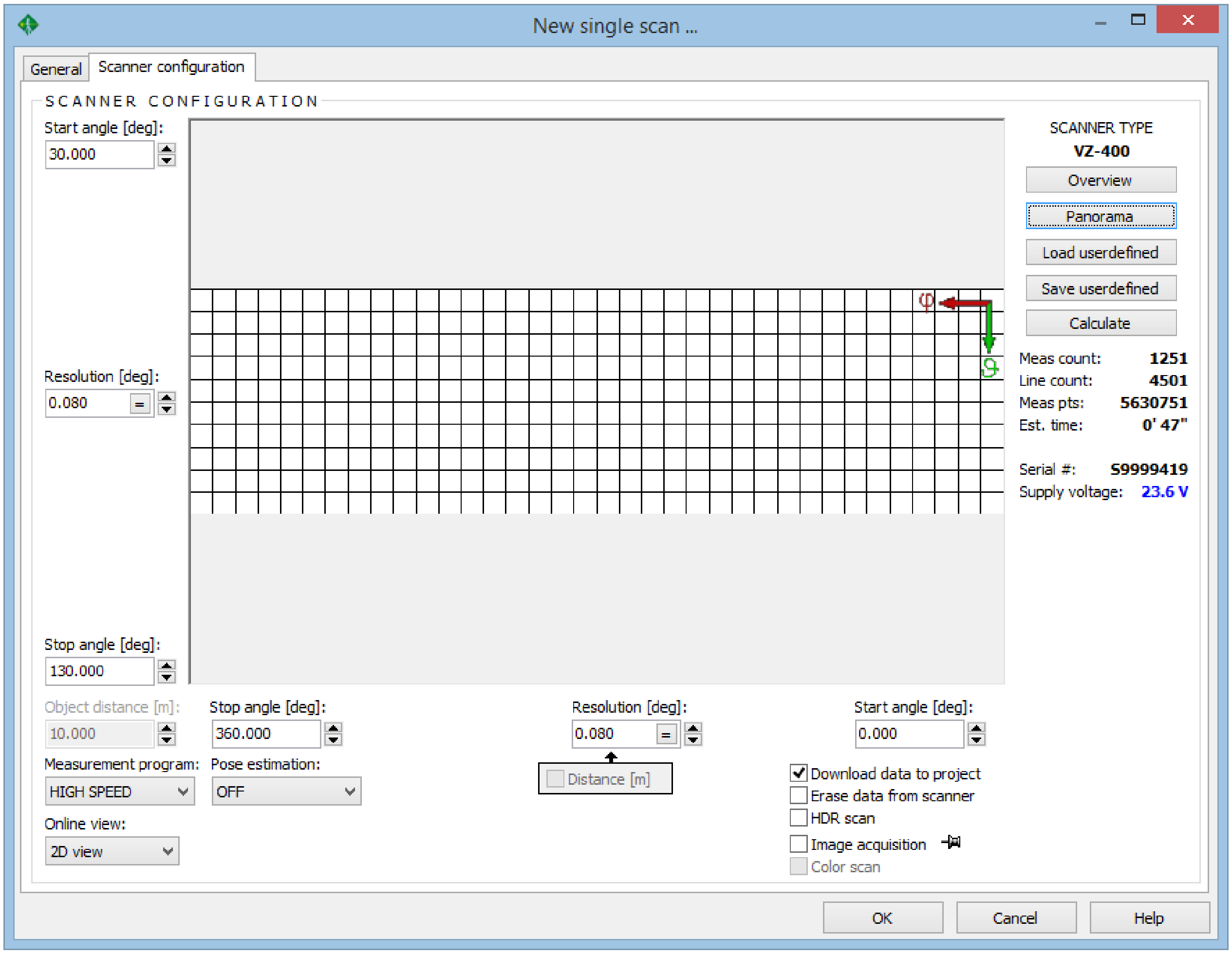
Scanner configuration (displayed as first page)

When the dialog is displayed, this page is displayed at first and RiSCAN PRO tries to connect to the instrument and requests several settings.

During this procedure no changes can be made (the input fields are locked =gray color) and the dialog can only be closed by clicking [CANCEL] (no scan will be performed).
If this procedure succeeds the input fields will be unlocked (=white color) and you can start configuring the scan. If no communication with the instrument can be established the input fields remain locked and an error message is displayed. Try the following:

1. check the batteries
2. check the cabling
3. check the communication port (see "Getting started: Create new project: Project settings 42")

On the page "Scanner configuration" you can configure the scan pattern that the instrument should use to acquire the data. The layout of this page depends on the instrument in use. At least the dialog looks like shown in the following image:



The scan pattern is defined by the following parameters:

phi start angle, **phi resolution**, **phi stop** angle (horizontal scan area)
theta start angle, **theta resolution**, **theta stop** angle (vertical scan area)
Beam focus (only available for instruments Z360 and Z360i)

To configure the scan pattern you can either use one of the default scan patterns ("Overview 90", "Panorama 91"), load a previously saved scan pattern (button "Load user defined"), or enter the parameters manually. If you enter the parameters manually click the button "Calculate" in order to update the information shown in the bottom right corner of the window.

The buttons are also operable via keyboard shortcuts:

Action	Key
Set pattern "Overview"	O
Set pattern "Panorama"	P
Load user defined pattern	L
Save user defined pattern	S
Calculate	C

Visual scan area definition:

The grid in the center of the dialog can be used to define the scan area (start and stop angles). The grid has a resolution of 20° deg. To define the scan area, move the mouse over the grid, hold down the ALT key, hold the left mouse button and draw a rectangle. Release the left mouse button to finish the selection - the start and stop angles are updated.

Note: If you opened this dialog by clicking on a scan (see above: "Detail scan 84"), the scan will be displayed instead of the grid.

Measure object distance (only available for detail scans 84, described above)**:**

To get a quick reference for the distance of a certain scanned object, left-click the object. This will set a marker. You can also click several times. In that case "Object distance" will display the average of all measurements.

To see how you can move and delete markers, please refer to "Data visualization: 2D view: Navigation 134".

Online view during data acquisition

You can observe the scanning progress by selecting the online view property.

There are three items:
<none> - no online view is displayed
2D view - a 2D online view 129 is displayed
3D view - a 3D online view 144 is displayed

Note: On slower PCs it is recommended select 2D view or even disable the online view. Otherwise you risk data loss because of performance problems!

Image acquisition

Enable this option for automatic image acquisition after scan acquisition. The images cover the complete scan area. The default camera and mounting calibrations are used by default. To **modify** the **calibrations** or the **overlap factor** click the button next to "Image acquisition". See also chapter Image acquisition 99.

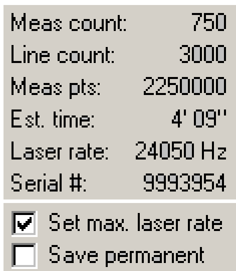
Color scan

Enable this option to color the acquired scan with the acquired images in a final step. See also chapter Coloring scans 220.

Note: This option is only available if the option "Image acquisition" is enabled!

Scan pattern and instrument information

In the bottom right corner you will see some additional information on the current scan pattern



... number of measurements per line
... number of lines per frame
... number of points to measure
... estimated time
... laser pulse repetition rate
... serial number of scanner device

... sets the laser rate to the maximum (recommended)

... all parameters will be permanently saved in the instrument

Scan mode

The scan mode describes the way the instrument will acquire two consecutive scans (frames). The scanner head either rotates in direction of increasing frame angle values (**=frame up scan**) or in direction of decreasing frame angle values (=**frame down scan**). The following modes are available:

- **Continuous bidirectional** *(recommended for scan sequences)*
  Bidirectional frame scans are consecutive frame scans with alternating frame up scans and frame down scans. No trigger from the software is needed to start the acquisition.
  Note: Since the scanner starts the data acquisition automatically if this mode is set, it is likely that the first frame of the scan sequence can not be recorded by the software due to timing problems. All consecutive frames are recorded without problems.

- **Triggered unidirectional** *(for compatibility with older instruments)*
  Only frame up scans are made. The software needs to start the acquisition of every single frame manually. Furthermore, the time between two consecutive frames is very long since the scanner must return to the start position before each frame. At least this mode is supported by the instrument.

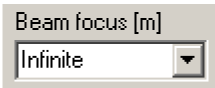
- **Triggered bidirectional** *(recommended for single scans)*
  Similar to "Continuous bidirectional" but data acquisition is triggered by the software for each frame (thus the problem with the first frame - as mentioned above - does not occur).

Note: Older instruments do not support all of these modes. Click the button [Calculate] to see whether your instrument supports the desired mode.

Warning: If you acquire a scan with decreasing frame angle values (triggered bidirectional mode) and you terminate the data acquisition the saved scan file can not be opened due to technical limitations.

Setting the beam focus (only available for the instruments types Z360 and Z360i)**:**

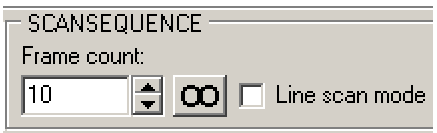
To set the beam focus use the "Beam focus" list. You can select "Infinite" or manually set a beam focus. That means that you can edit the "Beam focus" combo box by entering a distance to which you want to set the focus.



(not always available)

If you activate the option "Use object distance for beam focus" the currently selected object distance (see above) will be used to set the beam focus.

Additional settings for scan sequences:

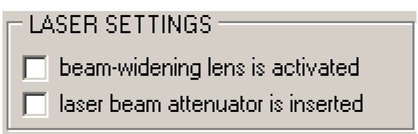


Frame count
Number of scans within one scan sequence. You can also set this to infinite.

Line scan mode
Perform only a single line scan at the horizontal start angle.

Warning: If you open a scan sequence in a 2D view a background thread is started which enables you to jump to different frames of the scan sequence. Since RiSCAN PRO can not save a project while a thread is running the project is not saved as long as a scan sequence is open in a 2D view. To solve this problem either click the "**Stop**" button or close the 2D view.

Additional laser settings for the instrument types LMS Z390, Z420 and Z420i:



Beam-widening lens:
The instruments types LMS Z390, Z420 and Z420i have a so called "beam widening lens". This lens increased the laser beam divergence from 0.25 mrad to 2.0 mrad. The beam widening lens is used with Panorama scans 91 in order to enhance the probability to detect all reflector targets within the scene.

Laser beam attenuator (only applies to Z420):
The laser beam attenuator is an optical filter, reducing the laser beam intensity (power) when inserted.

ATTENTION:
Be cautious when using a scanner without laser beam attenuator.
The following message will appear when scanning without the attenuator:

Finish configuration / start scan:

When you have finished configuring the scan pattern you may want to save it. To do so click the button "Save user defined". The scan pattern will be saved in the folder "COLLECTIONS / CONFIGS" within the project for future usage. Double click a scan pattern to edit it.

To finally start data acquisition click the button "OK". A short summary of all settings will be displayed. Acknowledge this information by clicking the button "OK". Now the online view is opened (if selected) and data acquisition is started. You can watch the progress of the data acquisition either in the online view or in the thread list window 16.

You can configure RiSCAN PRO to give an **acoustic feedback** once the data acquisition is completed. In this case RiSCAN PRO will play a sound by using the PC speaker or sound card. To see how to enable this feature please refer to the chapter "Program settings - Acoustical feedback" 29.

Note:
Before the summary of the settings is displayed RiSCAN PRO checks the **temperature** of the instrument's **range measurement unit**. If the temperature is out of range (either too high or too low) an appropriate warning message is displayed. Usually this message will be displayed if you have just powered up the instrument and the instrument is still cold. In this case it is recommended to wait a short time until the built-in heating has adjusted the temperature. Of course you can ignore the warning and scan while the temperature is out of range but in the worst case you will not reach the measurement accuracy specified in the data sheet.

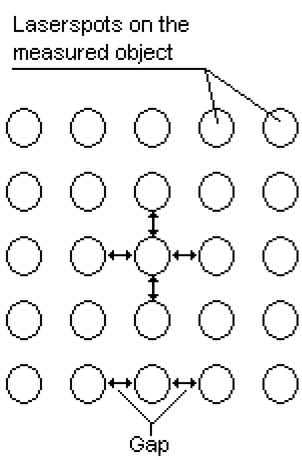
4.1.1.1 Overview scan

The scan pattern "Overview" (Overview scan) is meant to give you a quick overview of the scan area. The overview scan is a scan that covers the full field of view of the scanner.

Example:

Z360(i): 90 deg vertical and 360 deg horizontal field of view; takes approx 1.5 minutes to acquire
Z420(i): 80 deg vertical and 360 deg horizontal field of view; takes approx 1.5 minutes to acquire

The angular resolution of the scan is set to 0.200 deg
Each instrument has a smaller laser beam divergence than 0.200 deg Therefore there are gaps between the laser beam footprints on the object (see figure below).



4.1.1.2 Panorama scan

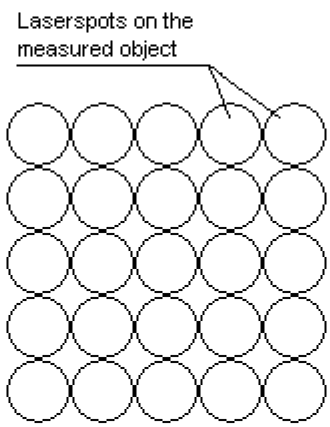
The scan pattern "Panorama" (Panorama scan) is used to acquire data covering the complete field of view of the scanner, but with a higher angular resolution than the [Overview scan](90). With the Panorama scan every reflector target within the field of view (and range) of the scanner will be detected.

Example:

Z360(i): 90 deg vertical and 360 deg horizontal field of view; takes approx 4 minutes to acquire
Z420(i): 80 deg vertical and 360 deg horizontal field of view; takes approx 4 minutes to acquire

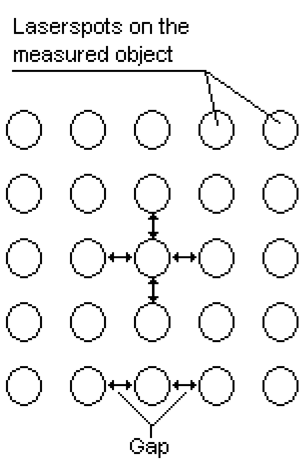
The angular resolution of the scan is set to 0.120 deg

For the **Z360(i)** this means that the laser spots are side by side without gaps (the entire surface is scanned):

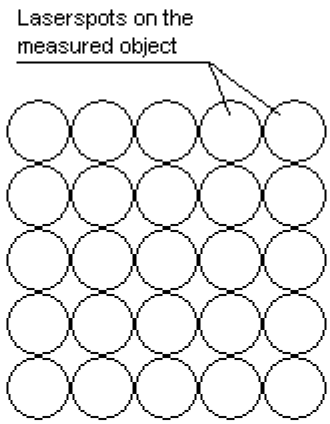


For the **Z420(i)**, which has a smaller laser beam divergence, this means that there will be gaps between the laser spots like in an [Overview scan](90). Therefore the instrument has an beam-widening lens. With this lens it is possible to increase the laser beam divergence and make a Panorama scan without gaps (compare diagrams below):

Beam-widening lens **deactivated** (laser beam divergence 0.25 mrad):



Beam-widening lens **activated** (laser beam divergence equal to angular resolution = 2 mrad):



When using the Z420(i) it's recommended to activate the beam-widening lens in order to detect all reflector targets.

4.1.1.3 Inclination sensors (optional)

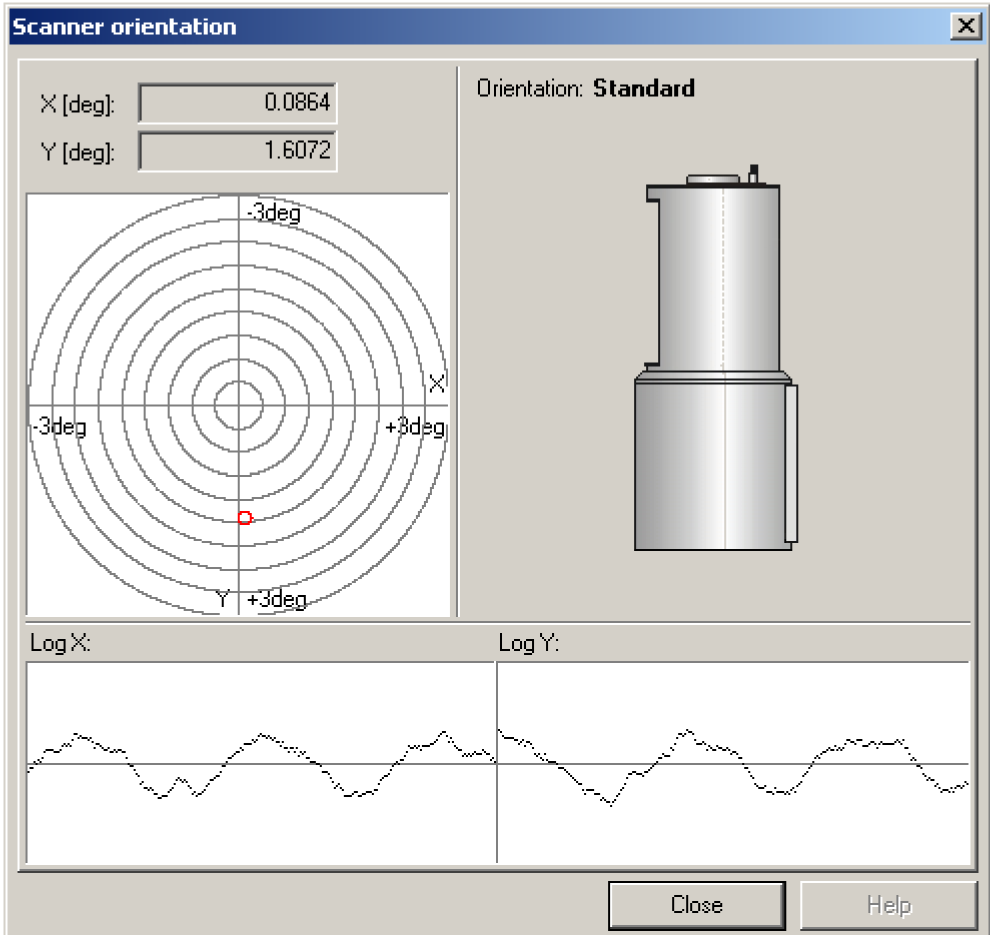
Some RIEGL LMS 3D laser scanners can optionally be equipped with inclination sensors. With these inclination sensors it is possible to measure the inclination of the instrument around the X, Y and Z axes. These sensors have a measurement range from approx. -5 deg to +5 deg This chapter describes how these sensors can be used in RiSCAN PRO.

Shock detection during data acquisition

During the data acquisition RiSCAN PRO checks the change of inclination values between every scan line. If the change is greater than a certain threshold (e.g. when somethings hits the scanner or the tripod or the ground underneath the tripod is weak), RiSCAN PRO displays a warning message in the message list. This warning is also displayed every time you re-open the scan after data acquisition. The threshold can be defined in the program settings, menu "**Tool > Options > General > Data acquisition > Maximum tilt angle**".

Aided manual alignment of the instrument

RiSCAN PRO has a built-in level tool. With this tool you can manually align the instrument vertically or horizontally.
To open the tool select "Scanner orientation" from the "Tool" menu. The following window will appear:



On the right side of the window you can see a sketch of the instrument representing its approximate alignment. This sketch will show one of the following five alignments:

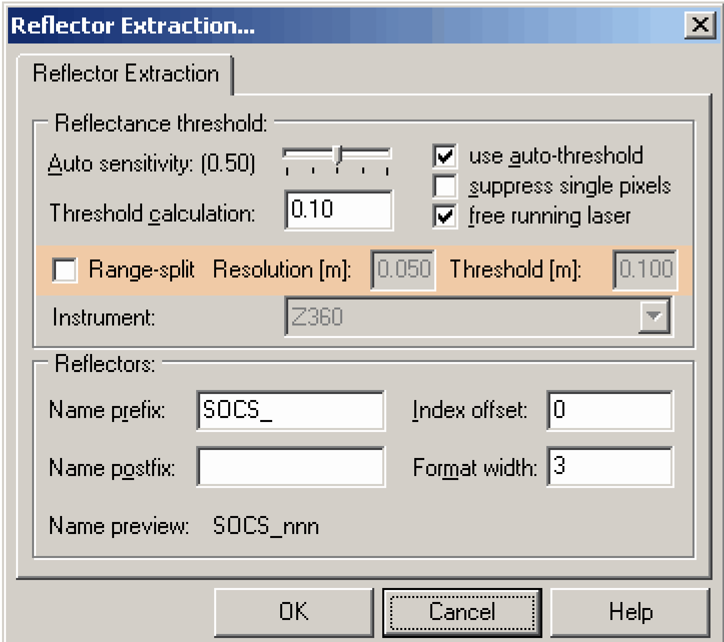
Standard	vertically aligned, head up	rotation about X and Y axes
Lay back	vertically aligned, mounting plate down	rotation about Y and Z axes
Top down	horizontally aligned, head down	no values available
Lay front	horizontally aligned, mounting plate up	no values available
Unknown	the tilt angle is out of range	no values available

Please note, that the inclination sensors will only provide angle values in the alignments **Standard** and **Lay back**.

The left part of the window shows the current rotation of the scanner about the scanner axes (either X & Y or Y & Z) in both a numerical and a graphical manner.
At the bottom of the dialog you can see a chart showing a log (=history) of the inclination angles.

4.1.1.4 Reflector extraction

This function extracts all retro-reflective objects from a scan and writes their coordinates into the corresponding tiepoint list. To run the reflector extraction perform a right-click on a scan and select "Find reflectors...".



Reflectance threshold:

- *Auto sensitivity:*

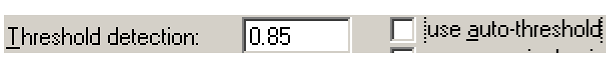
  Range: 0..1
  Default: 0.5
  Meaning: Sensitivity of the algorithm. A higher value means that more reflectors will be found. Be careful when setting this value. With high sensitivity the process lasts very long (also depending on the size of the scan) and it is highly probable that a lot of "wrong" objects will be detected.

  Note: This is only available when "use auto-threshold" is selected.

- *Threshold detection*

  Range: 0..1
  Default: 0.85
  Meaning: Only objects with an amplitude higher than this value will be recognized as reflectors.

  Note: This value is only available when "use auto-threshold" is not selected:



- *Threshold calculation*

  Range: 0..1
  Default: 0.10
  Meaning: This is used within a found reflector to exactly determine the center.

- *use auto-threshold*

  This switches between automatic calculation of threshold-detection and manual input of threshold-detection.

- *suppress single pixels*

  Objects represented by only a single pixel will be ignored.

- *free running laser*

  Check this box if the scan was acquired by a scanner in "free-running laser" mode.

- *Range-split*

  Selecting this option will define the minimum distance between any two reflectors. This is important if reflectors are placed very close to side each other to ensure that the scanner detects every reflector.

Reflectors:

- *name prefix*

  The name of the tiepoint starts with this prefix

- *name postfix*

  The name of the tiepoint ends with this postfix

- *Index offset*

  Range: at least 0 (Zero)
  The numbering of the tiepoints starts at this value. This value is automatically set to the first unused number but can be changed by the user.

- *Format width*

  Range: 1..20
  Default: 3

  The number of digits used for the tiepoint-naming-process.

- *Name preview*

  This shows an example for a tiepoint name generated with the current name-format settings.

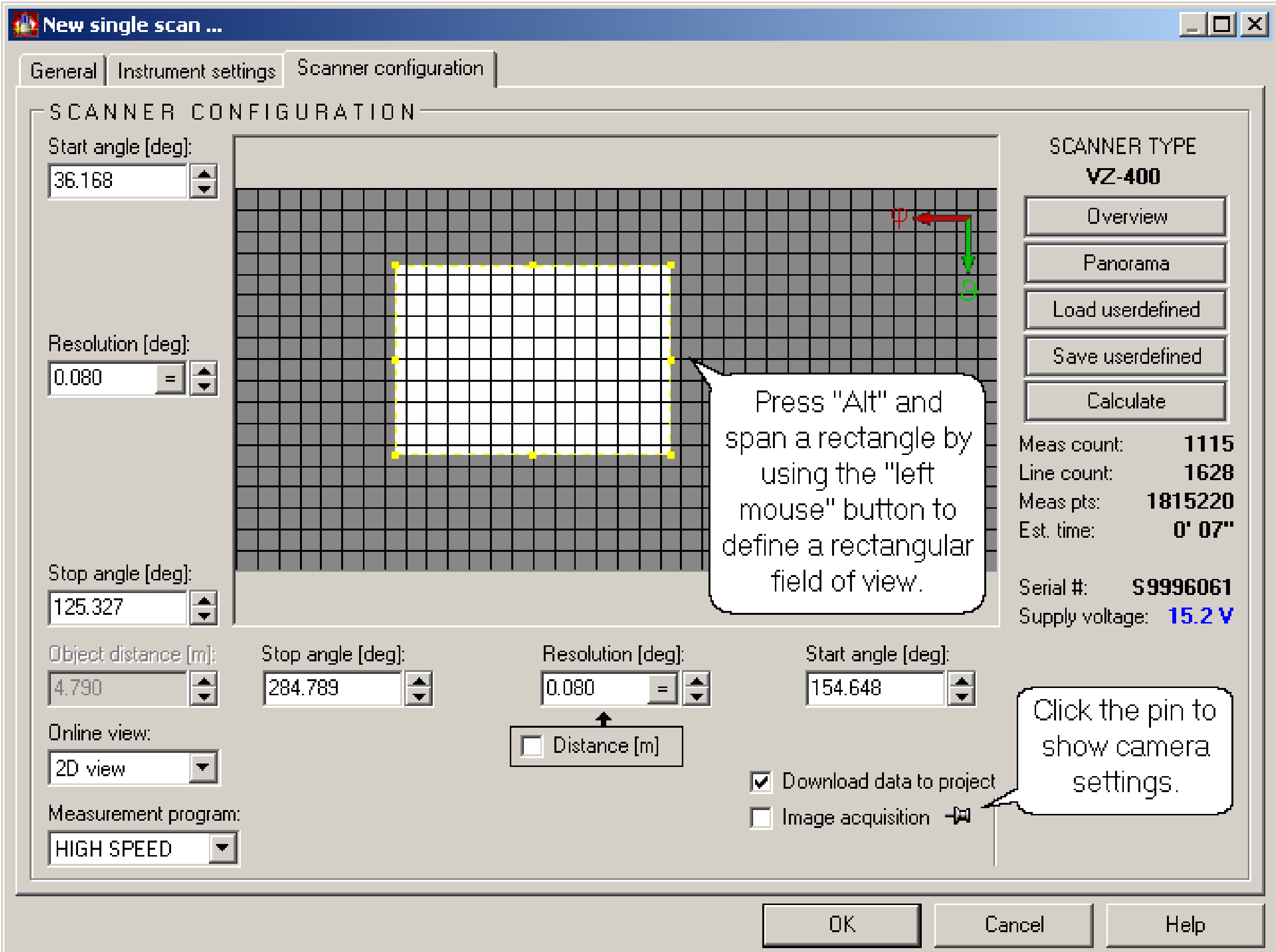
4.1.2 VZ-Line Scanner

General

On this page you can insert comments like operator, date, location and so on.

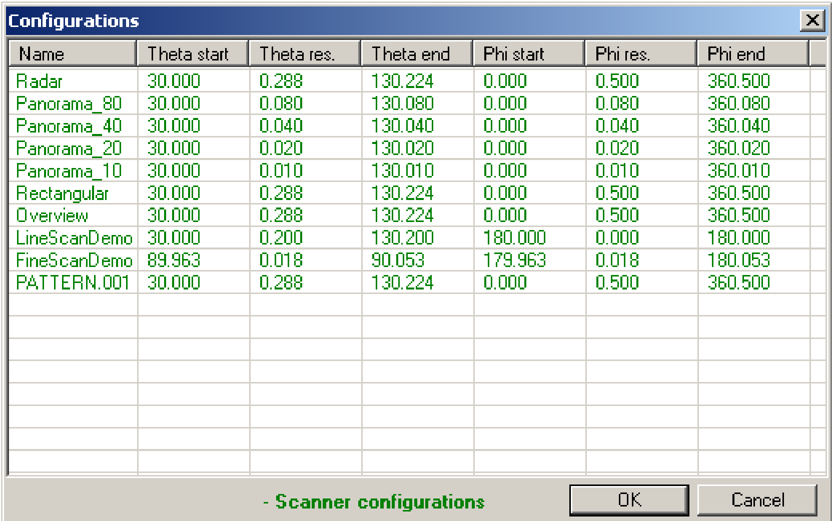
Scanner configuration (displayed as first page)

The page "Scanner configuration" allows you to configure parameters concerning the scan acquisition.



Scan configuration for a VZ-400 scanner.

- **Scan pattern**
  To define a scan pattern you can either directly enter the desired values for *"Start angle, Resolution, Stop angle"* for phi and theta direction or apply one of the predefined scan patterns by clicking the buttons *"Overview"* or *"Panorama"*. Moreover you can load a scan pattern from the project or the scanner by clicking *"Load userdefined"*. Vice versa you can save the current scan pattern to the project or the scanner by clicking *"Save userdefined"*. Additionally you can hold down the *"Alt"* button and define the rectangular field of view by spanning a rectangle using the *"left mouse button"* in the scan image.



Name	Theta start	Theta res.	Theta end	Phi start	Phi res.	Phi end
Radar	30.000	0.288	130.224	0.000	0.500	360.500
Panorama_80	30.000	0.080	130.080	0.000	0.080	360.080
Panorama_40	30.000	0.040	130.040	0.000	0.040	360.040
Panorama_20	30.000	0.020	130.020	0.000	0.020	360.020
Panorama_10	30.000	0.010	130.010	0.000	0.010	360.010
Rectangular	30.000	0.288	130.224	0.000	0.500	360.500
Overview	30.000	0.288	130.224	0.000	0.500	360.500
LineScanDemo	30.000	0.200	130.200	180.000	0.000	180.000
FineScanDemo	89.963	0.018	90.053	179.963	0.018	180.053
PATTERN.001	30.000	0.288	130.224	0.000	0.500	360.500

Load a user defined scan pattern.

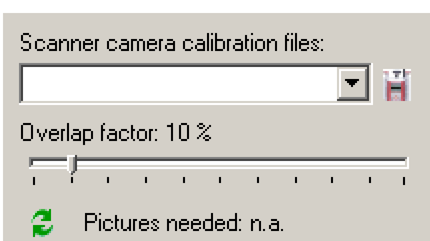
- **Measurement program**
  Use the list box *"Measurement program"* to select the desired measurement program. The available measurement programs will depend on your instrument. For further information please refer to your scanner reference.

- **Online view**
  Use the list box *"Online view"* to select either *"<none>", "2D view" or "3D view"* as an online view for the *"monitoring data stream"*. The online view gives you an online preview of the acquired measurement data in a low data resolution.

- **Download data to project**
  Check this check box if you want to download all acquired data (scan data and images) from the scanner to the RiSCAN PRO project or leave this check box unchecked if you want to download the acquired data later by using the "Download and convert wizard" 123.

- **Image acquisition**
  Check this check box if you want to take images directly after the scan acquisition. Depending on the check box *"Download data to project"* the images will only be taken or downloaded directly to the RiSCAN PRO project.

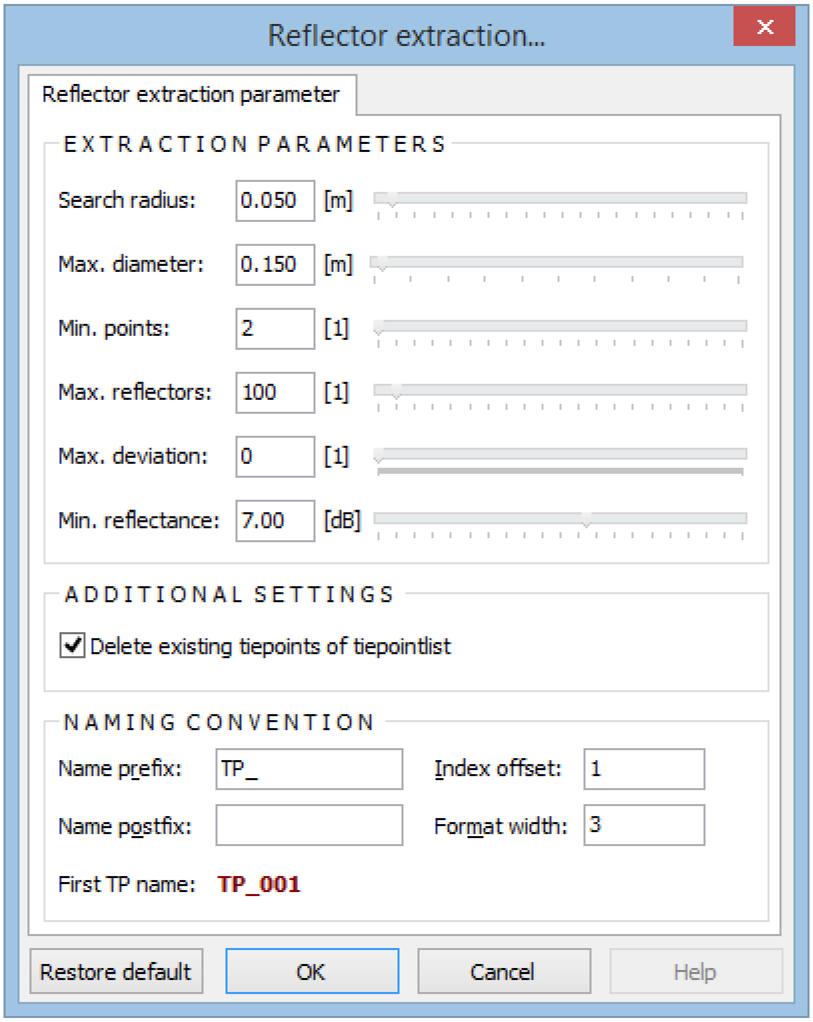
- **Camera calibration**
  Click the *"pin"* at the right side of the check box *"Image acquisition"* to show the camera calibration settings. The list box *"Scanner camera calibration files"* gives you a list of all camera calibration files stored in the scanner. Set the desired camera calibration file and overlap factor to configure the image acquisition. If you want to create a new camera calibration file or download an existing one to the scanner use the "Camera calibration export wizard" by clicking on the button at the right side of the list box.



Camera calibration settings.

4.1.2.1 Reflector extraction

This function extracts all retro-reflective objects from a scan and writes their coordinates into the corresponding tiepoint list. To run the reflector extraction perform a right-click on a scan and select "Find reflectors...".



Extraction Parameters

- *Search radius:*
  Unit: m, ft, yd
  Range: 0.01m .. 1.00m
  Default: 0.1m
  Meaning: The search radius represents some kind of "reflector size". Bright measurements within the search radius will be taken as one single object. Thus reflectors that have a smaller distance to each other than the specified search radius will "melt" together and appear as one resulting reflector.

- *Min. points:*
  Unit: 1
  Range: 1 .. 1000
  Default: 1
  Meaning: Found reflectors must consist of at least "Min. points" points, otherwise the found reflector will be

dismissed.

- *Max. reflectors:*
  Unit: 1
  Range: 1 .. 2000
  Default: 300
  Meaning: Limits the maximum number of resulting reflectors.

- Quality threshold:
  Unit: 1
  Range: 1..255
  Default: 25
  Meaning: Points with an quality less than this limit will be considered as part of a reflector.

- Min. reflectance::
  Unit: dB
  Range: -50..50
  Default: 5
  Meaning: Points with an reflectance higher than this limit will be considered as part of a reflector.

Additional settings

- Delete existing tiepoints of tiepointlist.
  Default: checked
  Meaning: If this check box is checked all already existing tiepoints of the corresponding tiepointlist will be deleted.

Naming convention

For additional information to the naming convention see Naming convention of "Z-Line scanner" 95.

4.2 Image acquisition

This chapter describes how to take a single photo or a series of snapshots from a scan position.

Important note: the following conditions have to be met before the Image acquisition can be used:

Z-Line & LPM scanner:
- The camera must be properly connected to the PC, laptop or camera server.
- A camera type has to be assigned (see Create new project 41)
- The camera plugin has to be installed (if the plugin is not installed, download it from the RiSCAN PRO download page 338)
- If you notice any problems when connecting to your camera through RiSCAN PRO, please check the "USB protocol" setting of the camera. This value must be set to "PTP" for NIKON cameras and to "normal" for CANON cameras. To change this setting please refer to the product documentation of your camera.

VZ-Line scanner:
- The camera must be properly connected to the VZ-Line scanner and switched on. Wait until the VZ-Line scanner detects the camera.
- A camera type has to be assigned (see Create new project 41)

With RiSCAN PRO and the connected camera you can easily take a photo with the digital camera mounted on the scanner.

Taking a single photo with RiSCAN PRO

To take a photo right-click a scan position or the "OBJECTS / IMAGES" folder and select "New single image...".
This will show a dialog with several pages:

Sheet "General"

On this page you can enter some comments about the photo (location, date, settings of the camera,...).

Sheet "Calibrations"

Z-Line & LPM scanner:
On this page you have to select the camera calibration (depending on the camera and the lens) and the mounting calibration (only available for images within a scan position). If the project contains more calibrations you may also define one calibration as "default". In this case this calibration will be selected automatically in this page. To select a calibration as the default calibration, right-click the calibration and select "Default" from the menu.

VZ-Line scanner:
On this page you have to select the "Scanner camera calibration file" that describes the camera model and mounting of the camera on the scanner. Refer to the V-Line reference guide for detailed information. You can export your existing camera and mounting calibration to the scanner by using the "Export camera calibration wizard...". Simply click on the corresponding button or perform a right click on "CALIBRATIONS" folder and choose "Export camera calibration wizard..." to start the wizard.

Furthermore you may want to specify whether the captured images shall be downloaded to the RiSCAN PRO project and erased from the scanner after downloading. This is done by checking the check boxes "Download captured images" and "Erase images after download".

Sheet "Position & Orientation"

The position and orientation of the camera (see "Embedding images into the project 345" for more details). This matrix is also called COP matrix. RiSCAN PRO automatically determines the COP matrix when the images are saved in the scan position. If you acquire an image saved in the folder "OBJECTS / IMAGES" the matrix remains unchanged. In this case see Registration of project images 208.

Sheet "Summary"

This page will hold information (such as size, color depth and resolution) about the photo *after* it has been taken.

Finally click "OK". The photo will be taken and saved within the project structure.

Taking a single photo out of a 2D view of a scan or an image

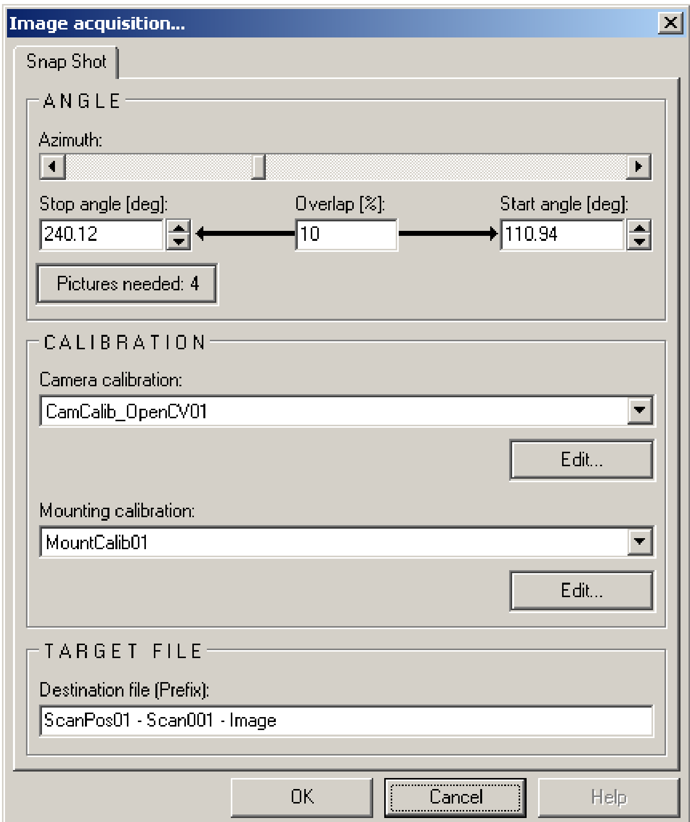
see Data visualisation > 2D view > General > Image acquisition 134

Acquisition of a series of images

With this function you can take a series of photos in order to cover a given area. During this process the digital camera is mounted on the scanner and the scanner turns from one snapshot position to the next. At each snapshot position the scanner stops and the camera takes a photo.

To start the image-acquisition process right-click a scan or a scan position and select "Image acquisition..." from the menu.
This will display the following dialog:

Z-Line & LPM scanner:



ANGLE

You can adjust the area which the photos should cover by editing the *start*- and the *stop-angle*.
The *overlap factor* specifies how much (in percent) of the images will overlap (default value is 10%).
Pictures needed shows how many pictures will be taken in order to cover the entire area. Note that this value isn't recalculated when you change the angles, the overlap factor or the camera calibration. To recalculate this value you have to click "Pictures needed" and the correct number of pictures will be shown.

CALIBRATION

In this area you have to set the camera calibration 48 and the mounting calibration 70 according to the camera, the lens and mounting used.

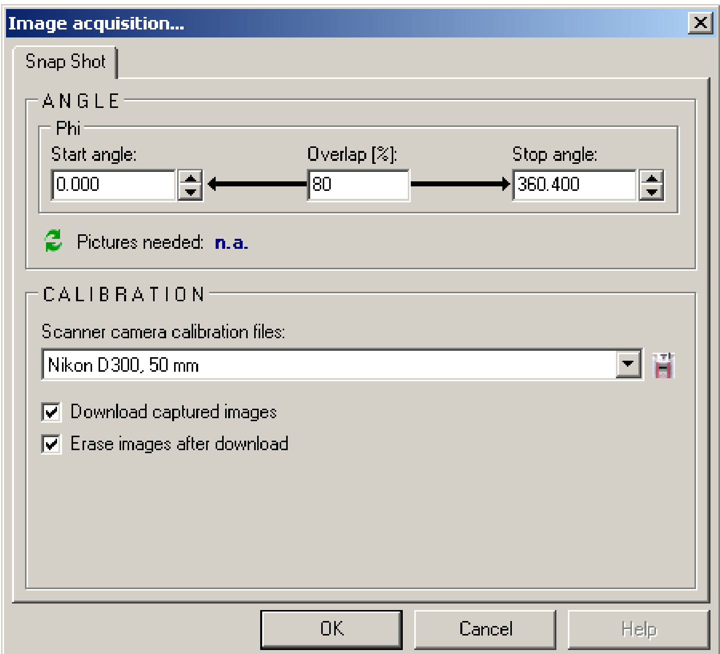
TARGET FILE

This will be the prefix of the saved photo (generated automatically, but editable).
In the example from above the photos will be named:

ScanPos01 - Scan001 - Image 001
ScanPos01 - Scan001 - Image 002
ScanPos01 - Scan001 - Image 003
ScanPos01 - Scan001 - Image 004

Note: If you have activated the option "**Ask before taking image**" (see program settings 29) or you have selected the "**Custom camera**" camera model (see project settings 42) you will be prompted to confirm the acquisition of each image.

VZ-Line scanner:



ANGLE

You can adjust the area the image acquisition should cover by editing the "Start angle" and "Stop angle" properties. Moreover you can apply an "Overlap" factor to acquire overlapped images. "Pictures needed" shows how many pictures will be taken in order to cover the entire area. Note that this value isn't recalculated when you change the angles, the overlap factor or the camera calibration. To recalculate this value you have to click the "Refresh" button and the correct number of pictures will be shown.

CALIBRATION

Select the "Scanner camera calibration file" that describes the camera model and mounting of the camera on the scanner. Refer to the V-Line reference guide for detailed information. You can export your existing camera and mounting calibration to the scanner by using the "Export camera calibration wizard...". Simply click on the corresponding button or perform a right click on "CALIBRATIONS" folder and choose "Export camera calibration wizard..." to start the wizard.

Furthermore you may want to specify whether the captured images shall be downloaded to the RiSCAN PRO project and erased from the scanner after downloading. This is done by checking the check boxes "Download captured images" and "Erase images after download".

To finally start the image acquisition just click the button "OK". The image acquisition is performed automatically.

Note: You must configure your camera to create and transfer JPG files. RAW or NEF (raw image) files are not supported. If your camera creates RAW or NEF files, they will be transferred by RiSCAN PRO, but they can not be displayed or used for any further processing. In this case, you must manually convert the files to jpeg (.jpg) files with third party software and place them in the same folder as the raw image files. RiSCAN PRO will automatically recognize and use the JPG files.

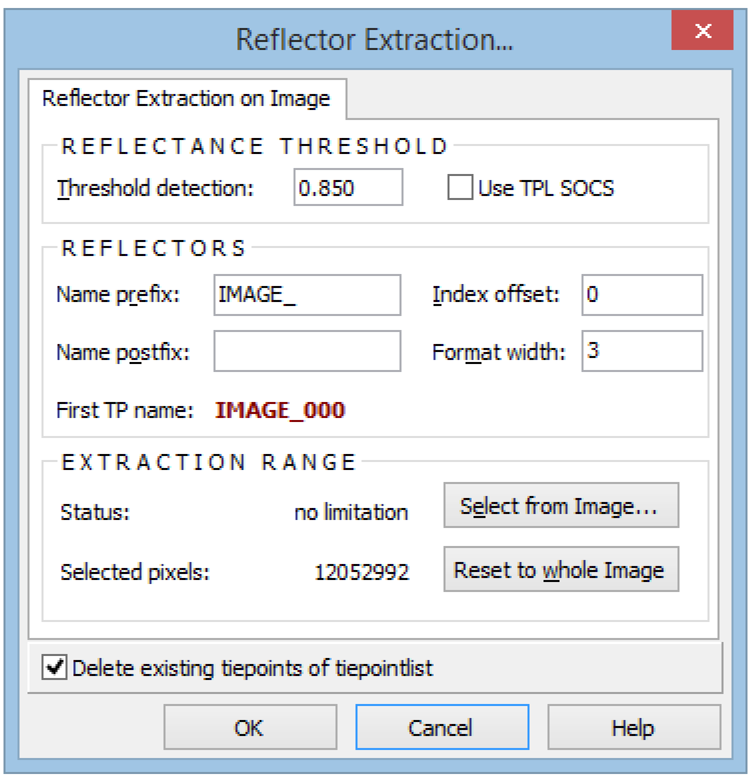
Further usage of the images

- Coloring scans 220
- Texture meshes 256

4.2.1 Reflector extraction

This function extracts all retro-reflective objects from an image and writes their coordinates into the corresponding tiepoint list.
The reflector-extraction of an image is needed for calculating the camera mounting or the camera calibration.

To run the reflector extraction right-click an image and select "Find reflectors...". This will show the following dialog:



Reflectance threshold:

- *Threshold detection:*

  Range: 0..1
  Default: 0.85
  Meaning: Only objects with an intensity (pixel brightness) higher than this value will be recognized as reflectors.

- *Use TPL SOCS:*

  If you active this option, the tiepoints are searched based on the tiepoints of the TPL SOCS transformed into the image. The found tiepoints will be automatically linked to the corresponding SOCS tiepoints. This function can be used for camera calibration and the readjustment of the Mounting calibration 70.

Reflectors:

- *Name - format:*

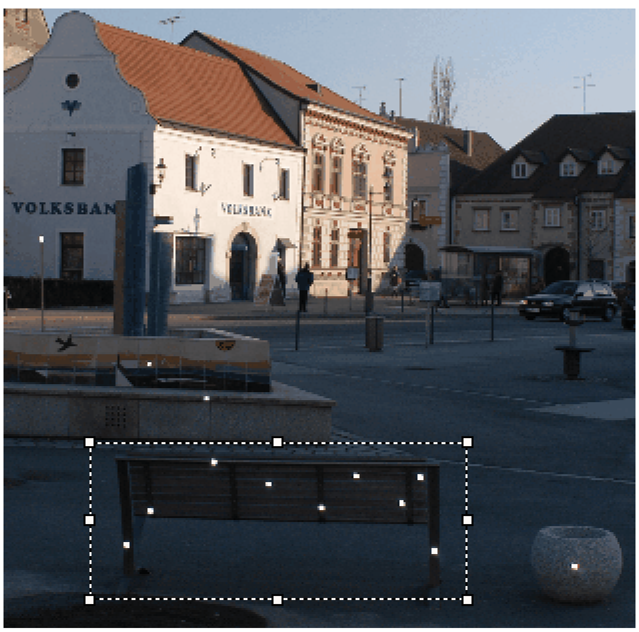
  see "Reflector extraction (Scan) / Name format 95" for information about formatting the reflector-name.

Extraction range:

You can select the range within which the reflector search will be performed. This is useful if there are a lot of bright spots in the image which should not be handled (recognized) as reflectors.
The default extraction range is the entire image. So "Status" is "no limitation" and "Number of pixels selected:" shows the total number of pixels of the image.

To select the range just click "Select from Image...". This will hide the dialog and show the image. You can now make your selection:

Rectangle selection: Hold down the "ALT" - key and draw the rectangle window with the mouse.

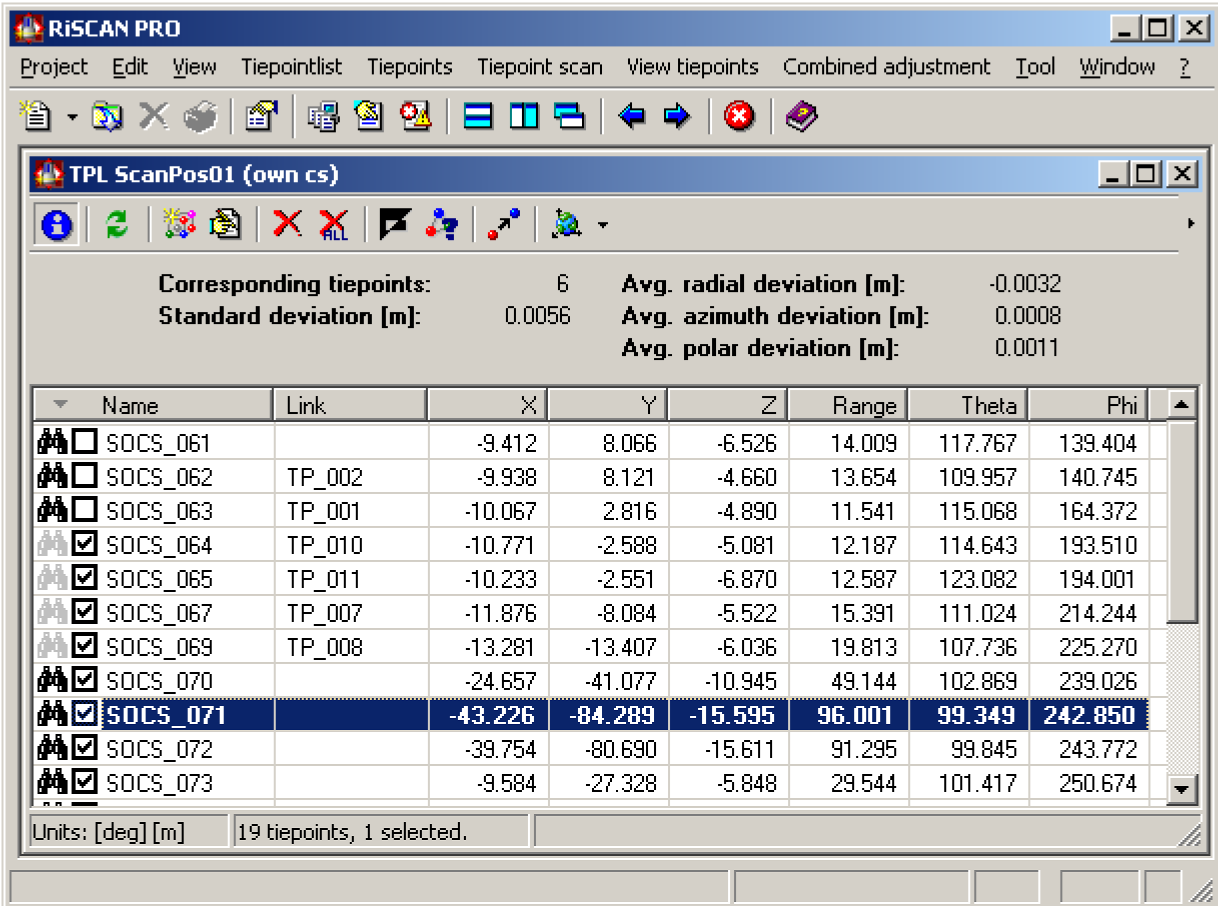


After you have performed the selection right-click to return to the "Reflector Extraction..." dialog.
By clicking [OK] the reflector extraction will be performed within the selected range.

4.3 Tiepointlist window

In the tiepointlist window you can manage the tiepoints.
The style of the tiepointlist window depends on the tiepointlist it represents and on the user-defined column selection.

The following graphic shows a screenshot of a TPL window of a scan position with the most important columns.



The tiepointlist-window is divided into three parts:

1. The icon-bar
2. The additional information area
3. The list showing the tiepoints

1. The icon-bar

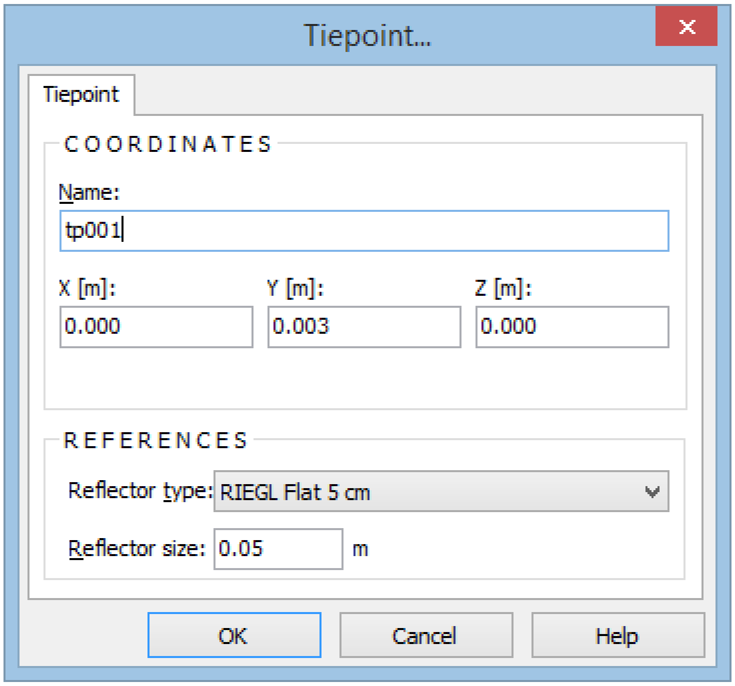
The icon-bar contains the most important functions available in the tiepointlist. All these functions (and a lot more) are also available in the menu in the main window of RiSCAN PRO.

- **Switch additional information On/Off** (only available in TPL SOCS)

  This shows or hides the additional information.

- **Add a new tiepoint** 

  This will display the "New tiepoint..." dialog.
  With this dialog you can add a new tiepoint to the list.
  The style of this dialog depends on the tiepoint you want to create. This dialog basically offers input fields for the coordinates (TPL of a Image: "u" and "v" otherwise "X", "Y" and "Z") and the tiepoint name:



With "Reflector type" you can select the type of reflector 75 represented by this tiepoint. If you choose a reflector the coordinates are recalculated corresponding to the type and dimension specified in the reflector calibration. Note that the coordinates will not change when "Keep values on change" is selected (by default this option is not activated)!

Is controlpoint (fixed): (only for PRCS tie points)
If the point is a control point with fixed coodinates, activate this option. In that case, RiSCAN PRO will never modify the coordinates of the point automatically (with one exception: the "height" parameter, see below).

Height: (only for PRCS tie points)
This value is added to the Z coordinate of the PRCS tie/control point. This can be helpful in case of reflectors mounted on top of vertical rods in combination with externally measured points.
Example:
Assume you have mounted and fine-scanned the reflectors on top of vertical rods positioned over known points.
Now you can use the reflectors to register some scan positions together without having control points (see chapter Registration via tiepoints 187).
This fills the TPL PRCS with some tiepoints (the coordinates still point to the top-ends of the rods).
Now you import coordinates of some ground points into the TPL GLCS.
To be able to register the PRCS onto the GLCS you need to have the coordinates of the ground points in the TPL PRCS. This can be done by editing a PRCS tie point and entering the rod height as negative "height" value. When the height of all reflectors is defined, use "Find corresponding points".

Note: The use of "Weight" is not implemented yet!

An alternative way to add new tiepoints is by using the 2D-Window or the 3D-Window.

To add a **new tiepoint via a 2D window** first set a marker by left-clicking the pixel you want to add as a tiepoint. You will see the marker. Then right-click the marker and choose the option "Add point to TPL". The dialog shown above appears with the coordinates of the marked point.

To add a **new tiepoint via a 3D window** right-click the point of the point cloud you want to add as a tiepoint to the TPL. The point is highlighted as a pick point. To improve the visibility of the pick point set the pick point size larger, e.g., 5 pixels. This can be done via the options settings in the 3D - View or as a general setting in the program settings in the 3D section.

- **Edit tiepoint**

Enables you to edit the tiepoint (name, coordinates and so on)
Note: This function is only available if ONE tiepoint is selected.
The dialog to edit the values of a tiepoint is the same as the "New tiepoint..." dialog (see the section "Add a new tiepoint 105" above for more information about this dialog).

- **Delete selected tiepoint(s)**

Deletes the selected tiepoint(s) after a confirmation.
Note: You can NOT undo this action!

- **Delete all tiepoints**

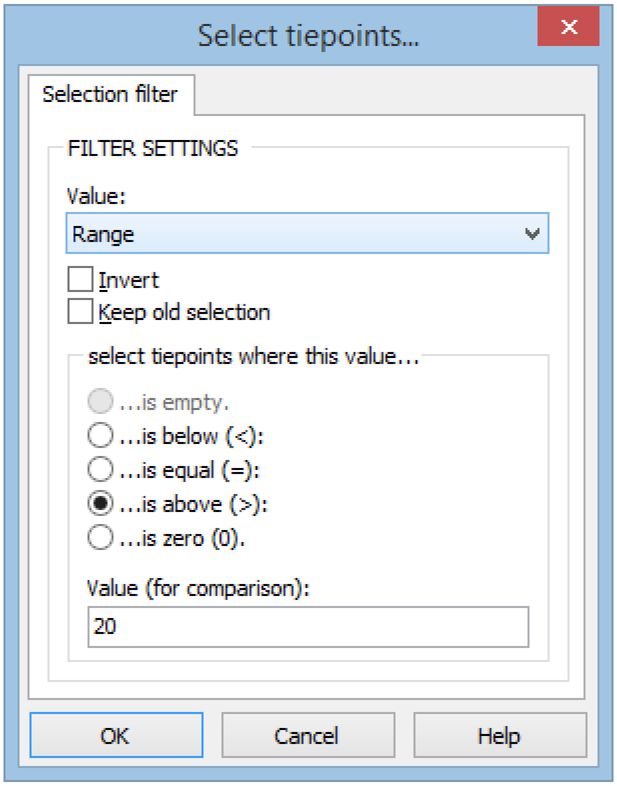
Deletes all tiepoints after a confirmation.
Note: You can NOT undo this action!

- **Invert tiepoint selection**

Inverts the selection of the tiepoints (Selected tiepoints are de selected and vice versa).

- **Selection filter**

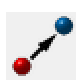
This is a tool to select all tiepoints matching a given criteria:



To use this tool just select a value (column) and the criteria (above, below, equal to,... this value).

If "Invert" is checked the result of the filter tool is inverted.

If "Keep old selection" is selected all tiepoints that were selected before using this tool are also selected after using it (works like an OR filter).
So you can make a "multiple" selection by running this tool with different settings and "Keep old selection" checked.

- **Find corresponding points**  (only available in TPL SOCS)

  see "Registration via tiepoints 187"

- **Coordinate system** (not available in TPL IMAGE)

  By clicking the arrow below this icon you get a list of coordinate systems in which the tiepoints should be displayed. By selecting one of the coordinate systems the data is reloaded and automatically transformed into this coordinate system.

  By clicking the icon itself you can reset the coordinate system to that of the tiepointlist (no transformation will be applied).

2. The additional information area (only available in TPL SOCS)

In the additional information area the deviations between the tiepoints and their corresponding (= linked) tiepoints is displayed.

The **standard deviation** is calculated as follows:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N} |A_i - B_i|^2}{3N-6}}$$

Whereas N is the number of points and A, B are the point coordinates (for example: A is list of SOCS tiepoints, B is list of PRCS tiepoints linked with the SOCS tiepoints). Please note, that both lists must be in the same coordinate system (RiSCAN PRO transforms list B into SOCS). This figure should give a feeling of how good the points (reflectors) of the scan position and the PRCS fit together.

Page 2 (extended) contains more detailed information: These values show the accuracy of the estimation of the position (left column) and the orientation (right column) of the laser scanner (this is also shown as "confidence" in the "Multi Station Adjustment" tool).

For example: if you have all reflectors on one side of the laser scanner (when viewed from top) and they are close to each other, the standard deviation of 1] may be very small but the SOP matrix may be defined very roughly (because if you - theoretically - move the scanner up, down or sideways and rotate it a little bit, the points will have the same deviation as before...). In the other case, when your reflectors are spread over the complete field-of-view of the scanner, the calculation of the SOP matrix will be more robust and accurate (because now no movements or rotations of the scanner are possible anymore).

3. The list showing the tiepoints

This list shows all tiepoints in the tiepointlist.
The style (columns to display) of the list can be set with the layout-editor 113

The checkbox in front of the tiepoint name shows the activated-state. This state defines which tiepoints should be used for various functions (like the Multi Station Adjustment).
The binoculars in front of the tiepoint name show the visibility-state.

You can click the symbols to change the states.

To link two tiepoints together you can drag one tiepoint and drop it on another tiepoint in an other tiepointlist.

4. Other functions (available in the menu-bar)

- **Menu "Tiepointlist"**

  - *Calculate translation for POP (only available in TPL GLCS)*

    This calculates and writes the translation in x,y,z - direction for the POP matrix.
    This transforms the "huge" numbers of the TPL GLCS to smaller numbers in the TPL PRCS to make all further calculations more precise.

    Use:

    -) Select "Calculate translation for POP" from the menu

    -) a dialog appears showing the calculated translation. You can edit the translation. To finally write the translation to the POP matrix press the button "OK", else hit "CANCEL"

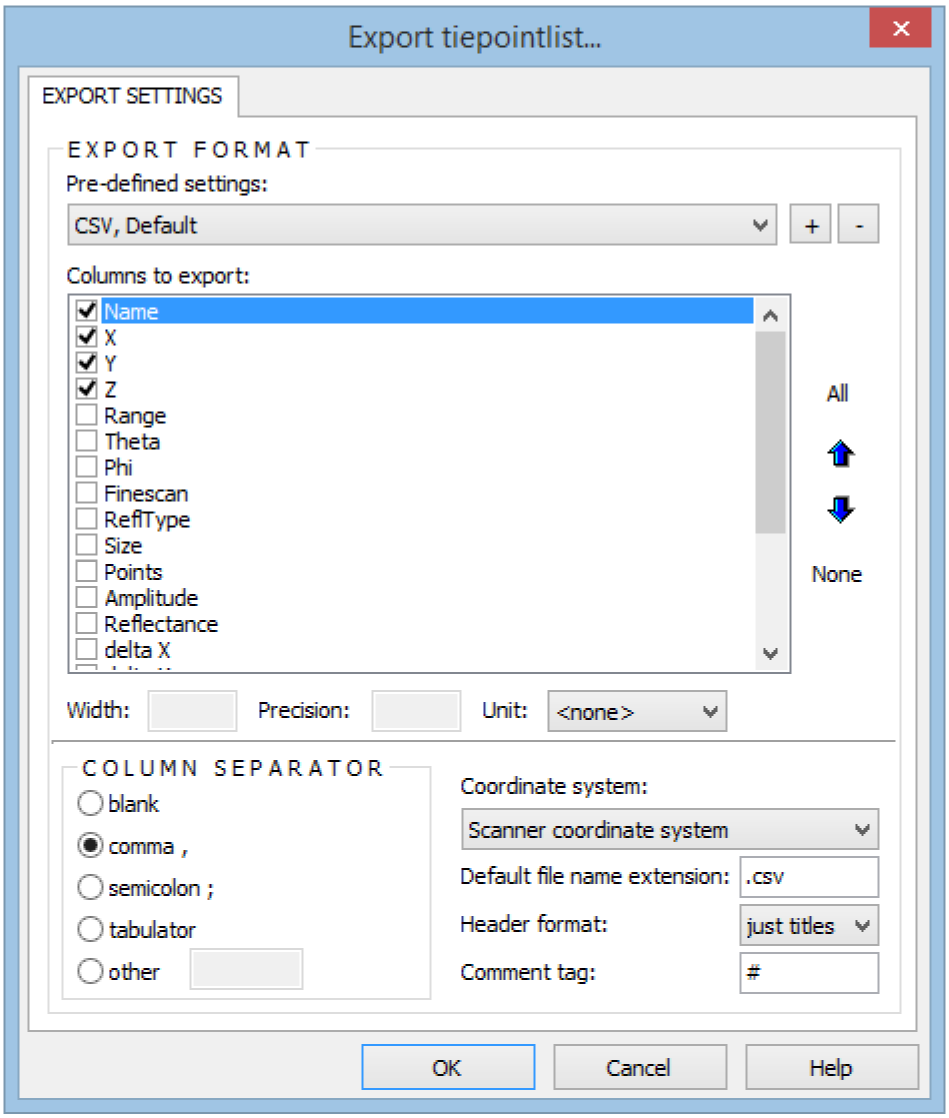
Optionally:

-) Use Copy selected tiepoints to... 114 TPL PRCS" to copy and transform the tiepoints to the TPL PRCS.

- *Export*

To export tiepoints in a common format (text file) select some tiepoints and select "Export" from the menu "Tiepointlist". If no tiepoints are selected, you will be asked if all tiepoints should be exported.

To configure the export format use the following dialog, which appears after clicking on "Export".



There are several settings you can make:

Column selection and order:
You can select which columns should be exported in which order by checking / unchecking and dragging & dropping the columns.

Value width and precision:

Select a column containing numerical data (e.g. X,Y or Z) and set the width and precision to acceptable values.

Value unit:
Select a column containing data with physical units (e.g. X,Y,Z,Theta,Phi) and select the unit from the drop-down box "Unit:".

Column separator:
This character will be inserted between the exported columns (e.g. "tabulator" will be useful for importing into an MS-Excel spreadsheet).

Coordinate system:
Select one of the coordinate systems from the drop-down box "Coordinate system:". The exported coordinates will be transformed into the selected coordinate system.
Note: The available coordinate systems depend on the tiepointlist you want to export.

Default file name extension:
This extension will automatically be added to the filename if no extension is given (default: ".csv").

Header format:
You can decide between three header formats:
none - no header will be exported
just titles - only the column titles will be exported (e.g. "Name, X, Y, Z")
full - the column titles and some other useful data will be exported (e.g. date/time exported, name of the project & tiepointlist)

Comment tag:
This character (or characters) will be placed in front of the header in order to mark it as "no data".

After all settings were made it is possible to save the settings. This provides faster export by just selecting one of the pre-defined format settings from the drop-down list at the top of the dialog. To save the settings click the button with the plus ("+") on it. You will be prompted for a name. Enter a name (Info: Adding "Default" to one of the names will cause RiSCAN PRO to use this pre-defined format settings as default) and click "OK" .
Wrong or out of date pre-defined format settings can be deleted by selecting them one by one from the drop-down-list and clicking the button with the minus on it.

To finally export the tiepointlist click the button "OK" at the bottom of the dialog.

- *Import*

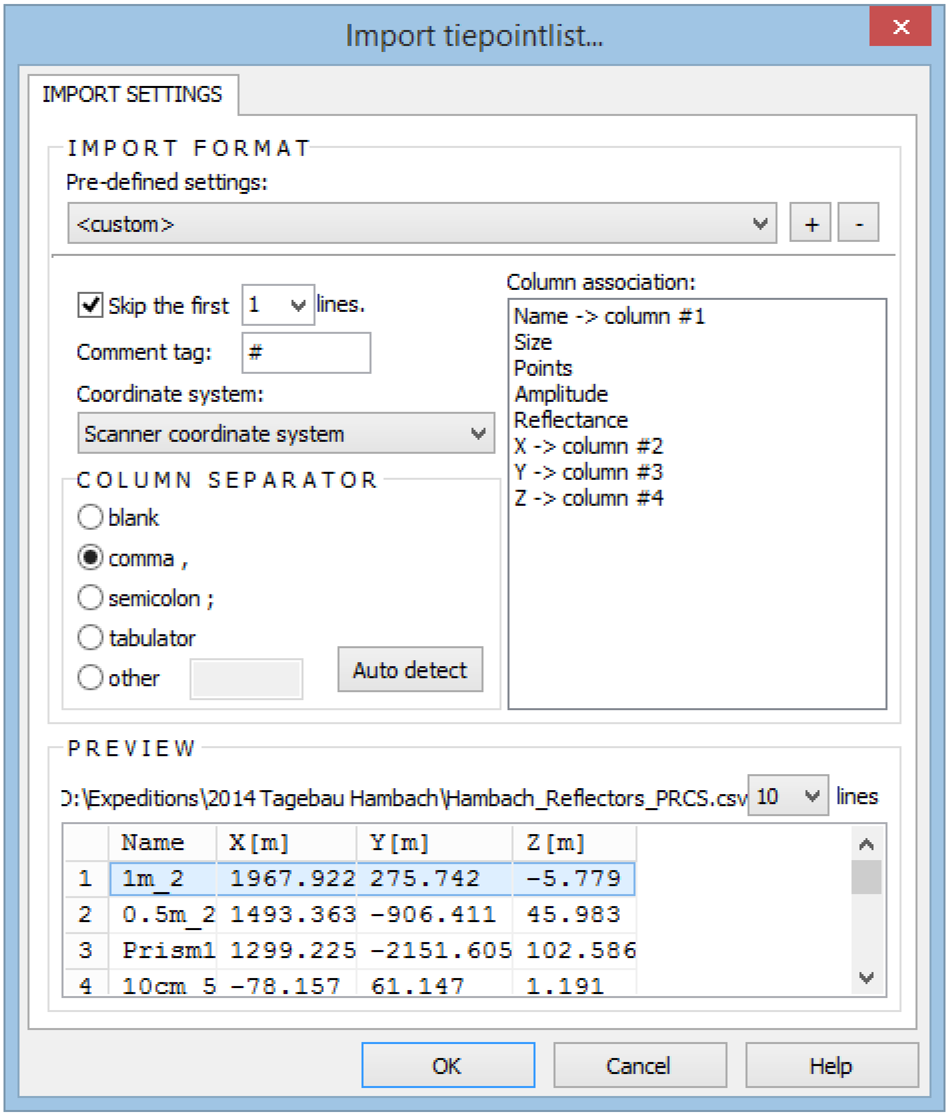
Imports tiepoints from several external data formats.

Supported data formats are:

- Gpsi (raw data from totalstations)
- Gor (Application "Caddy")

and also any ASCII (= text) file such as .CSV (comma separated values) files.

When selecting the import function you will be prompted to insert the file you wish to import. If you insert .gis or a .kor file the points will be imported without a dialog, otherwise the following dialog will appear:



This dialog allows you to import a wide range of differently formatted data files.

The settings you have to make in order to import tiepoints are:

Skip lines (optional):
This causes the import function to ignore the first n lines of the file (e.g. if this is just a comment or something else...).

Comment tag (optional):
Lines beginning with this(these) character(s) will be ignored

Column separator:
You have to set the column separator to the correct character in order to recognize the data columns from the file.
Normally this is a comma (","). If you don't know the column separator you can try clicking "Auto detect". This function attempts to find the correct character. Note that this function may get wrong results in very "noisy" files.
You can check the right setting for the column separator in the preview located on the bottom of the dialog.

Column association:
After the column separator has been set and you got a correct preview you can associate the columns. This is required in order to tell RiSCAN PRO which column of the file contains what data of the tiepoint. Just drag the column from the list-box showing all columns and drop it on the corresponding column of the preview.

After all settings are made it is possible to save the settings. This provides faster import by just selecting one of the pre-defined format settings from the drop-down list at the top of the dialog. To save the settings click the button with the plus ("+") on it. You will be prompted for a name. Enter a name (Info: Adding "Default" to one of the names will cause RiSCAN PRO to use this pre-defined format settings as default) and click "OK" .
Wrong or out of date pre-defined format settings can be deleted by selecting them one by one from the drop-down-list and clicking the button with the minus on it.

To finally import the tiepoints into the tiepointlist click the button "OK" on the bottom of the dialog.

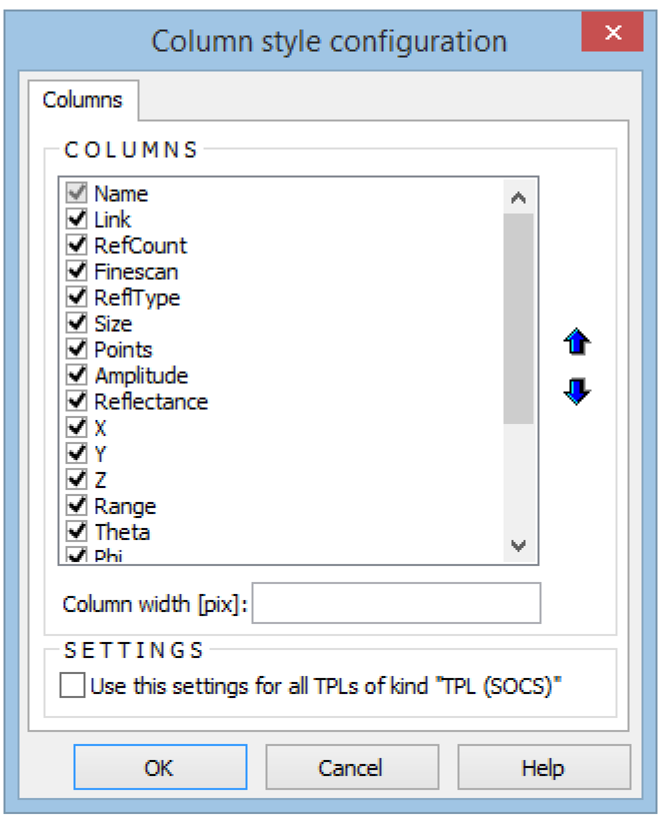
After importing points into a TPL PRCS you will be asked if these points are controlpoints (see "Set controlpoint state 116").

- *Reload*

  This reloads the tiepoint list. This refreshes the display and also recalculates the deviations (only in a TPL SOCS).

- *Layout*

  You can select which columns should be displayed in which order.
  When selecting this menu item the following dialog appears:



Just check or uncheck the columns you want to display or hide (by left-clicking into the box in front of the column name. You can change the order of the columns by dragging a certain column over the place where it should be. As an alternative you can select the column an click one of the arrow buttons to the right.
You can also change the size of each column. Just select one of the columns and resize it by editing it the width in the "Column width [pix]"   box.

By clicking the button OK the settings will be applied, but only for the current tiepointlist until RiSCAN PRO is closed. If you want to save the configuration permanently and for all tiepointlists of this type you have to check "Use these settings for all TPLs of kind "..." ".

Note: The first column (normally this is "Name") can NOT be moved or deactivated.

- **Menu "Tiepoint"**

  - *New*

    see "Add a new tiepoint 105".

  - *Edit*

    see "Edit TP 107"

  - *Set reflector type*

    Selecting this function allows you to set the reflector calibration 75. See also "Add a new tiepoint 105".

  - *Set reflector height* (only available in TPL PRCS)

    This will set the reflector height for all selected tie/control points. The reflector height is added to the Z coordinate of each point. See also "Add a new tiepoint 105".

  - *Delete all / selected tiepoints*

    Use these functions to delete the selected tiepoints or all tiepoints from the tiepointlist (You can not undo this function).

  - *Copy tiepoints to...*

    This copies the selected tiepoints to the selected destination TPL. The coordinates of the tiepoints are transformed using the SOPs and the POP between the source and the destination TPL. The copied tiepoints are automatically linked with their originals.

  - *Calc coordinates from linked tiepoint*

    This causes RiSCAN PRO to recalculate the coordinates of the selected tiepoint by taking the linked tiepoint and transforming it into the coordinate system of the local tiepoint.

  - *Calc coordinates from referring tiepoints* (only available in TPL PRCS)

    The coordinates of the PRCS tiepoint (no controlpoint) are recalculated in relation to all tiepoints with a link to it. SOCS and image tiepoints can be used as referring tiepoints. If only SOCS tiepoints are used the new coordinates are calculated as center of gravity of all SOCS tiepoints transformed into the PRCS. If SOCS and image tiepoints are used, the resulting point is a combination of the center of gravity of the SOCS tiepoints and a point with the least square normal distance to all rays given by the image tiepoints.

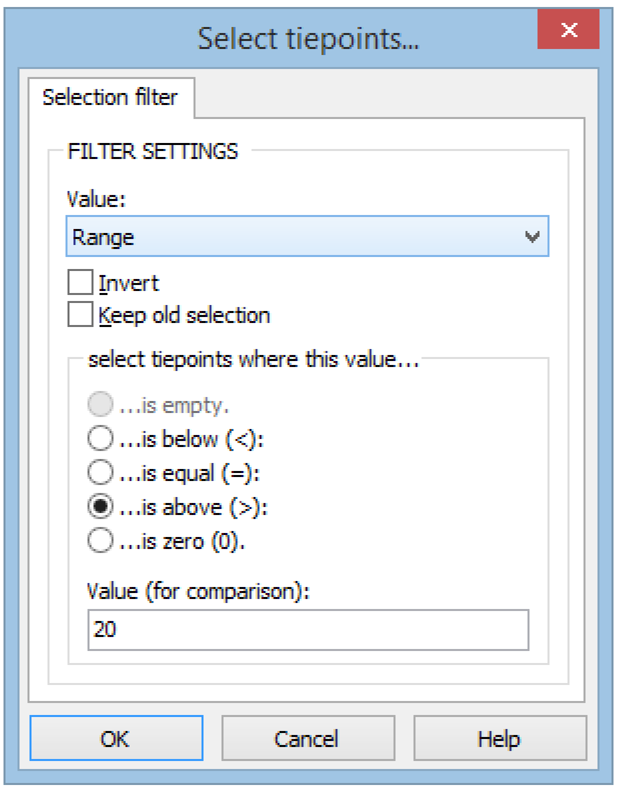
Note: Image tiepoints of unregistered images are not used for calculation. Tiepoints of faultily registered scan positions or images may compromise the accuracy of the calculated coordinates! This function is also executed **automatically** when you create a new link to a PRCS tiepoint either manually or automatically by means of "Find corresponding points". When you modify a SOP or COP matrix manually you have to run this function manually in order to get correct coordinates.

- *Select all / invert / no*

  With these functions you can quickly select all tiepoints, no tiepoint or invert the tiepoint selection.

- *Select tiepoints...*

  This is a tool to select all tiepoints matching a given criteria:



To use this tool just select a value (column) and the criteria (above, below, equal to,... this value).

If "Invert" is checked the result of the filter tool is inverted.

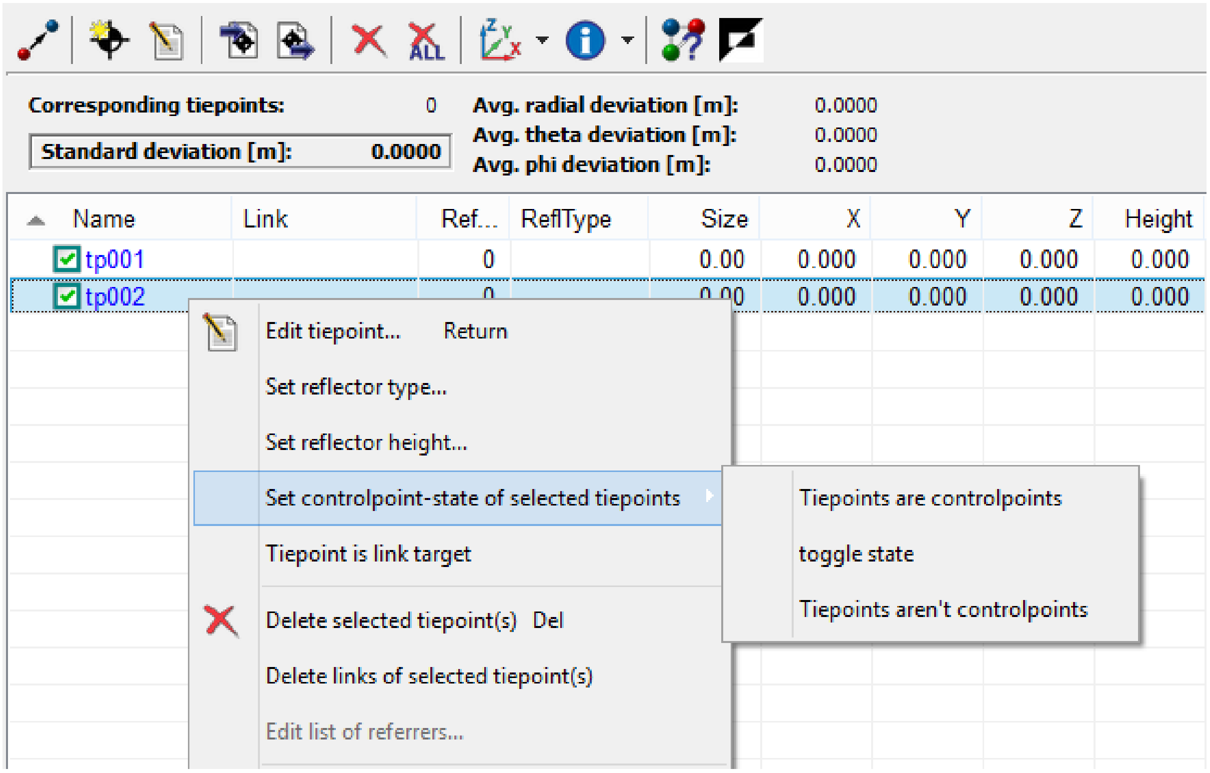
If "Keep old selection" is selected all tiepoints that were selected before using this tool are also selected after using it (works like an OR-filter).
So you can make a "multiple" selection by running this tool with different settings but "Keep old selection" checked.

- *Find corresponding tiepoints (only available in TPL SOCS)*

  see "Registration via tiepoints 187"

- *Set controlpoint state (only available in TPL PRCS)*

  Use this menu entry to determine if the tiepoint is a controlpoint or not.



  In this example tiepoints "tp001", "tp002" and "tp003" are controlpoints (underlined and light gray background color) while "tp004", "tp005", and "tp006" are "normal" tiepoints.

- **Menu "Tiepoint-scan"** (only available in TPL SOCS)

  - *Fine-scan selected tiepoints*

    Use this to make tiepoint-scans 117 of all selected tiepoints.
    The scanner will automatically fine scan all selected tiepoints. After this process the coordinates of the tiepoints are overwritten by the new (=more accurate) coordinates of the fine scanned tiepoints.

    Note:
    The tiepoints will automatically be sorted by phi before they are scanned in order to make this procedure faster (The scanning order is not the order in which the tiepoints are displayed).

  - *Recalculate tiepoint positions*

    This detects the reflector positions of existing tiepoint scans and sets the coordinates of the corresponding tiepoints.

    <u>All listed tiepoints</u>
    All tiepoints in the tiepointlist will be treated this way.

    <u>selected tiepoints</u>
    Only selected tiepoints in the tiepointlist will be treated this way.

from finescans (not listed tiepoints)
You can use this function to restore tiepoints from existing tiepoint scans.

- **Menu "View Tiepoints"**

  - *Show linked tiepoint*
    This opens the tiepointlist of the linked tiepoint and selects the linked tiepoint.

  - *Show additional information*
    This switches additional information 108 on/off

  - *View all / select / invert / no*
    these functions set the visibility of each tiepoint (Only tiepoints with the black binoculars in front of the tiepoint name in the tiepointlist will be displayed in a 2D or 3D-view).

- **Menu "Activate tiepoints"**

  - *Tiepointlist activated*

    This switches the use of the tiepointlist for various functions (like Multi Station Adjustment) on or off. With "Tiepointlist activated" you can switch the use for all tiepoints in this tiepointlist on/off without changing the real switch status (the checkboxes before the tiepoints will be grayed - disabled - but not unchecked).

  - *Activate all / selected / invert*

    This switches the use of the tiepoints on or off.

4.4 Tiepoint scans

In order to determine the exact position of a reflector, you can use a "Tiepointscan 117" or a "Fine-scan".

via Scan

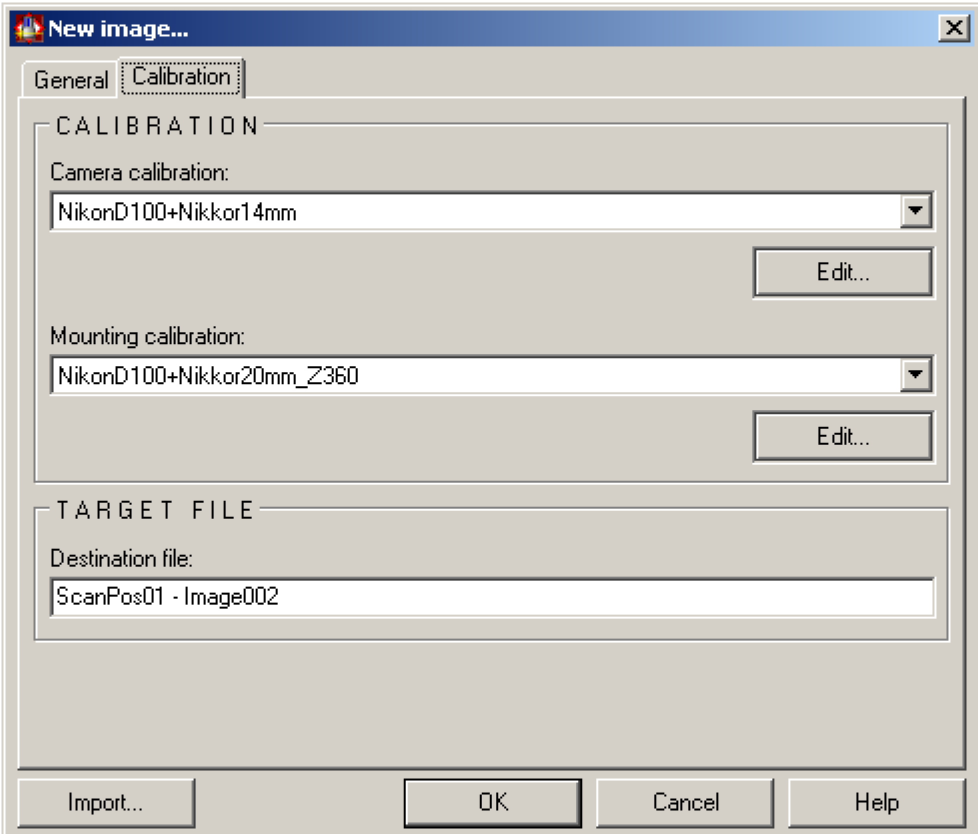
1. Make an Overview scan 90
2. Extract reflectors see "Reflector extraction 93"
3. Perform finescan(s) see The tiepointlist window 104

via Image

This procedure provides a very fast and convenient way to determine the position of a tiepoint.

Adapt the mounting 70 and camera 48 calibration settings.

Right-click the directory "SCANPOSIMAGES" from the scan position and select "New Single Image..." from the menu.



Sheet "General"

- *Description*

  Provide additional information (optional)

Sheet "Calibration"

CALIBRATION

- *Camera Calibration*

  select the desired camera calibration settings. You can change the settings by clicking the "Edit..." Button (see Camera Model 48).

- *Mounting Calibration*

  select the desired mounting calibration settings. You can change the settings by clicking the "Edit..." Button (see Mounting Calibration 70).

TARGET FILE

- *Destination File*

  Provide a name for the new image.

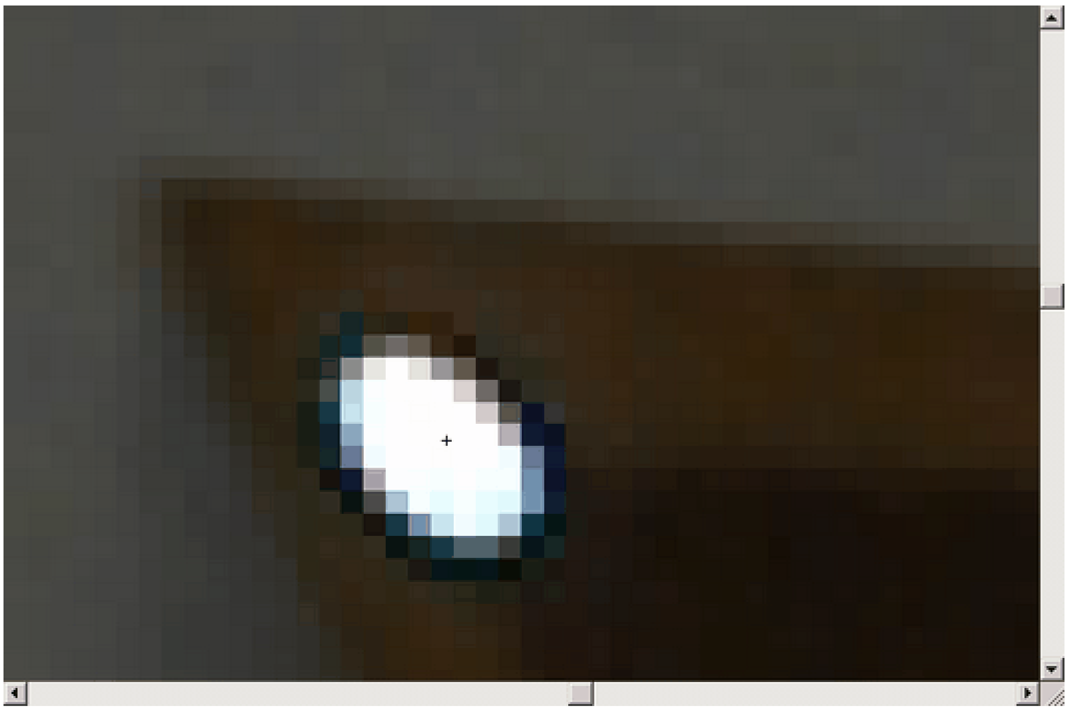
You can import an image by clicking the "Import..." Button (not recommended for this purpose).

Click "OK" to confirm the settings and create the image. The output will be stored in the directory "SCANPOSIMAGES".

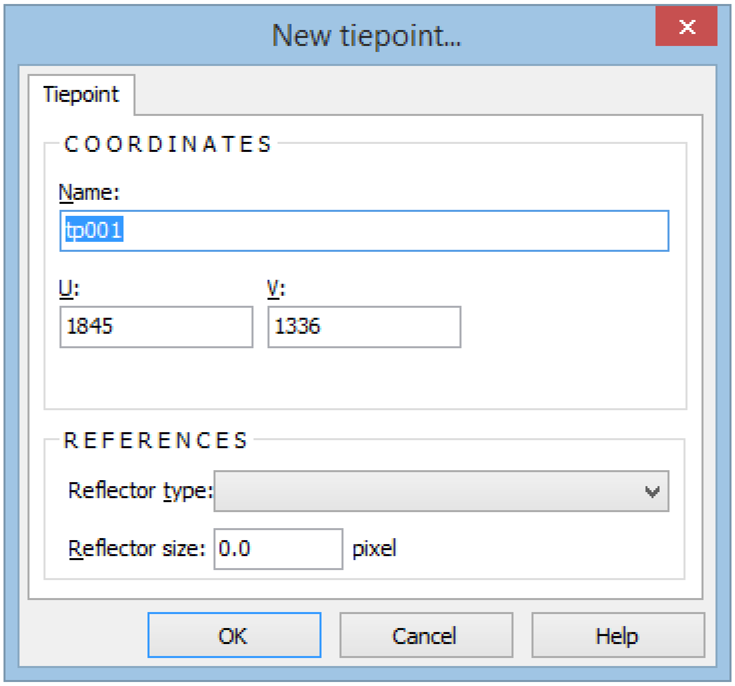
Adding Tiepoints

Open the image from the directory "SCANPOSIMAGES" by double-clicking it.

- select the desired tiepoint(s) in the image and left-click to set a marker (place it in the center of the tiepoint). This will position a "+"-symbol at the coordinates where you clicked.



- right-click the created marker and choose "Add point to TPL" from the menu (or "Delete marker" if you choose not to add the marker).



COORDINATES

- *Name*

  select a name for the tiepoint

- *U and V*

  these are the precise coordinates of the marker and should not be altered

References

- *Reflector type* 75

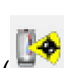
  select the proper calibration settings for the reflector

- *Reflector size*

  enter the approximate size of the reflector in pixels.

Confirm the settings by clicking "OK".

Open the tiepointlist by double-clicking the TPL (image) of the image ("SCANS" -> ScanPosXX -> "SCANPOSIMAGES" -> ImageXXX)

Select the desired tiepoints and click the "Finescan" button from the menu () to start the fine-scanning process. The output will be saved in the directory "TIEPOINTSCANS" and the tiepoints will be added to the TPL SOCS.

4.5 GPS

This chapter describes how to record and use GPS measurements with RiSCAN PRO.
The integration of GPS measurements in RiSCAN PRO is divided into three different tasks:

1. **Record GPS measurements**
   To record GPS measurements RiSCAN PRO offers the GPS Recorder 121 which allows you to configure the GPS receiver and record data sent by the GPS receiver.

2. **Postprocess GPS measurements**

   not implemented yet

3. **Use GPS position**

   not implemented yet

4.5.1 GPS Recorder

The tool **GPS Recorder** is used to configure a (D)GPS receiver and to record GPS measurements sent by the receiver.

Use of the GPS Recorder:

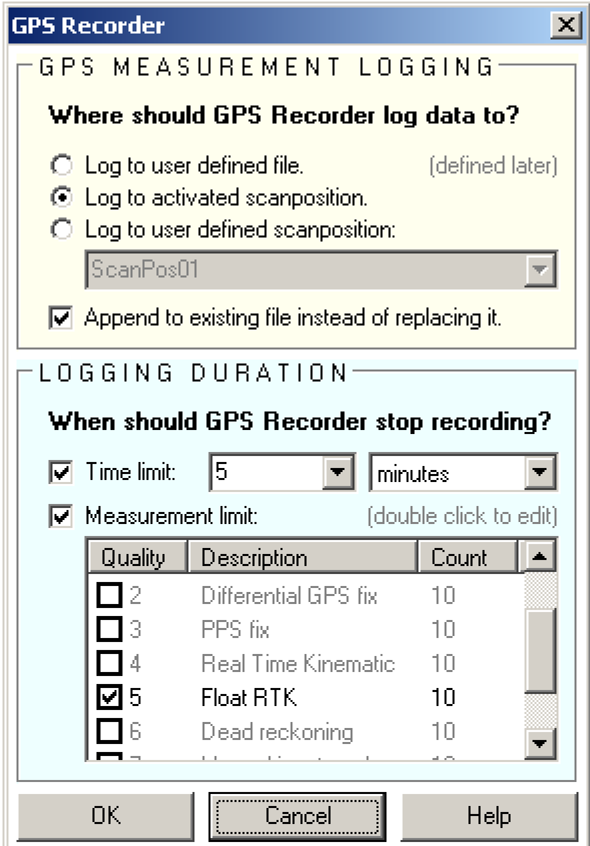
1. Open or create a RiSCAN PRO project.
2. Set the GPS communication settings and script files in the Project settings > GPS Receiver 44.
3. Display the GPS Recorder toolbar. To do so enter the menu "View > Toolbars" and select "GPS Recorder".
   The following toolbar will be displayed:

   The left button is used to connect to the GPS receiver (open communication port and - optionally - send init script, see Project settings > GPS Receiver 44).
   The right button is used to start the GPS recording (see below).

   Note:
   You can either manually connect before you start recording or you can directly start recording. In the latter case RiSCAN PRO will automatically connect and disconnect. If you have manually connected RiSCAN PRO will not disconnect automatically after the recording has finished.

4. Configure recording by clicking the red button. The following window will appear:



The window consists of two sections:

- **GPS MEASUREMENT LOGGING**

  In this section you can define where the GPS Recorder should save the received GPS measurements. By default it will log to a file located in the currently **activated scanposition**. But it can also log into any **user defined file** or into the fix GPS file of any other existing **scanposition.** In case you wish to record to a user-defined file you will be asked for the filename as soon as you click the button **OK**.
  Enable the option "**Append to existing file instead of replacing it**" to keep the contents of the log file. Otherwise the new measurements will overwrite any existing file contents.

- **LOGGING DURATION**

  GPS Recorder can automatically stop recording as soon as **any** defined criteria are fulfilled. "**Time limit**" is activated by default. This means that after a given maximum recording time the recorder stops. If "**Measurement limit**" is activated you can specify that the recorder stops as soon as a certain number of GPS measurements of a given quality have been received. The GPS quality (also called "GPS mode") is a value that indicates the accuracy of the GPS measurement (please refer to the manual of your GPS receiver). The different quality entries are activated by checking the column in front of the name. The number of measurements can be set by double clicking the quality entry.
  In the example given in the screenshot above the recorder will stop when 10 GPS measurements with a quality of 5 have been received or when the recording time exceeds 5 minutes.

5. Start recording by clicking the button **OK.**

6. If you configured the GPS recorder to log to a scanposition you can view the recorded GPS measurements in the attributes of the scanposition (right click the scanposition and select "Attributes..." from the menu)

after the recording has finished.

Note:
A standardized format is used for communication between GPS receivers and any other device or software (such as RiSCAN PRO). This standard is defined by NMEA, the National Marine Electronics Association. RiSCAN PRO is able to decode following NMEA strings: $GPGGA, $GPRMC, $INGGA.

4.6 Wizard Download and convert

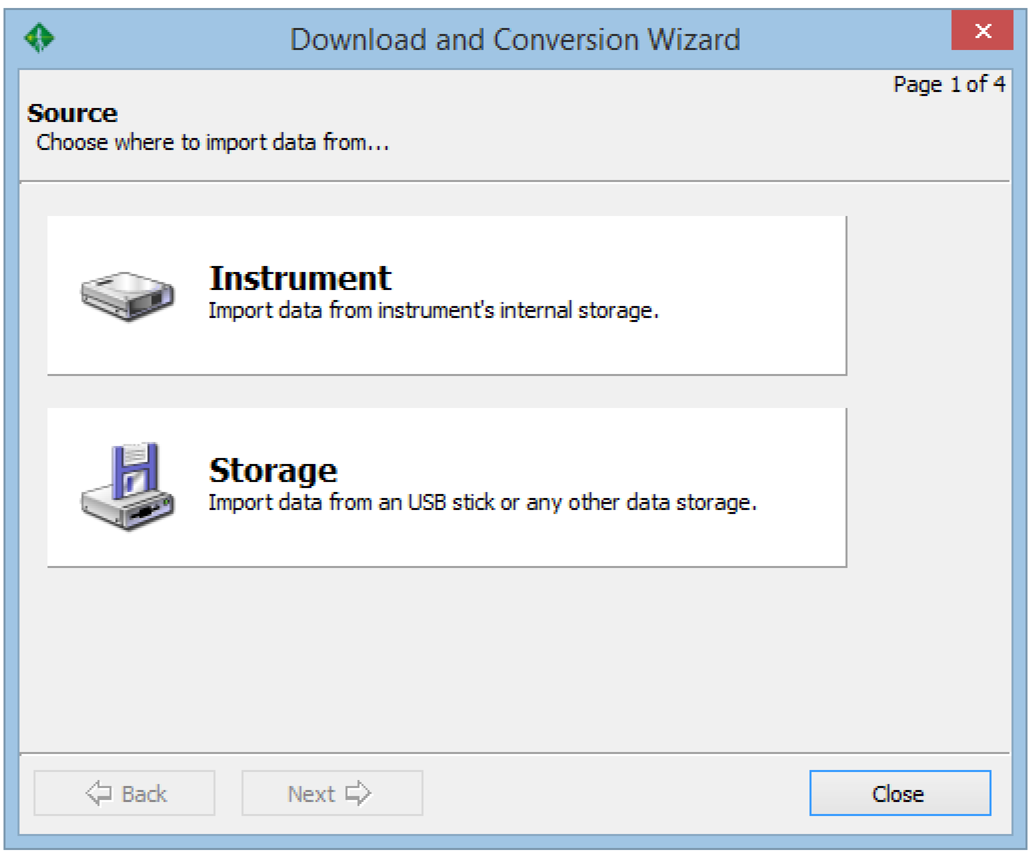
Some scanner (eg. VZ-400) offer the possibility to acquire data (scans, images) without using RiSCAN PRO. The acquired data can be stored either directly on the device or on an external mass storage device. In order to download the acquired data into a RiSCAN PRO project you can use the wizard "Download and convert".

Open the wizard "Download and convert" by choosing "Help ? > Wizard 'Download and convert'" from the menu bar.

1. Choose the desired download source

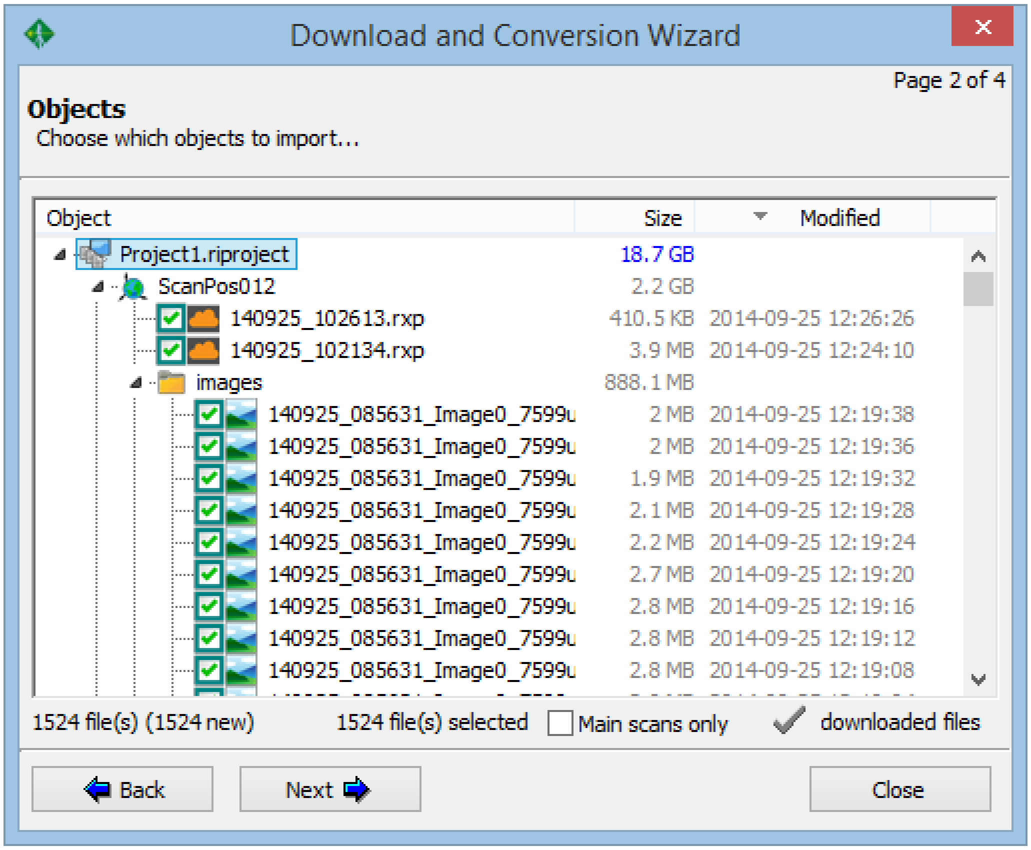
- **Instrument**
  Download scans, images directly from the scanner via TCP/IP through a LAN or W-LAN connection.

- **Storage**
  Download scans, images from a hard disk or any other mass storage device.



2. Select files for download and conversion

After selecting the desired download source you get a list of all available files on the scanner or mass storage device. Select the scans and images you want to download and convert and click "Next".

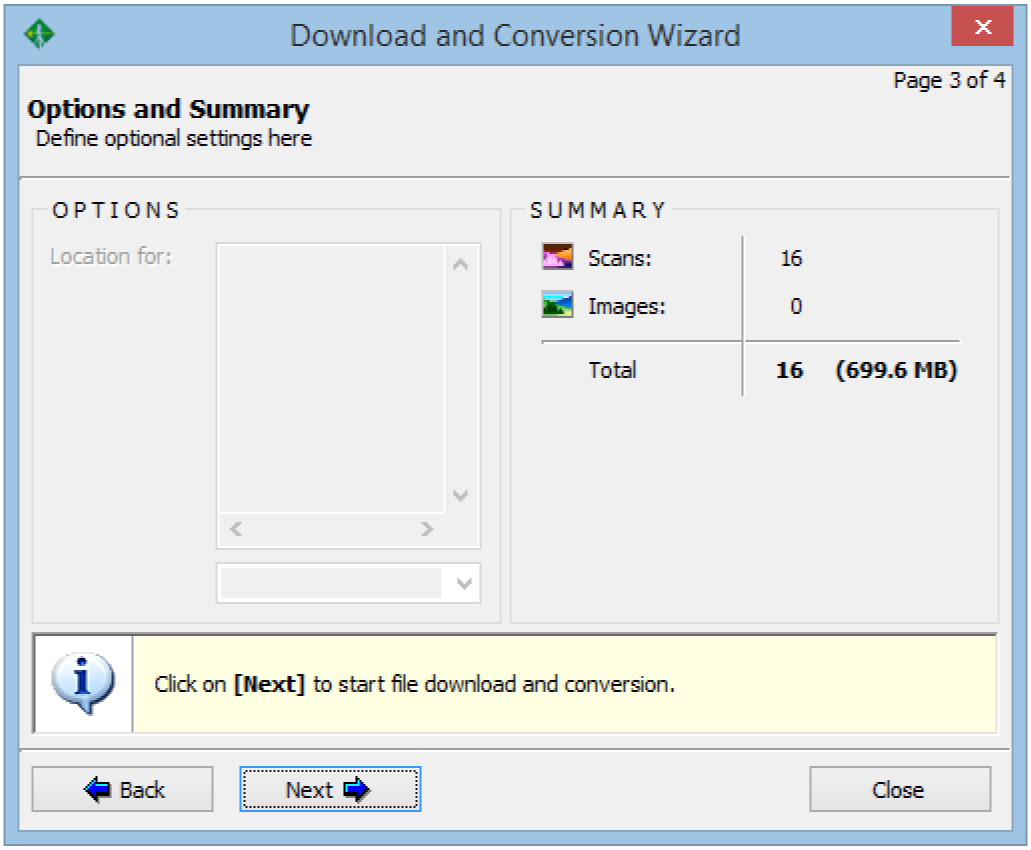


3. Adjust additional options, check summary and start

- **Options**
  When importing scans or images from a mass storage device there is no information available about the scanner that has acquired the scan. For this reason you have the possibility to select an instrument type for the imported data in the combo box "Instrument type". Furthermore you may want to select a location for imported files that are not situated in a scan position folder.

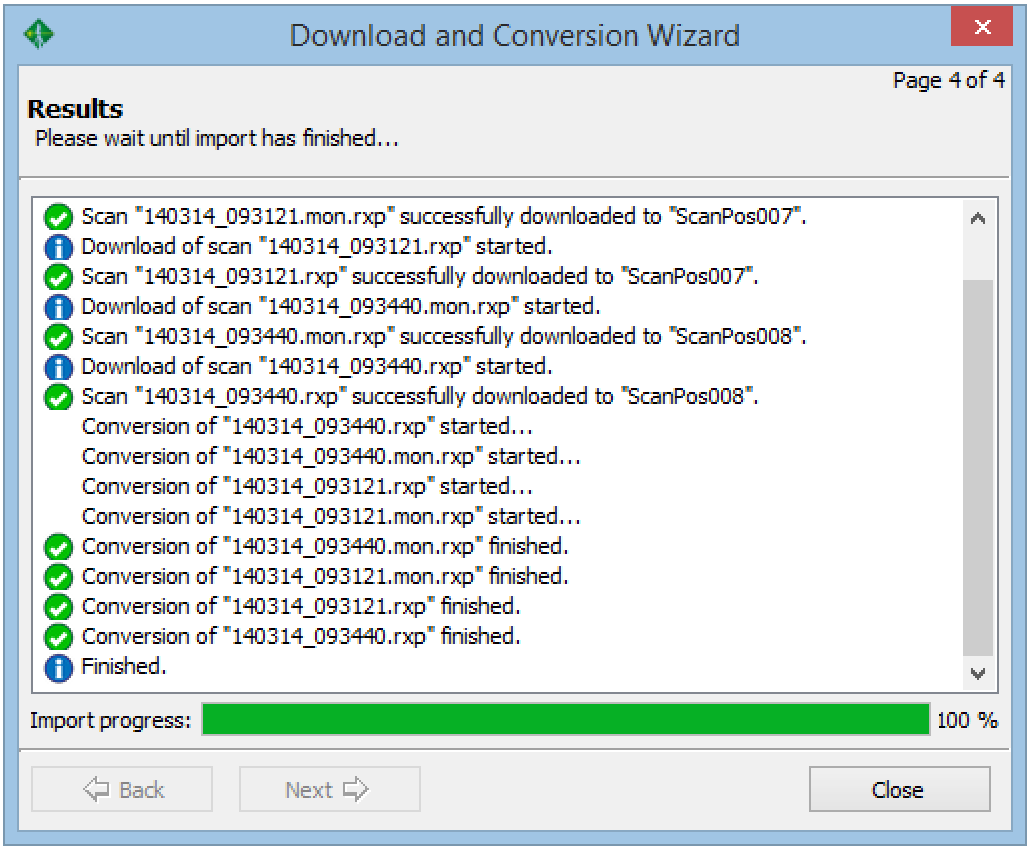
- **Summary**
  The group box "Summary" gives you a short conclusion about the downloaded files and the total size of all files.

Click "Next" to start the download an convert process. All selected files will be imported into the RiSCAN PRO project.



4. Check results

Finally check the results to make sure that all files have been imported correctly.


Download and Conversion Wizard
Page 4 of 4
Results
Please wait until import has finished...
Scan "140314_093121.mon.rxp" successfully downloaded to "ScanPos007".
Download of scan "140314_093121.rxp" started.
Scan "140314_093121.rxp" successfully downloaded to "ScanPos007".
Download of scan "140314_093440.mon.rxp" started.
Scan "140314_093440.mon.rxp" successfully downloaded to "ScanPos008".
Download of scan "140314_093440.rxp" started.
Scan "140314_093440.rxp" successfully downloaded to "ScanPos008".
Conversion of "140314_093440.rxp" started...
Conversion of "140314_093440.mon.rxp" started...
Conversion of "140314_093121.rxp" started...
Conversion of "140314_093121.mon.rxp" started...
Conversion of "140314_093440.mon.rxp" finished.
Conversion of "140314_093121.mon.rxp" finished.
Conversion of "140314_093121.rxp" finished.
Conversion of "140314_093440.rxp" finished.
Finished.
Import progress:
100 %
Back
Next
Close

Part V

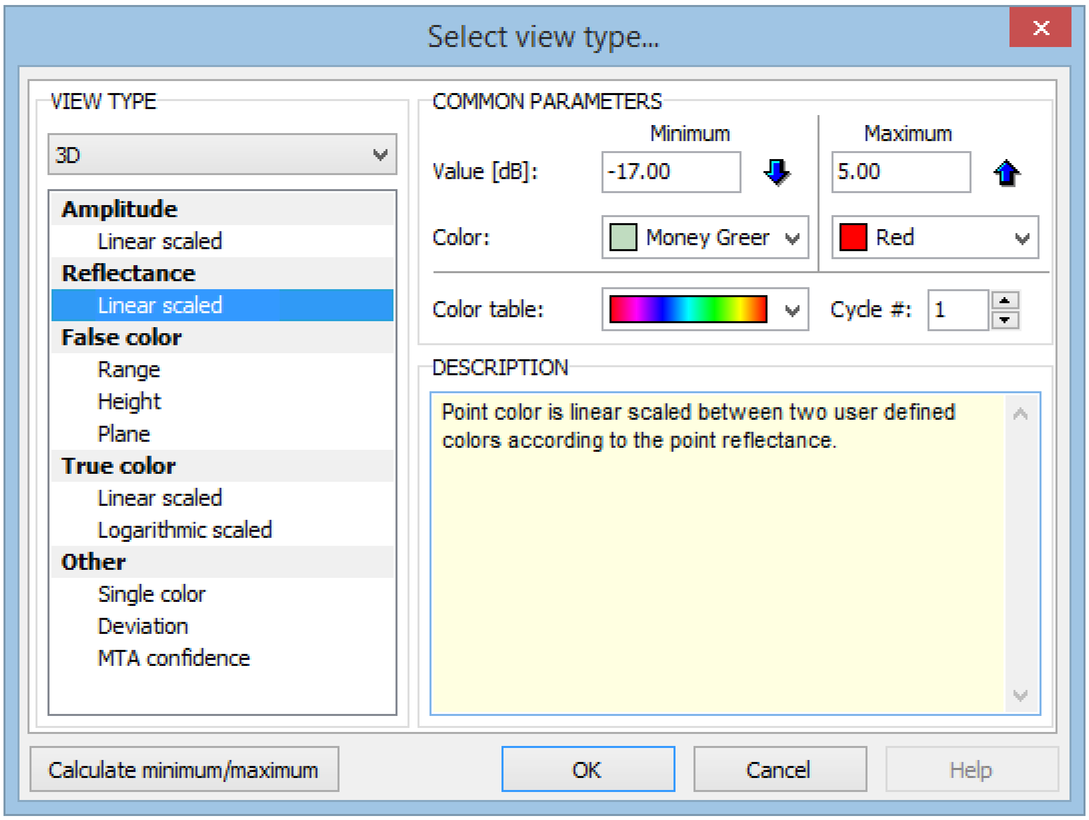
Data visualisation

5 Data visualisation

RiSCAN PRO can display the acquired data (scans, polydata, images) in differnt views:

- 2D view 129
- 3D view 144
- Panorama view 178

To open a view just double click on an item in the project manager (or click with right mouse button on the item and select "View...").
If the selected item is a **scan** or a **polydata** this will show the following viewtype selection dialog:



For a description of the viewtypes see "Viewtypes 128".

If you create a new 3D view a default logo will be automatically displayed in the view depending on the option Display the "Default" overlay automatically in new 3D views 38.

If you have selected an **image** or an **orthophoto**, no viewtype selection dialog will appear and the 2D view will be opened instead.

5.1 Viewtypes

The following view types are available for 2D, 3D and panorama:

Type	Sub type	View		Data loaded			Comment
		2D	3D	XYZ	AMP	RGB	
Amplitude (former "Intensity")	Direct	X	X	X	X		Point color is determined via amplitude (black = low amplitude, white = high amplitude)
	Histogram	X	X	X	X		Similar to "Amplitude direct" but a histogram is used to scale the amplitude of each point in order to get a better contrast. The scale factor for the amplitude is determined by counting the points having the same amplitude. The more points the higher the scale factor will be
	Scaled	X	X	X	X		Point color is linear scaled between two user defined colors according to the point amplitude
	Simple	X			X		Similar to "Amplitude direct" but no point coordinates are loaded (less memory consumption but no coordinate readout possible!)
Reflectance	Scaled	X	X	X	X		Point color is linear scaled between two user defined colors according to the point reflectance
Falsecolor	Height	X	X	X			Point color is calculated based on the height of the point above the X-Y plane of PRCS
	Height Intensity	X	X	X	X		Similar to "Falsecolor - Height" but with influence of the intensity
	Plane	X	X	X			Point color is calculated based on the normal distance of the point to the defined plane
	Plane Intensity	X	X	X	X		Similar to "Falsecolor - Plane" but with influence of the intensity
	Range	X	X	X			Point color is calculated based on the distance between point and origin of the coordinate system
	Range Intensity	X	X	X	X		Similar to "Falsecolor - Range" but with influence of the intensity
Simple	Simple		X	X			Only point coordinates will be loaded (less memory consumption but all points will be colored with the same color).
Truecolor	Linearscaled	X	X	X		X	The point color is taken from the true color channel of the data file (gained by the instrument or generated by "color from images")

Note: Not all view types are supported by all views and for all datasets (scans, polydata objects)

5.2 2D view

The 2D view is able to display the following objects:

- **Scans (3DD files)**
  In the 2D visualization 130 the angular data (polar 339 and azimuth 339 scan angles) is neglected and the measurements are put in a plane rasterisation of the image according to the indices within a 3DD data set. The pixel color may be determined by range, height, amplitude, or true color.

- **Scans (rxp files)**
  The 2D visualization of "a rxp scan file" 138 acquired by a "VZ-Line scanner" is a rasterized image of the scan. The angular data (polar 339 and azimuth 339 scan angles) are considered for the scan image rasterization. The pixel color may also be determined by range, height, amplitude, or true color.

- **Images**
  High resolution photographs acquired by RiSCAN PRO.

- **Orthophotos**
  Orthophotos generated by RiSCAN PRO 264

5.2.1 Z-Line & LPM Scanner

The toolbar of the 2D view:

The toolbar of the 2D view offers quick access to frequently used functions. The following screenshot shows all buttons of the toolbar.

Note: Not all functions are available in all kinds of 2D views.

Items of the toolbar described from left to right:

- **Properties menu**

Rotate

Use this menu to rotate the image/scan 90 deg left or right

Zoom

Zooms in and out.
Increase / Decrease zoom-sensitivity changes the zoom-sensitivity for dynamically zoom by 10 percent-steps. The value of the zoom-sensitivity can be between 10% - 300%. Keep in mind that a value of 100% will double the size of the image!

Select drawing plane... *(This function is only available for images)*

Use this function to define a drawing plane.
If a drawing plane is defined, you can read out 3D coordinates while you move the mouse over the image. The 3D coordinates are calculated as the intersection between the current line of sight (current mouse position) and the defined plane. These coordinates are displayed in the datareadout window 178 as usual.

You can also drag & drop a plane from the project manager onto the image window in order to define a drawing plane.
To switch back to default mode (undefined the drawing plane) click the button "Remove drawing plane" in front of the name of the drawing plane in the tool bar of the view window:

Image navigator *(This function is only available for images within a scan position)*

With the image navigator you can quickly navigate to neighboring images. If you activate the image navigator, four small arrows will be displayed at the edges of the image. If you move the mouse along an edge a button appears. Click the button in order to switch to the nearest image in the selected direction.

Instead of clicking on the buttons you can also use the following shortcuts:

Action	Key
Activate or deactivate image navigator	Ctrl + End
Goto left image	Ctrl + ←
Goto right image	Ctrl + →
Goto image above	Ctrl + ↑
Goto image below	Ctrl + ↓

Note:
The rotation of the image (display only) does not influence the search direction (i.e. if you click on the button "Right" the nearest image with an smaller phi angle than the current image will be searched).

Note:
If the end of an image series is reached, the next image displayed will be the first image of the series (e.g. if you click the button "Left" while the leftmost image is displayed the rightmost image will be displayed).

Save screenshot

Use this function to save the current scan/image to a file

Print

Use this function to print the image/scan

Viewtype...

This will open the viewtype property sheet. (see Data visualization: Viewtypes 128)

- **Fast switching to 3D View** (only applicable on scans)

This will open a new object view and display the scan in 3D. The 2D view will not be closed!

- **Zoom factor**

  Use this list to zoom to predefined zoom-factors.

- **Zoom in**

  zoom in by one sensitivity unit

- **Zoom out**

  zoom out by one sensitivity unit

- **Zoom 100%**

  Sets the zoom-factor to 100% (1:1). This means that one pixel of the image (one measurement of the scan) is represented by one pixel on the screen.

- **Zoom to window size**

  Sets the zoom-factor in order to fit the image into the window size.

- **Zoom to selection**

  Zooms to the last rectangle-selection 134. If there is no selection it will zoom to window size.

- **Image navigator** *(This function is only available for images with a scan position)*

  See section "Properties menu: Image navigator 131" above.

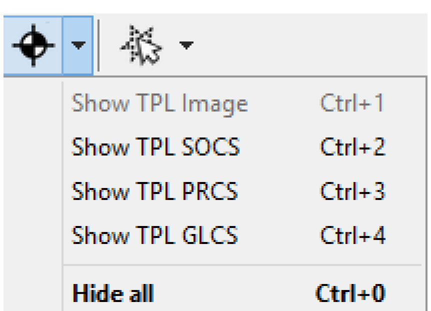
- **Rotate counterclockwise**

  Rotates the image 90° counterclockwise. (only the view; this is not saved to the image file!)

- **Rotate clockwise**

  Rotates the image 90° clockwise. (only the view; this is not saved to the image file!)

- **Show reflectors**



Use this menu to switch the display of tiepoints in a certain tiepoint list on/off.
If "Show TPL xxxx" is grayed then there are no tiepoints in this tiepointlist or this tiepointlist is not available

for this view.

"Hide all" hides (switches off) all displayed tiepoints.

For these functions **shortcuts** are also available:
CTRL+1: Show TPL **Image**
CTRL+2: Show TPL **SOCS**
CTRL+3: Show TPL **PRCS**
CTRL+4: Show TPL **GLCS**
CTRL+0: **Hide** all

To link two tiepoints together you can select them (see mouse-actions 134) right click anywhere in the image and select "Link tiepoints together" from the menu.

Additional toolbar for scan sequences

In case you have opened a scan sequence in the 2D view there's a second toolbar offering some special functions:

Functions decribed from left to right:

Display next frame
The next frame of the scan sequence is displayed. If the current frame is the last frame, the first frame is displayed.

Stop
When a scan sequence is displayed in the 2D view a thread runs in the background waiting for further user input (next frame, last frame, goto frame). While this thread is running it's neither possible to save or close the project nor to modify the scan sequence object (rename 341, edit properties). If you click on this button you can stop this thread. Note, that the functions "next frame", "goto frame" and "last frame" do not work anymore. To use these functions again, you have to re-open the scan sequence.

Go to frame
This function can be used to jump to a certain frame.

Go to last frame
The last frame of the scan sequence is displayed. If the current frame is the last frame, the first frame is displayed.

Current frame
Shows the number of the currently displayed frame and the total number of frames.

Note:
If you imported the scan sequence, the number of frames is unknown. To change this, right-click the scan sequence in the project manager and select "**Determine frame count**" from the menu. The knowledge of the total frame count is important for the function described above.

Warning:
If you open a scan sequence in a 2D view a background thread is started which enables you to jump to different frames of the scan sequence. Since RiSCAN PRO can not save a project while a thread is running the project is not saved as long as a scan sequence is open in a 2D view. To solve this problem either click the "**Stop**" button or close the 2D view.

Definition of tiepoints:

Within the 2D view you can also add a tiepoint to either the TPL IMAGE (if an image is open) or the TPL SOCS (if a scan is open). To do so left-click somewhere in the view. This will set a marker. Right-click this marker and select "Add point to TPL" from the menu. The corresponding dialog appears (see Tiepointlist window 105).

Image acquisition:

In the 2D view you can also acquire an image in a given direction with the connected digital camera. To do so open a scan or a scan position image in the 2D view, press and hold down the "I" key and left-click the point of interest. This point will be approx. at the center of the acquired image.

Note: For this function the project must contain at least one camera calibration and one mounting calibration. If you use this function from an image the calibrations assigned to this image are used. If you use this function from a scan you have to define default calibrations first (right-click "Default" for the desired calibration).

Visualization of point clouds within an image:

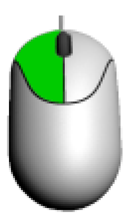
If the 2D view displays an image (high resolution photograph) you can visualize a point cloud (scan or polydata) as overlay of the image. This function can be used e.g. to check the mounting and camera calibrations. To load the point cloud into an open 2D image view, click a scan or polydata object (containing points) in the project manager and drag it onto the 2D view. The default viewtype 128 selection dialog appears where you can select your preferred viewtype. After clicking the button "OK" the point cloud is loaded (this may take some time). Once the point cloud is loaded the points will be displayed as single pixels which overlay the original image. The 2D view also offers a new toolbar:

Click the first button to **remove** the point cloud overlay.
Click the second button to toggle between **multi color** and **single color** mode. In **multi color mode** the pixels will have the color corresponding to the selected viewtype. In **single color mode** all pixels will have the same color. To change the color right-click the second button.

Measurements:
While the point cloud is displayed in the 2D image view it is possible to measure coordinates. To do so please use the data readout window 178 while you move the mouse over the image. The coordinates between two points of the point cloud are linearly interpolated.

5.2.1.1 Navigation Z-Line & LPM Scanner

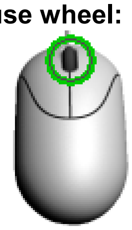
Actions with the left mouse button:

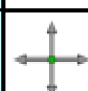


Action	Key	Mouseaction	Comment

Rectangular zoom		hold + move	Span rectangle from left to right.
Restore last perspective		hold + move	Span rectangle from right to left.
Set a new marker		click	
Move a marker		hold + move	
Select/deselect a marker	Shift ⇧	click	Also for tiepoint
Delete a marker	Ctrl	click	Also for tiepoint and rectangle selection
Select markers with a rectangle selection	Shift ⇧	hold + move	Also for tiepoints
Make rectangle selection	Alt	hold + move	Select a rectangular area eg. for a new detail scan.
Acquire single image	I	click	The clicked point will approximately appear in the center of the acquired image.

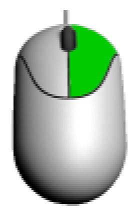
Actions with the middle mouse button and mouse wheel:

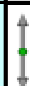


Action	Key	Mouseaction	Comment
Pan		hold + move	
Zoom in/out (fixed)		spin mouse wheel up/down	
Increase/decrease zoom sensitivity	Z	spin mouse wheel up/down	

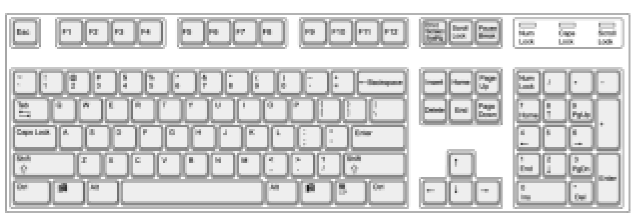
Change intensity	I	spin mouse wheel up/down	
Increase/decrease values "min height" and "max height" of falsecolor height coded scan	H	spin mouse wheel up/down	Only available for viewtypes "Falsecolor / Height" and "Falsecolor / Height Intensity"
Increase/decrease values "min range" and "max range" of falsecolor range coded scan	R	spin mouse wheel up/down	Only available for viewtypes "Falsecolor / Range" and "Falsecolor / Range Intensity"

Actions with the right mouse button:



Action	**Key**	**Mouseaction**	**Comment**
Zoom in/out		hold + move	
Show context menu		click	Show popup menu.

Actions with the keyboard:



Action	**Additional key**	**Key**	**Comment**
Restore last perspective		←Backspace	
Zoom all		Home	

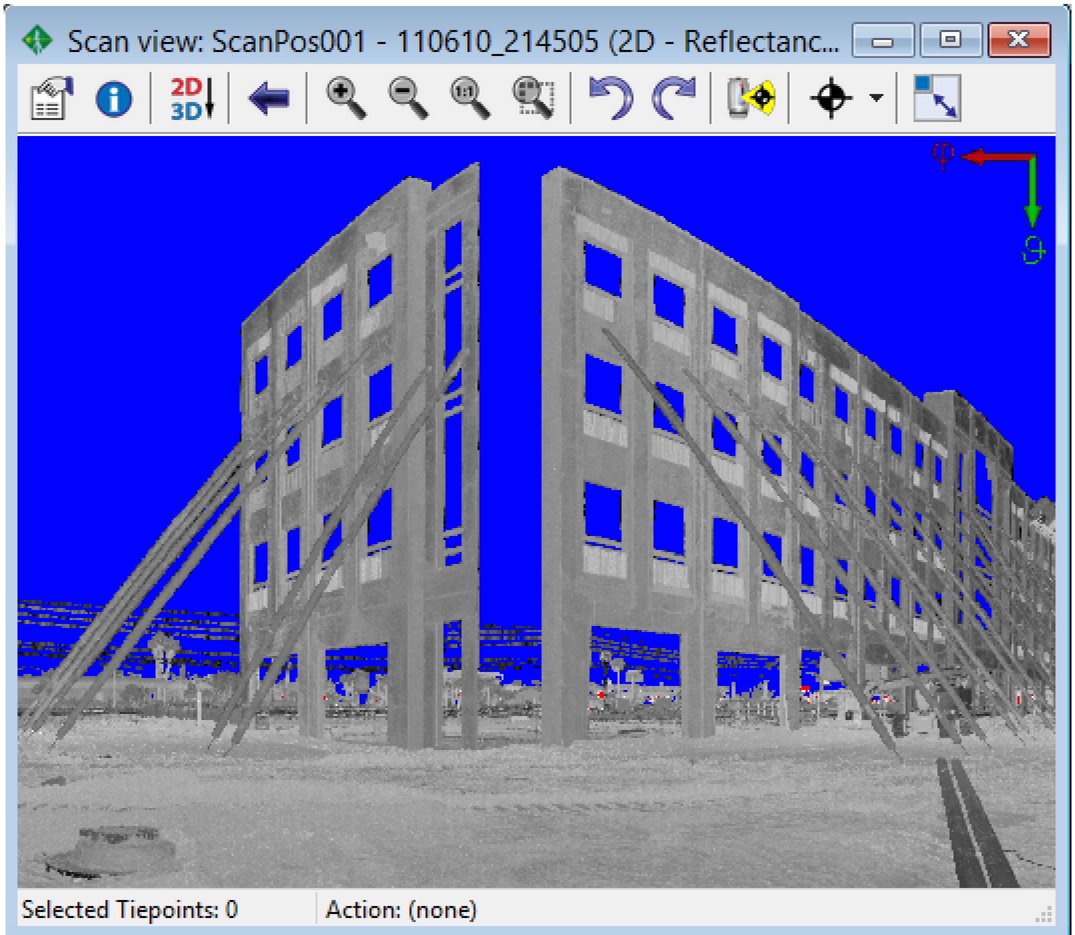
Zoom in		Page Up	
Zoom out		Page Down	
Move view port up		↑	
Move view port down		↓	
Move view port left		←	
Move view port right		→	
Rotate scan image left		L	
Rotate scan image right		R	
Change viewtype		V	
Show in 3D		# 3	
Fullscreen view		F11	
Draw polyline		P	Start the tool "Draw polyline..."
Show/hide all TPLs		Ctrl +) 0	
Show/hide TPL IMAGES		Ctrl + ! 1	

Show/hide TPL SOCS		Ctrl + @ 2	
Show/hide TPL PRCS		Ctrl + # 3	
Show/hide TPL GLCS		Ctrl + $ 4	
Select all tiepoints		Ctrl + A	
Invert tiepoint selection		Ctrl + I	
Finescan selected tieoints		Ctrl + F	
Delete selected tiepoints		Ctrl + Delete	You will be prompted before deletion.

Note: Tiepoints can **NOT** be moved or deleted like normal markers, use the tiepoint menu instead!

5.2.2 VZ-Line Scanner

The 2D view shows a rasterized image of a "RXP" file acquired by a VZ-Line scanner.



Toolbar

The buttons of the toolbar are described from left to right:

- **Change viewtype**
  Shortcut: V
  Description: Change the data coloring of the 2D view.
  Hint: Hold down **"I"** and turn the **mouse wheel up/down** to **lighten/darken** the scan image.

- **Show navigation info...**
  Shortcut: Ctrl + F1
  Description: Show the navigation info panel.

- **Show in 3D**
  Shortcut: 3
  Description: Show the current scan in a 3D view.
  Hint: You can define a region in the 2D view by holding down the ALT key and the left mouse button while drawing a rectangle with the mouse cursor. If you click on "Show in 3D" afterwards, then only points within that region will be displayed in the 3D view.

- **Last position**

Shortcut: Backspace
Description: View the scan from the last camera position.

- **Zoom in**
  Shortcut: Page up
  Description: Zoom in by 10%

- **Zoom out**
  Shortcut: Page down
  Description: Zoom out by 10%

- **Zoom all**
  Shortcut: Home
  Description: Adjusts the zoom level to fit the whole scan in the 2D view.

- **Zoom selection**
  Shortcut: Insert
  Description: Adjusts the zoom level to fit to the current selection rectangle (Selection is made by holding "Alt" and spanning a rectangle with the left mouse button).

- **Rotate 90° left**
  Shortcut: L
  Description: Rotate the scan image by 90° left.

- **Rotate 90° right**
  Shortcut: R
  Description: Rotate the scan image by 90° right.

- **Finescan tiepoints**
  Shortcut: Ctrl + F
  Description: Finescan the selected tiepoints.

- **Show/hide TPL**
  Shortcut: CTRL+0 Show/hide all
  CTRL+2 Show/hide TPL SOCS
  CTRL+3 Show/hide TPL PRCS
  CTRL+4 Show/hide TPL GLCS
  Description: Show/hide tiepoint lists (TPL SOCS, TPL PRCS, TPL GLCS).

- **Show/hide overview**
  Shortcut: none
  Description: Show/hide the overview window.

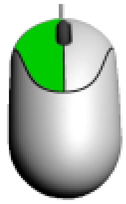
Actions

- **Rectangle selection**
  A rectangle selection is made by holding down "Alt" and spanning a rectangle with the left mouse button.

- **Draw polyline**
  Draw a new polyline by selecting "Draw polyline..." from the context menu or press the shortcut "P". Display or modify an existing polyline by dropping it into the 2D view. See chapter "Polyline within a 2D view" 267 for further details.

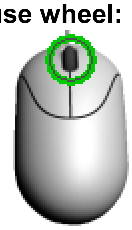
5.2.2.1 Navigation VZ-Line Scanner

Actions with the left mouse button:



Action	Key	Mouseaction	Comment
Rectangular zoom		hold + move	Span rectangle from left to right.
Restore last perspective		hold + move	Span rectangle from right to left.
Make rectangle selection	Alt	hold + move	Select a rectangular area eg. for a new detail scan.
Select tiepoint	Shift ⇧	click; hold + move	Click on the desired tiepoint to select it. Span a rectangle to select multiple tiepoints.
Toggle tiepoint selection	Ctrl	click; hold + move	Click on the desired tiepoint to toggle its selection. Span a rectangle to toggle the selection of multiple tiepoints.
Acquire single image	I	click	The clicked point will approximately appear in the center of the acquired image.

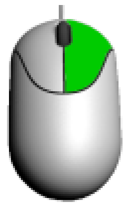
Actions with the middle mouse button and mouse wheel:



Action	Key	Mouseaction	Comment
Pan		hold + move	
Zoom in/out		spin mouse wheel up/down	

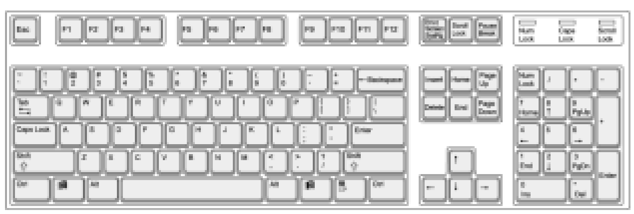
Change intensity	I	spin mouse wheel up/down	

Actions with the right mouse button:



Action	Key	Mouseaction	Comment
Zoom in/out		hold + move	
Show context menu		click	Show popup menu.

Actions with the keyboard:



Action	Additional key	Key	Comment
Restore last perspective		← Backspace	
Zoom all		Home	
Zoom in		Page Up	
Zoom out		Page Down	
Move view port up		↑	

Move view port down		↓	
Move view port left		←	
Move view port right		→	
Rotate scan image left		L	
Rotate scan image right		R	
Change viewtype		V	
Show in 3D		# 3	
Fullscreen view		F11	
Draw polyline		P	Start the tool "Draw polyline..."
Show/hide all TPLs		Ctrl +) 0	
Show/hide TPL SOCS		Ctrl + @ 2	
Show/hide TPL PRCS		Ctrl + # 3	
Show/hide TPL GLCS		Ctrl + $ 4	

Select all tiepoints		Ctrl + A	
Invert tiepoint selection		Ctrl + I	
Finescan selected tieoints		Ctrl + F	
Delete selected tiepoints		Ctrl + Delete	You will be prompted before deletion.
Link selected tiepoints		Ctrl + L	
Edit selected tiepoints		Ctrl + E	
New tiepoint		Ctrl + N	The new tiepoint will be set at the last clicked point.

5.3 3D view

In the 3D view the complete geometrical information is used. As a 3DD data set basically represents a point cloud, every measurement is represented as a point in 3D space. The color of the point for visualization may again be chosen to represent range, height, amplitude or something similar.

5.3.1 Object view

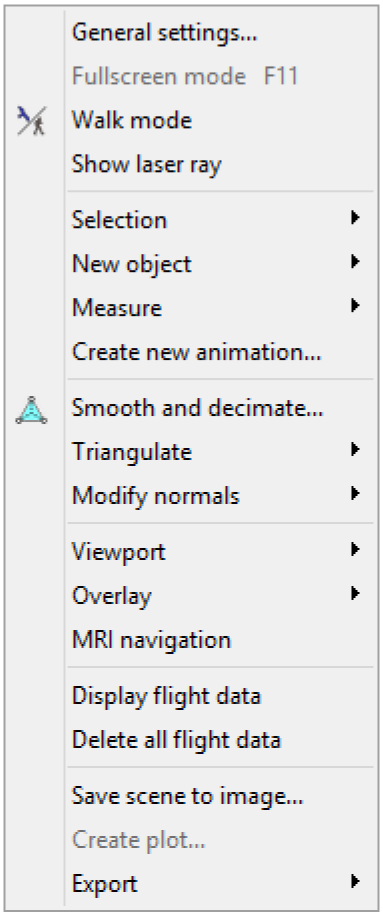
The object view provides a way to visualize several different objects (e.g. scan, polydata, ...). For more information on which objects can be displayed and which parameters can be adjusted see the "Object inspector 156". To create a new object view right-click the directory "VIEWS" in the project manager and select "New object view..." from the menu. This will create a new object within the directory and opens a new window.

To add some objects, drag and drop them into the object view or into the object inspector 156.

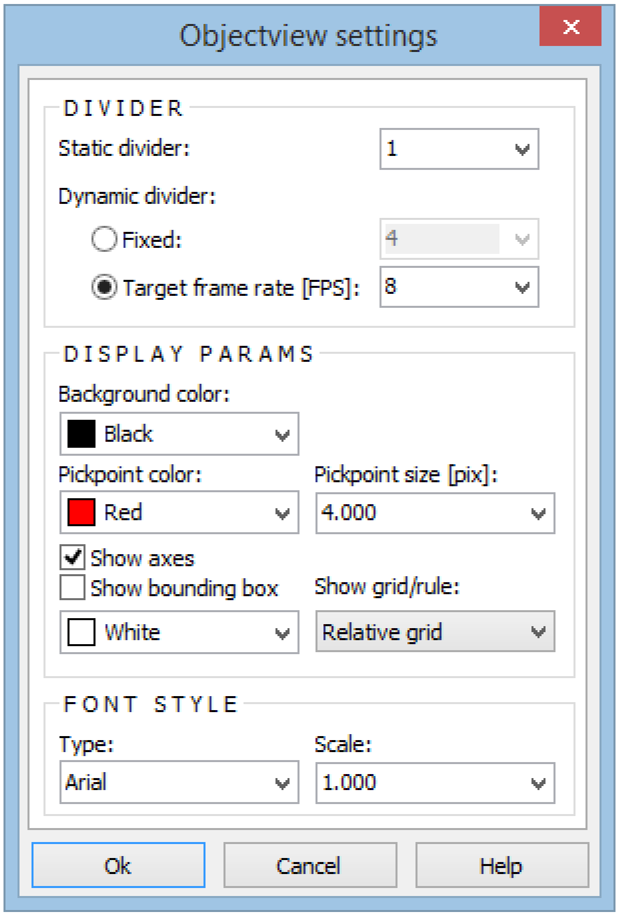
How to navigate within this view see "Navigation 151".

Popup menu:

If you right-click anywhere within an object view, the following popup menu will appear:



General Settings



With "**Static divider**" and "**Dynamic divider**" you can reduce the number of points/triangles displayed. This makes navigation easier:

- **Static divider**
  Is used while not navigating in the 3D scene..

- **Dynamic divider**
  Is used while navigating in the 3D scene (usually set larger than the "static divider").

  Fixed:
  The dynamic divider is used as-is.

  Target frame rate (FPS):
  The dynamic divider is calculated in order to reach the requested frame rate. This is done by measuring and averaging the time needed to render one frame.

  Note: The dynamic divider is limited to a maximum value that can be set in the program options (Menu "**Tool > Options... > 3D Settings > Display settings > Runtime settings > Max. divider**").

- **Background color**
  Set the background color of the object view window.

- **Pickpoint color**
  Set the color for the pickpoint.

- **Pickpoint size**
  Defines pickpoint size (in pixels).

- **Show axes**
  Show/hide axes symbol. For more settings see the program settings 34.
  The three axes have different colors:

  - **red** X axis
  - **green** Y axis
  - **blue** Z axis

- **Show grid/rule**
  Show/hide grid or a rule (only available in orthogonal mode). Both the relative grid and the rule do not show absolute values, but you can activate the "absolute grid". The absolute grid only works when the virtual camera looks perpendicular onto one of the main planes (XY, XZ, YZ), i.e. when you click on one of the default view ports (Bird's eye view, Front view,...).

- **Show bounding box**
  Show/hide bounding box. You can also select the color of the bounding box.
  The bounding box shows the maximum extensions of all objects.

- **Font type**
  Select the font you want to display with objects that have a caption.

- **Font scale**
  Select size of font. This value is a factor that is multiplied with a default size.

Fullscreen mode (Shortcut: "F11")

You can switch the object view to fullscreen mode. That means the whole screen will be used do display this object view.
To leave the fullscreen mode use the same menu item or press "F11".

Note: Some operations will not be available in fullscreen mode.

Walk mode

Enable/Disable walk mode. See Data visualisation > 3D view > Navigation 151

Show laser ray

This simulates the ray of the laser in the 3D scene. To use this feature you need to select a scanposition as reference coordinate system of the object view (see Object inspector 156). When the mouse is moved in the 3D scene the laser ray is drawn as half transparent cone that starts at the origin of the reference coordinate system and ends at infinity. The direction of the cone is determined by the point lying underneath the mousecursor.

Select

See "Data postprocessing > Data manipulation > Select 221".

New object

See "Data postprocessing: Create geometry objects 269".

Measure

See "Data postprocessing: Measurements 297".

Create new animation

See "Data postprocessing: Animations 306".

Smooth and Decimate...

This function modifies the surface structure of the polydata object by optimizing the point data (smoothing) and reducing the amount of triangles (decimating). See "Data postprocessing: Smooth & Decimate 250".

Triangulate...

See "Data postprocessing: Triangulation of arbitrary point clouds 243".

Modify normals

See "Data postprocessing > Data manipulation > Modify normals 234".

Viewport

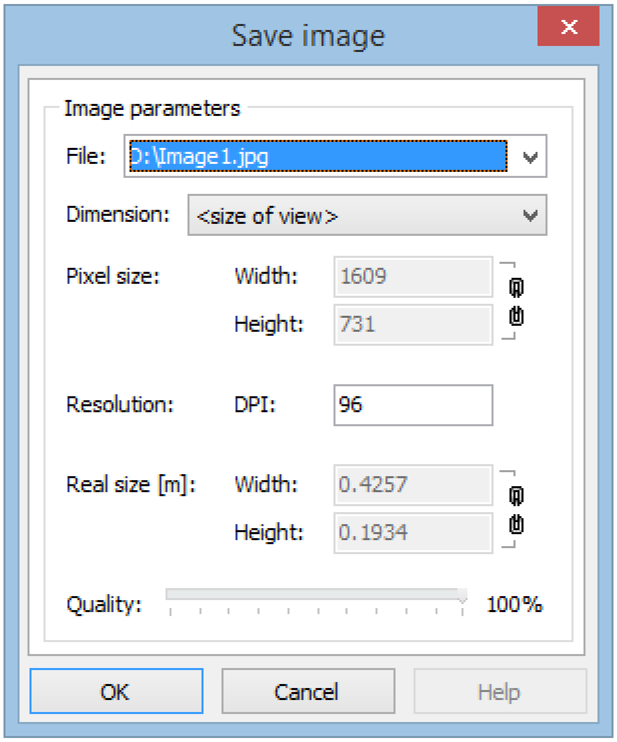
See "Data visualisation: Viewports 167".

Overlay

See "Data visualisation > 3D view > Overlays 167".

Save scene to image...

Use this function to render the current scene to an image file.



File: Filename of image file to be created. Supported image formats are **Bitmap** (.BMP) and **JPEG** (.JPG).

Dimension: "Pixel size" defines the width and height of the created image in pixels. You can either select a **predefined dimension** from the list, use the **current size of the view** window or enter **custom** width and height.

Resolution (DPI): The dots-per-inch value used to render the image (important for proper display and printing, default is 96 dpi).

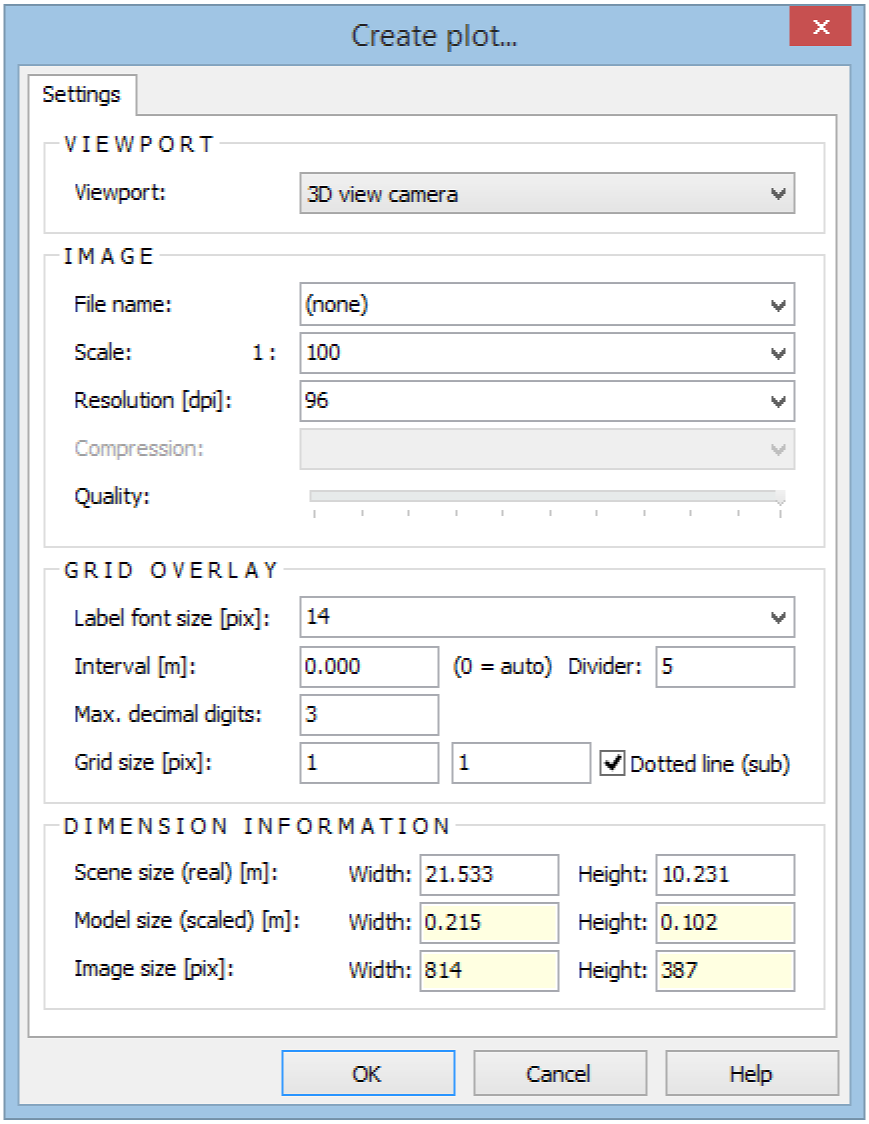
Real size: The real size of the image when displayed by a screen or a printer at scale 1:1.

Quality: This factor is only available when a JPG file should be created and defines the quality used for the compression procedure.

Note:
When "**<custom>**" is selected you have to enter the size of the image manually. You can either enter the pixel size or the real size of the image. The oposite values are calculated via the DPI factor. Use the **lock button** beside the edit fields to lock the aspect ratio.

Create plot...

This function is similar to "Save scene to image" but is only available in orthogonal view mode. The difference is that "Create plot" allows to specify the scale and resolution of the created images.



Viewport: Select "3D view camera" if you want to plot the scene as viewed within the 3D view. In addition to the "3D view camera" all plane objects from the current project (with limited width and height) are listed here. Choose a limited plane object from the list to plot the scene from the point of view of the limited plane object.

File name: Filename of the image file to be created. Supported image formats are **Bitmap** (.BMP), **JPEG** (.JPG), **TIFF** (GTIF) and **Portable Document Format** (.PDF, see notes below).

Scale: The scale of the created image as multiple of image (model) units.

Resolution (DPI): The dots-per-inch value used to render the image (important for proper display and printing, default is 96 dpi).

Quality: Defines the compression quality (only supported in JPG and PDF format). Move the handle to the right to get higher quality.

Grid overlay: Here you can define if and how a grid should be drawn on the image.

Dimension information: This section shows the size of the image expressed as:

- **Scene size:** the real size of the visualized scene. The default values are taken from the size of the 3D view window but you can change those values manually.
- **Model size:** the size of the plan (image) as defined by the scale factor (see above)
- **Image size:** the size of the image in pixels, depending on "Model size" and "Resolution"

Notes on the image size: Some image formats (eg.: JPEG) are not suitable for plotting huge images. Use the **Tagged Image File Format (*.TIF)** if you want to plot huge images instead.

Notes on PDF format: RiSCAN PRO creates a PDF file containing the image in JPEG format. The document also includes scaling information. This scaling information may be used by the "Adobe Reader" software to take distance, angle and area measurements directly in the image. However, these measurement tools must be enabled by "Adobe Acrobat Standard/Pro" software (at the moment RiSCAN PRO is not able to do this). To enable these tools, please open the generated PDF file in "Adobe Acrobat" and select "File > Save as > PDF with advanced Reader-functions > Activate comments and measurements..." from the menu. This creates a new PDF file with enabled measurement features which you can open in "Adobe Reader" and use the measurement tools on.

5.3.2 Navigation

RiSCAN PRO knows two different 3D navigation modes: "Fly mode" and "Walk mode".

Fly mode is based on a so called "pickpoint". The pickpoint defines the rotation center and the zoom direction. To set the pickpoint, click somewhere in the 3D scene with either the left, right or middle mouse button (see also tables below). The pickpoint position is determined by the nearest visible data point to the mouse position (line of sight). If no data is visible at all, the pickpoint position will remain unmodified. In **fly mode** the camera supports two different **navigation modes**:

- **Free** - In free mode the camera may be translated and rotated into all directions freely.
- **Constrained** - The constrained mode is very similar to the free mode but a little bit easier to navigate because the camera up vector is always aligned to the scene up vector.

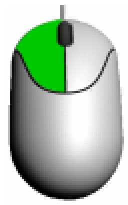
To change between Free and Constrained navigation modes for a single 3D View, open the Object Inspector, click on "Camera" and toggle the option in the "Properties" tab at the bottom.
To set either mode as a default, open the menu Tool and select Options... Within the Options... window choose 3D-Settings -> Camera settings. The parameter to change is "Navigation mode".

In **walk mode** you can navigate through the 3D scene as if you were in real scene. That means that you can turn the virtual camera left, right, up and down. You can move the camera left, right, up, down, forward and backward.

To switch between fly and walk mode you can use the corresponding button in the toolbar "3D - Control":

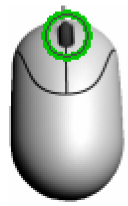
Note:
At very high zoom factors (you are very close to the model) you may observe that the virtual camera can only be moved stepwise (i.e. you can not move the virtual camera fluently).

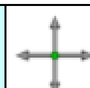
Actions with left mouse button:



Action	Key	Mouseaction	Comment
Set pickpoint		click	
Select object	S	click	The object will be marked in
Set reference point	R	click	Is used in the readout window
Define point coordinates for some operations	Shift ⇧	click	
Set center of camera	C	click	
Show information	I	click	Show some information of the point closest to the line of sight in the info window
Fly mode			
Rotate around pickpoint		hold + move	
Rotate around vertical axis	Ctrl	hold + move left/right	
Rotate around horizontal axis	Shift ⇧	hold + move up/down	
Walk mode			
Rotate camera		hold + move	
Rotate around vertical axis	Ctrl	hold + move left/right	
Rotate around horizontal axis	Shift ⇧	hold + move up/down	

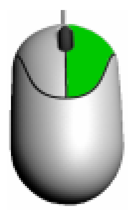
Middle mouse button and mouse wheel:



Action	Key	Mouseaction	Comment
Set pickpoint		click	
Perspective: Walk in/out Orthogonal: zoom in/out		spin mouse wheel up/down	Change position of camera Change scene scale of camera
Perspective: Zoom in/out	S	spin mouse wheel up/down	Change scene scale of camera
Increase/decrease point size	P	spin mouse wheel up/down	Changes also the line width
Pitch camera	X	spin mouse wheel up/down	The angle for rotation is defined in program settings
Turn camera	Y	spin mouse wheel up/down	
Roll camera	Z	spin mouse wheel up/down	
Fly mode			
Pan		hold + move	
Pan along horizontal axis	Ctrl	hold + move left/right	
Pan along vertical axis	Shift ⇧	hold + move up/down	

Walk mode			
Slide camera		hold + move	
Slide along horizontal axis	Ctrl	hold + move left/right	
Slide along vertical axis	Shift ⇧	hold + move up/down	
Change walk speed		spin mouse wheel up/down	

Actions with right mouse button:



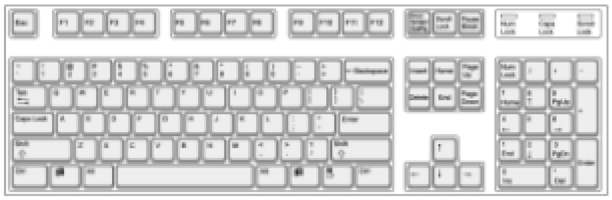
Action	Key	Mouseaction	Comment
Set pickpoint		click	
Roll camera	Shift ⇧	hold + move left/right	
Rectangle zoom	R	hold + move	Left to right → Magnification Right to left → View all
Fly mode			
Perspective: Walk in/out		hold + move up/down	Change position
Orthogonal: Zoom in/out		hold + move up/down	Change scene scale
Walk mode			
Walk forward/backward		hold + move up/down	Change position

Note:

Make sure that the mouse buttons are not swapped. To check this open the "mouse-settings" dialog and disable "Switch primary and secondary buttons".

Note:
If you are in fullscreen mode and walk mode is active the rotation is perfomed automatically when you move the mouse. To move forward/backward hold the left/right mouse button.
The cursor will also be invisible.

Actions with keyboard:



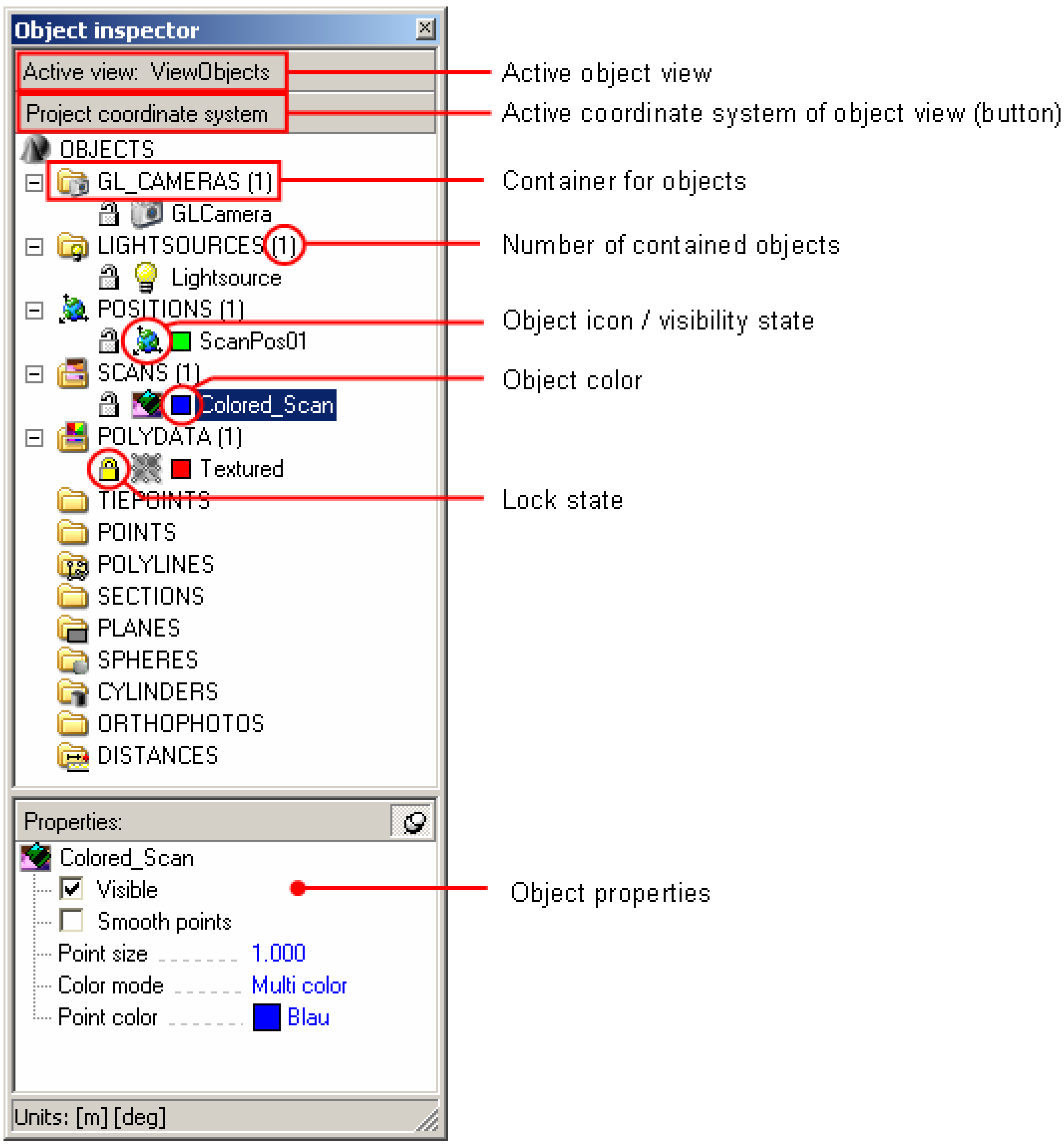
Action	Additional key	Key	Comment
Move forward/backward		↑ or ↓	
Turn around the horizontal axis	Ctrl	↑ or ↓	
Slide along the vertical axis	Shift ⇧	↑ or ↓	
Turn around the vertical axis		← or →	
Slide along the horizontal axis	Shift ⇧	← or →	
Toggle selection/view mode		Space	
Hold current pickpoint		H	Hold this key pressed during mouse click
Accelerate mouse action (eg. rotation, zoom, ...)		A	Hold this key pressed during mouse action
Slow down mouse action (eg. rotation, zoom, ...)		D	Hold this key pressed during mouse action
Fix dynamic draw mode		Alt	Hold this key pressed

5.3.3 Object inspector

The object inspector is the interface between the objects of a project (e.g. scan, polydata…) and an object view. There is only one object inspector window for the whole program. If the window is visible, it will be activated automatically if an object view gets active. To show the object inspector select "View" -> "Object inspector" from the main menu (or use the shortcut STRG + ALT + O).

With the object inspector you can manage all the objects that are displayed within an object view.
The main features are:

- add objects
- remove objects
- change object properties (visibility, color, …)
- rename 341 objects
- locate objects in the project manager (shortcut: CTRL+Enter)



The objects are arranged in special folders (containers), e.g. all scan objects are inserted into the "SCANS" folder.

Next to the folder the current amount of contained objects is displayed. To add objects to the active object view, drag and drop them to the object view window or to the object inspector. The newly added objects will be inserted into the folder structure.

Coordinate system:

To change the coordinate system click the button and select either "Scanner coordinate system", "Project coordinate system" or "Global coordinate system". If you select "Scanner coordinate system" you will be prompted to select the scan position of which you want to use the coordinate system. The coordinate system influences the data readout and the selection tool 223. It is also used when you create a new tiepoint, new sections and for the axes symbol of the object view.

Note:

When you open an object contained in a scan position in an object view the coordinate system will be automatically set to the corresponding coordinate system. Otherwise the coordinate system will be set to PRCS.

Lock state:

You can change the lock state by clicking on the lock icon. When an object is locked you can not change the properties of this object except the visibility state. It is also impossible to select or delete any data of this object.

To change the lock state of all selected objects at once press "CTRL" + "1".

Visibility state:

You can change the visibility state of an object by clicking the object icon or changing the "Visible" property. If the object is invisible the icon will be grayed.

To change the visiblity state of all selected objects at once press "CTRL" + "2".

Note:

Making an object invisible is not the same as removing it from the view. If you hide an object the object will remain loaded in the main memory. This influences the number of objects that can be displayed simultaneously and the time RiSCAN PRO needs to open a view.

Object color:

Some objects have a color property. If a color property is available it is displayed after the object icon. If you click the color icon you can switch between single color mode and multi color mode (only available for scans and polydata objects).

To change the color mode of all selected objects at once press "CTRL" + "3".

Object properties:

Every object has its own properties. These properties are displayed when you select the object. You can also select multiple objects (of same kind) and change their properties at one step.

Following objects are available:

- GLCamera 158
- Light source 159
- Position 159
- Scan 160
- Polydata 160
- Organized point cloud 162
- Tiepoint 163
- Tieobject 163
- Point 164
- Polyline 164
- Section 164

- Plane 165
- Sphere 165
- Cylinder 165
- Orthophoto 166
- Aerialview 166
- Distance 166

The table below shows the available objects and their properties. Each object type also has a specific context menu (right-click).

Common menu entries and actions:

- *Expand all*
  Expand tree structure.

- *Show all*
  Make all objects of this container visible.

- *Hide all*
  Hide all objects of this container.

- *Rename…*
  Rename 341 object.

- *Remove*
  Remove object from object view.

- *Locate in "project manager"*
  Locate and select object in project manager.

- *Unload*
  Unload the object's data without removing the object from the view.

- *Load*
  Load the object's data into memory.

- Double click the object icon in order to view the complete object in the center of the screen.

- Single clicking an object will show some additional information on the object in the info window.

GLCamera object (GL_CAMERAS):

Property	Value	Comment
Camera mode	Perspective Orthogonal	View mode of camera.
Position (X/Y/Z)	Floating point number	Position of camera.
Direction (X/Y/Z)	Floating point number	Direction vector of camera (unit vector).
Up (X/Y/Z)	Floating point number	Up vector of camera (unit vector).
Scene scale	Floating point number	Scale factor for linear zooming.
Focal length	Floating point number	Focal length of camera (mm).
Near plane	Floating point number	Near clipping plane of camera (read only).
Use auto depth	Yes No	If activated "Depth of view" is automatically calculated from the data contained in the view, otherwise this value can be manually defined.
Depth of view	Floating point number	Visual range counting from position of camera [m]

Note: Option "Use auto depth" is only available in "Perspective" camera mode.

Light source object (LIGHTSOURCES):

Property	Value	Comment
Shining	Yes	Turn on/off light source.
Direction		
Mode	Camera North-West North North-East East South-East South South-West West Custom	Select the shining direction of the light source. "Camera" means that the light source is mounted on the camera and shines towards the viewing direction. "Custom" means that the shining direction is determined via the entered "Azimuth" and "Elevation" angles. All other modes such as "North", "North-East", ... are predefined directions.
Azimuth	Floating point number	Only available when "Mode" is "Custom". Directly enter azimuth angle of the light source in angle units. Azimuth starts at north and heads over east.
Elevation	Floating point number	Only available when "Mode" is "Custom". Directly enter elevation angle of the light source in angle units. Azimuth starts on the ground and heads into the sky.

Position object (POSITIONS):

Property	Value	Comment
Visible	Yes No	Show/hide position object.
Show caption	Yes No	Show/hide position name.
Color	Color	Color of position object.
TP connection		
Visible	Yes No	Show/hide tiepoint connectivity (i.e. lines between the origin of the scanposition and used tiepoints).
Show distance	Yes No	Show/hide display of distance between scanposition and tiepoint.
Mode	TP SOCS TP SOCS (Linked) TP PRCS	SOCS tiepoints are displayed. Only SOCS having a link are displayed. Only referenced PRCS tiepoints are displayed.

- *Modify SOP…*
  Change position and orientation of position. See "Data registration: Interactive coarse registration 197"

- *Corresponding objects*
  You can perform some actions on the objects that belong to this position and which are also part of the same object view.

Scan object (SCANS):

Property	Value	Comment
Visible	Yes No	Show/hide scan object.
Smooth points	Yes No	Paint round points (looks better, but needs more time for drawing).
Point size	Floating point number	Size of points in pixel.
Color mode	Multi color Single color	In multi color mode the selected viewtype is used for coloring.
Point color	Color	Point color of scan object.

- *Change view-type…*
  Change current view-type of scan object. See "Data visualisation: Viewtypes 128"

- *Show as 2D*
  Open scan object in 2D window. The 3D view will not be closed.

- *View*
  You can set default views (such as Bird's eye view, Bottom view and so on), which only use the bounding box of the object. Thus you will not see the complete scene but only the selected object.

Polydata object (POLYDATA):

Property	Value	Comment
Visible	Yes No	Show/hide polydata object.
For point cloud:		
Visible	Yes No	Show/hide point cloud.
Smooth points	Yes No	Paint round points (looks better, but needs more time for drawing).
Color mode	Multi color Single color	In multi color mode the selected viewtype is used for coloring.
Point color	Color	This color is used in single color mode.
Point size	Floating point number	Size of points in pixel.
For triangulated surface:		
Visible	Yes No	Show/hide triangulated surface.
Smooth points	Yes No	Paint round points (looks better, but needs more time for drawing).
Color mode	Multi color Single color	In multi color mode the selected viewtype is used for coloring.
Polygon color	Color	This color is used in single color mode.
Point size	Floating point number	Size of points in pixel, used in point mode.
Line width	Floating point number	Width of line in pixel, used in wireframe mode.
Static	Polygon smooth Polygon flat Wireframe Points	Defines the static draw mode. Use polygon draw mode to paint as closed surface. For faster drawing use the point draw mode.
Dynamic	Polygon smooth Polygon flat Wireframe Points	Defines the dynamic draw mode. Use polygon draw mode to paint as closed surface. For faster drawing use the point draw mode.
Front face	Real color Single color Cull	Defines how the front face will be displayed.
Back face	Real color Single color Cull	Defines how the back face will be displayed. Select cull mode for faster drawing.
Face color	Color	This color is used in single color mode.
Wireframe overlay	None Static Dynamic Static & Dynamic	Select in which draw state the wireframe overlay should be used.
Wireframe color	Color	This color is used for the wireframe overlay.
Full wireframe overlay	Yes No	Select if also hidden parts should be overlayed.

For polylines:		
Visible	Yes No	Show/hide polylines.
Line width	Floating point number	Width of the polyline in pixel.
Node size	Floating point number	Size of the polyline nodes in pixel.
Polyline color	Color	Color of the polylines.
Node color	Color	Color of the polyline nodes.
Show nodes	Yes No	Show/hide polyline nodes
Point normals		Normal vectors of points
Visible	Yes No	Show/hide point normals.
Color	Color	Color of point normals.
Line width	Floating point number	Size of point normals in pixel.
Length	Floating point number	Length of point normals in range unit.
Poly normals		Normal vectors of triangles
Visible	Yes No	Show/hide poly normals
Color	Color	Color of poly normals.
Line width	Floating point number	Size of poly normals in pixel.
Length	Floating point number	Length of point normals in range unit.

- *Change view-type…*
  Change current view-type of polydata object. See "Data visualisation: Viewtypes 128"

- *View*
  You can set default views (such as Bird's eye view, Bottom view and so on), which only use the bounding box of the object. Thus you will not see the complete scene but only the selected object.

Organized point cloud (POINTCLOUDS):

Property	Value	Comment
Visible	Yes No	Show/hide pointcloud object.
Smooth points	Yes No	Paint round points (looks better, but needs more time for drawing).
Occlusion culling	Yes No	Hidden parts will not be rendered if this is activated.
Color mode	Multi color Single color	In multi color mode the selected viewtype is used for coloring.
Point color	Color	Point color of pointcloud.
Point size	Floating point number	Size of points in pixel.
Dynamic point size	Yes No	Indicates if the point size should be changed dynamically.
Dynamic splat size offset	Floating point number	This offset is added to the original splat size.
Use LOD	Yes No	This activates the level of detail calculation.
LOD factor	Floating point number	Used for level of detail calculation.

- *Change view-type…*
  Change current view-type of polydata object. See "Data visualisation: Viewtypes 128"

- *View*
  You can set default views (such as Bird's eye view, Bottom view and so on), which only use the bounding box of the object. Thus you will not see the complete scene but only the selected object.

Note: If **dynamic point size** is activated the point's size depends on the current viewport and the splat size parameter used to gererate the organized point cloud. You can adjust the splat size value of the point cloud with the **Dynamic splat size offset**.

Tiepoint object (TIEPOINTS):

Property	Value	Comment
Visible	Yes No	Show/hide tiepoint object.
Show caption	Yes No	Show/hide tiepoint name.
Draw mode	Point Reflector type	Draw mode for tiepoint object.
Point size	Integer between 1 and 20	Size of point in pixel. Is used in point draw mode.
Color	Color	Color of tiepoint object.

Tieobject (TIEOBJECTS):

Property	Value	Comment
Visible	Yes No	Show/hide tieobject.
Show caption	Yes No	Show/hide tieobject name.
Draw mode	Fill Line	Draw mode for tieobject.
Line width	Floating point number	Size of line in pixel. Is used in line draw mode.
Color	Color	Color of tieobject.

Point object (POINTS):

Property	Value	Comment
Visible	Yes No	Show/hide point object.
Show caption	Yes No	Show/hide point caption.
Position (X/Y/Z)	Floating point number	Position of point object.
Size	Floating point number	Size of point in pixel.
Color	Color	Color of point object.

Polyline object (POLYLINES):

Property	Value	Comment
Visible	Yes No	Show/hide polyline object.
Line width	Floating point number	Width of line in pixel.
Node size	Floating point number	Size of nodes in pixel.
Polyline color	Color	Color of polyline object.
Node color	Color	Color of polyline nodes.
Show nodes	Yes No	Show/hide polyline nodes.

- *View*
  You can set default views (such as Bird's eye view, Bottom view and so on), which only use the bounding box of the object. Thus you will not see the complete scene but only the selected object.

Section object (SECTIONS):

Property	Value	Comment
Visible	Yes No	Show/hide section object.
Draw mode	Line Points	Draw mode for section object.
Size	Floating point number	Size of section in pixel.
Color	Color	Color of section object.

- *View*

You can set default views (such as Bird's eye view, Bottom view and so on), which only use the bounding box of the object. Thus you will not see the complete scene but only the selected object.

Plane object (PLANES):

Property	Value	Comment
Visible	Yes No	Show/hide plane object.
Surface color	Color	Color of plane object.
Origin (X/Y/Z)	Floating point number	Position of plane object.
Direction (X/Y/Z)	Floating point number	Direction vector of plane object (unit vector).
Up (X/Y/Z)	Floating point number	Up vector of plane object (unit vector).
Width	Floating point number	Width of plane object.
Height	Floating point number	Height of plane object.
Draw mode	Fill Raster Border	Draw mode of plane object.

- *Modify…*
  Change position and orientation of plane object. This is described in the chapter "Interactive coarse registration 197". The same dialog is applicable for planes.

- *Invert plane normal*
  Invert normal vector of the plane object (i.e. rotation by 180° deg).

- *Calculate volume & surface area*
  See "Data postprocessing: Measure volume and surface 300"

Sphere object (SPHERES):

Property	Value	Comment
Visible	Yes No	Show/hide sphere object.
Radius	Floating point number	Radius of sphere object.
Position (X/Y/Z)	Floating point number	Position of sphere object.
Surface color	Color	Color of sphere object.

Cylinder object (CYLINDERS):

Property	Value	Comment
Visible	Yes No	Show/hide cylinder object.
Height	Floating point number	Height of cylinder object.
Radius	Floating point number	Radius of cylinder object.
Position (X/Y/Z)	Floating point number	Position of sphere object.
Up (X/Y/Z)	Floating point number	Up vector of cylinder object (unit vector).
Surface color	Color	Color of cylinder object.

Orthophoto object (ORTHOPHOTOS):

Property	Value	Comment
Visible	Yes No	Show/hide orthophoto object.
Draw style	Plane Points	Draw mode of orthophoto object.
Point size	Floating point number	Size of points in pixel. Is used in point draw mode.

Aerialview object (ORTHOPHOTOS):

Property	Value	Comment
Visible	Yes No	Show/hide aerialview object.
Origin (X/Y/Z)	Floating point number	Position of aerialview object.
Direction (X/Y/Z)	Floating point number	Direction vector of aerialview object (unit vector).
Up (X/Y/Z)	Floating point number	Up vector of aerialview object (unit vector).
Width	Floating point number	Width of aerialview object (read only).
Height	Floating point number	Height of aerialview object (read only).
Back face	Image Cull	Back face draw mode.
Interpolation	Yes No	The image will be interpolated.

- *Modify…*
  Change position and orientation of aerialview object. This is described in the chapter "Interactive coarse registration 197". The same dialog is applicable on aerial views.

Distance object (DISTANCES):

Property	Value	Comment
Visible	Yes No	Show/hide distance object.
Start point (X/Y/Z)	Floating point number	First point of distance.
End point (X/Y/Z)	Floating point number	Second point of distance.
Line width	Floating point number	Width of line in pixel.
Point size	Floating point number	Size of points in pixel.
Line color	Color	Color of distance object.
Point color	Color	Color of points.

Note:
Distance objects can only be created in an object view.
You can also display them only in that object view.

5.3.4 Toolbars

3D - Control

Icons and menus described from left to right:

- **General settings** - Opens the general settings dialog. For more information see "Object view 145".
- **Popup menu** - Shows the popup menu.
- **Select default view** - Select one of the default views

View	View plane	Direction	Up
Bird's eye view	x-y plane	-z vector	+y vector
Bottom view	x-y plane	+z vector	-y vector
Front view	y-z plane	-x vector	+z vector
Back view	y-z plane	+x vector	+z vector
Left view	x-z plane	+y vector	+z vector
Right view	x-z plane	-y vector	+z vector

- **Custom view**
  With that tool you can set the position and orientation of the virtual camera by defining two points. The first point is the position of the camera and the second point defines the orientation of the camera ("look at").
- **View all** - View the whole scene. The orientation of the camera is not changed.
- **Fullscreen mode** - Switch current object view to fullscreen mode.
- **Walk mode** - see Data visualisation > 3D view > Navigation 151

The other toolbars are described in the corresponding chapters.

5.3.5 Viewports

A viewport is a particular position and orientation within a 3D view such as the standard viewports (Bird's eye view, Bottom view, Front view, Back view, Left view, Right view and Scanner view).

Add a viewport

You can easily save your own viewports in the folder "VIEWPORTS" within the project.
To do so right-click into the object view window and select "Viewport -> Save". A window appears which shows a summary of the parameters of the virtual camera. Click the button "OK" to save the viewport.

Edit a viewport

Double-click the viewport in the project-tree (window project-manager). This will open the viewport-dialog where you can edit the position, orientation, focus and the mode of the viewport.

Load a viewport

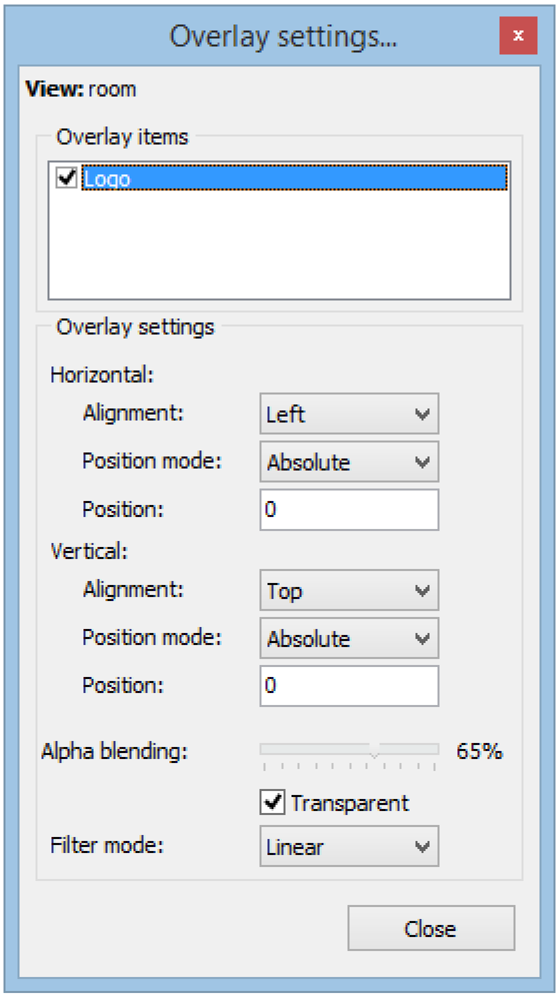
To restore a previously saved viewport, right-click into an object view and select "Viewport -> Load" from the menu or drag and drop it into an object view. The virtual camera of the view will be set to position saved in the viewport.

5.3.6 Overlays

Overlays can be used within an object view for presentations. Overlays are stored in the project manager under the "COLLECTIONS / OVERLAYS" folder.

To use an existing overlay as the default logo for new 3D views perform a right click on the overlay in the project manager and select "Default". The logo will only be visible if the option Display the "Default" overlay automatically in new 3D views 38 is checked.

Click "Overlay / Edit" in the object view popup menu in order to create a new overlay. You can also drag & drop an existing overlay directly into an object view.
Following dialog appears:



In this dialog you can see the items (images) of the overlay. To add a new item to the overlay drag any image from the project manager and drop it onto the box "Overlay items". When you select an item, its properties are displayed.
To place an item select the **alignment** (left, center, right / top, center, bottom) and the position. The position is defined through the **position mode** (absolute, relative) and the **position value**. The meaning of the position value depends on the position mode and the alignment (see example below).
With **Alpha blending** you can control the translucency of the item. If you active the option **Transparent**, the upper left pixel of the image will be used as transparent color. That means, that all pixels with this color will not be displayed.

Example:
Alignment = Right
Position mode = Absolute
Position = 10

In this example the distance between the right item border and the right window border is 10 pixels.

To edit an existing overlay in an object view right-click into the view and select "Overlay / Edit"; to remove an overlay from an object view select "Overlay / Remove".

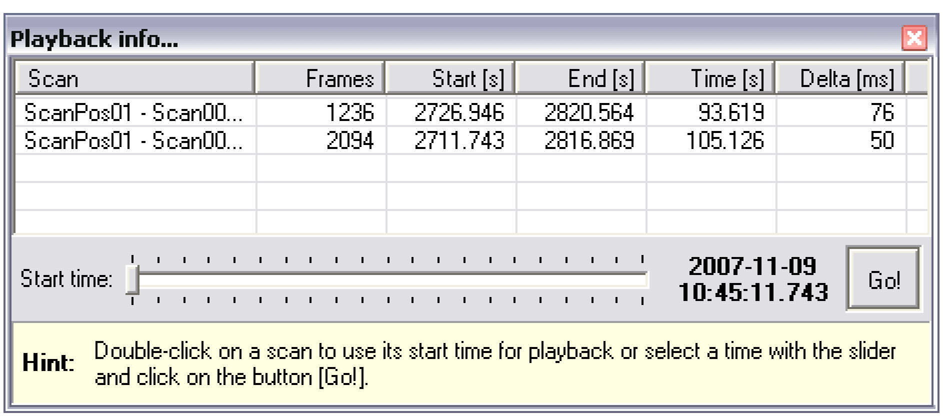
5.3.7 Scansequence play back

RiSCAN PRO offers a tool to play back scan sequences after data acquisition in the 3D view (object view). The tool can be used with one or more scan sequences, whereas one scan can be a sequence of line scans or even a sequence of frames containing more than one scan line.

To use this tool please follow these steps:

1. Create or open a 3D view (object view) window.
2. Load one or more scan sequences into the view.
3. Select all desired scan sequences in the object inspector window, right-click on them and select "Playback..." from the menu. The following tool window appears:

4. Specify the start time of the play back in the field "Start at [s]". This is the offset counting from the time epoch defined in the project settings 42. To make the definition of this offset more convenient, you can click the blue button in front of the field, which opens following window:

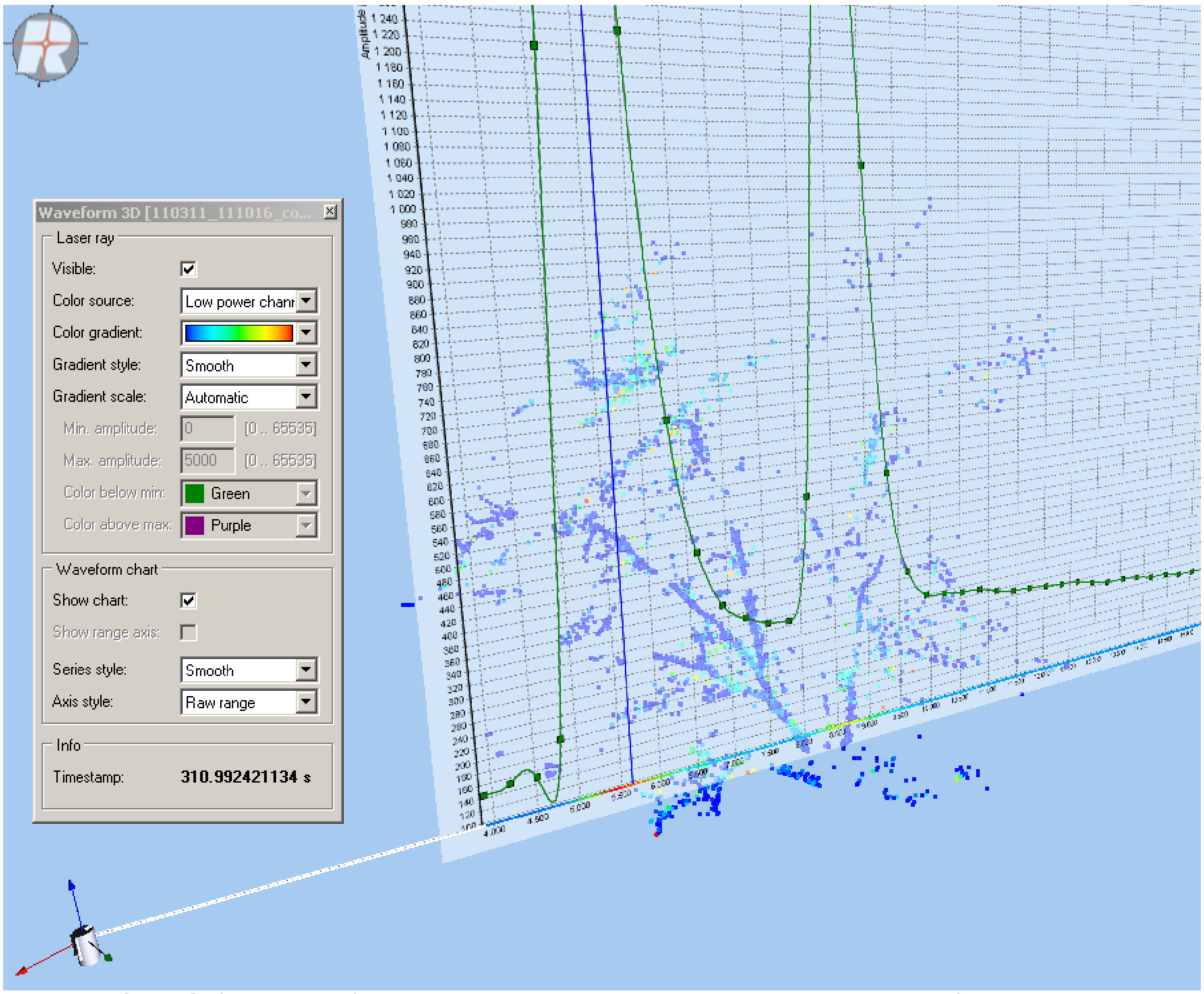


This window shows a list of all scan sequences that you selected previously. For each scan sequence the number of frames, start time, stop time, duration time and time between two frames ("Delta") is displayed. To start the playback at the same time as a scan sequence begins, just double click the scan sequence in the list. To select any other start time, use the slider "Start time" and click the button "Go!" to confirm the selected start time.

5. Specify the step width in seconds. This defines the time difference between two consecutive steps.
6. Define the play speed factor. A factor of 1 will play the scan sequence in real time. Factors higher than 2 will speed up the play back, values between 0 and 1 will slow down the play back.
7. Finally click "Play" to start the play back. RiSCAN PRO will now load the frame of each scan sequence that fits the start time and will then step to the next time stamp periodically. At each step the 3D view is updated and the current time is displayed.

5.3.8 Waveform 3D

The Waveform 3D tool shows the acquired waveform sample data of a point directly within the 3D view.



Hold down [Ctrl] + [Shift] + [W] and left click on a data point in the 3D view in order to execute the Waveform 3D tool and show the waveform of the clicked data point in the 3D view.

Procedures

1. Open a 3D view and drop in scan data acquired by a V-Line scanner.
2. Hold down [Ctrl] + [Shift] + [W] and left click on a data point in order to show the acquired waveform for that point directly in the 3D view.

Parameter description

Laser ray

The laser ray is visualized by a tube that starts at the theoretical laser origin, and heads through the clicked data point. The diameter of the laser ray tube at the theoretical laser origin is given by the beam exit diameter and increases accordingly to the beam divergence of the real laser module in the scanner. The theoretical laser origin is not identical to the origin of the SOCS! The color of the laser ray is given by linear scaling the sample values along the laser ray into an adjustable color space.

- **Visible:**
  Tick in order to show/hide the laser ray visualization in the 3D view.

- **Color source:**
  The color source property determines which Analog Digital Converter (ADC) channel of the scanner is used as a data source for laser ray coloring.

  - **Low power channel**

  - **High poser channel**

- **Color gradient:**
  Select a color space that is used for laser ray coloring.

- **Gradient style:**

  - **Flat**
    The laser ray color is constant along one sample interval along the laser ray.

  - **Smooth**
    The laser ray color is linear interpolated between two consecutive sample intervals along the laser ray.

- **Gradient scale:**
  In order to determine a sample interval color the raw sample amplitude for this interval is mapped into the the range from 0 to 1 which is then mapped on the current color gradient. To transform the raw amplitude value to the range from 0 to 1 the minimum and maximum raw amplitude values need to be known.

  - **Automatic**
    The minimum and the maximum raw amplitude values of all samples along the laser ray are calculated automatically and afterwards used as reference values for color mapping.

  - **Fixed**
    Use fixed minimum and the maximum raw amplitude values for color mapping.

- **Min. amplitude:**
  Only available if "Gradient scale" is "Fixed". Enter a custom minimum raw amplitude value. Sample intervals with raw amplitude values below that value will be colored with "Color below min".

- **Max. amplitude:**
  Only available if "Gradient scale" is "Fixed". Enter a custom maximum raw amplitude value. Sample intervals with raw amplitude values above that value will be colored with "Color above min".

- **Color below min:**
  Only available if "Gradient scale" is "Fixed". Select a color that is applied to sample intervals with raw amplitude values below "Min. amplitude".

- **Color above max:**
  Only available if "Gradient scale" is "Fixed". Select a color that is applied to sample intervals with raw amplitude values above "Max. amplitude".

Waveform chart

- **Show chart:**
  Tick in order to show a sample block chart along the laser ray in the 3D view.

- **Show range axis:**
  Only available if "Show chart" is deactivated. Tick in order to show a labeled raw range axis below the laser ray.

- **Series style:**

  - **Points**
    Each sample value is represented by one point in the sample block chart.

  - **Linear interpolation**
    Two consecutive sample values are connected by a line in the sample block chart.

  - **Smooth**
    Sample values are connected by a smooth line which has absolutely nothing to do with the actual waveform returned by the laser pulse.

- **Axis style:**

  - **Timestamp**
    The range axis is labeled with timestamp values.

  - **Raw range**
    The range axis is labeled with raw range values. Raw range means the range measured from the theoretical laser origin.

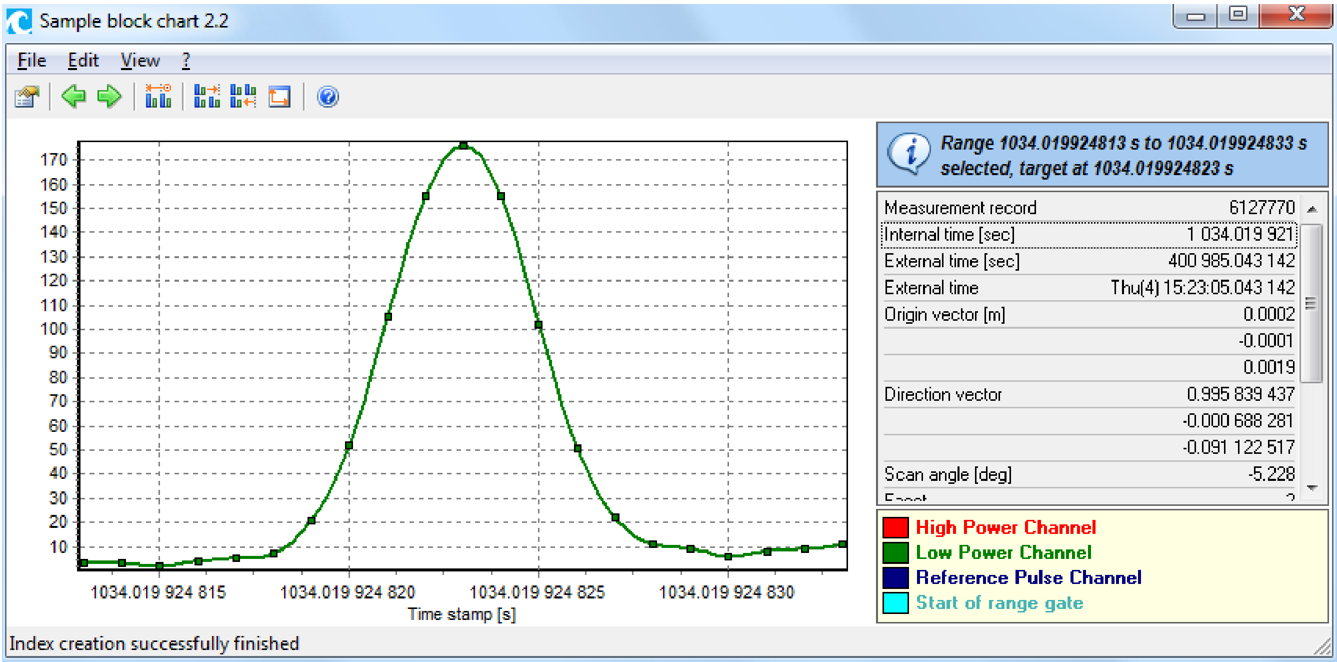
  - **Range gate index**
    The range axis is labeled with range gate index values.

Info

- **Timestamp:**
  Shows the timestamp value of the clicked point that is currently shown within the Waveform 3D tool.

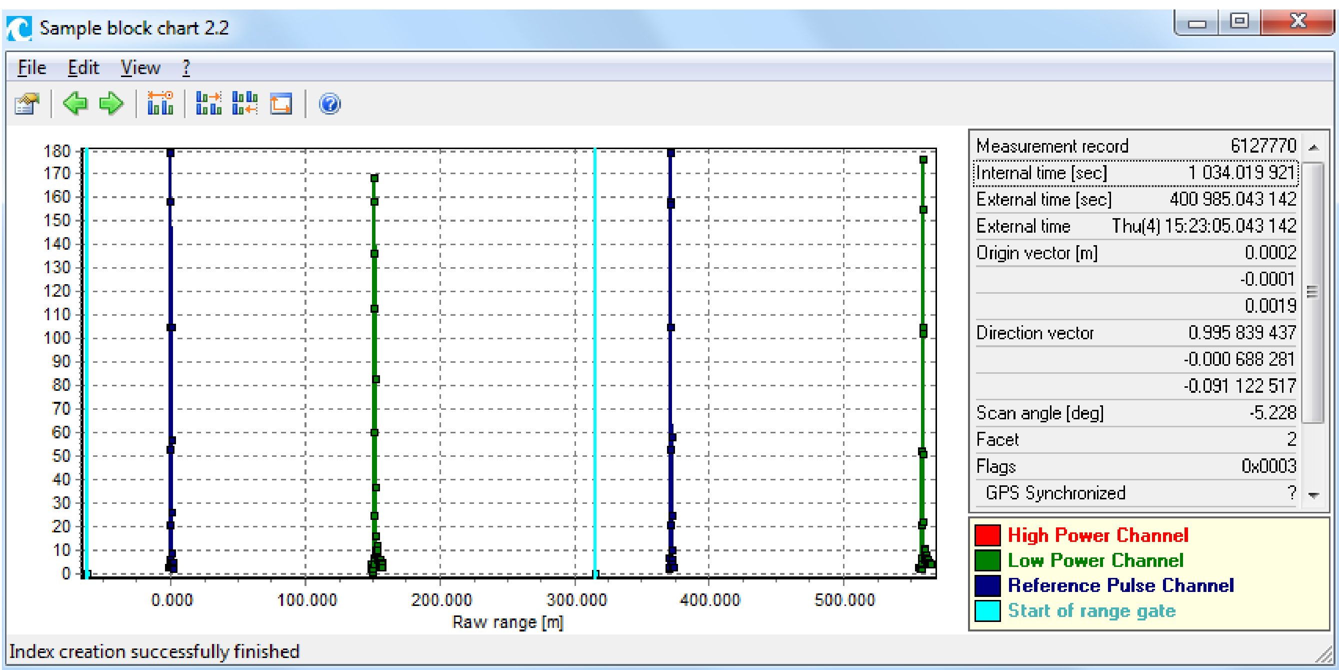
5.3.9 SampleBlockChart

The SampleBlockChart plugin allows to view waveforms of a scan. Hold Shift+W and left-click a point in the 3D view to open the SampleBlockChart window:



Note that only the waveform of the clicked point is shown!

By clicking all samples of the corresponding shot can be shown:



Use and to navigate the waveforms shot-by-shot.
Buttons and increment and decrement the number of successive measurement intervals to be shown.

Axis X can be configured to show:
- Time stamp [sec]: Time stamps of samples relative to SORG (Start Of Range Gate) of laser shot.
- Raw range [m]: Calculated distance of sample relative to first reference pulse.

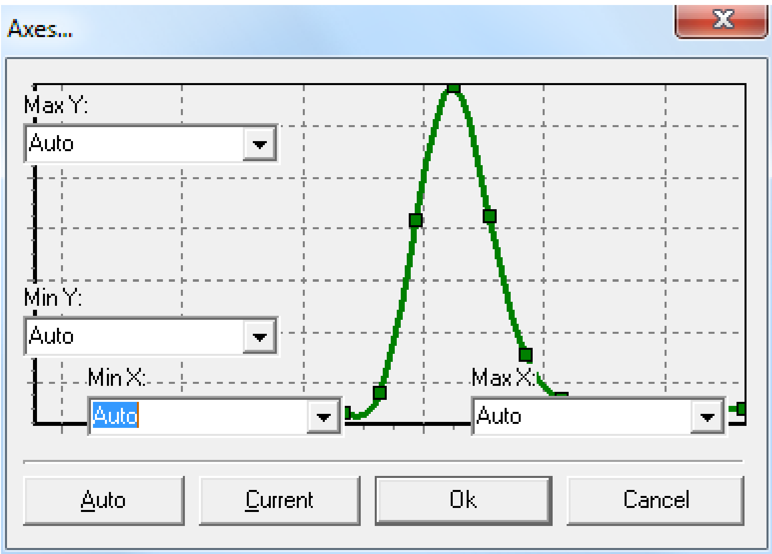
- Range gate index: Sample index relative to SORG (Start Of Range Gate) of laser shot.

Axis Y always shows amplitude values of samples.

Zooming and panning:

- Press the left mouse button to span a rectangle from left to right in order to zoom in. Span the rectangle from right to left to zoom out to view all available data.
- Press the right mouse button to pan the chart area.

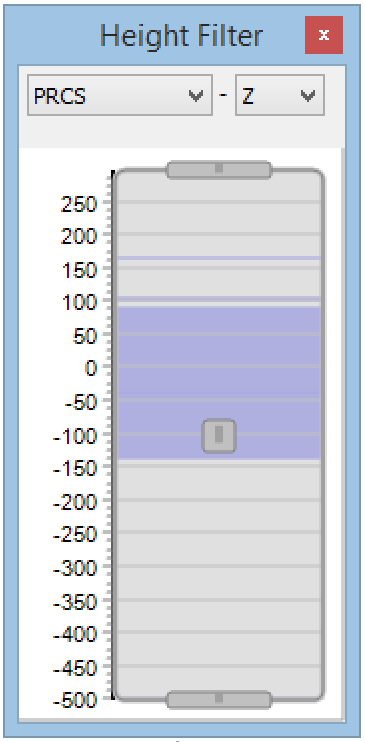
Use  to configure scaling (minimum and maximum) of axis X and Y:



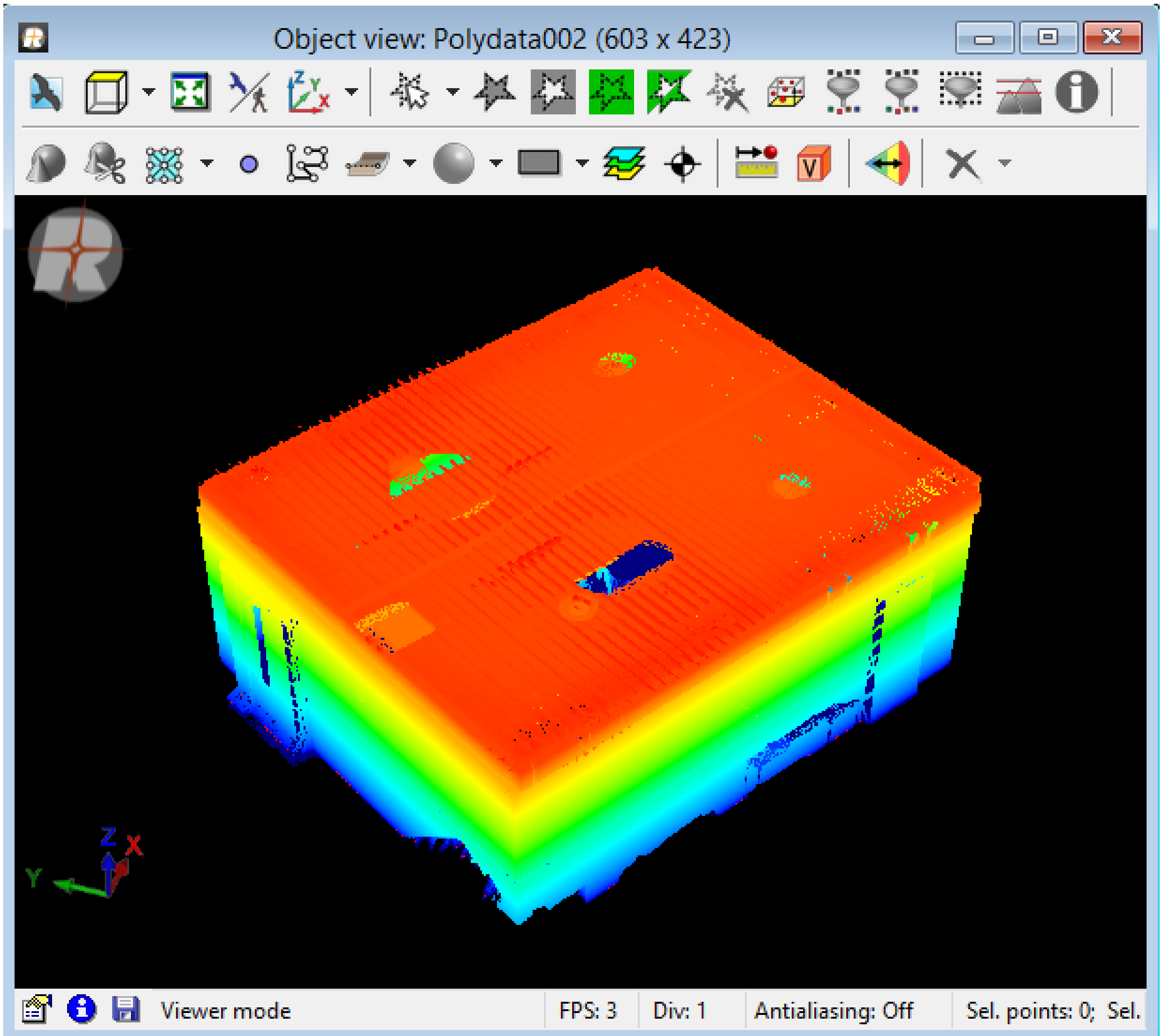
Click "Auto" to select auto scaling for minimum and maximum of all axes.
Click "Current" to show the values of current region zoomed/selected.

5.3.10 Height filter

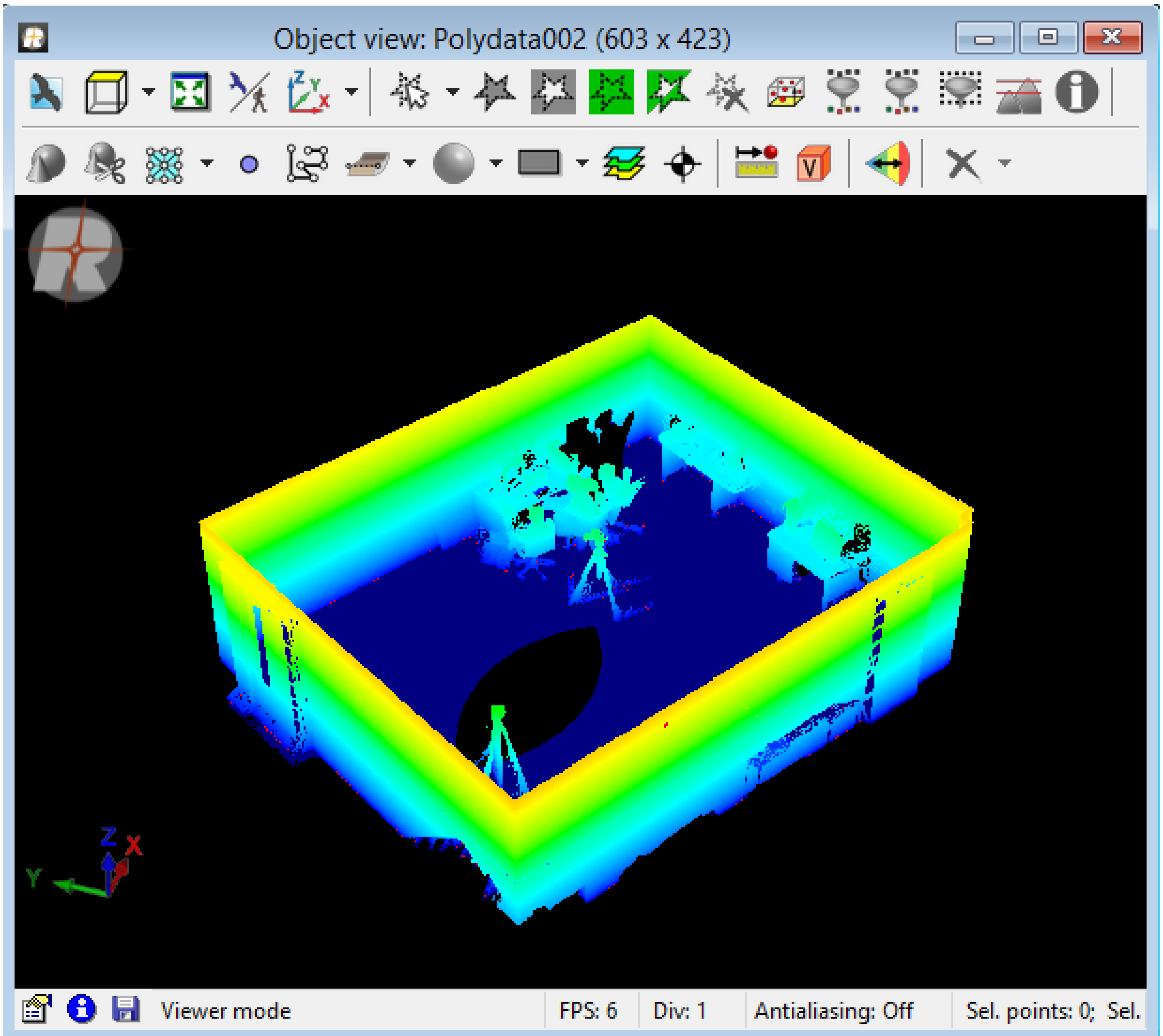
The height filter tool can be used to constrain the 3D pointcloud by moving two virtual planes along a configurable axis in a configurable coordinate system. Points that are between the two planes will remain visible all other points will be hidden.



Height filter tool



3D scene without height filter tool



3D scene with height filter to clip ceiling

Usage of the height filter tool

1. Open/create an object view 144 and add the desired objects to the view.

2. Start the height filter tool by pressing the button  in the toolbar.
As soon as the height filter tool comes up, it starts to analyse the pointcloud data in the 3D view. Once this is done the tool window will show the distribution of the 3D data points along the selected axis in the selected coordinate system. The vertical axis of the diagram shows the distance along the selected axis to the coordinate system origin. Areas for which 3D points are available are colored in blue. The darker the blue area, the more data points are within the area. White areas do not contain any data points at all.

3. Select a reference coordinate system and a reference axis.
The list of reference coordinate system will contain the PRCS, GLCS, all scan position coordinate systems of the project and all user created plane objects of the project. For example if you select PRCS as a reference coordinate system and Z as a reference axis then the diagram will show the height distribution of all data points in the PRCS.

4. The gray handles in the diagram indicate the position of the lower and the upper clipping plane. Only points that are above the lower handle and below the upper handle will be visible in the 3D view. Simply drag and drop the handles with the left mouse button to change their vertical position in the diagram. Drag and drop the center handle to move the lower and the upper handle simultaneously.

Diagram navigation

- Drag and drop the horizontal handles with the left mouse button to change clipping plane position.
- Zoom in and out by spinning the mouse wheel.
- Reset to full extents by clicking with the right mouse button into the diagram.
- Uses the left mouse button to scroll the diagram area vertically.

5.4 Panorama view

This view provides a simplified representation of an scan object.

Navigation:

- Turn virtual camera
  - Press left mouse button and move the mouse
  - Use the arrow keys of your keyboard

- Change field of view
  - Turn the mouse wheel
  - Press the "CTRL" key + "Up" or "Down" key

- Reset attributes of virtual camera
  - Double click in the view (except on a scan position)
  - Press "SPACE" key

If the project contains more than one scan position, all other positions will be displayed. You can navigate through the different positions by double click it in the view. A position is colored red, if it is hidden by scan data. When you move the mouse cursor above a position, you will see the name of this position and its distance from the current position.

In order to use this view you have to prepare a panoramic data set for the desired scan object.

5.5 Readout window

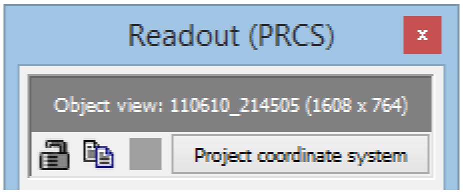
- **Readout window**

  If a view (2D, 3D, or object view) is open and you move the mouse-cursor in that view, this window will provide information about the data underneath the cursor, such as coordinates, amplitude, reflectance, color etc. The style of the readout window may differ between 2D-, 3D- or Object-View windows and depends on the available data.

  To display the readout window select "View" - "Data readout" from the main menu, press CTRL+Alt+D or press the button "Show Data readout window" from the menu ( ). It is also possible to display more than one readout window for different coordinate systems. All these readout windows will show the coordinates of the same point but transformed into different coordinate systems.

  Possible data sections of the data readout window follow below. Text in brackets describes when the section will be available.

- **Head** *(always visible)*



The head of the readout window displays the name of the view underneath the mouse cursor in the first two lines.

With the lock button (left button) you can lock the data of the readout window (data is not updated when you move the mouse). You can also lock the data by holding down the [CTRL]-key while you move the mouse.

With the copy button (second button from left) you can copy the data of the readout window into the clipboard (e.g. for further usage in MS Excel).

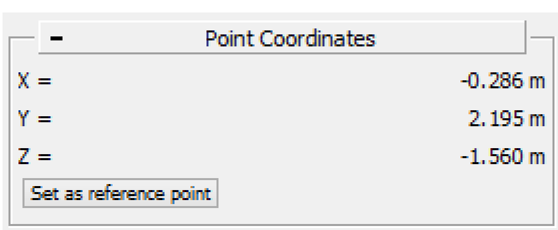
Note:
Only data of visible (expanded) sections will be copied. This gives you the chance to control what data is copied to the clipboard.

With the coordinate system button (the right button) you can modify the coordinate system in which the point coordinates and vectors should be displayed.

Note:
"Scanner coordinate system" (SOCS) is only available if the data was transmitted by either a 2D-View (scan or image) or an object view with a SOCS defined as base coordinate system.

- **Cartesian coordinates** *(2D & 3D scan, object view, 2D image with activated drawing plane)*

This section shows the cartesian coordinates of the point underneath the mouse cursor in the defined coordinate system (see section "Head 179").
The button [Set as reference point] enables you to uses the current coordinates for the reference point. This enables the section "Reference point 181".
You can also define a reference point directly in the view by pressing the key [R] and clicking on the data point.



Note: Coordinates coming from a 3D view are only approximate coordinates and should not be used for high precision measurement!

- **Polar coordinates** *(everytime cartesian coordinates are available and SOCS is selected)*

This section shows the polar coordinates of the current data in the order (Range, Theta, Phi). Phi angle (azimuthal angle) is the rotation about the z axis of the scanner. Theta angle (polar angle) is the angle between the zenith direction (positive Z axis of the scanner) and the laser ray.

- **WGS84** *(everytime cartesian coordinate are available and GLCS is selected)*

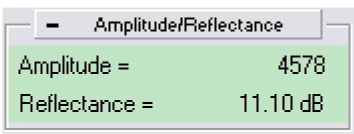
  This sections shows the coordinates as geographical longitude, latitude and height.
  Note: This section is only available when "Global coordinate system" is selected and your used global coordinate system is defined by means of (D)GPS.

- **Frame coords** *(2D scan and image)*

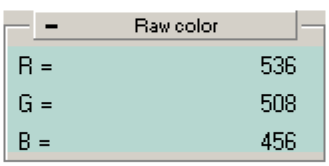
  This section shows the 2D coordinates u and v (column and row) within the 2D view of a scan or an image. u increases from left to right, v increases from top to bottom.

- **Amplitude and Reflectance** *(2D scan)*

  This sections shows the amplitude and reflectance (only for V-Line Laser Scanners) of the current measurement. The amplitude display can be scaled either 0..1, 0..255 or 0..65535. Reflectance is always in dB, whereas whereas 0 dB refers to an absolute white target which is aligned normal to the laser beam and is larger than the laser beam footprint (see chapter "Program settings 28" for details).



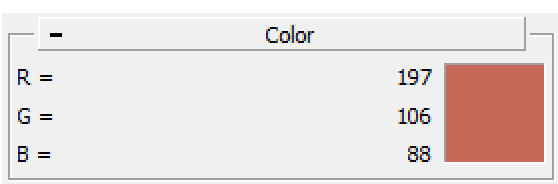
- **Raw color** *(2D scan, colored)*



  This section shows the components red, green and blue of the raw color of the measurement underneath the mouse cursor. The values can be displayed either from 0..1, 0..255 or 0..65535 (see chapter "Program settings 28" for details).

  Note: The raw color information of the scan file may be filled either by the instrument (if it has an built-in optional color channel) or by the function "color from images".

- **Color** *(Any view)*



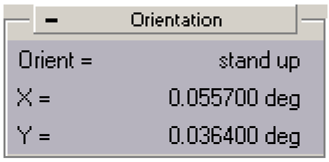
  This section shows the components red, green and blue of the color of the pixel underneath the mouse cursor (allways scaled from 0..255).

- **Timestamp** *(2D scan)*

  This section shows the time when the measurement was acquired. By default the time is displayed as an offset in seconds from a certain time (so called "Epoch", see Project settings 42). You can also switch to a display of the absolute date and time. To do so move the mouse over the timestamp value (the mouse cursor changes to a hand symbol) and left-click.

- **Orientation** *(2D scan, acquired with an instrument with built-in inclination sensors 92)*

  This section shows the coarse alignment of the instrument and the rotation around the X (or Z respectively) and the Y axes.

  The line "Orient =" shows the coarse alignment of the instrument. The value may be one of "stand up", "lay back", "top down", "lay front", "unknown". For more details please refer to chapter Inclination sensors 93.

- **Camera center** *(2D image)*

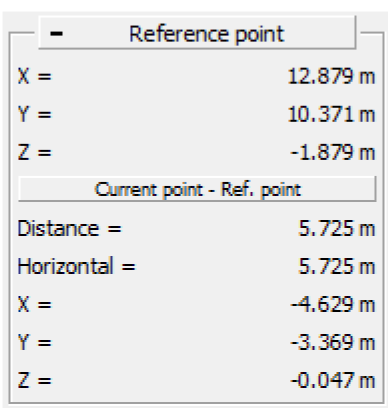
  This sections shows the center of the digital camera which has acquired the image.

- **Direction vector** *(2D image)*

  This section shows the vector of the ray defined by the mouse. In other words: if you move the mouse over an image you define a direction and the vector of this direction is displayed.

- **Reference point** *(everytime cartesian coordinates are available)*

  This section can be used for quick distance measurements in any view and even between different views.

  X, Y, Z are the coordinates of the reference point
  Distance is the distance between the current point and the reference point
  Horizontal is the horizontal part of the distance (in the x-y plane)
  dX, dY, dZ are the differences between the current point and reference point in all three coordinate axes

  There are two different ways to define a reference point:

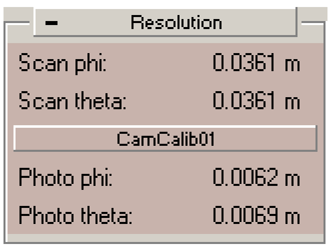
  1. Move the mouse over the point of interest.
     Press and hold the [CTRL] key (this will lock the data in the data readout window).
     Press the button [Set as reference point] in the Cartesian coordinates 179 section.

2. Move the mouse over the point of interest.
   Press and hold the [R] key while clicking with the left mouse button on the point.

- **Resolution** *(everytime cartesian coordinates are available)*

  This section shows the resolution of the scan (=distance between two measurements) at the distance of the current point. Analog to a scan it will also display the size of a pixel of an image when a default camera calibration is selected.

  Everytime new cartesian coordinates are available the scan/photo resolution is calculated from the angular scan/photo resolution and the measurement range.



  In the line between scan and photo resolution the name of the default camera calibration (the basis for the calculation of photo phi & theta) is displayed. To change the default camera calibration right click any camera calibration and select "Default" from the menu.

5.6 Tiepoint display window

The tiepoint display window is a tool window which offers the possibility to manage the tiepoint list and their tiepoints displayed in a 2D view. Herefor this window shows a tree view showing all tiepoints displayed in the currently active 2D view.

To display a tiepointlist in the 2D view you can either use the corresponding menu (see 2D View: General 129) or you just drag the tiepoint list from the project manager and drop it onto the tiepoint display window.

To **show or hide a tiepoint** quickly, click the magnifying glass in front of the tiepoint.

To **show or hide all tiepoints of a certain tiepoint list**, click the icon in front of the tiepointlist.

To **remove a tiepoint list** from the 2D view right-click the tiepoint list in the tiepoint display window and select "Remove" from the menu.

5.7 Image browser window

The image browser window offers a quick way to view thumbnails of all images contained in a project. You can find the image browser in the menu "View" of the RiSCAN PRO main window.

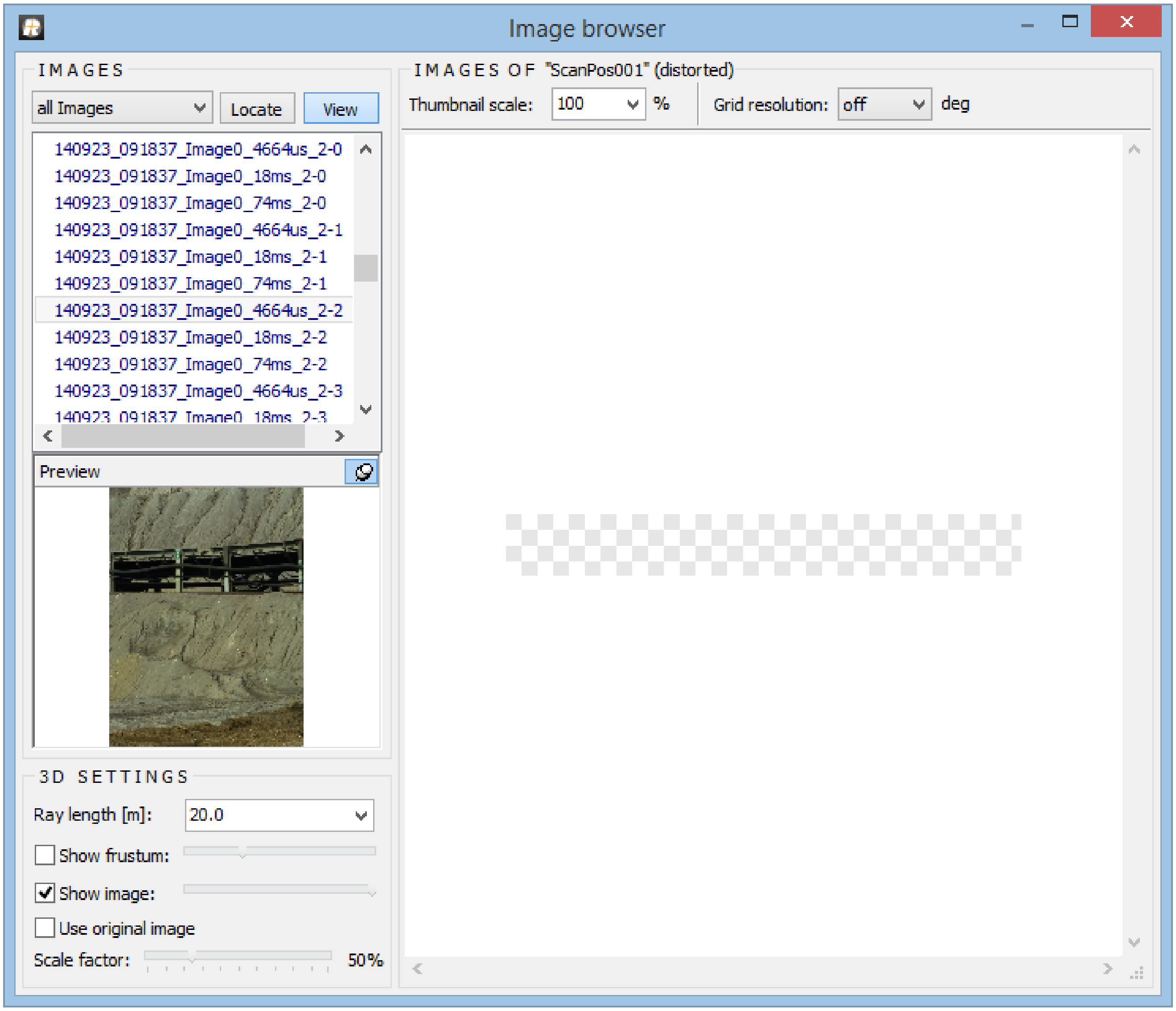


Image type filter

At the top of the window you can select which type of images should be displayed: "distorted images", "undistorted images" or "all images". The names of distorted images will be displayed in blue color. Undistorted images will be displayed in black color.

Image list & preview

The middle part of the window shows a list of all images grouped by scan positions. The preview will show the thumbnail of the currently selected image.

3D settings

This section only comes into affect if an object view is open. If an object view is open and an image is selected in the image browser, the image is displayed in the 3D view. This is done by drawing four lines representing the field of view of the camera. The length of these lines is set by **Ray length**. The image itself is projected onto a plane which is normal to the center ray of the image. The distance between plane and camera origin can be adjusted with the slider next to "**Show image**". This is a factor from 0% to 100% of "ray length". The four lines

can be connected by a **funnel** in order to make the orientation of the image more recognizable.
Normally the thumbnail of the image rather than the image is displayed. This makes the display faster. To change this, activate the option **Use original image**. Then the original image will be displayed in the object view scaled according to the selected **Scale factor**.

5.8 Demo Mode

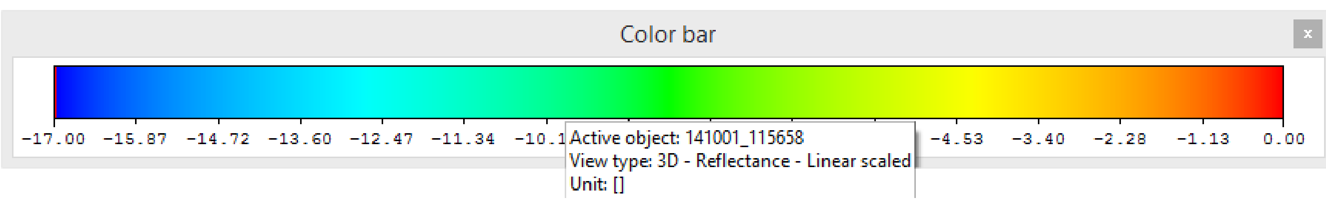
With the demo mode of RiSCAN PRO it's possible to create interactive demonstrations of both already acquired (postprocessed) data and online acquired data (point clouds) combined in one 3d view.

To activate demo mode you need to create a configuration file (File extension: RCF). This file defines which project to load, which 3D view to open, how to acquire online data and how to display the data.
In demo mode the 3D view offers an alternative navigation where the user can rotate the scene by moving the mouse (no key has to be pressed). If the mouse is not moved for a certain period of time an automatic animation is started (also defined by this configuration file). The animation can also be started by pressing the left mouse-button. By pressing the right mouse-button and moving the mouse you can move the virtual camera to (or away from) the rotation center ("zoom").

A template configuration file (Demo.rcf) is located in the program folder of RiSCAN PRO. This file contains a detailed description of all settings needed for demo mode.
To start RiSCAN PRO in demo mode just start the program with the name of the RCF file given as command line parameter (It's recommended to create a file link which does this job for you).

5.9 Color Bar

The color bar (or color legend) can be used together with scans or polydata objects in a 2D or 3D view while they are displayed in false color or amplitude color mode (except amplitude histogram).
To display the color bar select menu "**View** > **Color Bar**". The color bar will appear blank. The following two sections describe how to fill the bar with data.



Color bar and 2D views: To use the color bar with a scan displayed in a 2D window just right-click somewhere in the 2D view and select "**Update color bar**" from the menu.

Color bar and 3D views: To use the color bar with objects contained in a 3D window (object view) just right-click the desired object in the object inspector and select "**Update color bar**" from the menu.

NOTE: Whenever you change the viewtype you have to use "Update color bar" again to update the values of the color bar.

You can also resize the color bar window in order to get a bigger or smaller color bar. The color bar will be aligned horizontally or vertically.
Right-click the color bar to enter the menu:

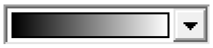
- **Bottom/Left --> Top/Right**
  Check this option to switch the draw direction (switch min and max values, i.e. draw from left to right or vice versa and draw from top to bottom or vice versa).

- **Save to file...**

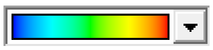
Use this option to save the current color bar including the values to an image file.

Color Tables

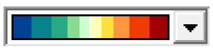
RiSCAN PRO offers a series of built in color tables for 2D/3D visualization such as:



Grayscale



Rainbow



Discrete

In addition to the built in color tables, user defined color tables will be loaded automatically during RiSCAN PRO startup from a certain color table directory 33 that can be configured in the program settings.
A user defined color table is an image file of type Gbmp, Gjpg, Gpng or Gtif with a size of at least 1 x 1 pixel. The first pixel row of the image file will be used as color table.

Example of a user defined color table.

Part VI

Data registration

6 Data registration

The process of registration of the various scan positions in the PRCS is the determination of the respective SOP matrix. This process is usually based on tiepoints within RiSCAN PRO. Tiepoints are managed using **tiepoint lists** (TPL). Tiepoints are usually defined by retro-reflective targets showing up clearly in the amplitude data of the scan data and which can be accurately localized using total stations. The tiepoint itself is commonly the center of a reflective target.

Every project can hold one tiepoint list in the project coordinate system **TPL (PRCS)**. Usually the data is gained by measuring the position of the tiepoints with a total station or by other means, e.g., DGPS. If the tiepoint coordinates are available in global coordinates, they should be entered into the global tiepoint list, **TPL (GLCS)**, and should be transferred into the TPL (PRCS) by defining an appropriate POP matrix to fulfil the requirement of single precision representation.

In order to register a single scan position into the project coordinate system, a tiepoint list in the SOCS system has to be acquired, which is done by fine-scanning the retro-reflective targets 116 visible from the specific scan position. RiSCAN PRO extracts retro-reflective targets from a so-called overview scan or panorama scan and supports the automatic subsequent sequential fine scan 116 of the targets. Once sufficient tiepoints have been gained the SOP matrix can be determined and the scan data can be transferred into the project coordinate system if desired.

6.1 Registration via tiepoints

How to register a scan position:

1. If available, import the externally acquired point data (total station or DGPS) into the TPL PRCS (see "The tiepointlist window / Import" 111) and define the tiepoints as controlpoints (you'll be asked after import).

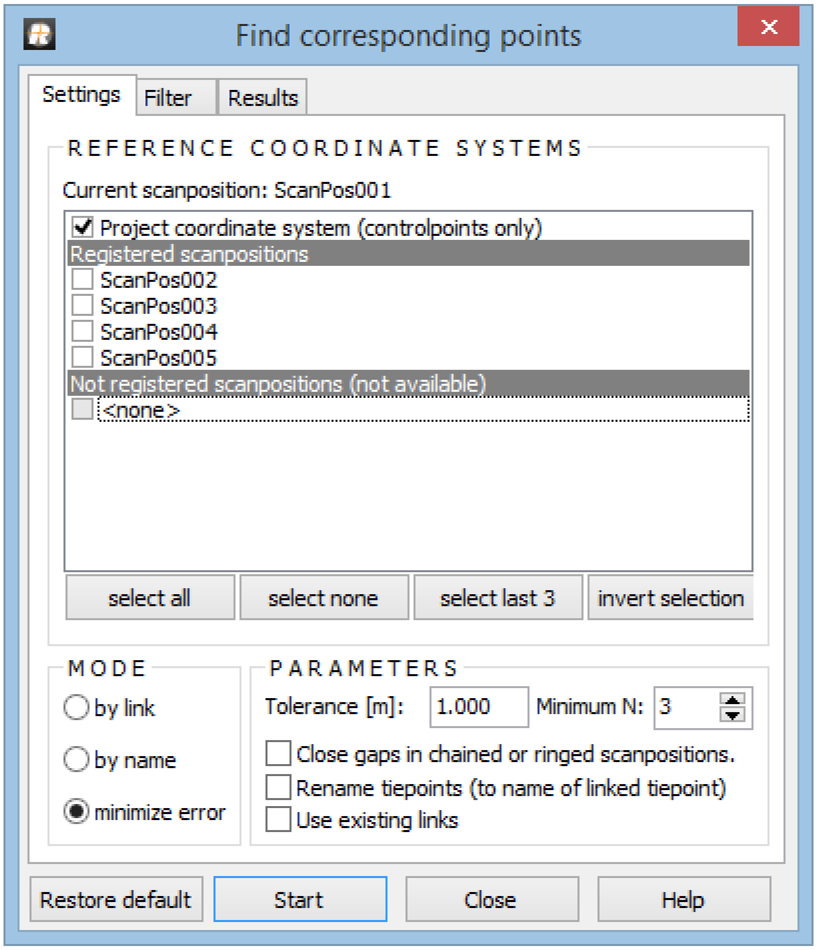
2. Do the reflector extraction and fine scanning for each scan position.

3. No controlpoints available:

   In this case you have to decide which scan position represents your project coordinate system (usually the first). Right click the desired scan position and select "Registered" from the menu (**Note:** the SOP should be the default matrix and make sure that the TPL PRCS is empty).

4. Open the TPL SOCS of the scan position you want to register.

5. Click "Find corresponding points..." - the following dialog appears:



REFERENCE COORDINATE SYSTEMS

Select the coordinate systems you want to use to register the scan position.

Select the first item "Project coordinate system" if the TPL PRCS holds controlpoints (default). Additionally you can select one (or even more) of the other (already registered and neighboring) scan positions (this is obligatory if no controlpoints are available).

The algorithm tries to find corresponding points between the current TPL SOCS and the selected coordinate systems. If correspondences between points of different scan positions are found, a new tiepoint in the TPL PRCS is created and all affected SOCS tiepoints are linked to this PRCS tiepoint. The coordinates of the PRCS tiepoint are calculated (averaged) from all linked SOCS tiepoints.

If the algorithm succeeds, the SOP matrix is calculated from the scan position. If the algorithm fails, no changes are made. Restart the process and try to activate more already registered neighboring scan positions.

MODE

- *by Link*

the SOP will be recalculated without changing the corresponding points (links)

- *by Name*

retrieve the corresponding points by comparing their names (the SOP will be recalculated)

- *minimize error (default)*

the point-pairs will be detected automatically (the SOP will be recalculated)

PARAMETERS

- *Tolerance*

  defines the search radius (the maximum distance between to corresponding points in order to recognize them as corresponding).

- *Minimum N*

  defines the minimum number of point-pairs. Setting a value can accelerate the calculation and make it more precise. So if you know that there are at least 10 corresponding points, enter 10 into this field (**Note:** If you set this value too high, you might get bad results because points might be linked together that are not related).

- *Close gaps in chained or ringed scan positions*

  Activate this option if your scan positions are organized as a ring or a chain.
  In both cases no modification of the SOP matrices is done, only corresponding tiepoints are found in order to create a proper condition for the Hybrid multi station adjustment 218.

- *Rename Tiepoints*

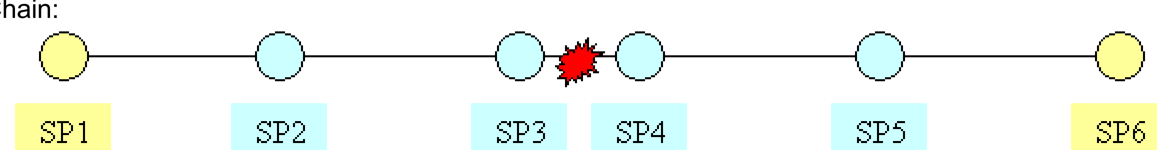
  Selecting this option will rename the tiepoints with the corresponding name of the linked tiepoint

- Use existing links

  If this option is activated, RiSCAN PRO will use existing links to tiepoints/controlpoints to speed up the process. To use this feature, create at least one link. To do so, you can drag one tiepoint of the TPL SOCS and drop it onto a tiepoint or controlpoint in the TPL PRCS. You may also use this option if RiSCAN PRO doesn't find the correct solution automatically.

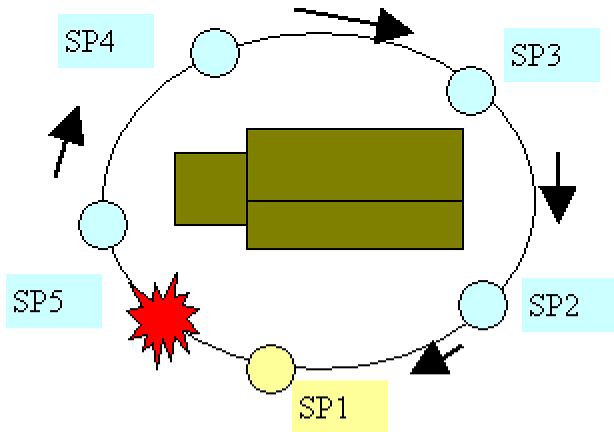
Examples:

- Chain:



At SP1 and SP6 controlpoints are available. At first SP1 and SP6 will be registered by using the controlpoints.
Then SP2 is registered onto SP1, SP5 onto SP6, SP3 onto SP2 and finally SP4 onto SP5.
If you call the Hybrid multi station adjustment 218 now, it's possible that the deviations between SP3 and SP4 are enormous. So it's important to create new tiepoints in order to connect SP3 and SP4.
To do so run "Find corresponding points" for SP4 again,
select only SP3 and activate "Close gaps in chained or ringed scan positions".

- Ring:



Possibly controlpoints are available at scan position SP1. Now SP2 is registered onto SP1, SP3 onto SP2, SP4 onto SP3, and SP5 onto SP4. There will by a huge deviation between SP5 and SP1.
If "Find corresponding points" is called for SP5 using SP4 and SP1 it is possible that links between SP5 and SP1 tiepoints are created. But if SP4 is misarranged (related to PRCS) due to the ringed formation it's probable that not all links are found.
And here the option "Close gaps in chained or ringed scan positions" is used.
Run "Find corresponding points" for SP5 again, select SP1 and activate "Close gaps in chained or ringed scan positions".

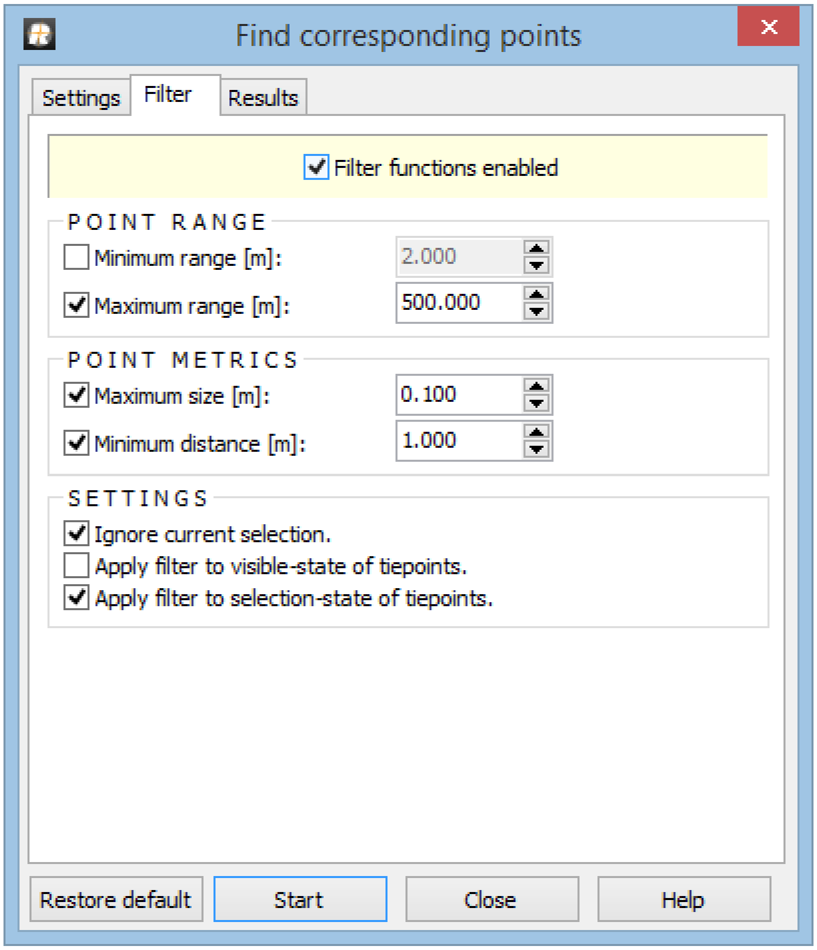
6. To start the calculation click the button "**Start**". As soon as a solution is found, you can see the number of corresponding points, the standard deviation (StdDev) of the residues (between tiepoints and PRCS tiepoints/controlpoints) and the calculated SOP matrix on the page "**Results**". To check the solution, you can open an 3D view now. Then load the scanposition into the view and display the tiepoints and controlpoints (done by drag & drop from the project manager into the view window). If you are satisfied with the solution, click the button "**OK**". Otherwise, click the button "**Next solution**" to calculate another solution (if there is one). To cancel the calculation click the button "**Cancel**".

7. Proceed with step 4 with each scan position you want to register

Possible problems:

- Not enough corresponding points found
  Try to activate more already registered neighboring scan positions. Or acquire more tiepoints (reflector targets).

- The process takes a lot of time and produces to no satisfactory results
  This generally occurs if too many tiepoints are available in the TPL SOCS. Try to reduce the number of tiepoints by either deleting unnecessary tiepoints or just deactivating them (the small hook in front of the name of the tiepoint in the tiepoint list window).
  The deactivation of the tiepoints can be automatically performed by RiSCAN PRO. Therefore use the second page of the "Find corresponding tiepoints" dialog called "Filter":



These filter functions allows you to reduce the number of tiepoints by defining a range gate ("Minimum range" & "Maximum range"), and the point metrics ("Maximum size" and "Minimum distance").

- *Filter functions enabled*

  Enable the filter functions by activating this checkbox

POINT RANGE

- *Minimum range*

  All tiepoints with a distance lower than this value will be deactivated (default: 2m).

- *Maximum range*

  All tiepoints with a distance higher than this value will be deactivated (default: 30m).

POINT METRICS

- *Maximum size*

All tiepoints with a size higher than this value will be deactivated (default: 0,3m).

- *Minimum distance*

  Defines the minimal distance between two tiepoints. Tiepoints lying closer together will be deactivated (especially helpful when the data acquisition is done on the street and a lot of car lights are detected as tiepoints).

SETTINGS

- *Ignore current selection*

  Activate this option if the current selection of the tiepoints should be ignored (all tiepoints will be used as input for the filter).

- *Apply filter to visible state of tiepoints*

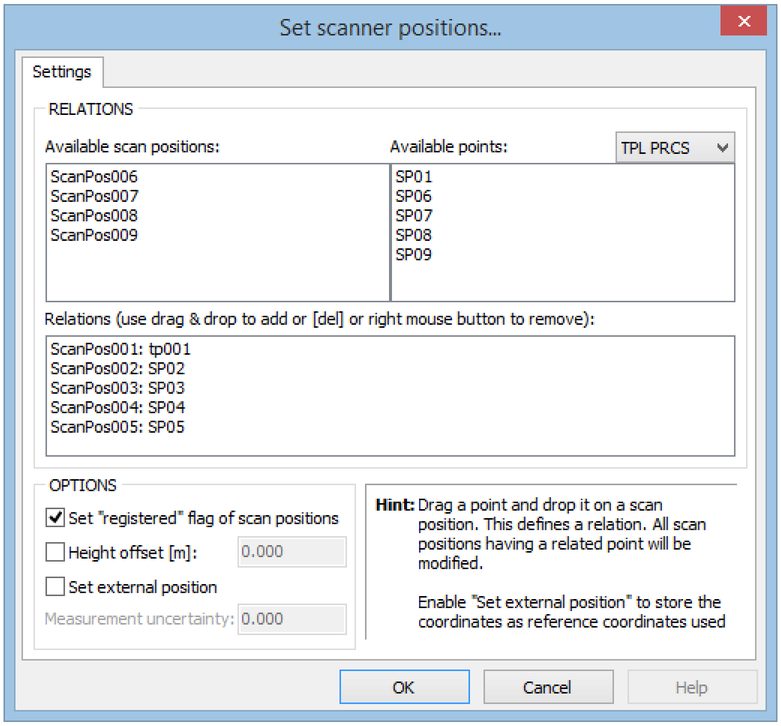
  This will set the visible states (the magnifying glass in front the tiepoint name) according to the filter output.

- *Apply filter to selection state of tiepoints*

  This will set the selection states (the small hook in front of the tiepoint name) according to the filter output.

6.2 Set scanner positions

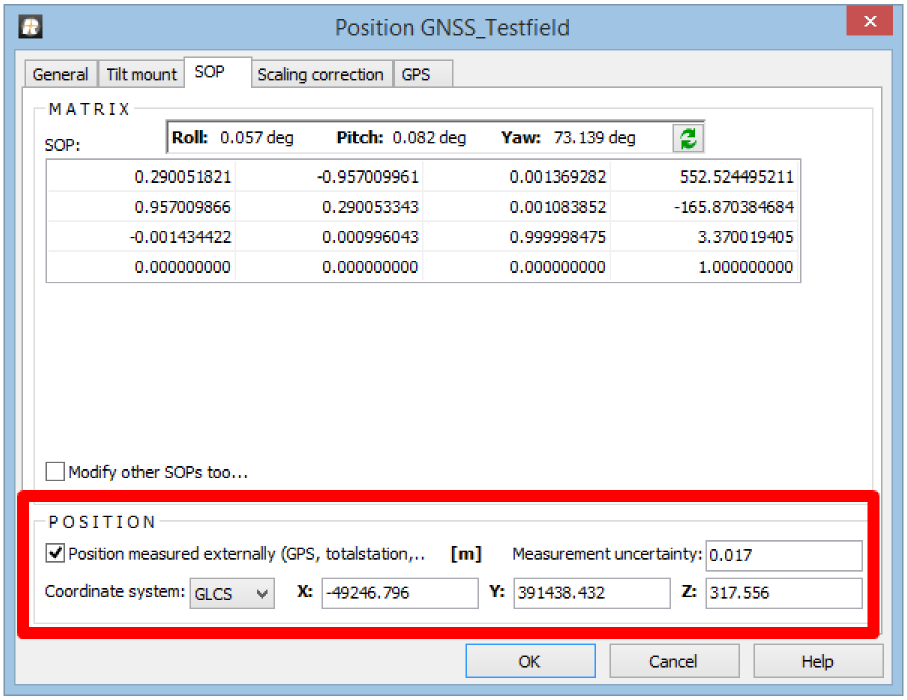
The tool "*Registration > Set scanner positions*" can be used to move scan positions to the coordinates given by control points located in the TPL PRCS or TPL GLCS.



On startup, the tool tries to find a matching control point for each scan position. Thereto the scan position and control point names are scanned for numbers. Relations are based on matching numbers.
To manually link scan positions with control points, drag a point and drop it onto the scan position (or vice versa). The scan position and the point are removed from the two lists and added to the list '*Relations*'.
To remove a relation, right click on it.

If '*Height offset*' is enabled, then the value is added to the point's Z coordinate (in project coordinate system). This can be used e.g. when the measured coordinates belong to a reflector mounted on top of the Laser Scanner.

If '*Set external position*' is enabled, then the coordinates are stored as 'External coordinates' which may be used later on by the MSA module:

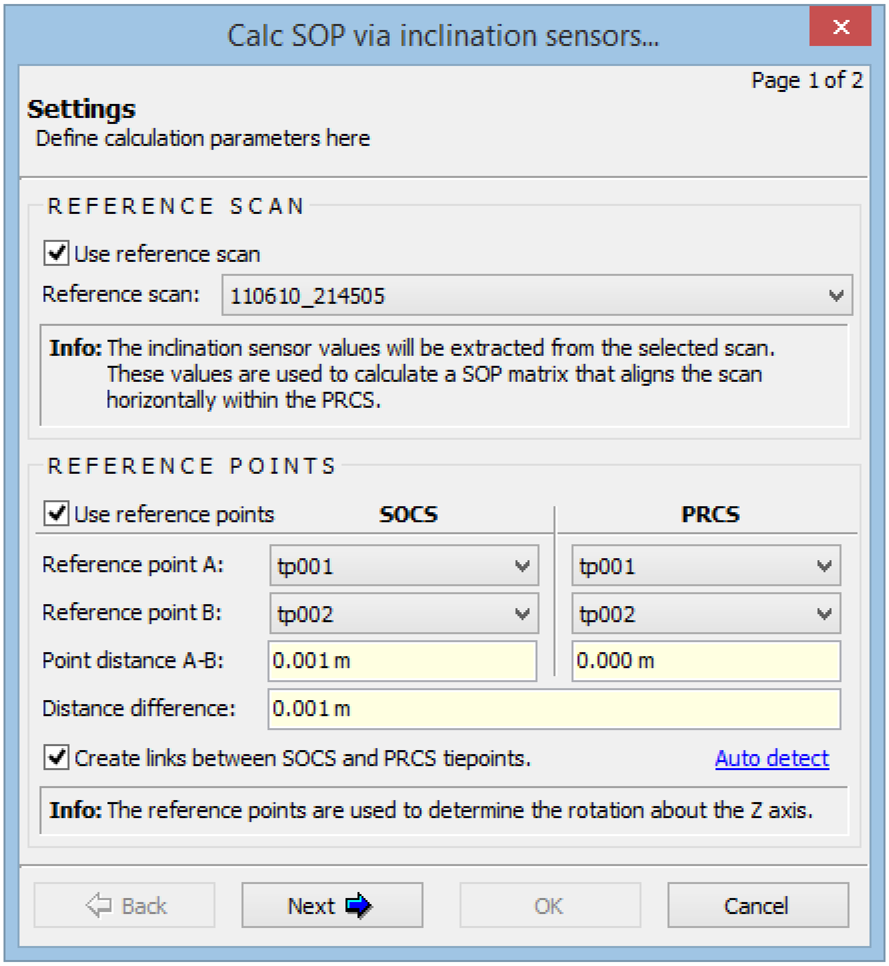


6.3 Registration via inclination sensors (optional)

Automatic horizontal alignment of acquired scandata

With RiSCAN PRO you can automatically align the acquired scandata using the information from the inclination sensors. This is especially helpful if it's not possible to register the scan position to the global coordinate system (gained by totalstation or DGPS). In that case you would set up the scanner at the first scan position, acquire the data, align the data horizontally with this function and register all further scan positions onto this scan position.

You can enter this function by right-clicking the SOP of a scan position and selecting "Calc via inclination sensors..." from the menu. The following wizard will appear:



Reference scan: Select the scan that should be used to extract the inclination sensor values from. It's recommended to use a scan with an big field-of-view (e.g. overview or panorama scan) rather than an tiepoint scan. If you deactivate the option "**Use reference scan**", then RiSCAN PRO assumes that the scan data is already horizontally aligned (i.e. the Z axis of SOCS is parallel to the Z axis of PRCS).

Reference points: You can also use reference points to determine the **rotation** of the scanner about the **Z axis** and it's **position**. In that case you need to know the SOCS and PRCS coordinates of two points (reference point A and B). The SOCS coordinates will likely be determined by means of finescans. The PRCS tiepoints may be imported from e.g. a totalstation.
To use this function enable the option "**Use reference points**" and select SOCS and PRCS tiepoints as reference points A and B. When you select a SOCS tiepoint RiSCAN PRO tries to find the corresponding PRCS tiepoint via an existing link, or - if no link exists - by matching names. Click the button "**Auto detect**" for a recommendation on which tiepoints to use (RiSCAN PRO will take the two SOCS tiepoints with the biggest distance to each other). Active the option "**Create links between SOCS and PRCS tiepoints**" to automatically link the SOCS tiepoint A to PRCS tiepoint A (and for point B too).

To calculate the SOP matrix click the button "**Next**". When the calculation has finished, the second page of the wizard containing the SOP matrix will be displayed. Finally click the button "**OK**" to save the SOP matrix.

Usage of inclination values in backsighting orientation

Please refer to chapter "Backsighting 201"

6.4 Registration via inclination sensors, compass and GPS (V-Line only)

Each V-Line scanner is equipped with inclination sensors, GNSS receiver (internal or external) and an optional compass. The scanner also offers a feature to automatically acquire its own position and orientation ("pose") at each new scan position. The pose information is stored in the scan file (RXP) by the scanner. RiSCAN PRO reads this information either after scan acquisition, or - when the scanner is used standalone - after scan import.

How to use it:

1. Data acquisition:

When you operate the scanner with RiSCAN PRO, set the option "Pose estimation" in the scan acquisition window to "ACCURATE" or "FAST". If you do not use RiSCAN PRO, please refer to your scanner's manual to see how you can activate that feature.

2. Data registration:

Enable the automatic registration option in the program settings: "**Tool > Options > General > Data acquisition**". At the same place, you can also select the coordinate system to use:

- **WGS84:** Select this option, if you use the internal GNSS receiver or your external receiver provides WGS84 coordinates only.
- **User Coordinate System (UCS):** Select this option, if you use an external GNSS receiver which also provides coordinates in a local coordinate system (e.g. a map projection like UTM).
  Please refer to your scanner's manual to see how to connect the external GNSS receiver to the scanner and how to configure both.

Whenever a scan is acquired with or imported into RiSCAN PRO, following steps are performed automatically:

- **WGS84 only:** If the POP matrix is undefined (identity matrix), a matrix is calculated and stored which defines a project coordinate system (PRCS) that is horizontally aligned (X/Y-plane) and touches the WGS84 earth ellipsoid at the coordinates stored in the scan (Latitude, Longitude). In other words, the PRCS X-axis points to east, the Y-axis points to north and Z-axis points up (anti parallel to gravity vector), whereas the origin of PRCS is defined by the position of the scanner. The global coordinate system (GLCS) is WGS84 Cartesian (also known as ECEF).

- **UCS only:** If the POP matrix is undefined (identity matrix), RiSCAN PRO uses the UCS as global coordinate system (GLCS) and assumes that the X/Y plane is horizontally aligned. The project coordinate system (PRCS) is defined by calculating a POP matrix that includes no rotation but an offset defined by the coordinates provided by the GNSS receiver.

- If the scan position that contains the scan is not marked as "registered", a SOP matrix is calculated and stored which aligns the scan position according to the pose information contained in the scan (respecting the previously calculated POP matrix, of course). If the compass value is missing, the Y-axis of the scanner is assumed to point to north.

- The scan position where the scan belongs to is marked as "registered" and the measured position is stored in the attributes. The measured position can be used in the Multi Station Adjustment 212 afterwards.

- Because of varying pose measurement errors, you may use the Multi Station Adjustment 212 feature of RiSCAN PRO to do the fine-registration of all scanpositions.

Note: If the SOP matrix is modified manually (Multi Station Adjustment or other registration methods), you can recalculate it from the scanner's pose by using right mouse click on the SOP in the project manager and selecting "**Calculate from scan**" from the menu. In this case the SOP matrix is always overwritten, not matter if registered flag is set or not.

6.5 Manual coarse registration

If no reflectors where used you can register the scanpositions manually. For that purpose RiSCAN PRO offers two different tools which are described in the following chapters. The coarse registration achieved with these tools may be used as initial situation for the multistation adjustment 212 with activated iterative closest point algorithm (ICP).

6.5.1 Interactive coarse registration

The following step by step description demonstrates the modification of the position and orientation of a scan position.
Note: Although this guide shows how to modify a scanposition, the same workflow can also be used for other objects such as planes, spheres and aerial views.

1. Open or create an object view

2. Insert the scan position(s) you want to modify into the object view (drag the scan position from the projectmanager and drop it onto the view window). To get a visual feedback of the modifications you should also insert some data according to this scan position.

3. Insert some reference data (which will not be modified, e.g. already registered scan positions) into the object view

4. To change the position and/or orientation select one (or more) scanposition(s) in the object inspector, right-click into the selection and select "Modify SOP…" (to modify other objects select "Modify..."). If more scanpositions or objects were selected they are modified synchronously.

5. The settings of the dialog are described below:

    - **Reference object**
      Select the scanposition that should be used as reference for translation and rotation actions while the coordinate system "OCS" (described below) is selected.

    - **Coordinate system**
      The translation and rotation actions are always based on either a X, Y or Z axis or on a user defined axis. In the first case it's necessary to know which coordinate system should be used.

    - **Values**
      In this section you decide how to move or rotate the scanposition:

      Use mouse movement:
      The scanposition will be moved or rotated according to the mouse movement. In this mode set the movement divider. With higher values the scanposition can be positioned or rotated more precisely, use lower values to move or rotate the scanposition faster.

      Use fixed offset:
      The scanposition will be moved or rotated by a fixed offset each time you click the mouse. You can use the values "translation offset" and "rotation offset" to control the stepwidth.

    - **Control**

Use the coordinate axes to move or rotate the scanposition. If "**use mouse movement**" is used click on an axis and move the mouse along the axis to move the scanposition. If "**use fixed offset**" is selected click on an axis to move or rotate the scanposition. You can also move along or rotate about two axes synchronous by clicking on the space between two axes (or click and move respectively).

- **Show axes in view**
  If this option is activated you will see the movement and rotation axes in the 3D view

- **Show advanced settings**
  Activate this option to show the advanced move or rotate parameters (on the right side of the dialog).

  Advanced settings are:

  - **Point selection mode**
    This mode determines which point should be used when you define the rotation center or the rotation/translation axis:

    "**Closest point**": The 3D point next to the mouse cursor will be taken:
    "**Point on surface**": The intersection point between the surface (triangle or plane) and the ray defined by the mouse cursor will be taken.

  - **User defined axes**
    You may define any desired translation or rotation axis. To do so select one of the following methods:

    - Define axis by selecting two points from the view. To select the first point click the button "**First point**". Then press and hold the "SHIFT" key and click a point in the object view. Click the button "**Second point**" and repeat the point selection. You select "First point" and "Second point" from the object view but you can also press the keys "2" (first point) and "3" (second point).

    - Define axis via input of coordinates of two points. To enter the coordinates of the first point click the button "**First point**". Then enter the coordinates of the first point. Click the button "**Second point**" and repeat the procedure. Use the button next to the coordinates in order to update the display of the axis.

    - "**Get from camera direction**". When you click on this button the axis perpendicular to the screen's surface is used.

  - **Rotation center**
    To rotate the scan position it's necessary to define a rotation center. To define the center you can use different methods:

    - **Origin of object**: The origin of the scanposition (the reference object respectively) will be used as rotation center.
    - **Origin of PRCS**: The origin of the project coordinate system will be used as rotation center.
    - **Origin of GLCS**: The origin of the global coordinate system will be used as rotation center.
    - **User defined**: You may define any point that meets your requirements. To do so select one of the following methods:

      - Press and hold the "SHIFT" key and left-click a point in the object view. You can activate this mode from the object view by pressing "1" if you are in modification mode.

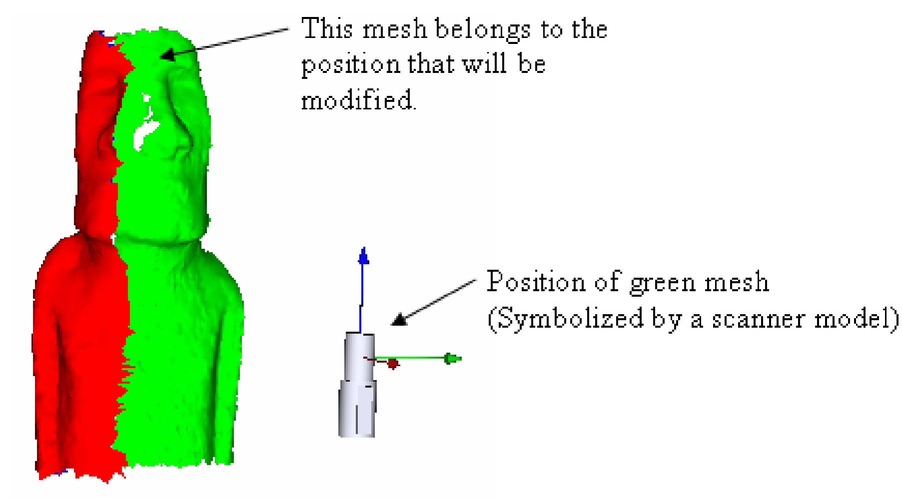
      - Enter the coordinates of the point directly. Press the button next to the coordinates in order to update the display of the rotation center.

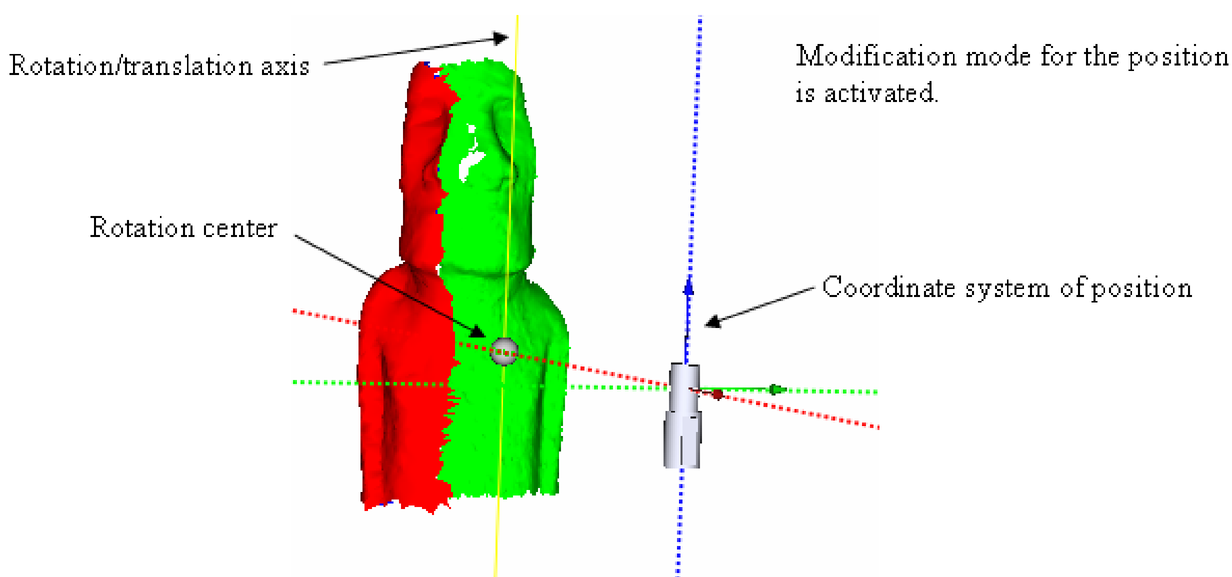
      - Click the button "Get from center of view". This will take the 3D point next to a virtual ray going through the center of the view window.

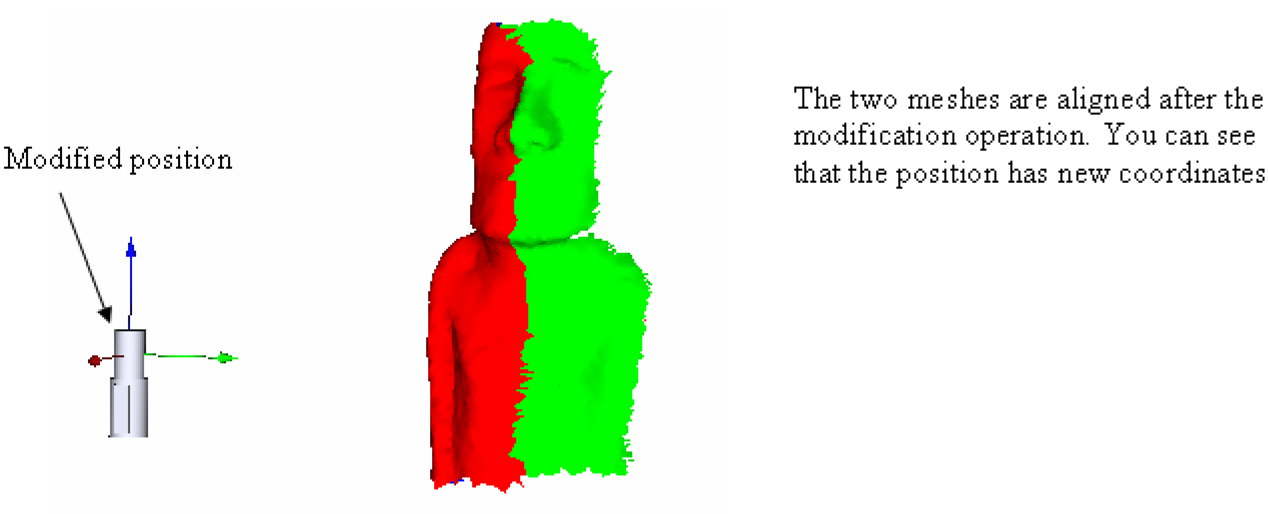
To display the a small sphere at the center of rotation select the option "Show rotation center in view".

Note: The color of point clouds or meshes with "Falsecolor" viewtypes (e.g "Falsecolor - Height") is not recalculated if you modify the position and/or the orientation of the corresponding scanposition. You have to apply the viewtype again to update the color.

Example: *Aligning two meshes by modifying the corresponding position*





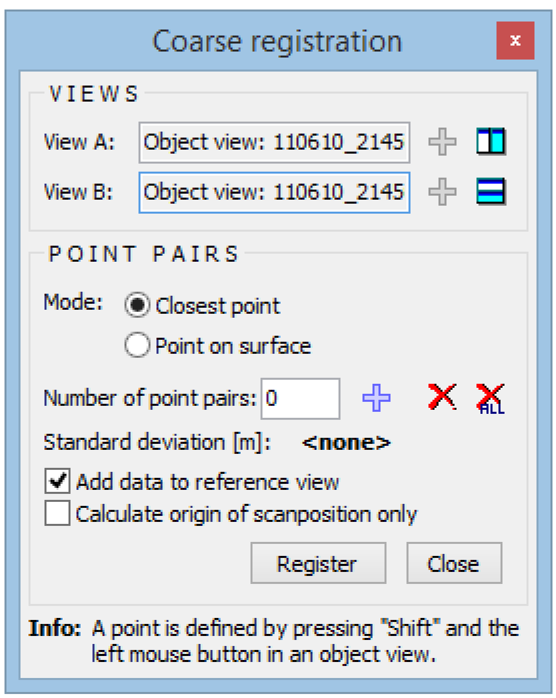


6.5.2 Coarse registration via corresponding points

Like the registration based on corresponding tiepoints you can also do a coarse registration by temporarily defining some (at least 4) corresponding points (e.g. well known features like corners, edges, points with high reflectivity and so on) between a dataset (a point cloud or a mesh) of a registered scanposition (or the PRCS) and a dataset of the scanposition to be registered.

Workflow:

1. Open the menu "Registration" and select "Coarse registration". The following dialog appears:



2. This tool needs two different datasets (point clouds or meshes) that are displayed in two different 3D views ("View A" and "View B"). Click the "**+**" button next to "**View A**" and "**View B**" to create two object view windows. Alternatively you can also define already existing views. To do so left-click into the box "View A" and then left-slick somewhere in the view window. Proceed with "View B" in the same way. You can use

the buttons next to the "**+**" buttons to align the view windows horizontally or verticaly.

3. Add **reference data** (= data of already registered scanpositions or PRCS) to **view A**. Add data of the scanposition **to be registered** to **view B**.

4. Define the corresponding points in view A and view B. To do so select a selection mode ("closest point" or "point on surface"), hold down the SHIFT key and left-click a point in view A. Proceed the same way with the corresponding point in view B. A small sphere with a label showing the point number represents the clicked point. You can correct your choice as often as you like. When the point pair is well defined confirm the settings by clicking the "**+**" button next to the box "**Number of point pairs**".

5. If at least 4 point pairs are defined you can click the button "**Register**". Now the proper SOP matrix is calculated and written to the scanposition. The object(s) of view B are automatically added to view A. The field "**Standard deviation**" shows the quality of the registration (see also Registration via tiepoints 187).

6.6 Backsighting

Calculate orientation and position via backsighting

You can use this tool to register the scan position using the well known coordinates of a certain point and the coordinates of a remote object (e.g. a church). The scanner must be either leveled manually or with the optionally built-in inclination sensors.

Note: The following steps describe an exemplary work flow. You may skip some of the steps.

1. Create a new scan position

Accurately setup the scanner in a vertical orientation (head up, Z axis anti parallel to the gravity vector).

Note: If the instrument has built-in inclination sensors and you decide to use them in step 6.3, you don't need to accurately align the scanner.

Create a new scan position by right-clicking the folder "SCANS" and selecting "New scan position".

2. Acquire scans, reflector extraction, finescans

Acquire the desired scans. If you would like to use a reflector as remote target (step 7.2) then you also have to perform the reflector extraction and finescan the desired reflector.

3. Start wizard "Backsighting orientation"

Open the wizard "Backsighting orientation" by right-clicking the SOP matrix of the scan position and selecting "Backsighting orientation...".

4. Define instrument position

On the first page enter the scanner's own position in global coordinates. If you are using a GPS mounted on the scanner you can import the coordinates by using a Guda file (Format: "Name, X, Y, Z") by clicking the button "Read from file". Open the Guda file and select one entry (=position) from the list.

"Instrument height": Insert the vertical offset between the well known ground point and the laser beam exit, indicated at the scanner head. That means if you enter the coordinates of a point on the ground, and the instrument is located 1.5 meters above this point, you must enter 1.5 meters as instrument height.

5. Target selection

On the second page you can decide how to align the scanner: either "against north" or "via remote object".

5.1 Via remote object

If "via remote object" is selected, enter the coordinates of a remote object in global coordinates (the GPS import via Guda-file is also available - see step 4).

5.2 Against north

If "against north" is selected you should align the scanner towards north (see next paragraph).

6. Alignment

Now you have to define the rotation around the Z-Axis of the scanner (the orientation of the instrument called "Northing angle").

6.1 Northing angle

In that case you have to turn the scanner until the remote target is within the telescope or the compass points to north. To use the northing angle click "Use northing angle".

"PARALLAX": Insert the horizontal offset between the center of the telescope and the center of the scanner.

6.1.1 From instrument

To retrieve the northing angle from the instrument please check the checkbox "Connect to device". You can now use the wizard to turn the instrument.
A single click on "Turn left" or "Turn right" will cause the scanner to start moving. To stop it again click the button "Stop turning". As an alternative you can press the keys "A" and "D" on the keyboard to turn left and right. The scanner will move as long as you press the key.

To regulate the frame speed use the slider (left means lower speed, right means higher speed).

After the scanner has been aligned click on the button "Get angle from device" to read the phi angle from the scanner (the "Northing angle" field is not updated after every movement!).

6.1.2 From file

The northing angle can also be loaded from a file. To do this you need a standard text file containing the northing angle. Such a file can be created manually or it can be created with the wizard by clicking "Save to file".

6.2 Use tiepoint

In that case you need a finescanned reflector (step 2). The northing angle is automatically calculated from the reflector position gained by the scanner.
To use a tiepoint click "use tiepoint" and click the button "Select tiepoint". Select the desired tiepoint from the list.

6.3 Inclination sensors

If the instrument has built-in inclination sensors you could use these measurements to automatically align the scanner vertically. You can either decide to read the inclination sensors from an already acquired scan (step 6.3.1, useful when registering the scan in the office) or to read the values from the instrument online (step 6.3.2, in the field).

6.3.1 Use inclination sensors OFFLINE

Activate the check box "Use inclination sensors OFFLINE" if you want to read the inclination angles from an already acquired scan file. You must also select the scan from the list below the check box. You can either use the fine scan of the optionally selected tie point (reflector) or use any other scan of the current scan position.

6.3.2 Use inclination sensors ONLINE

Note: This option is only available for instruments built after January 1st, 2008.

Activate the check box "Use inclination sensors ONLINE" if you want to read the inclination angles directly from the instrument. There are three different modes:

- **Fast mode** - Reads the inclination sensor values only once.
- **Default mode** - Reads the inclination sensor values at 9 different head rotation positions spread over the full 360 degrees field-of-view. All values are averaged before they are used.
- **Accurate mode** - Acquires two fast mode scans and averages the received inclination sensor values.

Note: If you do not use options 6.3.1 or 6.3.2 at all you have to ensure that the scanner is vertically aligned (see also step 1).

7. Calculate matrix

On the fourth page you can see a summary of the given data and the calculated matrix. In this step you can still go back to one of the previous pages in order to correct wrong settings.

8. Set matrix

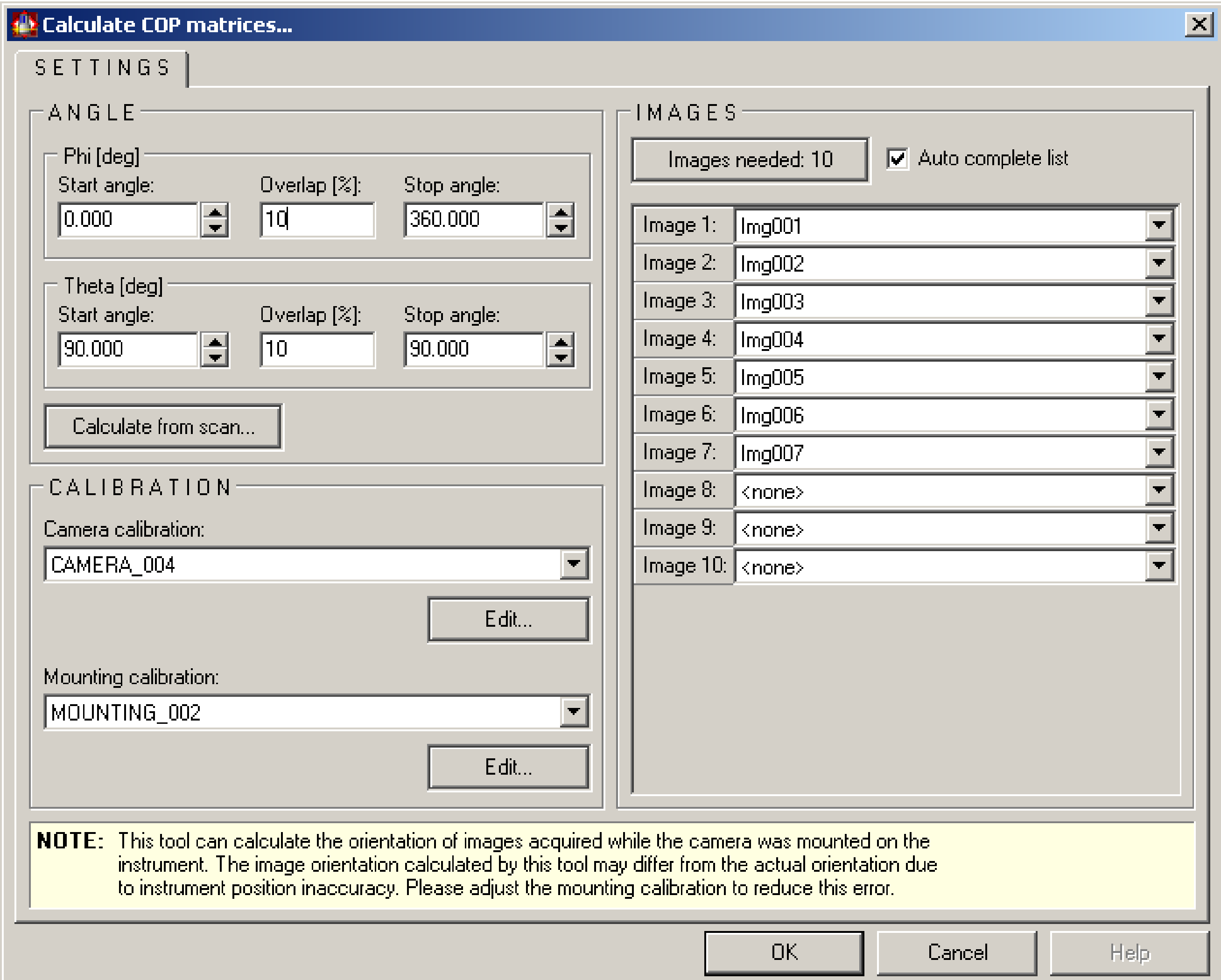
To finally write the matrix to the SOP of the scan position click the button "Set SOP". Before the matrix is written to the SOP, RiSCAN PRO checks if a modification of the POP-matrix is necessary. If so you will be prompted to confirm these values and the SOP is modified according to the new POP.

Finally click the button "Close" to close the wizard.

6.7 Registration of scanposition images

Scanposition images are automatically registered during acquistion (this is done by reading the orientation of the instrument online). If the COP matrices are destroyed for any reason, you can use the tool "Calc COPs" to recalculate the COP matrices automatically. To use this tool proceed as follows:

1. Open a project
2. Right-click the folder SCANPOSIMAGES containing the destroyed images.



- ANGLE

  Select the phi and theta range that was used to acquire the images. As an alternative you can also click the button "Calculate from scan...". A dialog is shown where you can select a scan. The angle extents of the selected scan will be used.

- CALIBRATION

  Select the camera and mounting calibration which will be used for the calibration and assigned to the images.

- IMAGES

  Click the button "Images needed" to calculate the number of images based on the given range, camera- and mounting calibration. Below the button you can see a list containing as many entries as images are needed. To define which image is "Image 1" select the proper image from the list beside "Image 1". If "Auto complete list" is checked the other entries are automatically filled, but they can be modified at any time.
  Click the button "OK" to finally calculate the COP matrices for the selected images.

Note:
The image orientation calculated by this tool may differ from the actual orientation due to instrument position

inaccuracy. Please adjust the mounting calibration to reduce this error.

6.8 Registration of project images

6.8.1 via Tiepoints

Images saved at project level are images which may have been acquired while the camera was not mounted to the scanner such as detail images. Thus these images are not automatically registered within the project coordinate system. RiSCAN PRO offers two functions to register these images by defining relations between image points and object points.

- Image registration tool 205 (convenient function, which encapsulates the "Manual image registration")
- Manual image registration 208 (flexible base function)

Note: It's recommended that you don't perform the registration of project images before you have registered all scan positions and the project.

6.8.1.1 Image registration tool

The "Image registration" tool allows you to register project images that have been taken manually from any position in the scan area. The COP matrix of the image is calculated by defining relations between object points and points in an image.

Note:
- *Register all scan positions first before you register project images.*
- *Make sure that the image has the right camera calibration otherwise you won't get plausible results.*

How to register a project image using the "Image registration" tool:

- Open the tool by choosing "**Registration > Image registration**" from the menu bar.

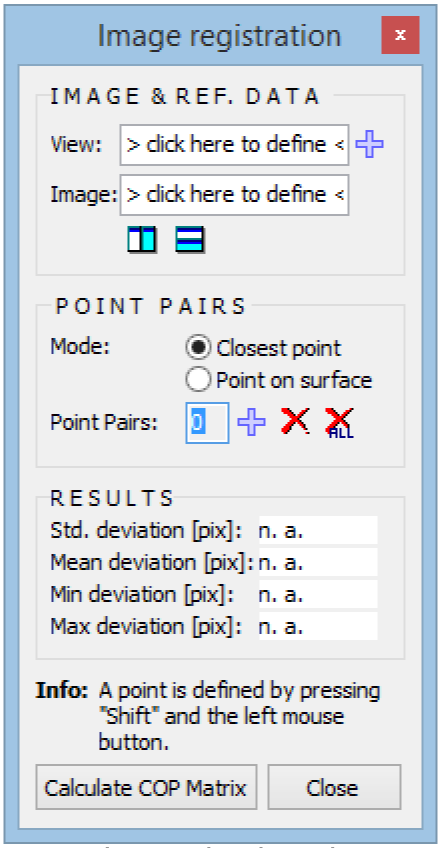
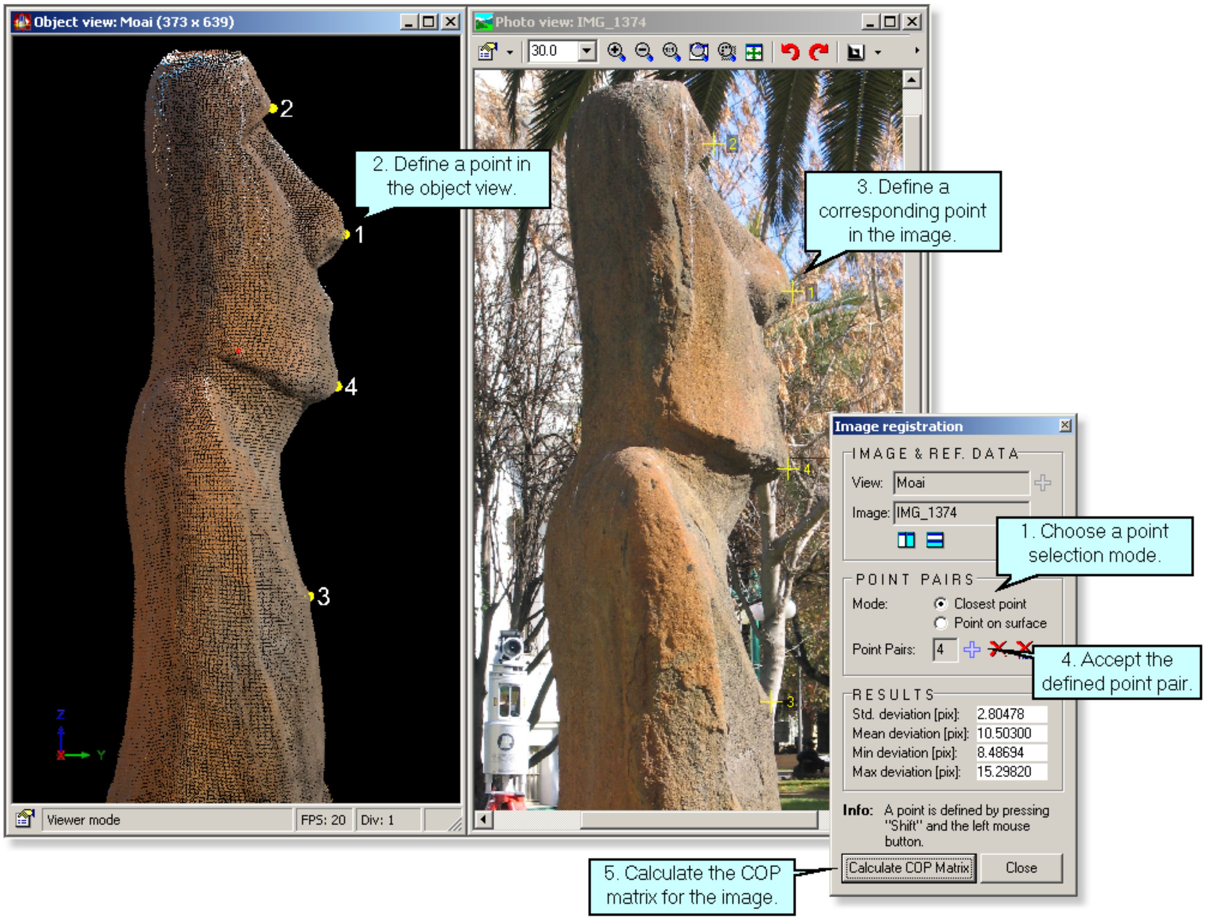


Image registration tool

- Open a new temporary view by clicking the symbol in the section "I M A G E & R E F. D A T A". Instead you can also drag an already existing view from the "Project Manager" and drop it into the line "View:" of the "Image registration" tool. As a third method you can also click into the line "View" of the "Image registration" tool and then click into one of the currently open views.
- Insert the scans on which you can see the same objects as on the image you want to register into the specified view.
- Drag the desired image from the "Project Manager" and drop it into the line "Image:" of the "Image registration" tool. *Note: You can only specify project images and not already registered images from "Scan Positions".*
- You can align the two windows horizontally or vertically by clicking the buttons in the section "I M A G E & R E F. D A T A".

Proceed with the next steps as described in the picture below:



1. Choose a point selection mode:
   The "Mode:" in the section "P O I N T P A I R S" specifies the point selection mode for the object view. "Closest point" can be used if you are working with point clouds and means that the point closest to the cursor position will be selected. "Point on surface" can only be used if you are working with "mesh objects" and means that points between actually scanned points can also be selected.

2. Define a point in the object view:
   A point is defined by holding "Shift" and left-clicking the desired point in the object view.

3. Define a point in the image:
   Defining a point in an image is very similar to defining a point in an object view.

4. Accept the defined point pair:

   Points can be corrected as often you want. They will only be accepted if you click the button in the section "P O I N T P A I R S" or press the key "**3**".

5. Calculate the COP matrix for the image:
   You have to define at least 4 point pairs to calculate the COP matrix.

The section "R E S U L T S" shows the results of the COP matrix calculation. If the deviation is too large try to delete the selected points and set new ones. It is sufficient to define some precise points to calculate a well-matching COP matrix.

6.8.1.2 Manual image registration

The following step by step description shows how to register a project image:

- **Define tiepoints in SOCS or PRCS**

  During the registration of the scan positions the TPL SOCS and TPL PRCS should have been filled with coordinates (tiepoints and/or controlpoints). To register a project image it is necessary that at least 3 points of the TPL PRCS or any TPL SOCS are visible in that image. If not you may create helping points by defining a tiepoint in a scan (TPL SOCS).

  Note: If you plan to use PRCS tiepoints for image registration, make sure that they have controlpoint state 116. This ensures that the coordinates of the PRCS tiepoints are not modified by faultily registered images (see also Calc coordinates from referring tiepoints 114).

- **Define image tiepoints**

  Now you have to add image tiepoints for every PRCS or SOCS tiepoint which can be seen in the current image (see 2D view: General 129).
  Hint: To make the next step easier, it's recommended to name the image tiepoints like the corresponding object tiepoints.

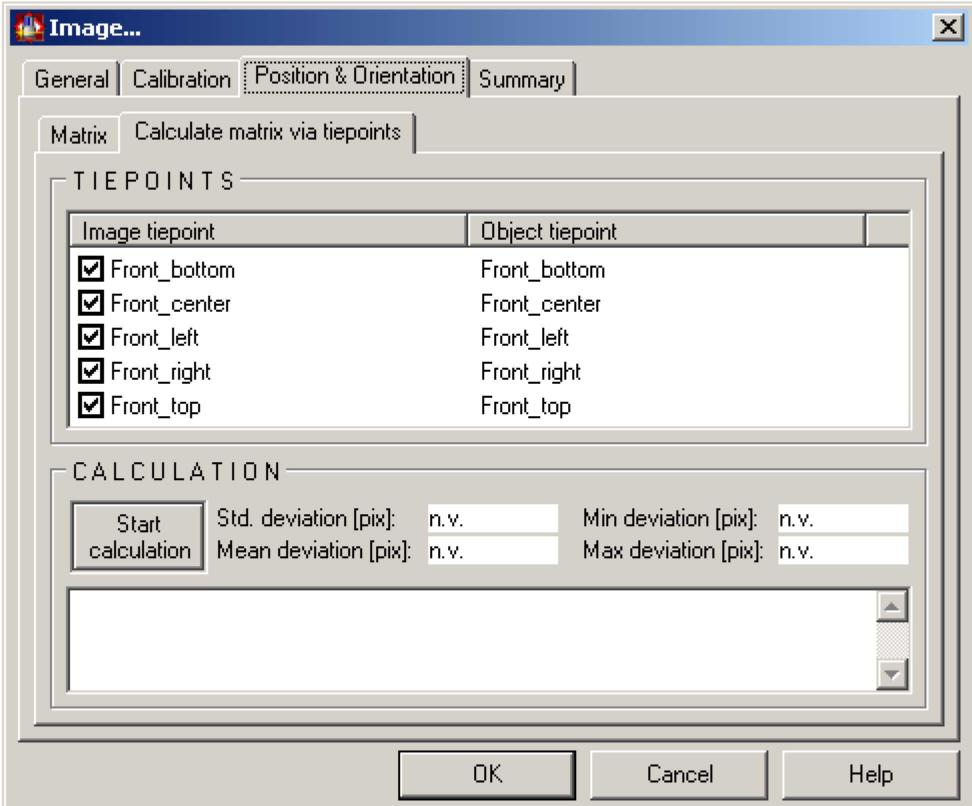
- **Link image tiepoints to object tiepoints**

  Open the TPL PRCS or a TPL SOCS and the TPL of the image. Establish the links between the corresponding tiepoints via drag and drop (e.g. drag the image tiepoint and drop it onto the corresponding PRCS or SOCS tiepoint).

  Note: When creating links to tiepoints of a TPL SOCS please make sure that the corresponding scanposition is registered. Otherwise the registration process of the image may produce wrong results.

- **Registration of image**

  Right-click the image within the project manager and select "Attributes..." from the menu. In the attributes dialog of the image switch to the page "Position and orientation". Within this page switch to the page "Calculate matrix via tiepoints":



In the box "TIEPOINTS" you can see a summary of the tiepoints which will be used for the calculation. The left column shows the names of the image tiepoints and right column shows the name of the linked tiepoints. To activate or deactivate tiepoints click the small box in front of the name of the image tiepoint (hook displayed = activated, hook not displayed = deactivated).

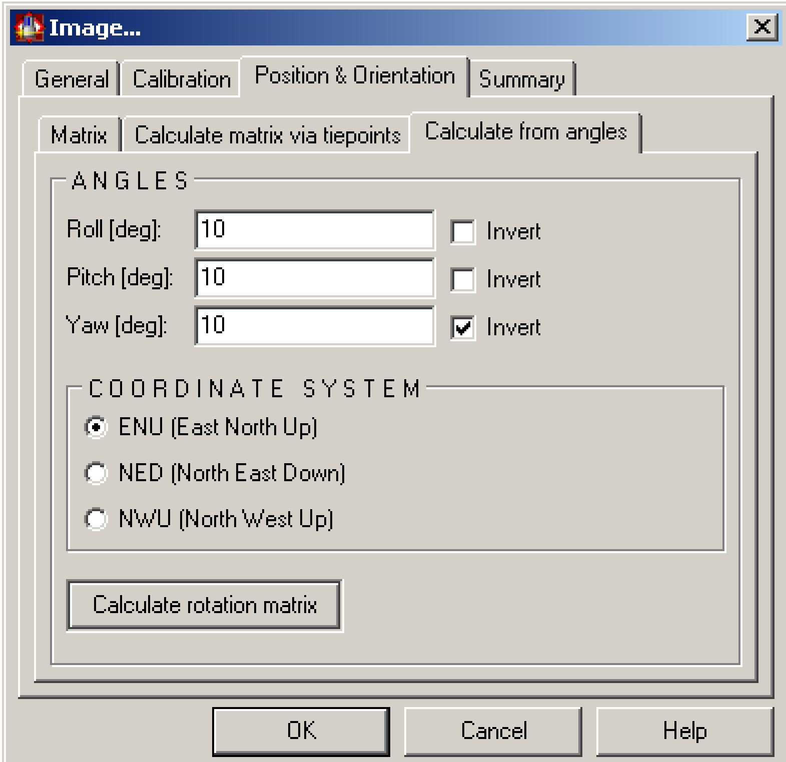
To finally start the calculation click the button "Start calculation". In the box at the bottom of this page you can see a log of the calculation. When the calculation is finished, the quality of the registration is written to the boxes ("...deviation") and the resulting COP matrix (transforming from image coordinate system to project coordinate system) is written to the first page "Matrix". To save the result click the button "OK".

Hint: If the result seems to be bad please check the linkage of the tiepoints and deactivate some tiepoints if necessary.

6.8.2 via Angle definition

This function is intended to be used when aerial views (images taken from planes or helicopters) are used. In this case the images contain additional orientation information consisiting of three angles (Roll, Pitch and Yaw, see below for details) and the position.

To use this registration, import the aerial view as project image, right-click the project image within the project manager and select "Attributes..." from the menu. Select the page "Position & orientation" and select the sub page "Calculate from angles":



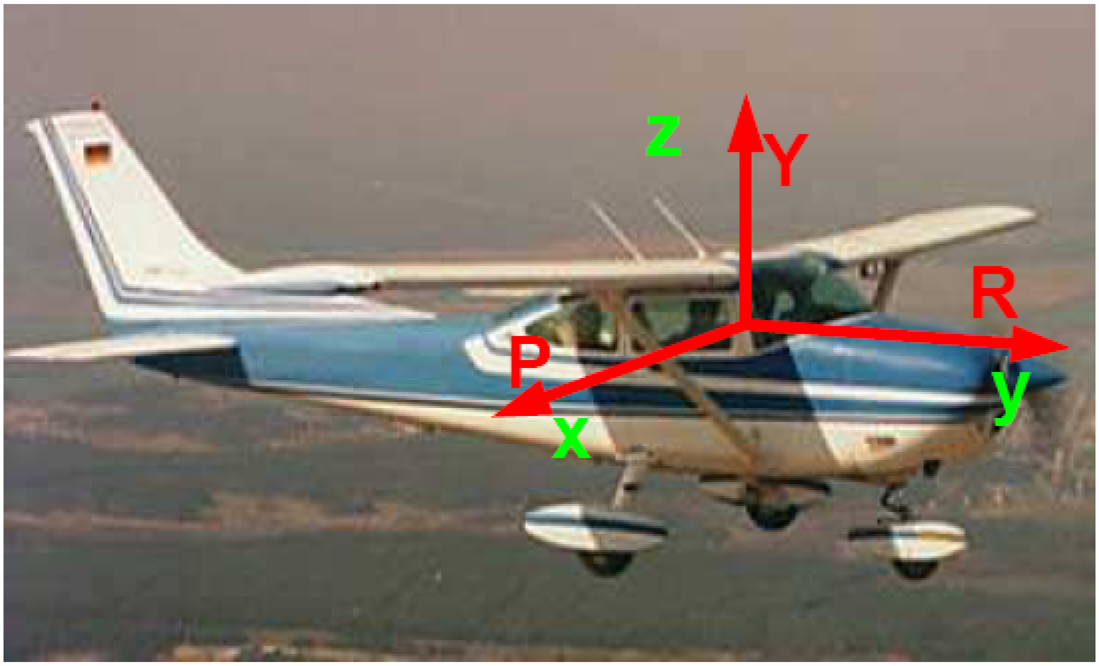
- ANGLES

  Enter the Roll, Pitch and Yaw angles here (see below). You can also activate the option "Invert" in order to negate the angle.

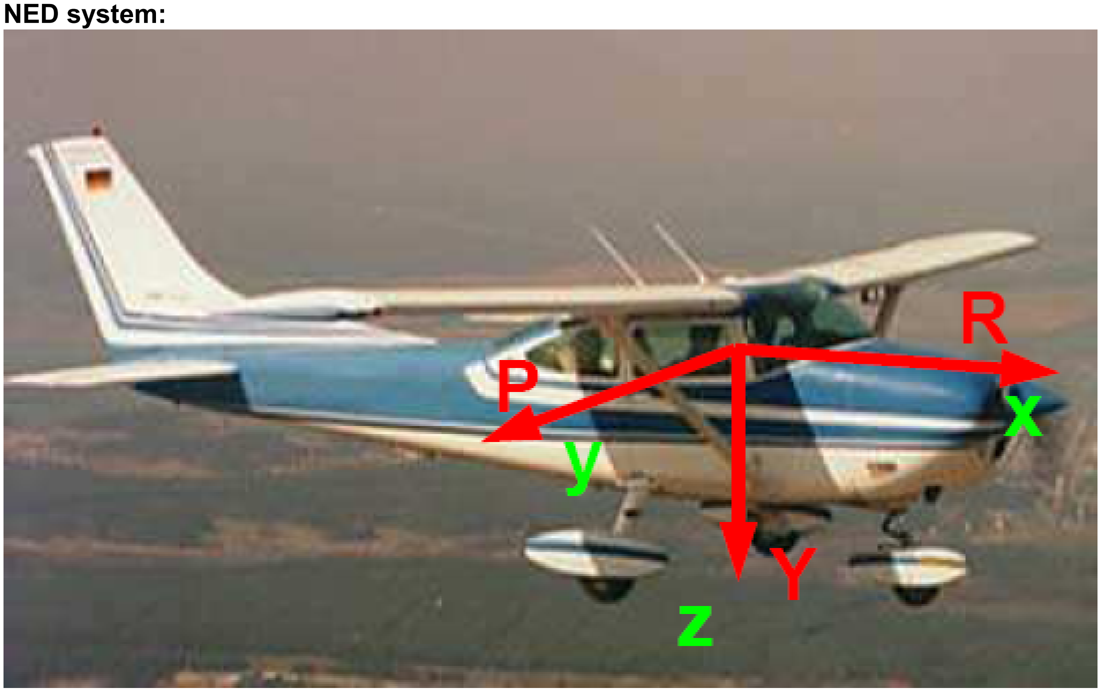
- COORDINATE SYSTEM

  Select the used coordinate system. The coordinate system of the aircraft is called body frame. The body frame depends on the choice of the navigation frame. The most frequently used navigation frames are the ENU (East – North – Up) and the NED (North – East – Down) system. In the figures below both systems are shown:

  ENU system:



NED system:



The green letters are used for the cartesian coordinate system. The red letters show the rotation axis of the angles.

Finally click the button "Calculate rotation matrix" to create the rotation part of the COP matrix from the angles. Then click the page "Matrix" and enter the position of the image (center of image within PRCS) in the fourth column of the matrix.

6.9 Multi Station Adjustment

The standard registration process in RiSCAN PRO is based on corresponding tiepoints (finescanned reflectors). This gives a quick registration but even though the tiepoints fit together very well it's possible that the other scan data (the objects of interest) show alignment errors. The main reasons for this problem may be an unstable reflector set-up, non-optimal reflector positioning or measurment errors. Also the two cases "chain" and "ring" as described in Registration via tiepoints / Examples 189 are problematic. In those cases each scan position is registered to it's direct predecessor. At the end there will be a more or less big error between the last and first scan position of the chain or ring.
To minimize these errors RiSCAN PRO has a plugin function called "Multi Station Adjustment" (MSA). The MSA tries to improve the registration of the scan positions. For that purpose the orientation and position of each scan position is modified in several iterations in order to calculate the best overall fit for them. To compare the scan positions the **tiepoints**, **tieobjects** and **polydata objects** (reduced point clouds) are used.

Note:
To use the function "Multi Station Adjustment" you need a valid license key. You'll be prompted to enter a valid license key if no proper key was found.
To receive a license key please contact us via support@riegl.com

How to use the Multi Station Adjustment:

1. First of all perform the registration as usual (see "Data registration 187", you can use any of the described registration methods).

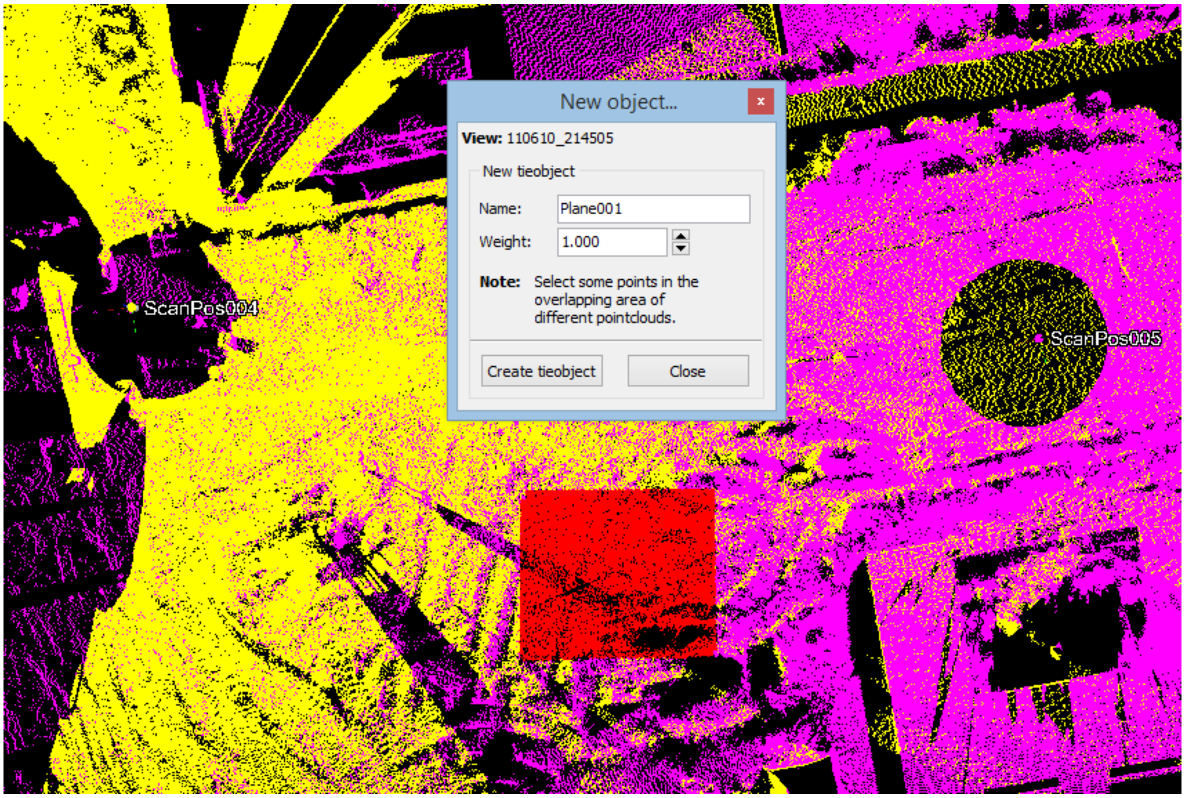
2. Preprocess the data. As mentioned above the MSA can also use surface data of the scanned objects to align the scan positions. For that two different methods are available:

   2.1 Manual definition of corresponding plane surface patches.

   This can be used to register two or more point clouds together by defining plane and overlapping parts of the surface. The MSA tries to modify the scan position in order to minimize the distance between the defined planes.
   To define plane surface patches do the following:

   - Open a 3D view.
   - Add the data (point clouds) of interest to the view. **Note:** A prior coarse registration of the data is necessary.
   - Right-click into the view window and select "New object / Tieobject..." from the menu.
   - Find a part of the surface where two or more point clouds are overlapping and the points lie within a plane.
   - Use the selection tools to select the desired points.

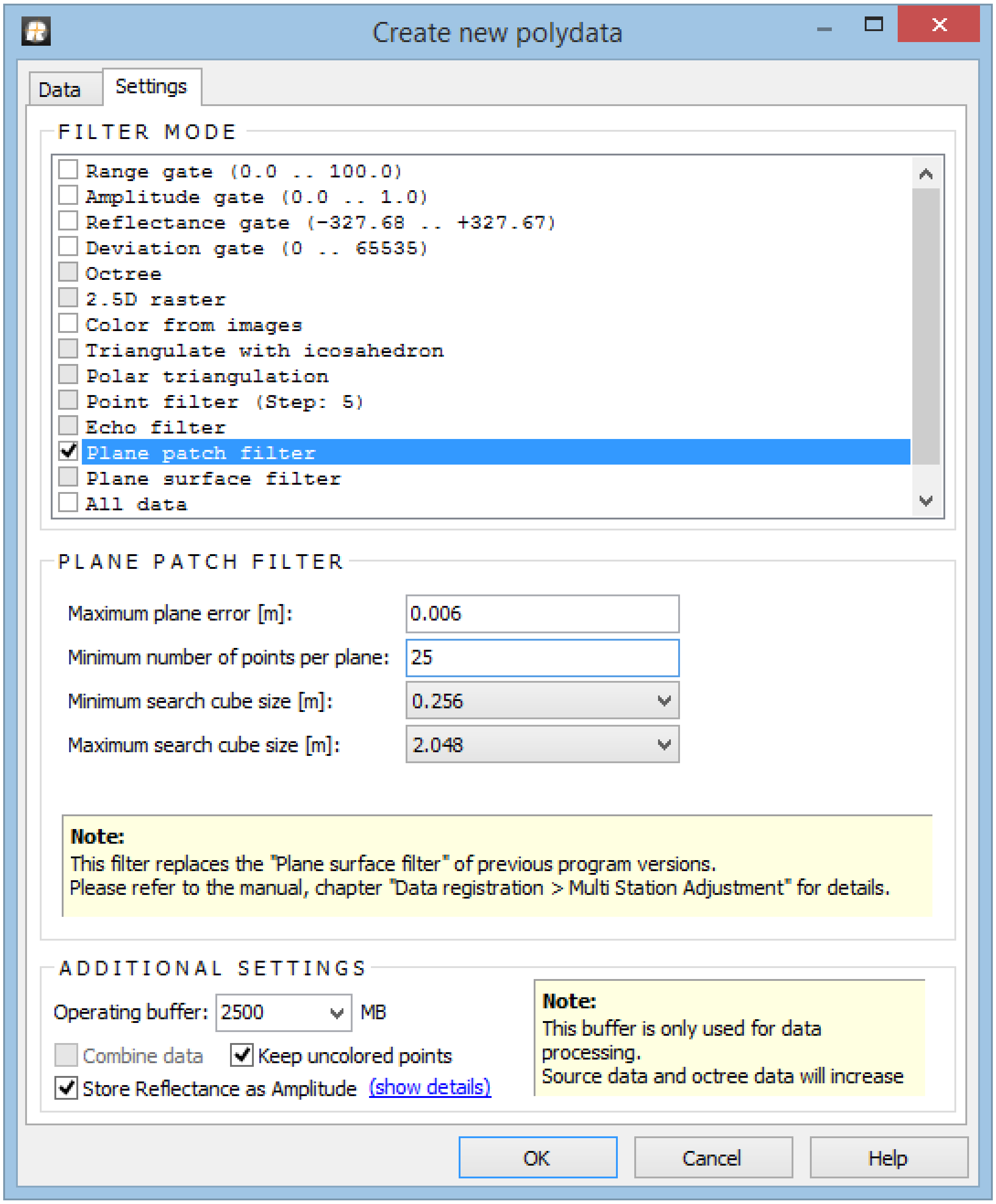
     The following screenshot shows the 3D view displaying two point clouds (white and blue) from different scan positions, the "Create tieobject" window and the selected points (red).



- After selecting points click the button "Create tieobject". A plane will be calculated from the selected points of each point cloud. The data of the planes (origin, surface normal, boundary points) are saved into the corresponding tieobject list (TOL) of the scan positions. The selected points will be deselected and the box "Name" will display the next possible name for the tieobject.
- Repeat the last two steps until all desired plane surface patches have been selected.

2.2 Automatic search for corresponding points using the iterative closest points algorithm (ICP).

RiSCAN PRO can automatically determine corresponding points. This is done by detecting the closest point of the other point clouds for each point of a point cloud (so called ICP algorithm). To speed up this process it's necessary to prepare (=reduce) the point clouds. To do so select the menu entry "**Registration > Multi Station Adjustment > Prepare data...**". This opens the filter dialog. On the first page ("Data") select the scans or polydata objects you want to use for the MSA. On the second page ("Settings") you have to select the filter "Plane patch filter":



The plane patch filter searches for planar areas (plane patches) in the point cloud. The algorithm behind this filter works as follows:

- Divide the space (point cloud) into equal sized cubes of a certain size.
- For each cube try to estimate a best-fit plane (least-squares method) from all points inside the cube.
- If the standard deviation of the normal distances between all points and the plane is less than "**Maximum plane error**" then the plane is added to the resulting list of plane patches.
- If the above condition is not fulfilled, the cube's points are divided into 8 smaller cubes, each having the half edge length of the current cube.
- For each sub cube the plane estimation as described above is repeated.

- The repetition is stopped when either a valid plane was found, the number of points inside a cube drops below "**Minimum number of points per plane**" or the cube size (edge length) drops below "**Minimum search cube size**".
- For each plane patch found, the center of gravity of its points and the normal vector are stored in a new point cloud in the "POLYDATA" folder of the scanposition.

This algorithm produces plane patches with biggest possible size (i.e. in smooth areas, the patches will be larger and close to edges they will be smaller). You can control the minimum plane patch size by adjusting "**Minimum number of points per plane**" and "**Minimum search cube size**".

3. Start the Multi Station Adjustment

To start the Multi Station Adjustment select the menu item "**Registration > Multi Station Adjustment > Start adjustment...**". A dialog window is displayed.

At the top of the window you can see a list of all existing scan positions ("**SCANPOSITIONS TO ADJUST**"). Next to each scan position the name of the position (X, Y, Z) and the orientation (Roll, Pitch, Yaw) is displayed. The last column shows the sum of observations used for each scan position. Each tiepoint point-pair results in three observations whereas corresponding points of tieobjects or polydata objects give one observation (e.g. five corresponding tiepoints of ScanPosA and ScanPosB, then each position will have an observation count of 15).

The bottom left box ("**OBJECTS of ...**") shows a list of all tiepoints, tieobjects and polydata objects of the currently selected scan position that can be used for the adjustment.
With the bottom right box you can configure and control the adjustment.

3.1 Define which scan positions should be used. This is done by switching the checkbox in front of the scan position name on or off.

3.2 Define which scan positions should be locked.

The adjustment iteratively modifies the position and orientation information of each scan position until the error reaches a minimum. But the data has to be bound to a reference coordinate system. If you're using control points (saved in the TPL GLCS) these points define your reference coordinate system. If no controlpoints are available you should lock the position and orientation of at least one scan position (e.g. the scan position that defines your PRCS). You can either lock any of the 6 parameters separately with the checkboxes in front of the parameters or you can use the context menu (right-click the scan position) to lock or unlock all at one step. To modify the state of more than one scan position simultaneously press and hold the shift key while clicking the checkbox or use the context menu.

3.3 Define which tiepoints, tieobjects or polydata objects should be used.

To do this click on a single scanposition in the list. Then you can activate or deactivate the objects with the checkbox in front of the objects's name. You can also define a weight for any single object (e.g. controlpoints may have a higher weight than tieobjects).

Note: At the moment it's recommended to use weight 1.0 for all objects (individual weights influence the calculated error value).

Note: In the object list polydata meshes are also displayed. You can also use such meshes for the adjustment but keep in mind that the number of triangles directly influences the time the adjustment takes.

3.4 Define the adjustment parameters:

In addition to the detailed object selection and weighting you can generally activate or deactivate object classes and define a common weight for each object class.

Ignore tiepoints/tieobjects/polydata objects/measured scan positions
All objects of the class will not be used for the adjustment.

Use tiepoints/tieobjects/polydata objects/measured scan positions
All objects of the class will be used with their individual weight for the adjustment.

Use tiepoints/tieobjects/polydata objects, with common weight
All objects of the class will be used with a common weight for the adjustment.

Note: At the moment it's recommended to use weight 1.0 for all objects (individual weights influence the calculated error value).

The option "**Use measured scan positions**" can be used to tie the position to measured coordinates (e.g. measured by GPS or totalstation). To use this option, you have to define the measured coordinates first. This can be done in the attributes window of a scan position (right-click the scan position in the project manager) on the page "SOP". Just activate the option "Position measured externally", select the source coordinate system of your coordinates and enter the coordinates in the corresponding edit boxes.

Nearest point search

As mentioned above, RiSCAN PRO searches for the corresponding (=nearest) point in the other point clouds for every point of a (reduced) point cloud. You can either search **one nearest point (fast)** or **all nearest points (recommended)**. The result of "all nearest points" for a particular point of a dataset is a set of points containing the nearest points of each remaining dataset. "One nearest point" searches for the nearest point in all remaining datasets. It's recommended to use "all nearest points" because this gives a better connectivity and thus a better adjustment. On the other hand this mode is slower because more point-pairs are found.
Search radius is used to limit the nearest point search (only two points within the given radius are considered to correspond).
Max. tilt angle is used to remove incorrect point-pairs. Because of the filter process described above, each point represents a plane whereas each plane has a surface normal. If the angle between the surface normals of two planes is smaller than the maximum tilt angle then the two planes are considered to correspond.

Adjustment

Min. change of error 1 / Min. change of error 2
The iterative process stops as soon as the change of error (described below) is less than "Min. change of error 1". If polydata objects are used the closest point search is started once more and the iterative process starts again. This procedure is repeated until the change of error is less than "Min. change of error 2".

Outlier threshold
After "Min. change of error 2" has been reached all outliers are removed from the list of corresponding points. Outliers are point-pairs showing a distance greater than "Outlier threshold" multiplied by "Error" (described below). After this, the adjustment is started once more with the remaining point-pairs (no nearest point search now) until "Min. change of error 2" divided by "Outlier threshold" has been reached.

Calculation mode
This parameter defines how the error is calculated. With "**least square fitting**" the square distance (of the point-pairs) is taken which means that outliers will have a greater influence to the overall result. If "**Robust fitting**" is used the absolute distance is used an thus this mode is more stable. On

the other hand "robust" may take more time because of smaller steps between the iterations. Once the data is aligned very well there will be no difference between "least square fitting" and "robust fitting".

Update display
You can watch the progress either in the list of scan positions (absolute changes) or in any 3D object view. Because the update of the 3D view takes some time you can adjust the update rate in three steps (never, seldom and often).

Statistics:

- **Error:** Displays the overall standard deviation of the distances between all used pairs of tiepoints, tieobjects and polydata objects. In the case of a pair of tiepoints the distance is the real distance between the two points. In the case of a pair of tieobjects or polydata objects, the distance is calculated as the average normal distance between both planes.
- **Time running:** The time elapsed since the current calculation was started
- **Number of pointpairs used for calculation:** Displays the number of used pairs of tiepoint, tieobject and polydata objects.
- The page "**Results**" will show some information about the used observations in both graphical and tabular manner. On the sub page "**Graphical summary**" you can see a 3D visualization of the orientations of the used planes (tie objects or polydata objects) in the project coordinate system (PRCS). Every point represents the direction of the surface normal of one plane. The color of the point is based on the absolute distance between the two planes of the observation (red: small error, blue: big error). Additionally the distance is added to the radius of the sphere to highlight outliers even more. The **histogram of residues** shows how many observations have a certain distance. On the sub page "**Tabular summary**" all observations are listed showing the names of used objects (tie points, tie objects, planes) and the remaining distance between. Click a column to sort the list ascending or descending.

3.5 Do the analysis

You may wonder how good your registration is before the adjustment is started. To get a answer to this question click the button "**Analyse**". This starts an analysis run (search of corresponding points pairs and calculation of error as described above) but no modification of the parameters (=position and orientation of the scan positions) is performed.

3.6 Start the adjustment

Click the button "**Calculate**" to finally start the calculation. The adjustment begins to run and the display mode changes to **Show absolute change of parameters**. That means that instead of the position and orientation information the 6 columns of the scan position table shows the change of the parameters (= difference after adjustment - before adjustment) now. You can switch back to the old display mode by selecting **Show parameters** again at any time. To hide the list showing the scan positions and the list with the objects click the button "**>> Minimize**".
When the calculation is finished the results are immediately written to the project structure (but the project is not saved automatically).
If the results are not good you can use the buttons "**Undo last**" and "**Undo all**" to restore the last or the first parameters (position and orientation).

3.7 Finish

To finally save the results click the button "**Close**" and save the project as usual.
You may also want to save the position and orientation parameters together with the statistics. This can be done by clicking "**Save calculation statistics to file**". This creates a text file (GCSV) which can be read by any spreadsheet program (e.g. MS. Excel).

6.10 Hybrid Multi Station Adjustment

The Hybrid Multi Station Adjustment (HMSA) is a RiSCAN PRO plugin which tries to improve the registration of the scan positions. For this purpose the orientation and position of each scan position is modified in several iterations in order to calculate the best overall fit for them.

Note: The menus described below are available only if the plugin is installed.

Where to get the plugin:

You will find the plugin on the RiSCAN PRO download page 338

How to use the HMSA:

1. First of all perform the registration as usual (see "Data registration 187").

2. Select the scan positions to be modified:
   By default every registered scan position will be included in the calculation. To change this, open the TPL SOCS of the scan position you want to disable and deactivate it. (see "The tiepointlist window 104").

3. Start the HMSA: select "Registration" > "Hybrid Multi Station Adjustment" from the menu and then select "Start calculation".
   The HMSA begins the calculation. You can watch the progress in the Messagelist or the Threadlist. When the HMSA is finished the SOPs of all activated scan positions will be modified according to the calculation results. The position of the tiepoints in the TPL PRCS (not controlpoints!) will also be modified.

4. To check the results you can compare the deviations displayed at the top of the TPL SOCS of each scan position.

5. If you are not satisfied with the result you can undo the calculation by clicking "Registration" > "Hybrid Multi Station Adjustment" and selecting "Undo last calculation". This will restore the original SOPs (As an alternative you can also restore just a single scan positions by right-clicking the corresponding SOP and selecting "Undo" from the menu).

Part VII

Data postprocessing

7 Data postprocessing

7.1 Data manipulation

7.1.1 Coloring scans

The raw scan files (3dd) do not contain color information unless you use an instrument with an optional color channel. But if you use a digital camera mounted on top of the instrument to acquire high resolution photos you can join this color information with the point data. During this process each point of the acquired point cloud is colored like the the corresponding pixels of the assigned images.

Color from images

To color a scan right-click the scan in the project manager and select "**Color from images...**" from the menu. A dialog appears where you can select which images should be used to color the scan points (on page "Images"). Use the buttons "**All**", "**None**", "**Toggle**" to modify the image selection. The button "**Current Position**" selects all images of the scan position the scan belongs to.
On page "**Settings**" you can define filters as follows:

- **Color only first and single targets**
  Activate this option to assign color only to points that are the first or only returns (targets) of a measurement (only for V-Line instruments).

- **Region of interest**
  Activate this option to define which parts of an image to use for coloring the point cloud. This could be used to cut away unwanted objects that occur in every image (e.g. parts of the laser scanner the camera is mounted on).
  The region of interest is defined as rectangular area whereas the borders (left, right, top and bottom edges) are defined as fraction of the image width and height.
  Example: If left is set to 10% and right to 90%, then 10% of the image on each side will not be used for coloring the point cloud.
  Note: The borders are relative to the top and left edges of the original, **not rotated** image!

Click the button "**OK**" to start the coloring process.
Z-Series instruments: The result will be saved in a separate scan file whereas the name will be "Color_" plus the original scan's name.
V-Line instruments: The result will be saved in-place, i.e. the color is stored to the original scan.

Note: In the dialog described above all images of all scan positions can be selected although the "Color from images..." function does NOT perform any visibility checking! Be careful when selecting images from other scan positions. Selecting images from other scan positions may make sense if the vertical aperture angle of the camera lens is smaller than the vertical aperture angle of the instrument. In that case you may acquire the scan at only one scan position but acquire images from two (or more) scan positions whereas the scanner was tilted by means of a Tiltmount 78.

Color from viewtype

You can also color the scans (not V-Line scans) and polydata objects with the color generated by a viewtype (e.g. falsecolor range, falsecolor height,...). To do so right-click the scan or polydata object and select "**Color from viewtype...**". The same viewtype dialog as for displaying data appears (see also chapters "Data visualisation 128" and "Viewtypes 128"). The settings "type" 2D or 3D is ignored here. The result will be saved as new scan or polydata file.

7.1.2 Close holes

Especially when the facade of a house is scanned it is likely that the glass of the windows will lead to loss of measurements. These holes can be closed directly in the scan file (3dd, no polydata object is created). The holes are closed by projecting points onto a defined plane.

Workflow:

- Open the scan in a 2D view 129.
- Right-click into the view and select "**Close holes...**" from the menu.
- The view automatically enters the selection mode. Choose either the rectangular, polygonal or freeform selection and select the measurements surrounding the hole you want to close (refer to chapter Select 221 to see how the selection tools work).
- Choose which plane should be used:

  Calculate plane from selection
  The plane is calculated as best fit plane of the selected points

  Use existing plane
  You can select a existing plane from the list below.
  With the option "**Move plane origin**" you can move the plane along it's surface normal until a certain point lies on the plane. To define that point press and hold down the button SHIFT while you click with the left mouse button into a measurement in the 3D view.

  Define new plane
  You can also define a new plane by selecting three points. Click "First point" and define the point's coordinates (either hold SHIFT and click onto a point in the view or enter the coordinates manually). Proceed this way for "Second point" and "Third point".

  "**Modify only points behinde plane**"
  If this option is activated only points behind the defined plane are modified. Points in front of the plane (the side where the normal vector points to) are not modified.

- Click the button "**Close Holes**".

Warning: The result is saved "in-place". That means that the changes are saved to the original scan file instead of creating a new file.

7.1.3 Select

In an object view you can select data in order to perform operations on the selected parts. If you want to select data, you have to activate selection mode and set the selection properties. You can find a description of the available properties in the table below. After selecting data you can see the selected areas colored with the selection color which you can define in the program options 36. In the status bar of the object view you can also see how many points, triangles and polyline segments are selected. How to work with selected data see "Actions on selected data 226".

Button	Action	Comment
	Selection tool	Start selection tool
	Selection mode	Activate/deactivate selection mode. You can also activate this by pressing the "SPACE" key in the object view.
	Rectangular selection	Keep the left mouse-button pressed while moving the mouse to create the desired rectangle.
	Polyline selection	Press the left mouse-button to define the edges of the polyline. The right mouse-button will finish the selection.
	Freeform selection	Keep the left mouse-button pressed while moving the mouse to create the desired selection. Release the button to finish.
	Triangle selection	Select a triangle by clicking with the left mouse-button on it.
	Mark selected area	Points or triangles within the selection become selected.
	Toogle selected area	Points and triangles within the selection invert their selection status (selected -> unselected, unselected -> selected).
	Unmark selected area	Points and triangles within the selection become unselected.
	Inside filter	Select, unselect or toggle data lying inside the selection.
	Outside filter	Select, unselect or toggle data lying outside the selection.
	Line filter **(2D view only)**	Only pixels underneath the selection boundary will become selected.
	Front face	Select only triangles, which have a normal vector pointing to the virtual camera.
	Back face	Select only triangles, which have a normal vector pointing away from the virtual camera.
	Select only whole triangles	All three points must be selected in order to select the corresponding triangle.
	Select all triangles	When any point of the triangle is selected the triangle itself becomes selected.
	Select only whole polyline segments	The start and the end node of the polyline segment must be selected in order to select the polyline segment.
	Select all polyline segments	All polyline segments that are connected to the selected nodes will be selected.
	Plane selection mode	With this tool you can either select or display points in the vicinity of a plane (see below).
	Toogle selection	Toogle the selected area. All selected items become unselected and all unselected items become selected.
	Deselect data	Remove selected. All selected items become unselected.

Plane selection mode

With this tool you can either select or display points which lie in the vicinity of a plane. The result is a band of points or triangles (sometimes also called "section").
Parameters:

Plane
Select a default plane or select "**Select...**". In the latter case you have to select a plane object in the object inspector

Bandwidth
These parameters control which points will be selected or displayed. "**Above"** is the maximum normal distance of points lying above (or in front of) the plane whereas "**Below**" is the maximum normal distance of points lying below (or behind) the plane. Click the button with the **infinity** symbol to select all points above or below the plane. Activate the button with the **lock** to use the same maximum distance in both directions.

Offset
Is an additional offset that allows a movement of the plane along the normal vector (it's not a real movement, only the decision whether a point is visible/selected or not is based on this offset).
The default value is 0.0 (equal to the plane).

Increment
This value can be used to modify the **offset** value with the buttons "**+**" and "**-**". This allows you to move the section through the model.

Mode
- Set selection state: Points in the vicinity of the plane will be selected. All other points will be deselected.
- Add selection state: Points in the vicinity of the plane will be selected. The old selection is preserved.
- Set visibility state: Points in the vicinity of the plane will be displayed. All other points will be hidden.

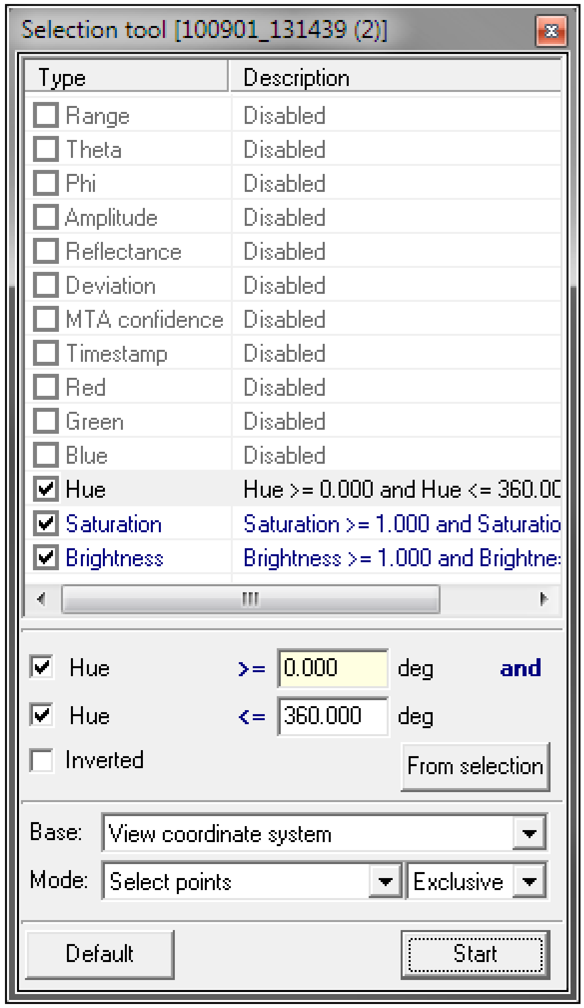
Polyline selection mode

Additionally to the plane selection described above, you can also select data with a 3D polyline object. To do so, load or create a closed 3D polyline in the the object view, right-click onto the polyline object in the object inspector and select "**Select data**" from the menu. All data lying within the 3D polyline - **as seen from the current point-of-view** - will be selected.

7.1.3.1 Selection tool

The selection tool may be used to select points within an Object view 144 by certain filter criteria such as Range, Theta, Phi, Amplitude, Reflectance and Deviation.

In order to start the selection tool you have to open an object view and click the corresponding button on the 3D - Select 221 toolbar. Moreover you can use the Popup menu of the Object view.



Description

1. Section 1 lists all available "selection criteria" so called "selectors 224".
2. Section 2 shows the currently chosen selector and allows to modify the selection term 225. Use the button **From selection** to calculate **Value 1** and **Value 2** from the points that are selected in the 3D view.
3. Section 3 contains the common settings 225 such as "Operation". "Mode" and "Coordinate system (CS)".
4. Section 4 contains the control buttons.

Selectors

Selectors are selection criteria that are used to evaluate whether a point is selected or not. Each selector is formed by the selection term 225.

Available selectors are:

- **Range** - Select points by range. The reference coordinate system may be selected in section 3 CS (coordinate system) 225.
- **Theta** - Select points by theta angle. The reference coordinate system may be selected in section 3 CS (coordinate system) 225.
- **Phi** - Select points by phi angle. The reference coordinate system may be selected in section 3 CS (coordinate system) 225.

- **Amplitude** - Select points by amplitude.
- **Reflectance** - Select points by reflectance.
- **Deviation** - Select points by deviation.

Selectors with a check mark in the column "Type" are active and therefore applied during the selection procedure. You may select one or more selectors at a time to achieve the desired result. A point has to meet all selection criteria to become selected. The column "Description" shows a short verbal description that expresses the selection term.

Selection term

The selection term is available for each selector and forms the selection criteria. You can change the selection term of the currently chosen selector by modifying the values in section 2. Changing the check marks in front of each term activates or deactivates the corresponding term. Changing the "Inverted" check mark will influence the operators.

The selection term is of the form:

Term1 TermOperator Term2

where Term1 and Term2 are:

Term1 = (Selector Operator1 Value1)
Term2 = (Selector Operator2 Value2)

The following table shows all available combinations that form the selection term on the example of the selector range.

Inverted	Use term 1	Use term 2	Selector	Operator 1	Value 1	Term operator	Selector	Operator 2	Value 2
FALSE	TRUE	TRUE	Range	>=	100 m	and	Range	<=	200 m
TRUE	TRUE	TRUE	Range	<=	100 m	or	Range	>=	200 m
FALSE	TRUE	FALSE	Range	>=	100 m	inactive	inactive	inactive	inactive
FALSE	FALSE	TRUE	inactive	inactive	inactive	inactive	Range	<=	200 m
TRUE	TRUE	FALSE	Range	<=	100 m	inactive	inactive	inactive	inactive
TRUE	FALSE	TRUE	inactive	inactive	inactive	inactive	Range	>=	200 m

You can change value 1 and value 2 by directly editing the corresponding edit boxes or by holding down "Shift" and performing a left click into the Object view. The term operators can be changed by the check box "Inverted".
Use the button **From selection** to calculate **Value 1** and **Value 2** from the points that are selected in the 3D view.

Settings

CS (coordinate system):
Selects the coordinate system that is used for point selector evaluation.

- Object coordinate system - Select points related to the object's own coordinate system.
- View coordinate system - Select points related to the currently active coordinate system 157 in the object view .

Mode:

Influences the selection result and is applied on points that pass the selector evaluation.

- Select points - Points that meet the selection criteria are selected.
- Deselect points - Points that meet the selection criteria are deselected.
- Invert point selection - The selection state of points that meet the selection criteria is inverted

- Exclusive - The selected operation will be applied to all points that meet the selection criteria. All other points will experience the opposite operation.
- Additive - The selected operation will be applied to all points that meet the selection criteria. The selection state of all other points wont be changed.

7.1.4 Actions on selected data

When you have selected data you can perform several actions. For how to select data see "Select data 221".
In the table below you can see a description of available operations with the selected data.

Button	Action	Comment
	Show LSQ plane info	Provides information about the selected data.
	Remove selected traingles	Removes all selected triangles, but does NOT delete data points.
	Remove selected polyline segments	Removes all selected polyline segments, but does NOT delete data points.
	Delete selected area	All selected data will be deleted.
	Delete selected area and create new polydata object	Creates a new polydata object from the selected data and delete then all the selected data .
	Create new polydata object	Creates a new polydata object from the selected data.
	Hide selected area	All selected data will be hidden.
	Show only selected area	Only selected data will be visible.
	Show all	All hidden data will be visible.
	Triangulate	Starts triangulation mode.
	Smooth & Decimate	Starts smooth & decimate action.
	Modify normals	Starts modify normals action.

Triangulation ... for more information see triangulation of arbitrary point clouds 243.
Smooth & Decimate ... for more information see smooth & decimate 250.
Modify normals ... for more information see modify normals 234.

You can also define a plane from the selected data, see "Create plane 281".

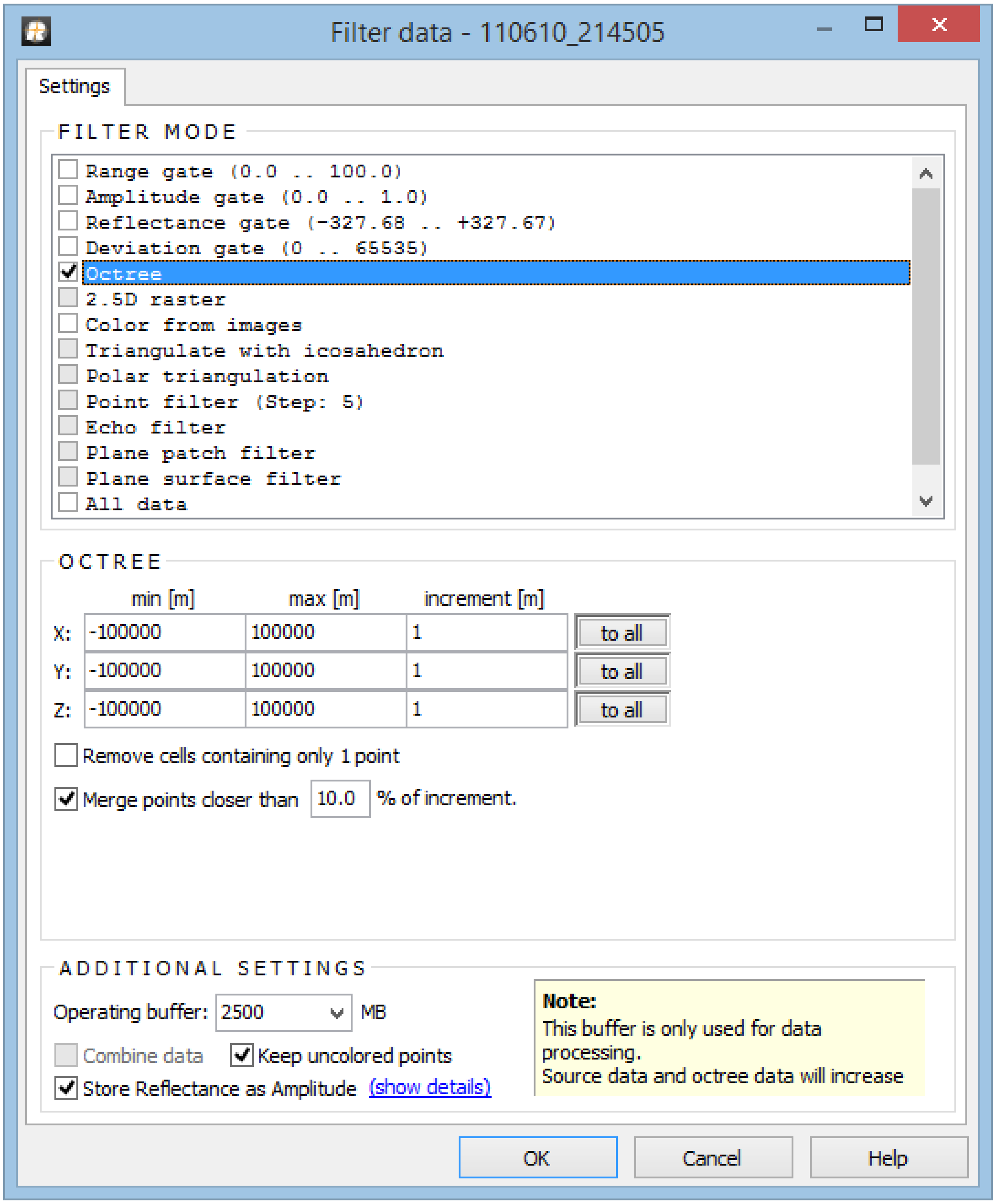
7.1.5 Filter

You can manipulate data objects (Scans, Polydata, Sections) by defining filter operations. You can filter a single object, but you can also do this with multiple objects.

- **Single object:**
  Activate the popup menu of a scan, polydata, section and select "Filter data…"

- **Multiple objects:**
  Select some objects (scans, polydata, section) and select "Filter data..." or activate the popup menu of a "POLYDATA" folder (you can locate such a folder in the project manager within a scan position or in the "OBJECTS" folder) and select "Create new polydata…"

The following dialog appears:



In this dialog you can specify a number of parameters for different filters. When filtering multiple objects you can also select which data objects you want to use (on the page called "Data" which is not visible on this screenshot) and whether you want to combine all selected data to one single data object ("Combine data").

The following **filters** are available:

- **Range gate:**
  Only data within a specified range is added to the resulting polydata object. The range is always calculated in the coordinate system of the object.

- **Amplitude gate** (former "Intensity gate")**:**
  Only data within a specified amplitude range is added to the resulting polydata object.

- **Remove isolated points:**
  A point is added to the resulting polydata object if at least a minimum number of surrounding points has a distance smaller than a given value. This filter is only available for a scan (3DD file).

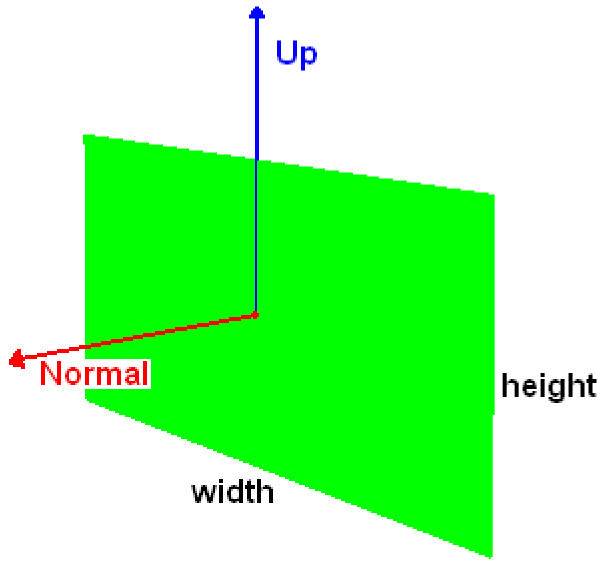
  Note: This filter is not accessible through this dialog anymore. Use right click on a scan and "Remove isolated points" instead!

- **Octree:**
  This filter procedure is done by using an octree structure. That structure is based on a cube which is divided into 8 equally sized cubes which are again divided and so on. The extension of the base cube can be entered in the dialog (min and max X, Y, Z). The division into sub cubes is done on demand by filling the points into the octree and stopped as soon as a given minimum cube size is reached (Increment X, Y and Z, usually between 0.1 and 1.0 m).
  After generation of the octree, one cube contains one point, which is the center of gravity of the averaged points in general representing a larger number of points.
  You can use the option "**merge points closer than xx% of increment**" to provide a more homogeneous pointcloud. If points from neighbouring cubes are closer than the given threshold value, they are merged.
  You can use the option "**Remove cells containing only 1 point**" to filter out isolated points.

  Note: The resulting object contains only point information no matter what type of source data you have selected.

- **2.5D raster:**
  This filter generates a 2.5D rasterized point cloud of the given source data. 2.5D means that each raster cell will be represented by a single point. If two or more points belong to the same raster cell it is definable whether the filter should take the highest, lowest or the center of gravity of all points falling into one raster cell.

  Parameters:
  To use this raster you have to select a **reference plane**. This is the plane where the raster should lie in and could be one of the default planes (XY, XZ, YZ in either PRCS or GLCS) or any other user defined limited plane 281. If you have selected one of the three default planes you have to define the **dimension** of the plane (width and height). The dimension is entered by means of **X/Y/Z** min and max values. It's also necessary to define the **resolution** of the raster. This is the size of the cells in both dimensions of the plane. If you selected a **user defined limited plane** "**resolution width**" defines the resolution along the edge that is perpendicular to the plane's "up" vector and "**resolution height**" defines the resolution along the edge that is parallel to the plane's "up" vector:



If you selected a **default plane** "resolution width" defines the resolution along the X axis of the PRCS/GLCS and "resolution height" defines the resolution along the Y axis of the PRCS/GLCS.

There are six **modes** to select from: **Minimum**, **Maximum**, **Average**, **True Minimum**, **True Maximum** and **True Average**. In the case of the first three modes, the points resulting from the filter process will always be placed in the center of the 2D raster cells (only the distance to the plane - i.e. the height - will vary for each cell) and thus an evenly distributed point cloud will be produced. The "**True**..." modes' will produce points which are not evenly distributed, because the the true horizontal coordinates of the points within a single raster cell are used. Please note that the "True…" modes require more RAM memory.

The option **Remove cells containing only 1 point** can be used to e.g. remove isolated points.

- **Triangulate with icosahedron:**
  The source data points are inserted into an icosahedron data structure. An icosahedron is a polyhedron with 20 faces, which has equilateral triangles as faces.

  Parameters:
  - *Center point*
    Origin of the icosahedron.
  - *Level*
    Defines how often the initial triangles should be subdivided. Each triangle is subdivided into four new triangles.
  - *Create watertight surface*
    Activate this to close the resulting triangle mesh. The ranges of undefined triangle points are set to "default range".
  - *Last target only*
    If this is activated only input points that have a range larger than the maximum range (calculated for each icosahedron point) minus "Threshold" value are considered for calculation.

- **Polar triangulation:**
  To see how to use the parameter please refer to the chapter Polar triangulation 243.

- **Point filter:**
  Only every n-th point is added to the resulting polydata object (n is the user defined factor).

- **Plane patch filter:**

This filter is used to prepare the data used by the Multi Station Adjustment module. Please refer to the chapter Multi Station Adjustment 212.

- **All points:**
  All points will be added to the resulting polydata object (you can use this filter to clone objects, or to combine objects).

- **Create organized point cloud**
  Scans and polydata objects within RiSCAN PRO can be visualized in 3D. Because they are based on unstructured point cloud data formats the rendering procedure is not very fast (on the other hand it offers comfortable functions like selecting or deleting points). To be able to render big point clouds (i.e. more than 10 million points) it's necessary to create a so called structured or organized point cloud. RiSCAN PRO uses an octree structure to organize the point cloud. Because of this structure the data can be rendered very fast but it's not possible to select or delete points. So the organized point clouds can be used for presentation of big, post-processed and combined point clouds.

  Parameters:
  As mentioned above an octree structure is used to organize the point cloud. The octree is generated recursively until one octree cell contains less than **Max. bucket size** points. To get the impression of a closed surface each point of the point cloud is represented by several pixels on the screen so that two neighboring points will touch. For that feature it's necessary to define a **Splat size** that is the average real distance between two neighboring points. If you create an organized point cloud from a scan (3dd) the splat size is automatically determined from the scan resolution. For polydata objects you have to define the splat size manually (if the splat size doesn't fit very well you can modify it when the point cloud is displayed in the object view).

Note: Combination of all filters is not possible. Some filters do not accept certain other filters.

The result of a filter operation is always a polydata object.

Additional settings:

- **Operating buffer**
  Use this option to define the maximum amount of memory used to load the source data (such as scans and polydata objects). If the source data is larger than the entered buffer size, the data is loaded in several steps until the complete amount of data is processed. Already processed data will be written to temporary generated files located in the project folder.

  Note:
  If you activate the filter "octree" there will be additional memory consumption, as the octree is not saved to temporary files.
  Scans (3DD files) also result in additional memory consumption, because they can only be loaded as a whole.
  Ensure that you have write permission to the project folder and sub folders (please check access rights).

- **Combine data**
  When you start the filter action from the folder "OBJECTS/POLYDATA" the place where the resulting polydata object is saved depends on the setting of the "Combine data" option:

  Combine data activated:
  All data will be saved within one single polydata object located in the folder "OBJECTS/POLYDATA", except if you selected data from only one scan position. In the latter case the result is placed in the corresponding "POLYDATA" folder of the scan position.

  Combine data deactivated:

For each selected source object a new polydata object containing the filtered data will be created in the same folder.

7.1.6 Terrain filter

The terrain filter can be used to separate off-terrain points (e.g. vegetation, small objects, moving objects such as vehicles, outliers, etc.) from terrain points. In the course of the filter process, the distances of the points from an estimated ground surface are analyzed. Based on these distances, the points are classified either as “terrain” or “off-terrain”. Note that the filter is not intended to filter large objects (e.g. buildings) without points below their surface since the used method requires a certain amount of terrain points underneath the off-terrain objects. The representation of the terrain surface is restricted to 2.5D. Hence, the filter does not work properly in areas where overhangs occur. However, the filter may be applied separately to such regions by specifying an appropriate reference plane (see below).

Usage:

The input of this tool is a point selection (in the 3D view) and a reference plane (“grid plane” - usually, the XY plane of the PRCS, but any other user-defined plane object may be specified).
Note: It is recommended to prepare the point cloud in a such a way that regions with a very high point density (e.g. near the scan positions in case of terrestrial scans) are avoided.

Step-by-step:

- Open a 3D view and add some point clouds (scans or polydata objects)
- Select the points of interest (using the selection tools as usual)
- Click on the button "Terrain filter" ( ) in the tool bar "3D - Select".
- Define reference plane and parameters (see next paragraph for detailed description of parameters)
- Click on OK to start the filter process
- After the process, the off-terrain points will remain selected and the terrain are not selected
- Now you can use other tools on the selected points (like delete points)

Description of the method:

The filter works in a hierarchic manner with several level of details using a coarse-to-fine approach. The filter process is based on a grid representation of the data at each level. In the first step, a coarse grid is specified in the grid plane. For each cell of the grid, one representative point is selected from the point cloud – if there is any within the cell. This is done based on the parameter “percentile” (see below). After that, those representative cell points (RCPs) are used to estimate a local surface for each non-empty cell by estimating a robust plane through the central cell's RCP and its neighbors. After that, for each cell, a tolerance range above/below its estimated plane (i.e. a region limited by two parallel planes above/below it) is defined according to the parameter “tolerance factor”, which specifies the range's value (see below). For each cell, those points, which have not yet been classified as “off-terrain” and which are outside the tolerance range, are marked as “off-terrain” points and not considered anymore. The remaining points are assigned to one of the 4 sub-cells of the next finer level (the cell size is divided by the factor 2 from level to level), at which again the RCPs are determined and so on, until the finest level has been reached. After this hierarchic filter step, a fine filter step with a final tolerance value is performed (see below). For certain applications, it may be useful to perform a second hierarchic filter step (with a smaller tolerance value) between the first one and the final one (see below).

Description of the parameters:

- **Base grid size:**
  The base grid is the grid corresponding to the finest level (level 1). This parameter specifies the edge length of one quadratic cell of the base grid.

- **Number of levels:**
The number of levels (n) used for the hierarchic filter process. A cell of level k contains 4 cells of level (k-1) (where n >= k > 1). Hence, the grid size of the coarsest level n results by multiplying the base grid size with 2^(n-1).

- **Tolerance factor:**
The tolerance factor specifies the value of the tolerance range above/below the plane estimated for a cell of a certain level (see description above). It is expressed in units of the level's grid size. All points outside the tolerance range from the plane are marked as "off-terrain" points in the current level. Example: Given a base grid size of 0.5m, 4 levels, and a tolerance factor of 1.2, the tolerance values would be ±4.8m for level 4, ±2.8m for level 3, ±1.2m for level 2, and ±0.6m for base level 1.
If the tolerance factor is too high (conservative), the off-terrain objects may not be filtered properly. If it is too low (aggressive), terrain points may be classified as "off-terrain".

- **Percentile:**
The percentile specifies the percentage of points within a cell that shall be below the representative cell point (RCP). For example, in case of a percentile of 1%, the RCP is selected in such a way that 99% of the other (still not marked) points are above it and 1% below it. In case of value 0%, the RCP simply corresponds to the (still not marked) point with minimum height inside the cell. The latter value should be avoided since negative outliers (points below the surface) may cause wrong filter results.

- **Maximum slope angle:**
It specifies the slope of the terrain (actually: the slope of the estimated plane of the cell), up to which the filter shall be applied. A value of 90° means that the filter is applied everywhere, a value of < 90° prevents steep areas from being filtered.

- **Second filter step:**
If specified, a second hierarchic filter step is performed, which may be – to a certain degree – useful to filter (high enough) objects, below of which are few or no terrain points. The idea is to perform a first (rather) conservative (i.e. high tolerance factor) and a second (more) aggressive (i.e. low tolerance factor #2) filter step. After the first step, all base grid cells are marked, at which at least one point has been classified as "off-terrain". Only those cells and a certain neighborhood are considered for the two remaining filter steps (the second as well as the final one).
The second filter step should be performed in cases where the usage of a single tolerance factor does not provide a satisfying classification result.

- **Tolerance factor #2 (only relevant if second filter step is performed):**
Same meaning as tolerance factor, but valid only for filter step #2. Choose it lower than the tolerance factor of step #1).

- **Buffer zone width (only relevant if second filter step is performed):**
Number of base grid cells used for morphological filter.
After filter step #1, a binary image (marked cells vs. not marked cells) at the base grid level is generated. This binary image is morphologically filtered by adding all cells within a neighborhood (buffer zone) of the marked cells. If the objects to be filtered tend to have high parts only at their center and low parts at there margin, a higher value of this parameter is recommended in order to get rid of the lower object points, too. If the objects tend to have high enough parts on their margin, a small value of this parameter is recommended.

- **Fine filter tolerance value:**
Tolerance value (maximum distance from plane) for the fine filter step. It should be smaller than the tolerance value given by the tolerance factor (#2 in case of) of the finest level (in our above-mentioned example, it should be smaller than 0.6m – e.g. 0.1m).

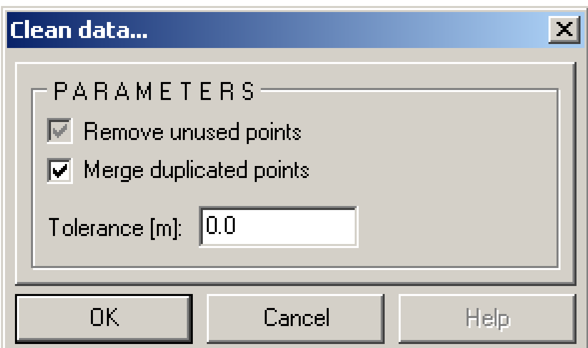
- **Mark points BELOW estimated terrain surface only:**
Points below the terrain surface (e.g. caused by mirror reflection on water surfaces) may have - if they occur in a certain density - a negative impact on the filter result. Hence, they should be eliminated before. If

this option is checked, the filter tries to find such points and will mark ONLY them.
If you suppose that the point cloud contains areas with several points below the terrain, the following workflow is recommended: Run the filter using a parameter set where this option is activated, and delete the marked points. Note: since the resulting selection may contain classification errors (i.e. marked terrain points), it is recommended to perform a visual check (and possibly, a manual manipulation) of the resulting point selection before deletion. Afterwards, apply the filter again to the remaining point cloud using the settings for the actual filter process.

- **RAM being used:**
  Maximum size of memory in megabytes being used. Based on this size, the number of points fitting in the memory is estimated. If this point number is exceeded, a temporary file on the disk is used for swapping data, which significantly slows down the process.

7.1.7 Clean

You can clean up the data of a polydata object, by selecting it in the project manager and activate the popup menu. Then select "Clean data…" and the following dialog appears:



- **Remove unused points:**
  All points which are not referenced by any data array (such as point cloud or triangulation) will be removed (this option is always activated, because you can not take use of unreferenced points).

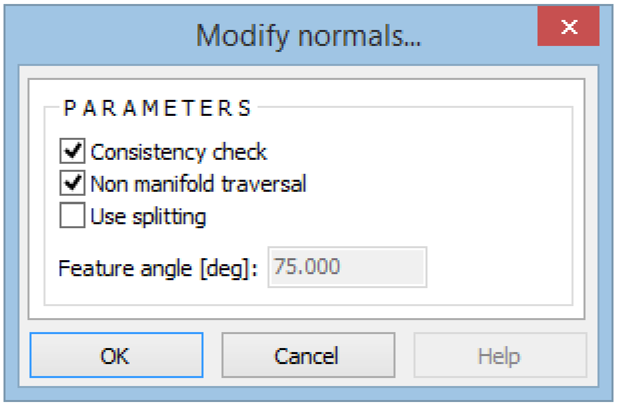
- **Merge duplicated points:**
  Points with the same point coordinate will be merged to a single data point.

- **Tolerance:** (only available for point clouds)
  If this value is greater than zero, then points within a specified tolerance will be merged to a single data point. This value is only used if "Merge duplicated points" is activated.

To finally start the cleanup procedure click the button "OK". The resulting data will be saved in a polydata object located in the same folder as the source polydata object.

7.1.8 Modify normals

You can modify the surface normals of a triangulated polydata object by selecting it in the project manager and activating the popup menu. Then select "Modify normals…" and the following dialog appears:



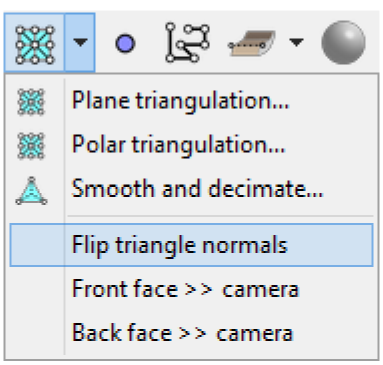
- **Consistency check:**
  Enable this for enforcement of consistent polygon ordering.

- **Non manifold traversal:**
  Enable this to traverse across non-manifold edges. This will prevent problems where the consistency of polygonal ordering is corrupted due to topological loops

- **Use splitting:**
  Enable this to split sharp edges. The feature angle will define a sharp edge. If the difference in angle across neighboring polygons is greater than this value, the shared edge is considered "sharp". This means that the affected points will be duplicated in order to prevent blurry edges when they are rendered.

To finally start the procedure click the button "OK". The resulting data will be saved in a polydata object located in the same folder as the source polydata object.

You can also modify the surface normals in an object view. To use this operation you have to open an object view an load the data you want to manipulate. Click the "modify normals" button and select an operation from the popup menu. The button can be found in the "3D - Modify" toolbar.



- **Flip triangle normals:**
  The surface normals of the (selected) triangles will be inverted.

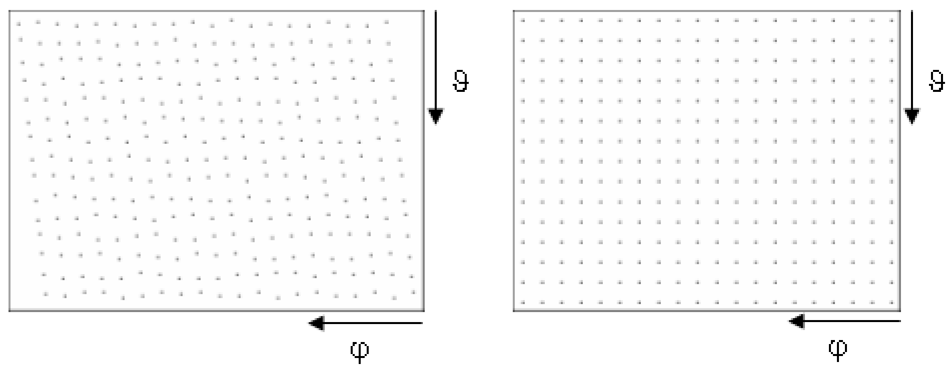
- **Front face >> camera**
  After this procedure the surface normals of all (selected) triangles will point to the virtual camera.

- **Back face >> camera**
  After this procedure the surface normals of all (selected) triangles will point away from the virtual camera.

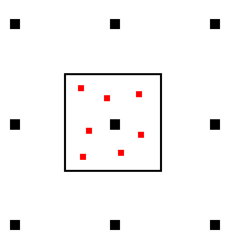
7.1.9 Resample

General aspects

In most cases scan data of RIEGL laser scanners can be addressed as an organized point. The scan data is acquired sequentially on a more-or-less regular grid in a $\vartheta-\varphi$ plane, whereas ϑ and φ denote the polar 339 angle and the azimuth 339 angle respectively. This data acquisition can also be addressed as taking the scan line-by-line in azimuth direction and measurement-by-measurement within one line in polar direction (compare the left diagram in the Figure below).



By re-sampling a scan a new grid in the $\vartheta-\varphi$ plane is generated. The extent of the grid is defined by one of the original scans to be re-sampled. The resolution of the grid is defined by the user in a dialog. During the process of re-sampling all range and amplitude data falling within one cell of the grid is averaged (red dots in the figure below). There are different options and parameters influencing the averaging which are discussed in more detail below. The result of re-sampling is a 3D data set with a strictly regular grid in the $\vartheta-\varphi$ plane (compare the right diagram in the Figure above).



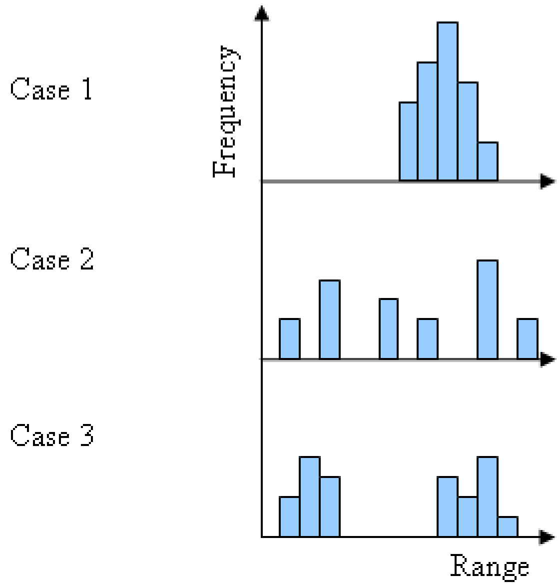
In the following cases re-sampling scan data is of advantage:

- Reducing range and amplitude noise by re-sampling of a scan sequence or of a number of scans taken at the same scan position.
- Reducing range and amplitude noise by re-sampling a single scan with a lower scan resolution.
- Removing temporal targets from a scan sequence, e.g., cars moving on a highway.

Controlling the averaging process

During the re-sampling process each grid cell will contain a number of data (measurements) before executing the averaging of range and amplitude data. The figure below shows three different examples for the distribution of range within a single cell of the grid. Wether the final cell will have a valid range or not is judged on the basis of the standard deviation which is compared to a threshold. In case 1 all the range data are distributed near an average range and the standard deviation is quite low. In case 2 the range data are distributed fairly wide giving quite a large standard deviation. The data may arise from measurements taken at, e.g., walking pedestrians. In case 3 we have two distinct ranges with low variation each.

The averaging process is controlled by the option "Last target only" and the "Threshold".



"last target only" OFF

In this case the standard deviation of all range data with every cell is calculated and compared against the threshold value. In case the deviation is smaller than the threshold, the range in the cell is set valid and is set to the average range. In the examples described above, only in case 1 a valid range would be calculated.

"last target only" ON

This mode allows to suppress near range clutter signals. In this case **only** the range values larger than the maximum range minus five times the threshold value are considered for standard deviation calculation and averaging. In the examples described above cases 1 and 3 will give valid ranges.

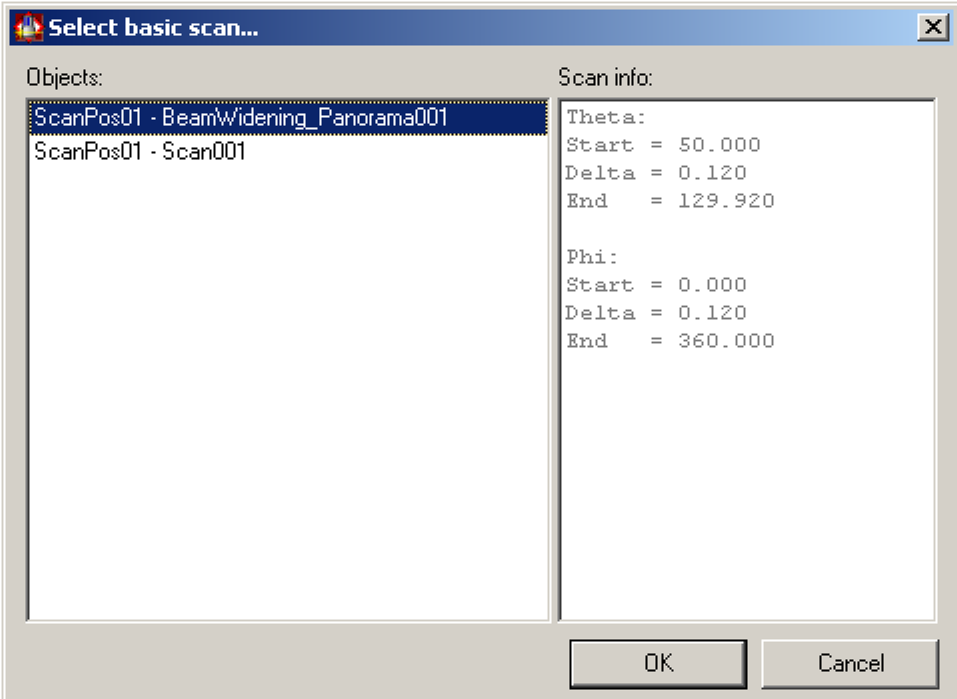
Average theta and phi angles

If you only average the range values without averaging the angle values, this may lead to anomalies in the resulting scan. If you are not satisfied with the result, then try to activate this option.

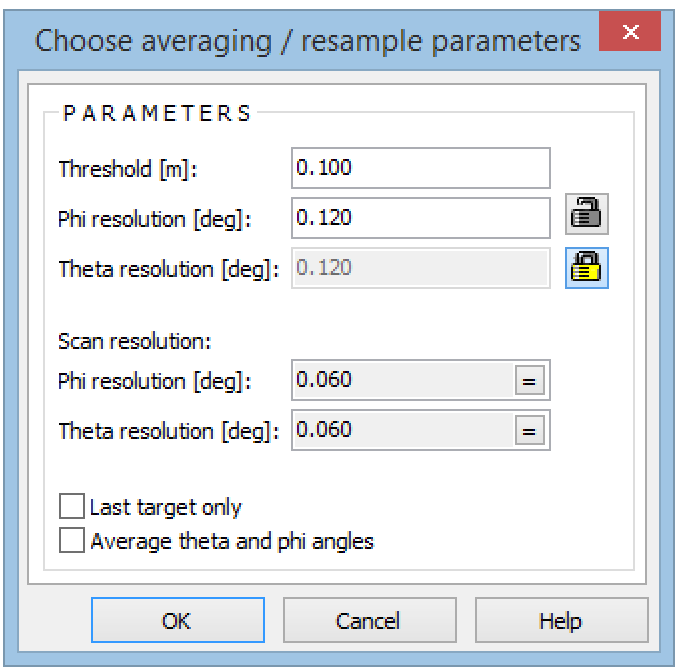
Resample example:

If you want to resample one (or more) scan(s), then mark the scan(s) and click the right mouse button. Choose "Resample..." from the context menu.

If you decide to resample more than one scan, you have to define the basic scan. That means that this scan is used to adjust the resample parameters and the dimension (angular extents).



The next step will be to set up the resample parameters. (Description see above 236)



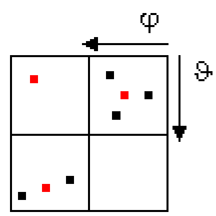
You can use the "=" - buttons to set the output resolution equal the scan resolution.

7.1.10 Preprocess 3DD

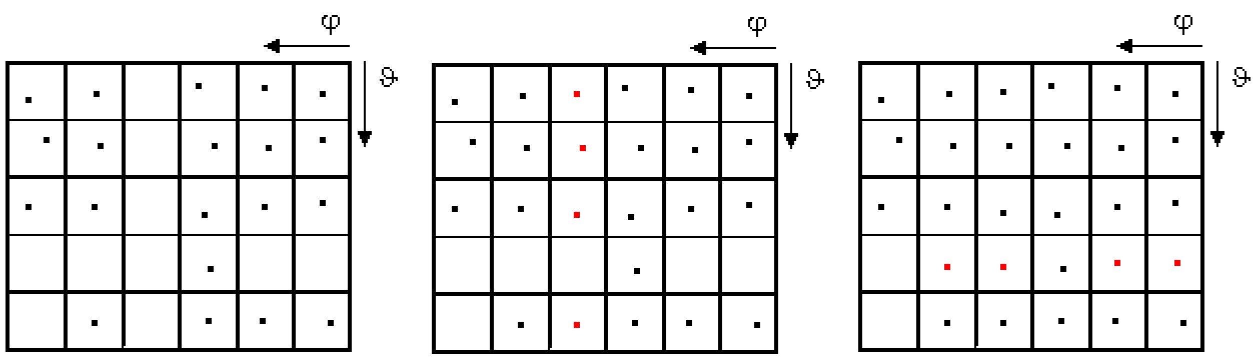
General

In most cases scan data of RIEGL laser scanners can be addressed as an organized point cloud. The scan data is acquired sequentially on a more-or-less regular grid in a ϑ-φ plane, whereas ϑ and φ denote the polar and azimuth angle respectively. This data acquisition can also be addressed as taking the scan line-by-line in azimuth direction and measurement-by-measurement within one line in polar direction. Especially high-resolution scans show anomalies in the grid which may cause problems when the scan is processed with third party postprocessing software.

By preprocessing a scan, a grid is generated in the ϑ-φ plane. The extents and the resolution of the grid are defined by the original scan. First the 3dd preprocessor averages the values of all range, azimuth, polar, color and amplitude data of all measurements falling in the same cell of the grid (black dots in the figure below). Cells without any measurement remain empty. The result of this operation is a 3D data set with a maximum one data point in each cell of the grid (red dots in the figure below; this is similar to resampling, but without a strictly regular grid).



The second operation of the 3dd preprocessor is interpolating empty grid cells. If there is a cell without any data, the preprocessor looks for valid data in the cells before and after the empty cell and averages all values of them to generate a valid point for this cell. If the cell before or after the empty cell is empty too, no action is taken.
This interpolation is first done in φ direction and then in ϑ direction.

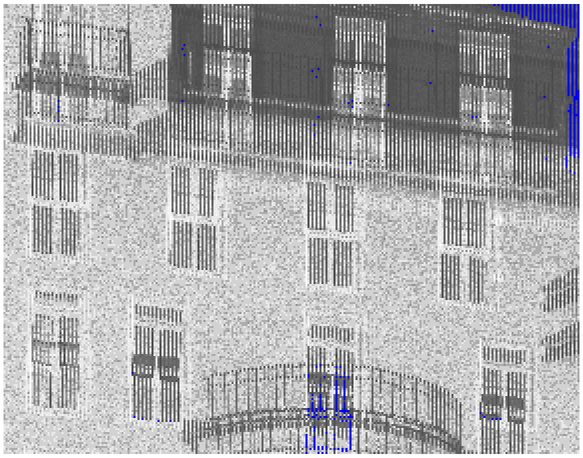


See the figure above: The left figure represents valid data points before interpolation. The preprocessor starts interpolation in φ direction (red dots in the middle figure) and then continues in ϑ direction (red dots in the right figure).

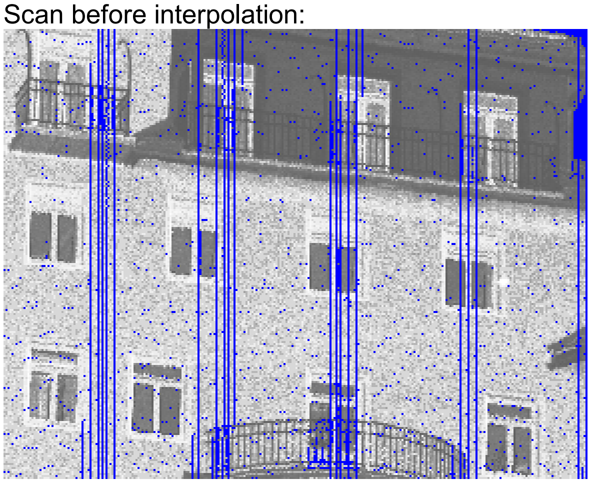
Usage of 3dd preprocessing / Example:

If you want to preprocess a scan, right-click the scan in the project manager and select "Preprocess 3DD" from the menu. There are no parameters to set. The pictures below show a part of a facade before preprocessing, before interpolation and after preprocessing. The blue areas represent invalid points.

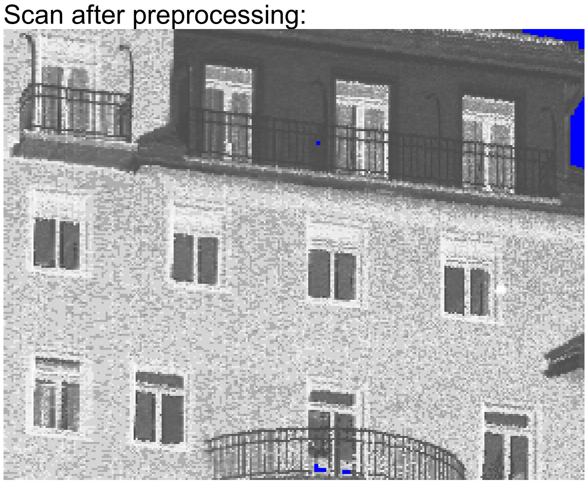
Scan before preprocessing:



Scan before interpolation:



Scan after preprocessing:



7.1.11 Tile data

The function "Tile data" can be used to split point clouds into several tiles. Each tile has a given size and contains all data that lies above and below a given plane. This can useful for further data post processing inside RiSCAN PRO or in other software programs.

To use this function, select one or more scans, right click and select "Tile data...". In the dialog window, you can select which **plane** to use. **Note:** Only limited planes (those where width and height is not equal to zero) can be used (this is because the number of tiles is calculated using that information). In the group "**Tile**" you can specify the width and height of the tiles. Within "**Output Folder**" you can define where the generated PolyData objects should be stored.

7.2 Triangulation

Triangulation is the process of creating a surface out of a point cloud where the surface consists of triangles connecting the data points. Triangulated data (also called a "mesh") provides a familiar representation of the scanned object. Additionally triangulated data can be textured 256 with the high resolution images taken with the digital camera which leads to a nearly photo-realistic model.

In RiSCAN PRO two different functions to triangulate data are implemented:

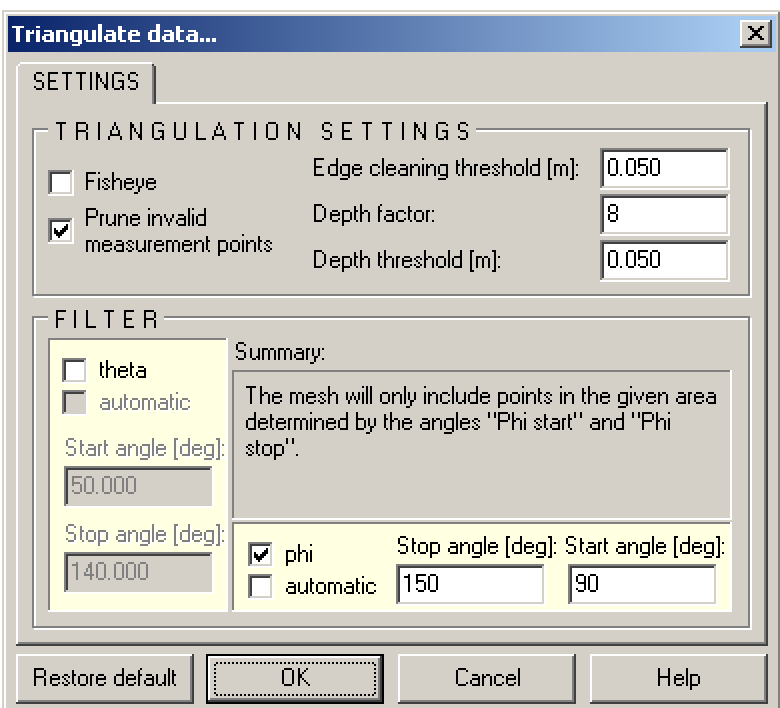
- Triangulation of a scan 241
  This function can be used to triangulate a point cloud (a 3DD file) automatically. This function is only applicable to point clouds acquired with a scanner and thus located at a scan position.

- Triangulation of arbitrary point clouds 243
  This function is more interactive. The user defines which part of the point cloud should be triangulated. Therefore it is an iterative process where small parts of the point cloud are triangulated until the desired result is achieved. This function can be used for any arbitrary point cloud located either at a scan position or in the folder "OBJECTS" (project coordinate system).

7.2.1 Triangulation of a scan

Triangulation is a process to create a surface from a point cloud by connecting the points with triangles.

Right-click on a scan and select "Triangulate scan...".



TRIANGULATION SETTINGS

- *Fisheye*

  This function is used for debug purpose.

- *Prune invalid measurement points*

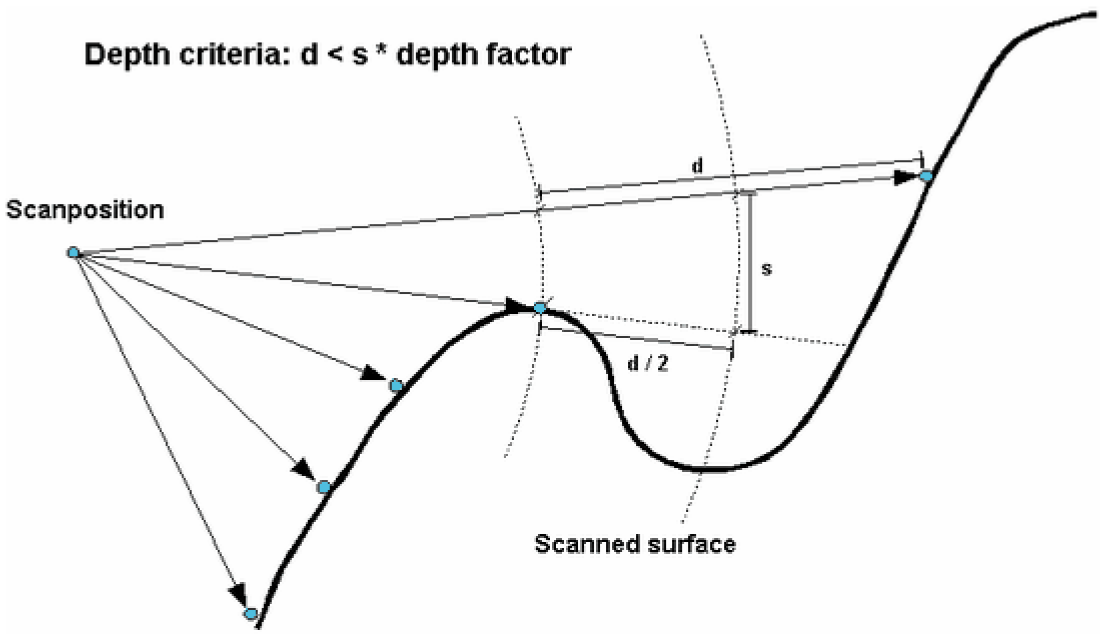
  Points that have angles but do not contain measurement information will be neglected.

- *Edge cleaning threshold*

  describes the quality of the edges.
  Note: if this value is set to a small value (high quality), the surface might contain holes.

- *Depth factor*

  defines the valid edges of a triangle. Each three edges of the triangle have to satisfy the following criteria:



- *Depth threshold*

  Points that are very close to each other may produce an unpredictable orientation of triangles. Setting this value higher than the noise level would preserve these triangles.

FILTER

Limit the output by selecting a range from the mesh.

- *theta*

  refers to the vertical output of the mesh. Possible values range from 0° - 180°.

- *phi*

refers to the horizontal output of the mesh. Possible values range from 0° - 360°.

The triangulation process will create an object in the folder "POLYDATA" having the identical name as the scan. You can view the generated object by double-clicking it or right-clicking it and selecting "View...".

If you are visualizing an image in 2D, you can triangulate a part of the image by holding down the Alt-key while left-clicking and moving the cursor to create a rectangle.
Click the button "Preferences" from the menu and select "Triangulate scan...".

7.2.2 Triangulation of arbitrary point clouds

A 2D-Delaunay triangulation algorithm is used to triangulate arbitrary point clouds. To use this triangulation, right-click into an object view window and select "Triangulate". Alternatively you can use the triangulate button from the toolbar "3D - Modify" 226.

There are two different modes available "**Plane triangulation**" and "**Polar triangulation**".

In both modes you have to select points from only one polydata object for the triangulation process, because the resulting triangle mesh is stored in the same polydata object. To triangulate a scan with this procedure please create a polydata object first (e.g. select some points of the scan in the object view and click on the button "Create new polydata object 226").

Plane triangulation:

In this mode, the triangulation is computed from the 2D coordinates of the points mapped to the computer screen (useful to close holes or to triangulate terrain models).

First you have to define some **settings:**

- **Max. triangle edge length** - Defines the maximum length of the edges for a triangle. That means if one edge of a triangle is larger than the specified value the triangle is removed.
- **Max. triangle tilt angle -** The triangle's tilt angle is the angle between the surface normal of the triangle and the line of sight. Triangle's of which the tilt angle is larger than the specified value are removed.
- **Min. triangle angle** - If at least one of the three triangle angles is smaller than this constraint the triangle will be removed. This value can be adjusted to remove needle triangles.
- **Crop triangles outside polylines** - Indicates that triangles that are not enclosed by a polyline will be removed. This option allows you to triangulate concave closed polylines. **Note:** If this option is activated and there is no closed polyline in the view all triangles will be removed.

As mentioned above the triangulation is done from the current point of view. Thus rotate the point cloud in order to get a good viewpoint. Overlapping points should be avoided. To finally triangulate the points click the button **"Triangulate"**. The resulting triangles will be marked as highlighted, so if you are not satisfied with the result you can easily undo the last operation by pressing the button "Remove selected triangles". 

Polar triangulation:

Polar triangulation works similarly to the plane triangulation. The only difference is that the selected points are projected onto a disk and not onto a plane. This means that the polar triangulation is independent of the current point of view. In order to perform a polar projection of the data points the function needs to know the position from where the data was recorded (scan position).

First you have to define some **settings:**

- **Max. edge length** - Defines the maximum length of the edges for a triangle. That means if one edge of a triangle is larger than the specified value the triangle is removed.
- **Max. triangle tilt angle -** The triangle's tilt angle is the angle between the surface normal of the triangle and the laser beam. Triangle's of which the tilt angle is larger then the specified value are removed.
- **Min. triangle angle** - If at least one of the three triangle angles is smaller than this constraint the triangle will be removed. This value can be adjusted to remove needle triangles.
- **Depth threshold** - The radial distance between two points of an triangle's edge must not be larger than this value.
- **Depth factor** - The radial distance between two points must not be larger than **Depth factor** G horizontal distance of both points at averaged range (see sketch in "Triangulation of a scan") 241.
- **Center point** - Defines the origin of the triangulation process. You can use predefined point information or select <*custom*> to set your own center point coordinates. The <*automatic*> mode can only be used if the selected data is from a scan position. The center point is then automatically defined as the data's scan position.
- **Create watertight surface** - Activate this to close the resulting triangle mesh. This means that all resulting holes in the mesh are closed by creating triangles from the two points of the boundary edges and the center point.
- **Crop triangles outside polylines** - Indicates that triangles that are not enclosed by a polyline will be removed. This option allows you to triangulate concave closed polylines. **Note:** If this option is activated and there is no closed polyline in the view all triangles will be removed.

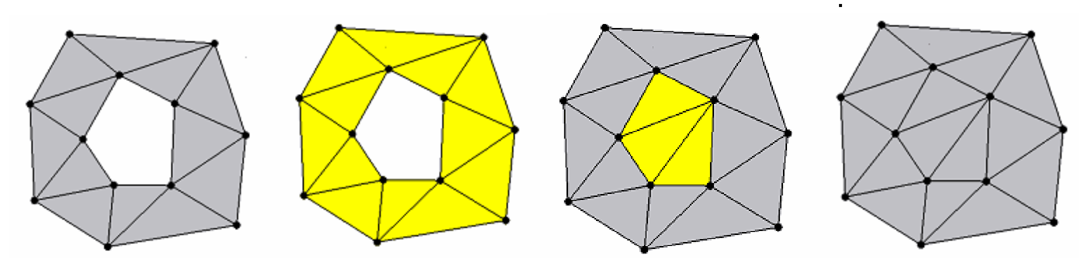
To triangulate the points click on the button **"Triangulate**". The resulting triangles will be marked as highlighted, so if you are not satisfied with the result you can easily undo the last operation by pressing the button "Remove selected triangles".

Note:
The triangulation tools "Plane triangulation" and "Polar triangulation" mainly use your graphics card. Thus you will experience huge performance gains for triangulation on state of the art graphics hardware.

Triangulation examples and tips:

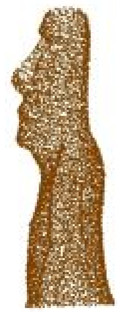
1. Use the triangulation for hole filling.

First of all select the surrounding triangles of the hole. Afterwards you can use the plane or polar triangulation to close the hole.



Initial mesh | Select surr. triangles | perform triangulation | after triangulation

2. How to triangulate volumetric objects that have been scanned from many different scan positions.

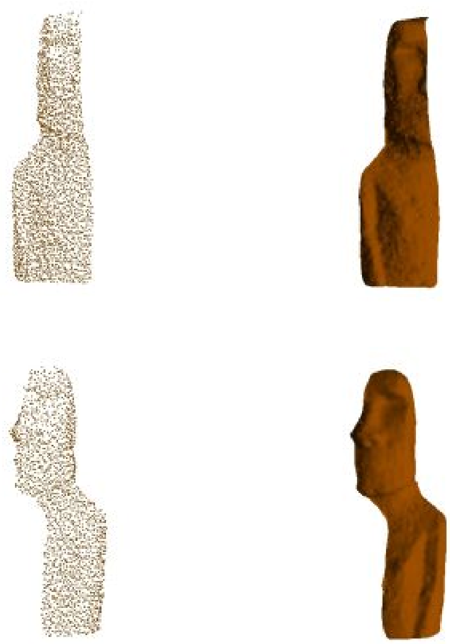


Problem:

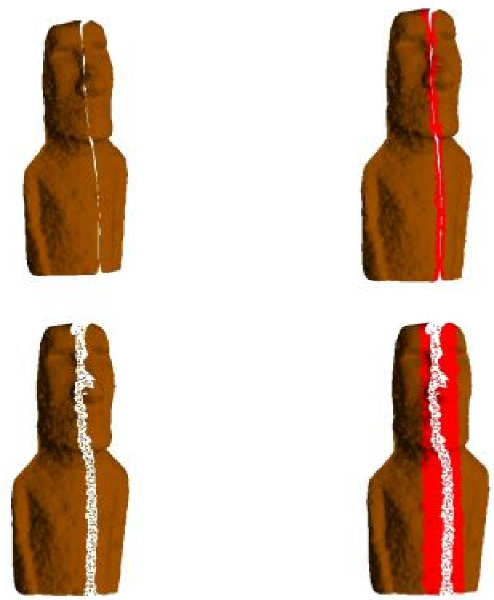
- Due to the many different scan positions "Polar Triangulation" is not suitable because it expects one scan position to transform the points. As a result you need to **work with "Plane triangulation"**.
- "Plane triangulation" takes the points as you see them on the screen and triangulates them in 2D. No depth information is used for the triangulation. This implies the problem that points that lie far from each other in 3D space (ie somewhere in the background) appear to lie next to each other in 2D space. Depending on the triangle constraints (max. edge length, angles, ...) very odd triangles can be produced.

Solution:

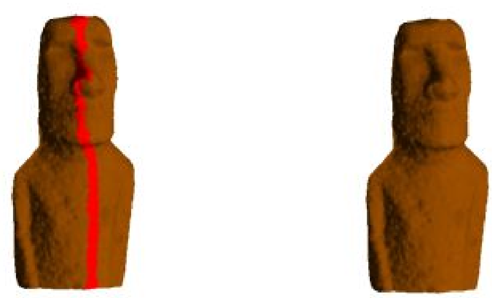
- Partially triangulate the point cloud and finally sew the meshes together to obtain one big closed mesh.



Use the plane triangulation to triangulate the point cloud partially from different views so that only points are selected that belong to the surface.



Use the selection tool to break up the triangles in the transition area between the two meshes. Afterwards select both meshes with the points in the transition area again and sew the meshes togeter using the plane triangulation.



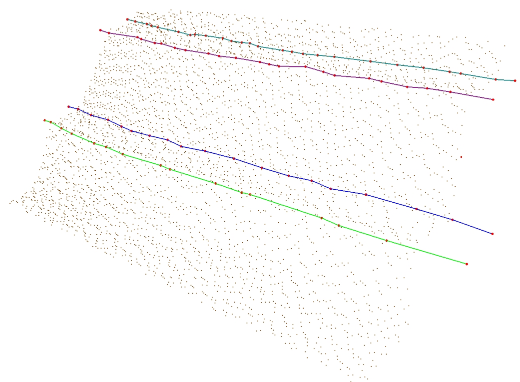
As a result you optain one closed mesh triangulated from different points of view by making use of the plane triangulation.

3. How to use polylines (breaklines) for triangulation.

You can include polylines into the triangulation to achieve one of the following scenarios:

- Polylines can be used to determine the shape of the resulting mesh.
- Edges in the mesh formed by polylines are not changed by the Smooth & Decimate 250 process.
- Polylines can be used to triangulate concave shapes.

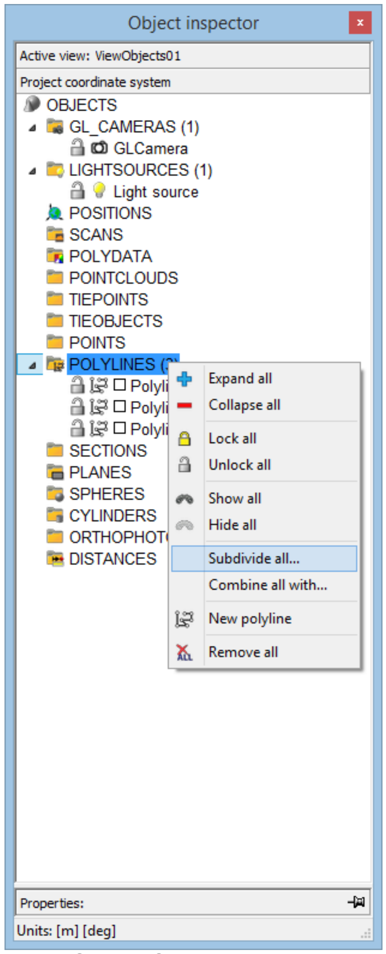
3.1 Using polylines as breaklines in mining applications to preserve shapes:
Usually breaklines are formed by manually measured points and imported into RiSCAN PRO. Alternatively you can also extract the breaklines from a pointcloud by using the edge modeling 273 tool.



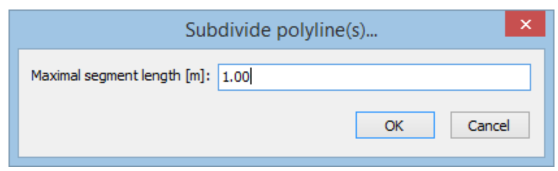
Mining example with polylines (breaklines)

To be able to use breaklines for triangulation you have to carry out the following steps.

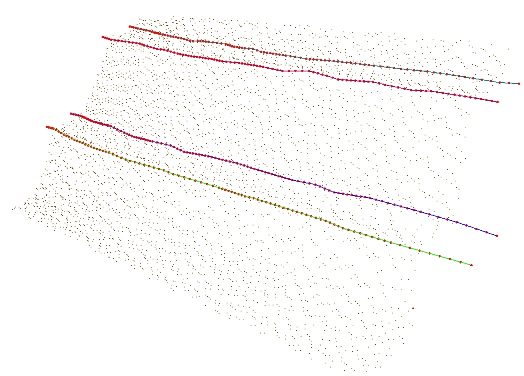
- **Subdivide polylines (breaklines):**
  Usually breaklines consist of only very few actually measured points. For better triangulation behaviour you can increase the number of points. This is done by right-clicking the folder "POLYLINES" in the "Object Inspector" and selecting "Subdivide all...". A dialog will appear that allows you to enter the maximum segment length of the polyline. New points will be added to the polyline by linear interpolation between the existing ones.



Select "Subdivide all..."



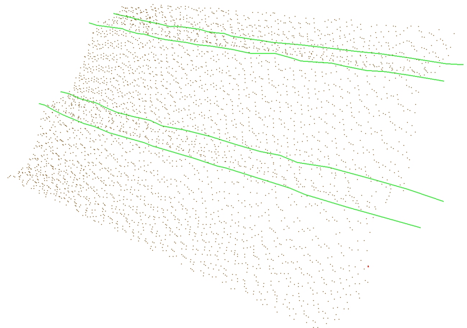
Enter the max. segment length.



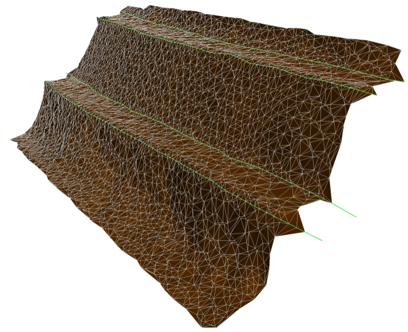
Additional points have been added by linear interpolation.

- **Combine the breaklines with the polydata object.**
  In order to use the breaklines for triangulation you have to merge them into the polydata object. This is done by right-clicking the folder "POLYLINES" in the "Object Inspector" and selecting "Combine all with...". Once the polylines have been merged you can select and edit them. See Actions on selected data 226 for details on how to edit polylines.

- **Select the points and breakline segments you want to triangulate and perform a plane or polar triangulation.**

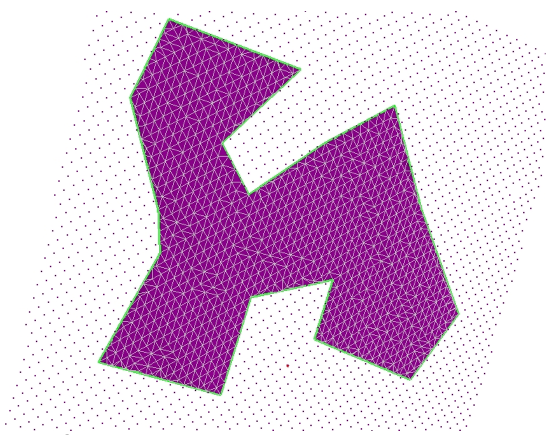


Polydata object with combined breaklines.

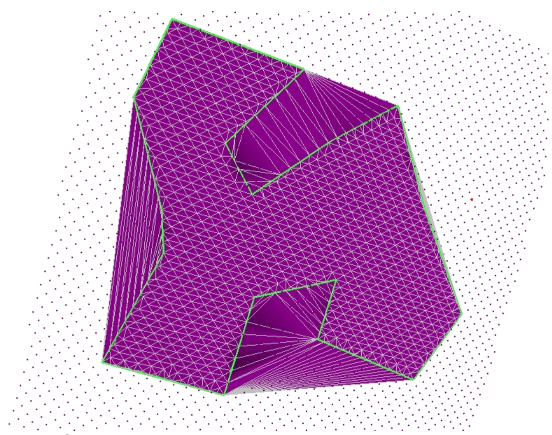


Mesh with breaklines.

3.2 Using polylines to triangulate concave shapes:
In some applications it may be useful to triangulate concave shapes. The triangulation tools can not directly produce concave shapes. For this reason you have to define a **closed** concave polyline and specify the option "**Crop triangles outside polylines"** in the plane or polar triangulation dialog. If there is no closed polyline in the view all triangles will be removed.



"Crop triangles outside polylines" enabled



"Crop triangles outside polylines" disabled

7.2.3 Triangulation of a plane

RiSCAN PRO offers the possibility to triangulate a plane object 281. To do so select one or more planes in the project manager. Right-click the selected plane(s) and select "Create polydata..." from the menu. A dialog to configure this process appears:

Resolution - enter the maximum triangle size here

Combine data - activate this option in order to create just one polydata object containing all planes. If this function is deactivated a polydata object is created for each select plane object.

Click the button "OK" in order to create the polydata object(s).

7.2.4 Triangulation of a sphere

RiSCAN PRO offers the possibility to triangulate a sphere object 277. To do so select one or more spheres in the project manager. Right-click the selected sphere(s) and select "Create polydata..." from the menu. A dialog to configure this process appears:

Stacks & Slices: Determines the number of sections along horizontal and vertical axis of the object. Lower values will give a coarse representation of the original object, while higher values will result in more triangles.

Combine data - activate this option in order to create just one polydata object containing all spheres. If this function is deactivated a polydata object is created for each select sphere object..

Click the button "OK" in order to create the polydata object(s).

7.2.5 Triangulation of a cylinder

RiSCAN PRO offers the possibility to triangulate a cylinder object. To do so select one or more cylinders in the project manager. Right-click the selected cylinder(s) and select "Create polydata..." from the menu. A dialog to configure this process appears:

Stacks & Slices: Determines the number of sections along the horizontal and vertical axis of the object. Lower values will give a coarse representation of the original object while higher values will result in more triangles.

Combine data - activate this option in order to create just one polydata object containing all cylinders. If this function is deactivated a polydata object is created for each select cylinder object.

Click the button "OK" in order to create the polydata object(s).

7.3 Working with meshes

7.3.1 Smooth & decimate

This function modifies the surface structure of the polydata object by optimizing the point data (smoothing) and reducing the amount of triangles (decimating).
This menu can be called by right-clicking on an object from the directory "POLYDATA" (the object has to be triangulated - see Triangulation of a scan 241 and Triangulation of arbitrary point clouds 243 - but must not be textured) within the project manager window or by right-clicking anywhere within the Object view 144 window.

The menu provides two different modes:

- **Default settings**

  In this mode the smooth & decimate procedure works on the selected data with default parameters (see also end of this chapter: "Recommended workflow").
  The default parameters are saved in the file "SAD.ini" (a simple text file) located in the program folder of RiSCAN PRO. You can modify it to meet your requirements.

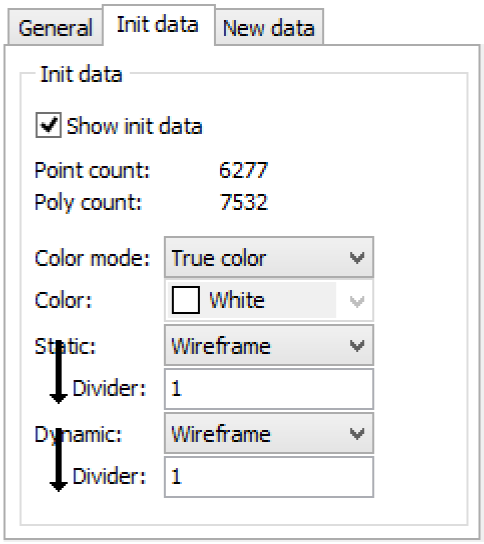
- **Advanced settings...**

  If you select this mode you can manually configure the smooth & decimate parameters:

  Sheet "General"

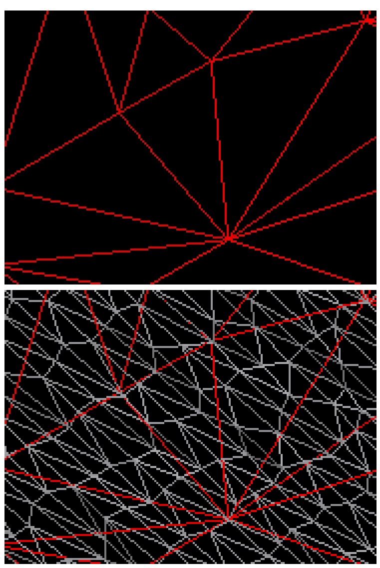
  this tab provides some settings on the view and the background color

  Sheet "Init Data"



- ***Show init data***

if this option is activated and changes have been applied, the Initial data will be visible together with the New object in the bottom screen.
Note: to better visualize a difference, choose a different color for the Init data (disable the option "Apply change to all")!


New data with "Show init data"
New data without "Show init data"

- ***Color mode***

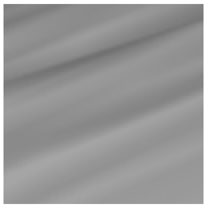
choose between single and true color

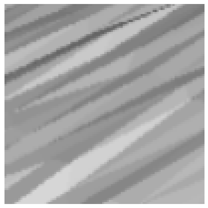
- ***Color***

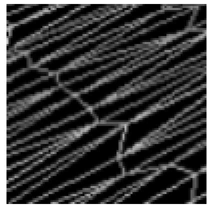
if the color mode is set to single color, select the desired color from the list.

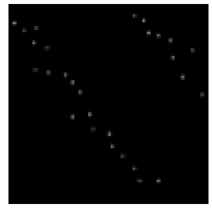
- ***Static***

select the type of structure that should be applied to the object:


Polygon smooth


Polygon flat


Wireframe


Points

- ***Divider***

reduces the amount of points that are shown. The number of points is divided by the value entered here.

- ***Dynamic***

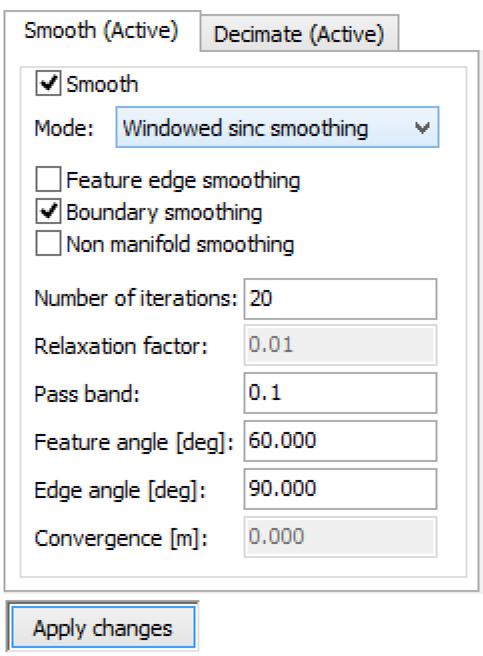
same as Static, with the exception that these settings will be applied during any movement of the object

Sheet "New Data"

Provides the same information as the initial data for the new object

Sheet "Smooth"

Smoothing is a process to optimize the coordinates of the point data to make the surface smooth while preserving the amount of polygons and points. If your mesh contains polylines the check box "Boundary smoothing" will be disabled because boundary smoothing is not allowed with polylines. The smoothing process does not affect polylines nor their bordering triangles at all. Their shape will appear unchanged in the output file.



- ***Smooth***

  if this option is enabled, the settings will be applied to the New data.

- ***Mode***

  a filter to make cells better shaped and vertices more evenly distributed

  Laplacian smoothing - the coordinates are modified according to an average of connected vertices to reduce high frequency information in the geometry of the mesh.

  Windowed sinc smoothing - the coordinates of each vertex are modified using a windowed sinc function interpolation kernel (Taubin describes this method in the IBM tech report RC-20404 (#90237, dated 3/12/96) "Optimal Surface Smoothing as Filter Design" G. Taubin, T. Zhang and G. Golub).

- ***Feature edge smoothing***

  Excessive smoothing may lead to a loss of important details and the surface may shrink towards the centroid. Enabling this feature will help reduce this effect.

- ***Boundary Smoothing***

  enables the smoothing operation of vertices that are on the boundary of the mesh. This switch is disabled if there are polylines in the mesh because boundary smoothing is not allowed in combination with polylines.

- ***Non manifold smoothing (*****only available with Windowed sinc smoothing)**

  smooth non-manifold vertices.

- ***Number of iterations***

  determines the number of times the smoothing algorithm will be applied.

  Note:
  when using the Windowed sinc smoothing, the value should be between 15-20; when using the Laplacian smoothing, the value should be between 10-200.

- ***Relaxation factor (*****only available with Laplacian smoothing)**

  defines the amount of displacement for the modification of the vertex coordinates.

  Note:
  as in all iterative methods, the stability of the process is sensitive to this parameter. Generally small relaxation factors and large numbers of iterations are more stable than larger relaxation factors and a small number of iterations.

  Default value = 0.01

- ***Pass band (*****only available with Windowed sinc smoothing)**

  limits the frequency modes in a polyhedral mesh.
  Valid values: 0.0 - 2.0 (default = 0.1)

  Note: a lower value will produce more smoothing.

- ***Feature angle***

  This angle is used to define edges between two triangles (i.e. if the surface normal between two adjacent triangles is greater or equal to the feature angle, an edge exists).

- ***Edge angle***

  Vertices are smoothed along their connected edges, if the angle between their edges is less than the value entered here.

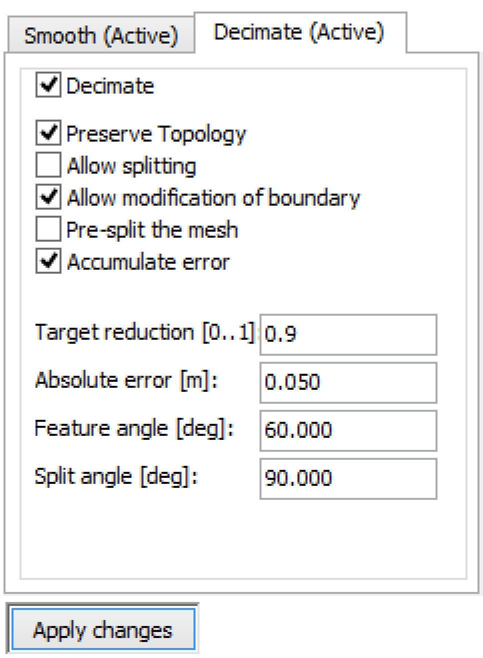
- ***Convergence (*****only available with Laplacian smoothing)**

  limits the maximum point motion. If the maximum motion during an iteration is less than the convergence, the smoothing process will terminate.

  Note: if the value = 0, the convergence will be ignored.

Sheet "Decimate"

is a process to reduce the amount of polygons and points in the mesh. If your mesh contains polylines the check box "Allow modification of boundary" will be disabled because a modification of the boundary is not allowed with polylines. The decimate process does not affect polylines nor their bordering triangles at all. Their shape will appear unchanged in the output file.



- ***Decimate***

  if this option is active, the settings will be applied to the New data.

- ***Preserve topology***

  a condition for the smoothing algorithm. If enabled, the mesh splitting and hole elimination will not occur.

Note:
a greater smoothing (reduced mesh) may be achieved, if the topology does not have to be preserved

- ***Allow splitting***

  if enabled, the mesh will be split at corners, along edges, at non-manifold points or anywhere else a split is required.

  Note:
  Turning splitting off will better preserve the original topology of the mesh, but may not obtain the desired reduction.

- ***Allow modification of boundary***

  if enabled, vertices at boundaries are deleted. This switch is disabled if there are polylines in the mesh because a modification of the boundary is not allowed in combination with polylines.

- ***Pre-split the mesh***

  if this option is enabled, the mesh will be split according to the specified split angle, into semi-planar patches, that are disconnected from each other. In some cases, this will produce better results.

- ***Accumulate error***

  to force incremental error updates and distribution to surrounding vertices as the mesh is modified. If this option is disabled, the error will be computed directly from the mesh.

  Note: requires additional memory and time to compute.

- ***Target reduction***

  specifies the reduction of the mesh. Because of various constraints, the desired level of reduction may not be achieved. For highest reduction, disable "Preserve topology", set the "Absolute error" to a high value, and enable "Allow splitting" and "Allow modification of boundary".

  Note: a higher value will lead to a greater reduction

  Valid values: 0.1 - 1.0 (default = 0.9)

- ***Absolute error***

  set the highest offset for the coordinates of the points.

- ***Feature angle***

  This angle is used to define edges (i.e. if the surface normal between two adjacent triangles is greater or equal the feature angle, an edge exists).

- ***Split angle***

  is used to control the splitting of the mesh. A split line exists if the surface normal's between two edge connected triangles are greater or equal the Split angle.

- ***Restore default***

  all settings will be restored with the default values.

- ***Apply changes to all***

  all the settings and views will be applied to the initial- as well as the new data

- ***Lightsource on/off***

If the settings are complete, initiate the smoothing/decimate process by pressing "Apply changes".

The object will be recalculated according to the settings and show the results in the New Data window (bottom). To save the new data, click "OK". This will apply the changes and save the created object to the folder "POLYDATA".

Recommended workflow:

First step:
- *Windowed sinc smoothing:* 20 iterations, pass band = 0.086

Second step:
- *Laplacian smoothing:* 200 iterations, feature edge smoothing active, feature angle = 30 deg
- *Decimate:* Rate = 0.6, feature angle = 25 deg

Third step:
- *Decimate:* Rate = 0.7, feature angle = 15 deg

7.3.2 Texture

The texture function combines the scan information (polydata, triangulated meshes) with the high resolution photographs.

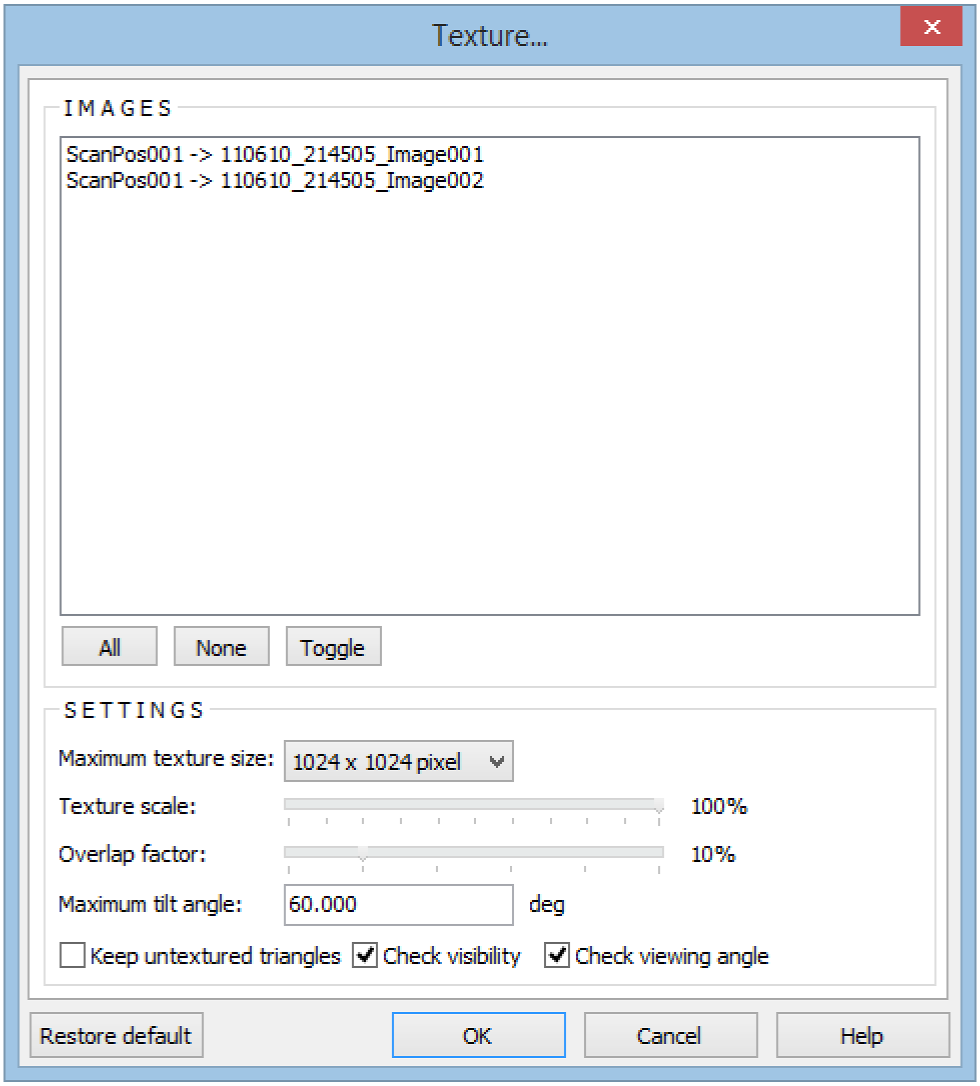
Prerequisites

Images taken with the camera might be slightly distorted by the lens. Before RiSCAN PRO can texture the mesh the images have to be undistorted. To do so please select the desired images, right-click on them and select "undistort" from the menu. All undistorted images will be saved in the folder "UNDISTORTED IMAGES".

Note:
this procedure will also create at least one new camera calibration which will be assigned to the undistorted images. This camera calibration is a copy of the original camera calibration except the lens distortion values. Do not assign this camera calibration to images taken by the camera nor change the calibration values.

Texturing polydata within a scan position

Right-click the desired polydata object from the folder "POLYDATA" within a scan position and select "Texture..." from the menu.



The dialog shows a list of all undistorted images of all scan positions. The undistorted images of the scan position the polydata belongs to are selected automatically.

SETTINGS

- *Maximum texture size*

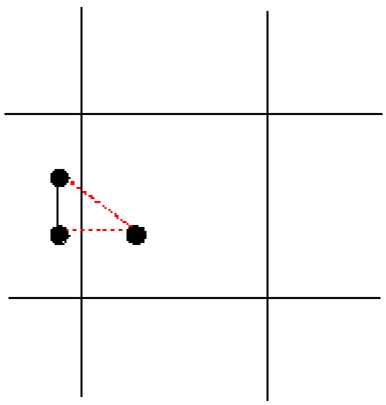
  The images will be split into frames with the selected size (the default value depends on the graphic card - the highest resolution is recommended).

- *Texture scale*

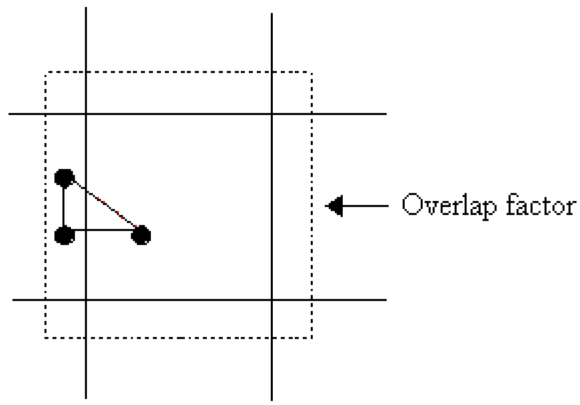
  With this factor you can scale the images before they are used for the texture process. The default value is 100%. A smaller value results in less data but also in worse quality.

- *Overlap factor*

  Since the images are split into frames (with the size entered before), it is likely that triangles need to be textured with two or more frames, which is not possible. Therefore an overlap factor can be set. The borders of the image-frames will not be strict - the frames will overlap. This will ensure that each triangle can be textured using just one frame. You will have to raise the overlap-factor if the mesh you are trying to texture has rather big triangles (e.g. if the mesh was smoothed and decimated). (default is 10%).



The triangle will not be recognized



The triangle will be recognized and applied with texture

After the texturing process has finished a new polydata object will be created (the suffix "_Textured" will be appended to the name). You can view the new polydata object by double-clicking it (see also Object view 144).

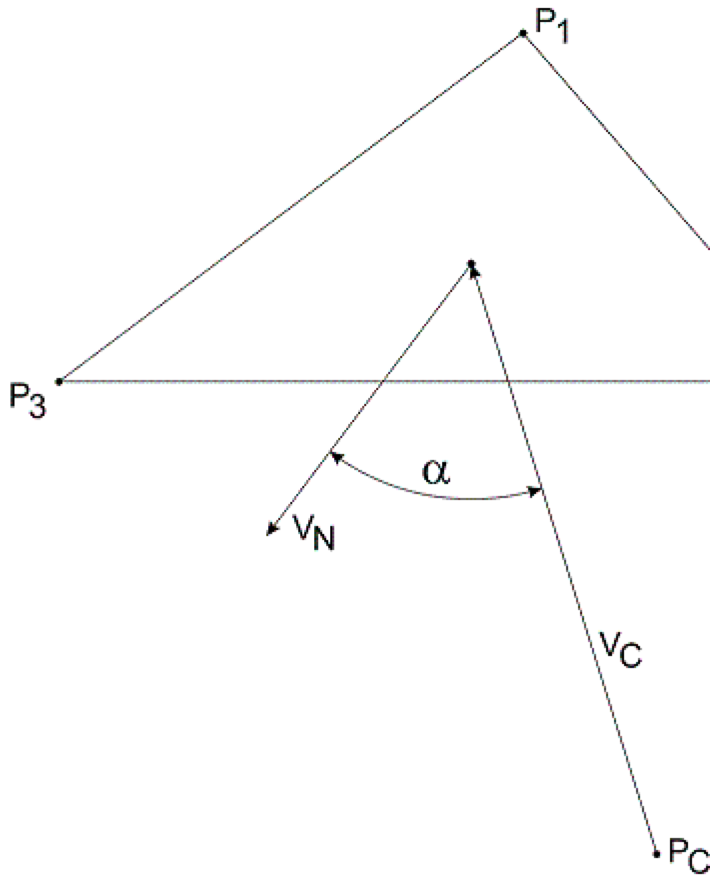
Texturing polydata with the project coordinate system

The method described above is only applicable for single polydata objects located in a scan position. Combined meshes located in the project coordinate system (folder "OBJECTS/POLYDATA") can also be textured by using undistorted images of scan positions and undistorted free orientated images.

Right-click the desired polydata object from the folder "POLYDATA" within the folder "OBJECTS" and select "Texture..." from the menu.
A dialog like that shown above will appear. There are two additional parameters:

- *Maximum tilt angle*

  The texturing procedure takes every triangle and tries to find the optimal image to texture it. The image has to meet several criteria such as smallest distance between camera position and center of triangle, visibility of the triangle in image (no other objects between camera position and triangle) and smallest angle of view. With "Maximum tilt angle" you can configure a filter which removes all images whereas the angle "alpha" between the triangle's surface normal and the line of sight (see sketch below) is larger than the given value. The higher the angle "alpha" is the less pixels of the image can be mapped to the triangle and thus the worse the quality of the texture will be.



P_1, P_2, P_3...edge points of triangle
V_N...normal vector of triangle

P_C...position of camera
V_C...ray of sight

α ...angle between V_N and V_C

- *Keep untextured triangles*

  Triangles which have no texture at the end of the process will not be present in the resulting mesh. Enable this option in order to keep them.

  Note:
  Not textured triangles will be copied from the source mesh to the new mesh as they are. That means that they will have the wrong color or no color information at all.

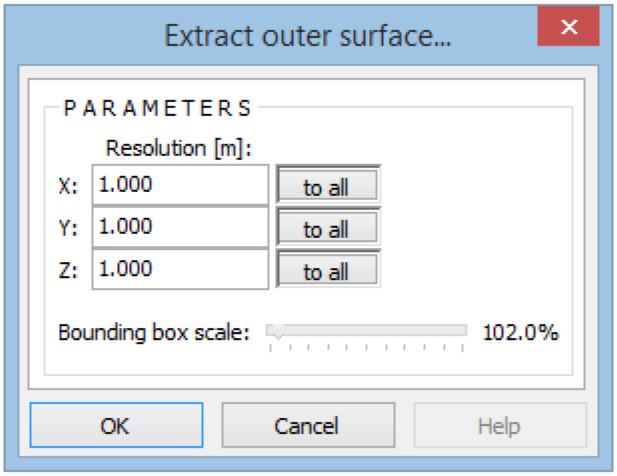
- *Check visibility*

  If this option is activated RiSCAN PRO does not check if the triangle can be seen from the camera position from which the image was acquired. This leads into higher performance but may result in faulty textures. Use with care!

7.3.3 Extract outer surface

With this function you can extract the outer surface of meshes which describe a closed surface. This is done by converting all the triangles from the selected polydata objects into an octree structure. The resulting surface is the combination of all extracted triangles, created from the intersections between the octree grid lines and the input triangles.

To start this function select triangulated polydata objects and select "Extract outer surface..." from the popup menu.



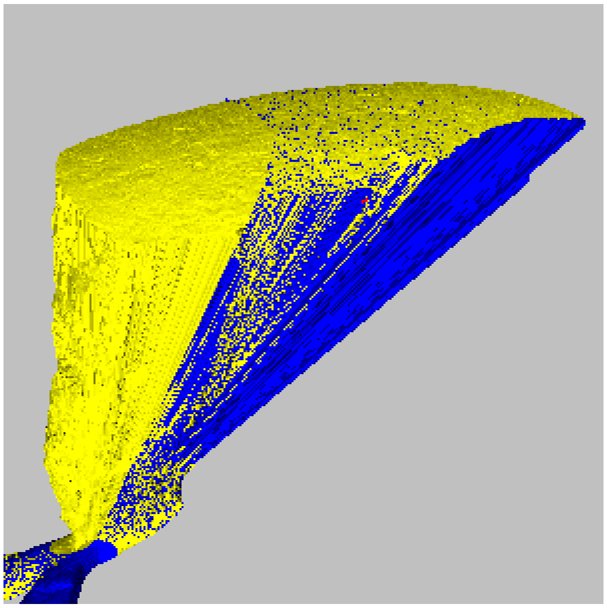
Parameters

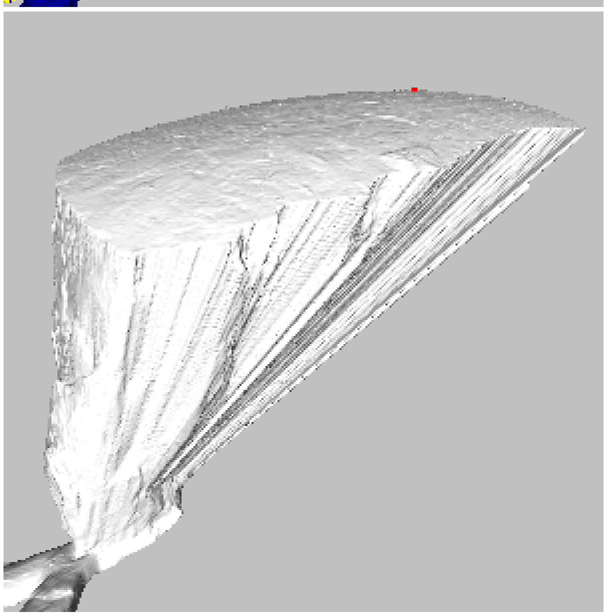
Resolution - The resolution of the octree structure.
Bounding box scale - You can adjust the bounding box of the octree structure. The bounding box is automatically calculated from the input data. The scale factor is always greater than 100% to avoid artifacts. If you are not satisfied with the result it may help to change the scale factor.

Example:

In this example two single point clouds of a cave were triangulated (polar, watertight) and used as input for the "Extract outer surface" function.
The resolution was 0.25m in all dimensions.

Input meshes: Output mesh:





7.3.4 Surface comparison

You can compare the surface structure of one or more scans or polydata objects (henceforth referred to as "Base data") to a reference polydata object (henceforth referred to as "Reference mesh"). The reference polydata object must be a triangulated mesh. For each data point of the base data objects the distance is calculated according to the selected mode.

There are two possible modes available to calculate the surface differences:

- *Reference plane*
  The distance from a base data point to the reference mesh is calculated by intersecting a ray vector (obtained from the plane's surface normal and centered at the data point) with the reference mesh.

- *Normal vectors*
  The distance from a base data point to the reference mesh is obtained by calculating the normal distance between the base data point and the plane of the closest data point of the reference mesh.

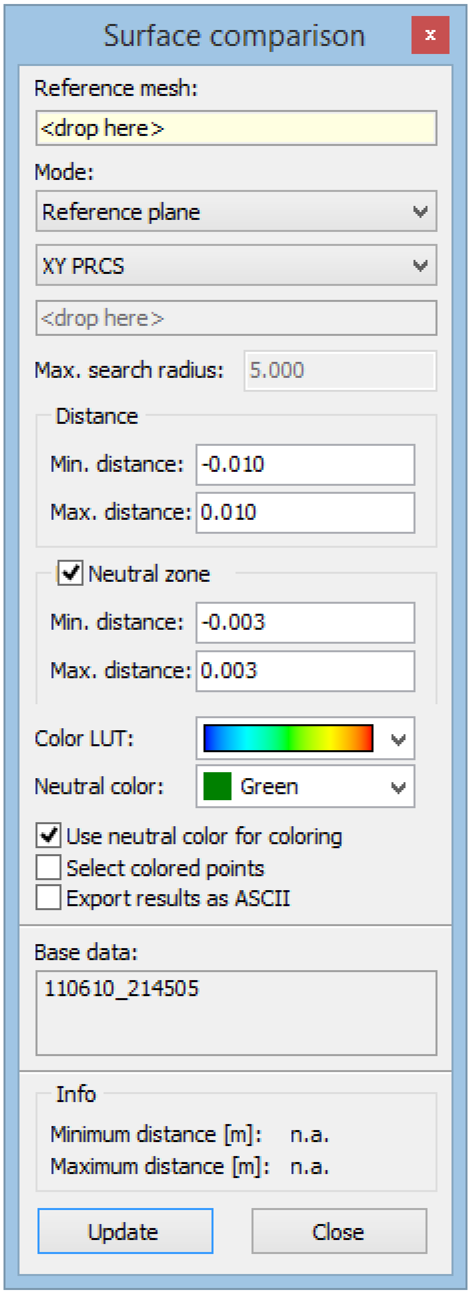
- The plane of a reference point is defined by averaging all adjacent triangle normal vectors.
- For searching the closest reference point, only points are considered which lies within "Max. search radius".

The color for each base data point is derived from the calculated distance and the selected color LUT.

Step-by-Step workflow:

Definition:

- First open/create an object view and load all polydata objects you want to compare with the reference mesh (there is no need to load the reference mesh too).
- Start the operation by selecting one or more scans or polydata objects in the object inspector and select "Surface comparison..." from the popup menu. The following dialog appears:



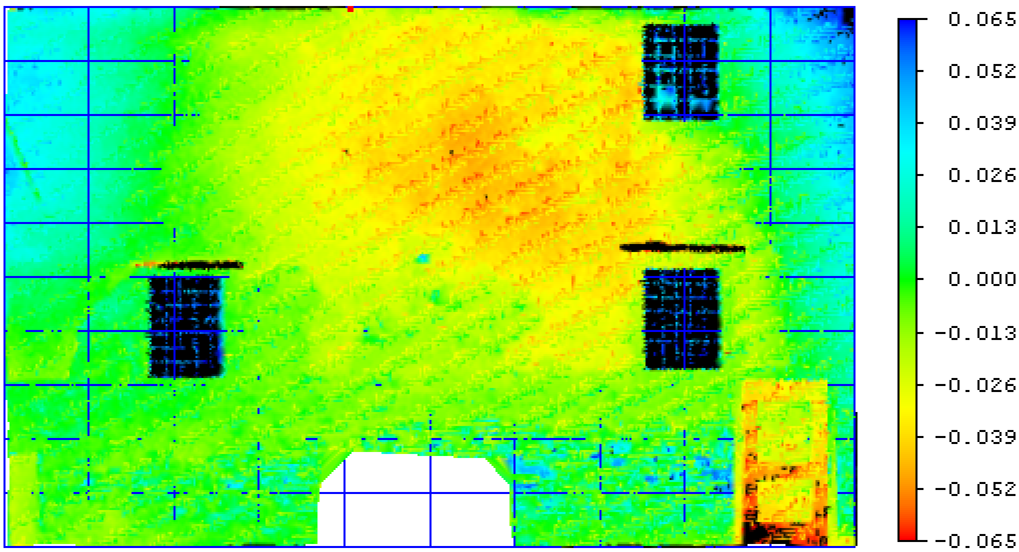
- Define a reference mesh by "Dragging & Dropping" an existing triangulated polydata object from either the project manager or the object inspector into the reference mesh field.
- If the selected mode is "Reference plane" you have to define a reference plane. You can choose one of the standard planes (XY, XZ, YZ) or use an existing plane object from the project. The definition is equal to the reference mesh.
- Adjust the parameters and click "Update". The distances will now be calculated according to the selected mode.

Coloring:
- If a base data point distance lies within the "Min/Max distance" values a color value is calculated considering the selected Color LUT (Look-Up-Table).
- You can also define a "Neutral zone". This means that if a distance lies within "Min/Max distance" of the

neutral zone the color value is set to "Neutral color" if the "Use neutral color for coloring" option is selected.

Example:

In this example a scanned facade of a house (colored mesh) was compared to a CAD model (blue grid lines).



7.4 Create Orthophotos

RiSCAN PRO offers the possibility to create true orthophotos from scans using the color information from the acquired high resolution images.

For that, two plugins are available:

- Orthophoto plugin 264
  This plugin was developed by RIEGL LMS. It is based on triangulated and textured meshes.

Both plugins can be downloaded from the RiSCAN PRO download page 338 and enable the user to create TRUE ORTHOPHOTOS from scan data and image data.

Additionally the module also provides depth information and orientation information in the project's coordinate system to the image data of the orthophoto. This additional information contained in a separate file in a documented format (Description of ZOP file format 329) provides the ability to construct in 3D on the orthophoto in CAD applications, e.g., AutoCAD.

Data generation is conducted by the user by specifying the orientation, position, resolution and size of the frustum of the orthophoto with depth information and the scans images to be used.

Orthophotos are saved in the folder "OBJECTS/ORTHOPHOTOS" of the project. You can view the orthophoto in a 2D view by simply double clicking on it. To view the orthophoto in a 3D view just drag it from the project manager and drop it onto an opened object view 144.

7.4.1 Orthophoto plugin

1. Undistorting Images

Generation of orthophotos is based on geometry information (scan data) and image data. Before the image information can be applied, the images have to be undistorted. Thus the first step is to undistort the distorted snapshots of the scan position where the scan data you intend to use for the orthophoto is located. To do so, select the images you want to undistort from the directory "SCANPOSIMAGES" and right-click an image. Select "undistort" from the context menu. Now all selected images will be undistorted using the assigned camera- and mounting-calibrations (this may take some time). The undistorted images will be saved in the folder "UNDISTORTED IMAGES" at the current scan position.

Note:
If you modify either the camera- or the mounting-calibration the already undistorted images become invalid and you must restart the undistort process!

2. **Creating meshed data**

The second step is to create a triangulated mesh from the single scan you intend to use for the generation of the orthophoto (see Triangulation 241).

3. **Texturing the mesh**

Texturing a mesh requires a texture mesh AND texture coordinates for every point of the mesh to be textured (see Texture 256).

4. **Creating the True Orthophoto**

To create a orthophoto open the folder "OBJECTS" of the project structure and right-click the folder "ORTHOPHOTOS". Select "New orthophoto..." from the context menu. The dialog that appears consists of several steps:

First step:

On the first page of the dialog you can select the meshes you want to use for the orthophoto. After selection click the button "Next step >>". The meshes will be loaded and displayed (this may take a few seconds).

Second step:

In the second step you can select how the data should be displayed (triangulated/point cloud, truecolor/singlecolor, color of the selected points and color of the defined plane).

Third step:

In the third step you can select points in order to define the projection plane. As an alternative you can load a previously saved plane and use this plane as your projection plane by clicking the button "Load plane" (see fourth step for information about saving a plane). The camera for generating the orthophoto will be positioned at the center of that plane and is orientated anti-parallel to the surface normal of the plane.

To select the points within the plane switch to selection mode by clicking "Selection mode" (or pressing the "S" key). The model will be fixed (no zooming or rotation can be done)

Now you can select the points by drawing a fence. Use the left mouse-button to set the corner points of the fence. Use the right mouse-button to close the fence. After drawing the fence click the button "Add selected points" (or press the "A" key) to add the points within the fence. Note that only points within a certain depth (defined by the deviation value) are selected. Thus for selecting large areas on a facade, the facade has to be parallel to the imaging plane.
You can repeat the selection process as often as you like.

Finally leave selection mode by clicking "Selection mode" (or pressing the "S" key) again.

Now you have to decide on the orientation - Three different orientations are available:

- vertical orientation

  Intended for generating orthophotos of facades. The plane is strictly parallel to the Z axis of the project coordinate system.

- horizontal orientation

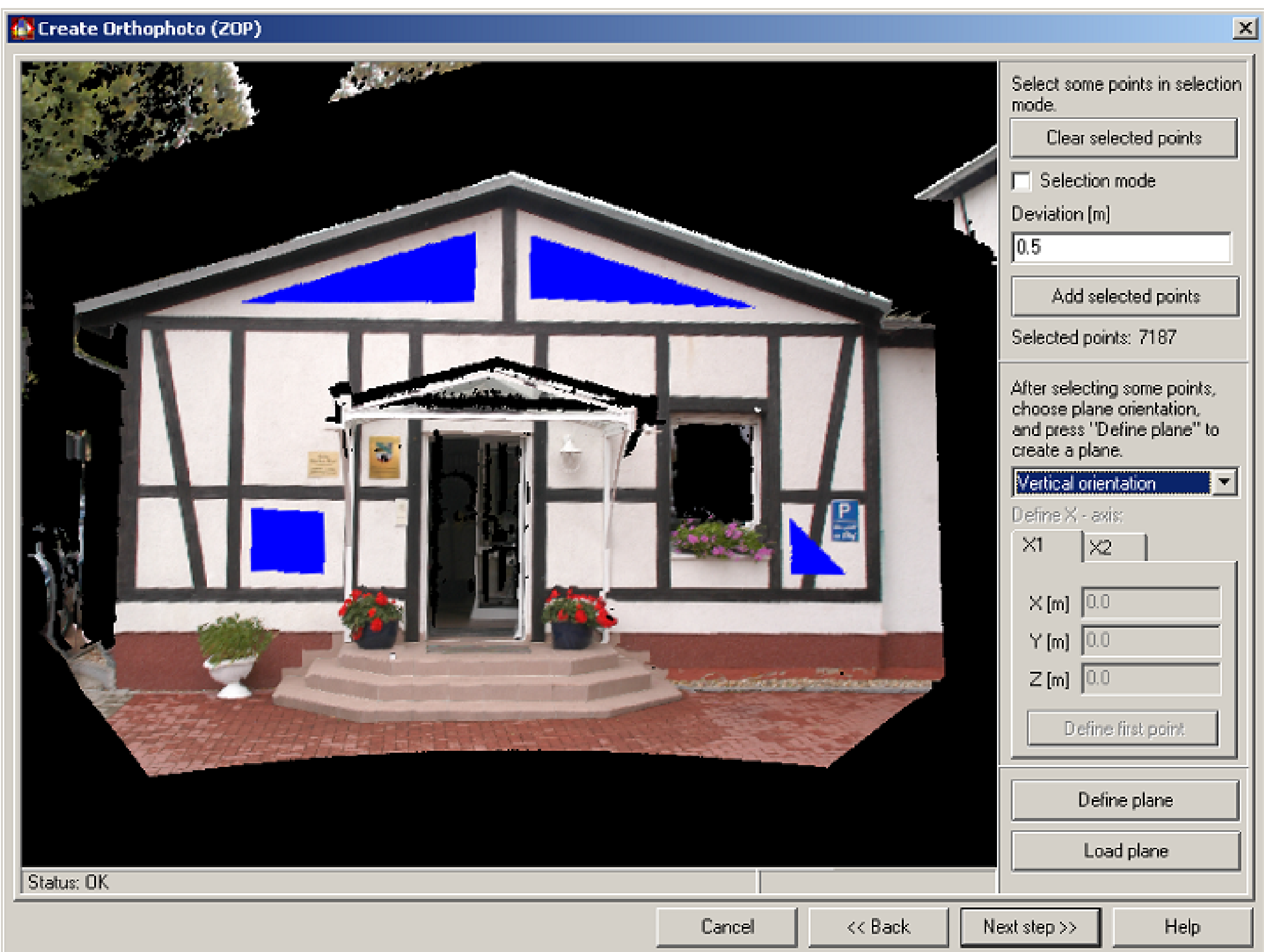
  Intended for generating orthophotos of the floor or ceiling. The plane's surface normal is parallel to the Z-axis of the project coordinate system. The X-axis has to be specified (see "free orientation").

- free orientation

  In this mode you have to define the X-axis with two points (X1 and X2). To do so click the button "Define first point" (X1) and click the corresponding point in the 3D-scene. Proceed this way with the second point (X2).

Finally calculate the projection plane by clicking "Define plane". The plane position, size, and orientation will be calculated and the plane is displayed.

A screenshot of step three:



Fourth step:

In the fourth step you can modify the projection plane's position and size.
Just edit the input fields "Plane width" and "Plane height" and click the button "Apply dimension changes".
To change the position of the plane use the cursor-buttons. The offset used for changing the position can be entered in the input field "Additional constant". Every time you click on one of the cursor-buttons on the screen the plane will be moved in the selected direction by that offset.
Finally you can save the plane in order to use it again for other orthophotos. Just click the button "Save plane" and enter a name for the plane in the dialog (Saved planes can be used in the third step).

Fifth step:

In the fifth step you can define the near plane and the far plane. These planes are parallel to the projection plane. The values you enter are the distances (along the surface normal) between the projection plane and the near plane and the projection plane and the far plane. Only triangles with all three edges between near- and far-plane will be used for the orthophoto.

Furthermore you can modify the so-called "Offscreen resolution". An offscreen resolution about 0.01 (=default) means that one pixel of the created orthophoto will represent one centimeter. Note that smaller values will increase the size of the orthophoto and due to this the calculation time will increase greatly).

Now RiSCAN PRO has all the information it needs to create the orthophoto, so click the button "Create orthophoto".
The orthophoto will be created (this may take some time, depending on the size) and saved in the folder "ORTHOPHOTOS" (folder "OBJECTS") with the name "OrthoPhotoXYZ" (XYZ is an consecutive number).

7.5 Create geometry objects

7.5.1 2D

This chapter describes how to create geometry objects based on geometry data (scans, polydata,...) loaded into an 2D view 129.

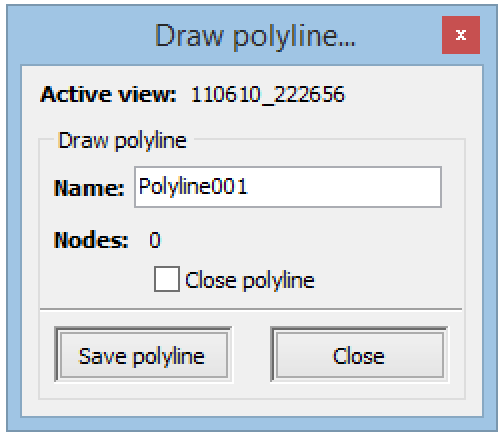
7.5.1.1 Polyline

Draw or modify a polyline in 2D view (scan or image):

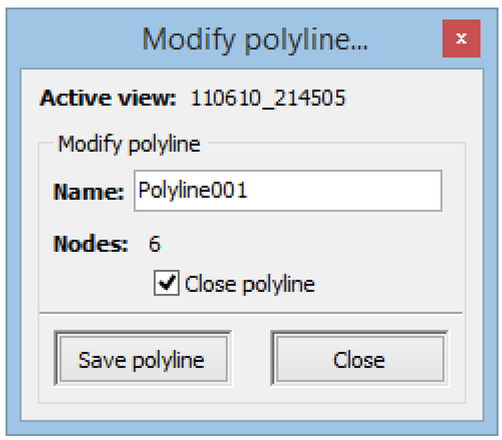
1. Open a scanposition image or a scan in a 2D view.

2. Create a new or load an existing polyline:

   - **Create a new polyline:**
     Right-click into the 2D view and select "Draw polyline..." from the popup menu or press the shortcut button "P":



- **Modify an existing polyline:**
  Drag a polyline object from the project manager and drop it onto the 2D view. The polyline is drawn in the view. Some nodes may be invisible. The number of invisible nodes is displayed in the "Modify polyline" -window. Invisible nodes can't be modified (see also the following section "Working with more than one view 269").



3. To rename 341 the polyline, click into the text box, enter the new name and commit by clicking "Save polyline".

4. Left-click into the view in order to add a new polyline node. The current number of nodes is displayed in the window.

5. Repeat step 4 until all polyline nodes are defined and continue with step 6.

6. To create a closed polyline (= polygon), enable the option "Close polyline".

7. To delete a polyline node, right-click it.

8. To move a polyline node, simply drag and drop it on the new position.

9. To continue drawing the polyline, click on a free area of the 2D view and go back to step 4 again.

10. Finish drawing the polyline with a right-click anywhere in the 2D view.

11. Saving the polyline:

- **Saving a polyline from a scan:**
  To finally save or create the polyline, click on the button "Save polyline". RiSCAN PRO determines the 3D coordinates of the polyline nodes from the scan and saves the polyline in the folder "OBJECTS/POLYLINES".

- **Saving a polyline from a scanposition image:**
  Select a plane or triangulated polydata (mesh) in the project manager and click the button "Save polyline". Since there is no 3D information available in the image, RiSCAN PRO determines the rays of the polyline nodes and intersects them with the selected plane or triangulated polydata to calculate the 3D coordinates. The polyline is saved in the folder "OBJECTS/POLYLINES".

VZ-Line 2D view:
Polylines drawn within a VZ-Line 2D view may appear bent. This is due to the visualization of the 3D data within a plane. Thus straight lines within a 3D view appear bent within a VZ-Line 2D view.

Working with more than one view:

Z-Line & LPM 2D view:
It's also possible to draw a polyline by using more than one 2D view. You can start drawing in one view and continue in another one as follows:

1. Open a scanposition image or a scan as 2D view.

2. Select "Draw polyline..." from the popup menu or drag a polyline object from the project manager onto the view.

3. Draw the polyline as described above.

4. Open or activate another image or scan from the same scanposition in 2D view. The visible parts of the polyline are displayed in the new view. Nodes that are not visible in the new view can't be modified there. **Note:** The new view must be of the same type (scan or image) as the old one. It's not possible to start drawing in a scan view and continue drawing in an image view or vice versa.

5. Continue drawing the polyline in the new view as described above.

VZ-Line 2D view:
Polylines drawn within a VZ-Line 2D view can not be modified within more than one view simultaneously. To continue drawing in another view simply save the polyline, close the tool and drop the polyline into the new view.

7.5.2 3D

This chapter describes how to create geometry objects such as points, polylines, edges, spheres, planes or cylinders.

There are two different ways to create such objects:

1. Manual definition of the object's parameters

You can define the geometry objects by entering the parameters like position, orientation and size manually. To do so right-click the desired folder within the "OBJECTS" folder and select "New <object>..." from the menu (whereas <object> must be substituted with the desired object type).

Note: All entered coordinates refer to the project coordinate system. Some parameters are reserved for future usage and have no effect now (like the direction vector of a cylinder).

2. Interactive definition based on geometry data (scans, polydata,...) loaded into an object view 144.

- Create or open an object view
- Add the objects of interest
- Right-click into the view window and select the menu item "New object" which offers a submenu with the following items:

  - Point... 271
  - Polyline... 271
  - Edge... 273
  - Sphere... 277
  - Plane 281
  - Section... 285
  - Tiepoint... 287

  As an alternative you can also use a button in the toolbar "3D - New object" (use the view menu 17 to display the toolbar):

  (the functions described above are ordered from left to right on the toolbar)

  The parameters needed to create the geometry objects are described in the subsequent sections.

Common options:

- 3D Point definition:

  Most objects are defined by at least one point. This is done interactively by holding the shift key and **left-clicking** near a point in the 3D scene. To determine which point of the scene should be used two different modes can be selected:

  1. **Closest point**

     If you click into the 3D scene the point nearest to the line-of-sight is detected.

     Note:
     Only points of loaded and visible datasets will be used. The search may take some time if the view contains a lot of data.

  2. **Point on surface**

     If you click into the 3D scene, the point is calculated as the intersection point of the line-of-sight and the triangle or plane with the smallest distance to the current viewpoint.

  As an alternative you can also define the coordinates using **drag & drop**. Just drag a **point, tiepoint or sphere object** and drop it onto the edit fields.

  Nearly all geometry objects that need at least one point to be specified also offer the option to **enter the coordinates directly**. The coordinates displayed and entered always belong to the coordinate system currently selected in the object inspector 156.

- Shortcuts:

Some of the "create new objects" dialogs have keyboard shortcuts (define point 1, define point 2, create,...). These shortcuts are only functional if the object view window has the input focus. To set the input focus just left-click into the object view window.

7.5.2.1 Point

Create point from geometry data:

1. Open the "New object..." dialog to create a point as described in "Create geometry objects 269".
2. Define the point with the mouse 270 or enter the coordinates directly. If you enter the coordinates directly click the button next to the coordinates in order to update the position of the point displayed in the 3D scene.
3. To finally create (save) the point click the button "Create point" or press the "3" key. The point will be saved in the folder "OBJECTS/POINTS" and added to the current object view.

Create point object from intersection between a Polyline and a plane:

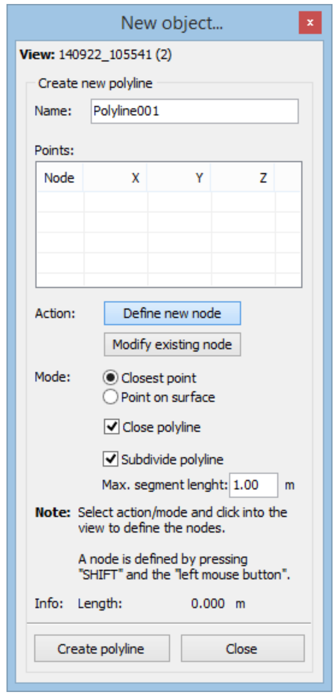
1. Open/create an object view and load the data you want to work with.
2. Select a polyline and a plane in the object inspector.
3. Open the popup menu of the plane and select "Intersect" in order to create and a new point object.

Note:
An intersection only occurs if a line segment of the polyline is intersecting with the plane.
If the polyline has only one line segment this segment is treated as a ray and therefore the intersection point does not need to lie within the segment.

7.5.2.2 Polyline

Create polyline from geometry data:

1. Open the "New object..." dialog to create a polyline as described in "Create geometry objects 269":



2. Click the button "Define new node" or press the "1" key.

3. By defining a point 270 a new polyline node will be added. The new node will be displayed in the list.

4. Repeat step 3 until all nodes of the polyline are defined and continue with step 5.

5. To create a closed polyline (=polygon) enable the option "Close polyline". If you want to automatically subdivide the polyline segments into a certain maximum segment length check the option "Subdivide polyline" and enter the desired maximal segment length in "Max. segment length".

6. To modify a polyline node, select the node in the list, click the button "Modify existing node" (or press the "2" key) and re-define the point 270. Instead of adding a new node the coordinates of the selected node will be modified.

7. To finally create (save) the polyline click the button "Add polyline" or press the "3" key. The polyline will be saved in the folder "OBJECTS/POLYLINES" and added to the current object view.

Create polylines from tiepoints:

Open a tiepoint list and select some tiepoints. Then open the popup menu and select "Create geometry object…/ Polyline".

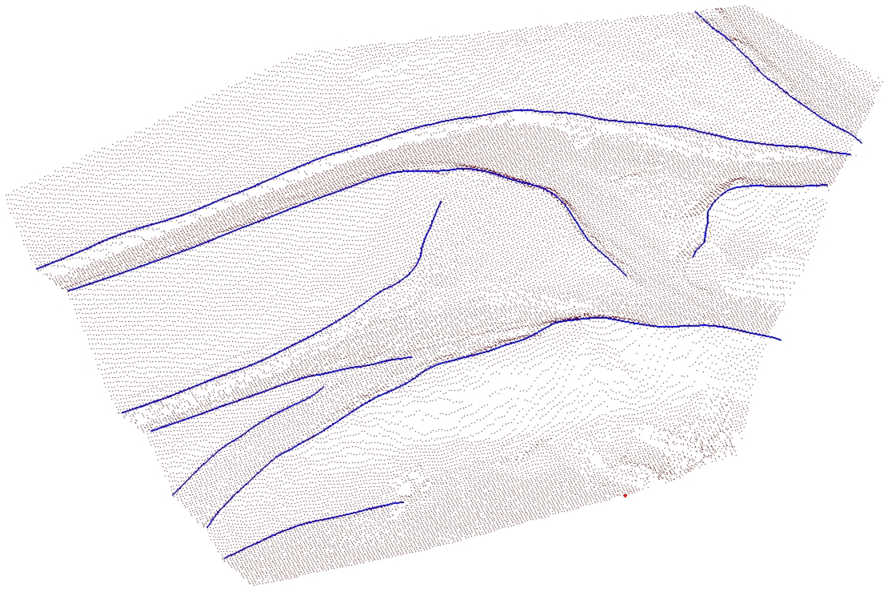
Note:
At least 2 tiepoints must be selected in order to create a polyline.

Create polyline from point objects:

Select some point objects in the project manager and open the popup menu. Select "Compose polyline" in order to create a polyline.

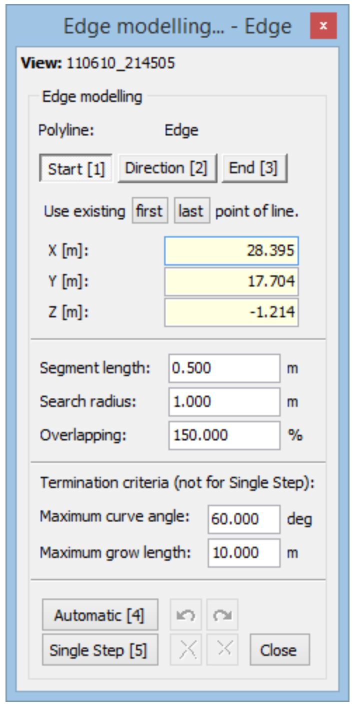
7.5.2.3 Edge

Edge modeling or breakline modeling is used to extract edges directly from pointclouds. The generated edges (polylines) can be further processed during the triangulation (using breaklines) 246 process and the smooth and decimate 250 process.



Example showing extracted breaklines.

RiSCAN PRO allows you to extract edges (breaklines) from raw pointclouds in a semi-automatic way using the "Edge modeling" tool. Start the tool by clicking the corresponding button in the toolbar "3D - New object" or by right-clicking into the 3D view and choosing "New object - Edge..." from the popup menu. Alternatively you can also right-click an existing polyline in the Object Inspector 156 and choose "Model edge..." from the popup menu.



Edge modelling tool

General information

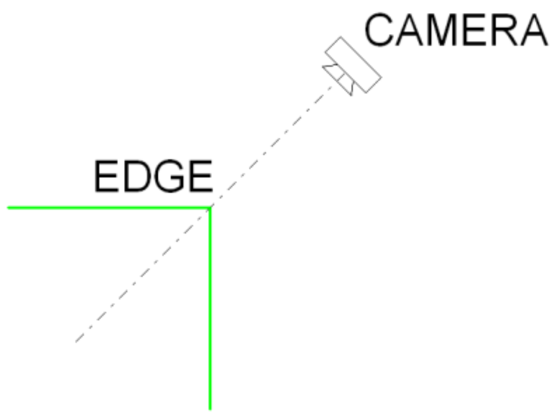
For the edge modeling procedure you have to define several parameters (ie: start point, direction, segment length, ...). All parameters that can be adjusted are represented trough edit boxes in the "Edge modelling" tool window. To adjust a parameter you can either directly enter the desired value or just define the value by clicking into the view.

- To define a parameter click into the corresponding edit box in the "Edge modeling" tool window. The background color of the edit box will change from white to a light yellow. This means that this parameter is active and can be adjusted.
- To adjust the active parameter just hold down the key "Shift" and perform a left click into the view.

Workflow of the edge modeling procedure

1. Define the right view

First of all you have to define the right view for edge modeling. Rotate the view until no points that belong to the edge overlap any more.

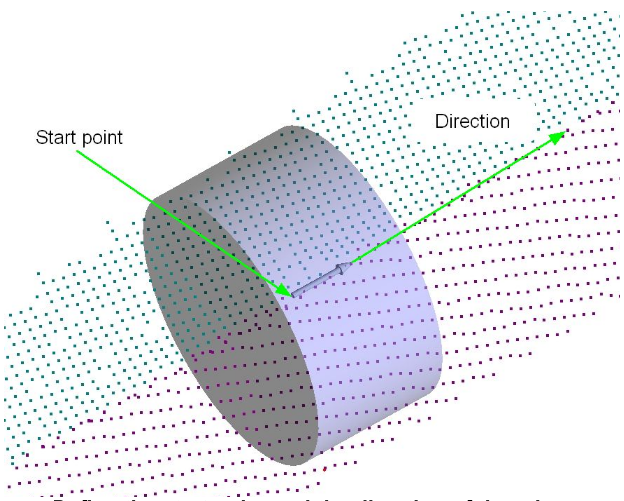


Example of a good camera position.

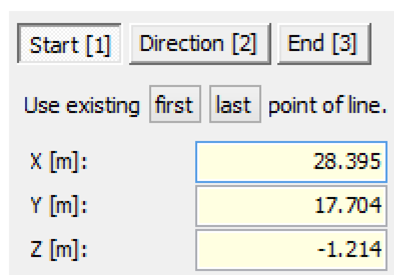
2. Define the start point and the direction of the edge

The next step is to define the start point and the direction of the edge that should be modeled.

- **Start point:** The start point is any point on (or near) the edge and defines from where the tool will start modeling.
- **Direction:** The direction parameter describes the direction of the edge and defines in which direction the tool will continue modeling.
- **End point:** Additionally you can define an end point but this is not compulsory. If the tool runs up against the end point it will stop modeling. The parameter is very useful for modeling corners. To achieve this simply set the end point directly into the corner and start modeling.



Define the start point and the direction of the edge.



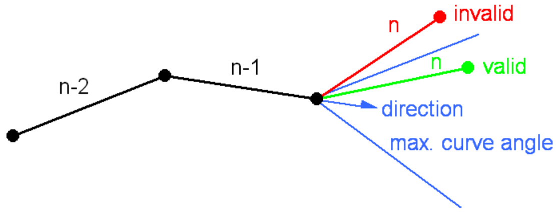
Click into any edit box and define a start point by holding "Shift" and performing a lift click into the view.

3. Define modeling parameters

The last step is to define the modeling parameters that control the modeling procedure.

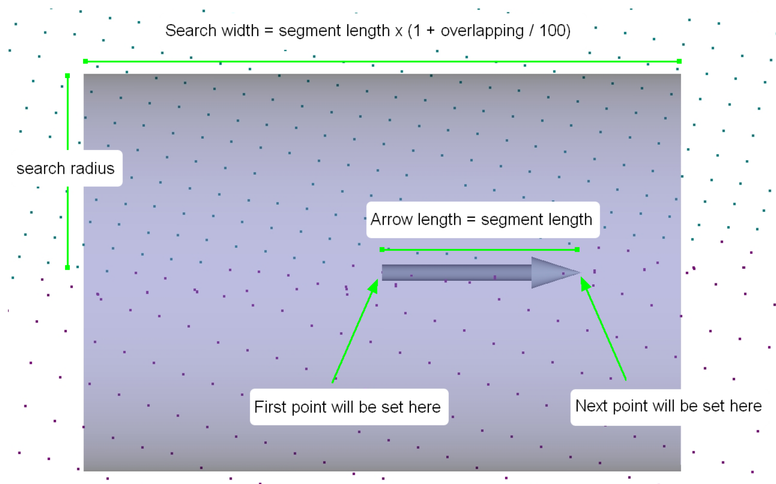
- **Segment length:** Defines the node distance of the resulting polyline (edge).
- **Search radius:** Defines the cylinder radius. All points within the search radius are considered for edge modeling.
- **Overlapping:** Defines a factor in percent and influences the search width (cylinder height). All points within the search width are considered for edge modeling. A too small overlapping factor can produce a zigzag line whereas a too large overlapping factor will smoothen the edge. search width = segment length x (1 + overlapping / 100)
- **Maximum curve angle:** If the angle between the direction and the new line segment is bigger than the maximum curve angle then the line segment is invalid and the algorithm terminates. This termination

criteria is not used in "Single Step" mode.



Maximum curve angle

- **Maximum grow length:** If the length of the line since the start of modeling exceeds the maximum grow length the algorithm terminates. This termination criteria is not used in "Single Step" mode.



Description of the modeling parameters

Note: There is a difference in behaviour between a defined "End point" and the modeling parameter "Maximum grow length".

- A defined end point means that the tool checks whether the end point is within the search cylinder or not. If the tool recognizes the end point on its way along the edge it shifts the search cylinder backwards so that no point beyond the end point is used for edge modeling. The parameter end point is very suitable for modeling sharp corners.
- Maximum grow length simply defines a secure termination criteria. Assuming that you defined an end point for the edge but unexpectedly the algorithm never reaches this end point so the edge keeps growing and growing until it reaches the maximum grow length.

4. Start edge modeling

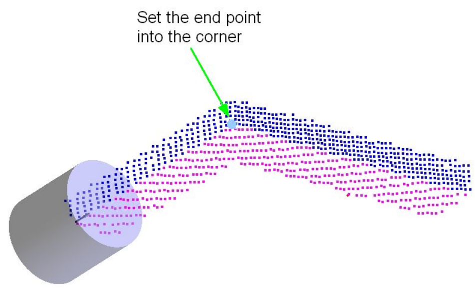
Finally you can start edge modeling. There are three different modes:

- **Automatic:** The tool automatically runs along the edge and stops as soon as at least one termination criteria is fulfilled.
- **Single Step:** Only one single point on the edge is modeled. Termination criteria are not considered.
- **Manual Step:** Use "Ctrl + Shift + Left Mouse Button" to directly add the clicked data point to the edge line without any modeling operation.

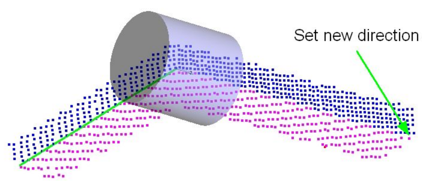
Depending on the parameters the result will differ every time. Try to fine tune the parameters for every edge to reach the best result.

Edge modeling tips

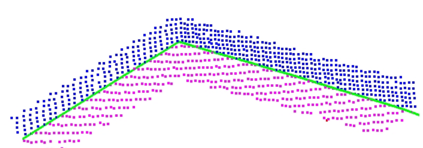
- **Modeling of corners**
  In order to model corners you have to place the end point directly in the corner and start modeling. The algorithm will stop at the end point. Now change the direction and start modeling again. The result is a sharp modeled corner.



Place the end point in the corner.



Change the direction.



Result: Sharp modeled corner.

7.5.2.4 Sphere

1. Open the "New object > Sphere" menu as described in "Create geometry objects 269".

2. In that menu you can select between different modes:

   - **From center point and radius...**
     The sphere is defined by the center point and the sphere radius.
     Define the radius of the sphere by moving the mouse or entering the radius directly. If you use the mouse the action "modify radius" must be activated (press the "1" key to do so). If you enter the radius directly, click the button next to the coordinates in order to update the radius of the sphere in the 3D scene.

   - **From center point and point on surface...**
     The sphere is defined by the center point whereas the radius is defined by a second point (radius = distance between the two points).

   - **From two points on surface (axis)...**
     The sphere is defined by two points which represent the axis of the sphere.

   - **From selected points...**
     The sphere is fitted into the selected points of a 3D view.

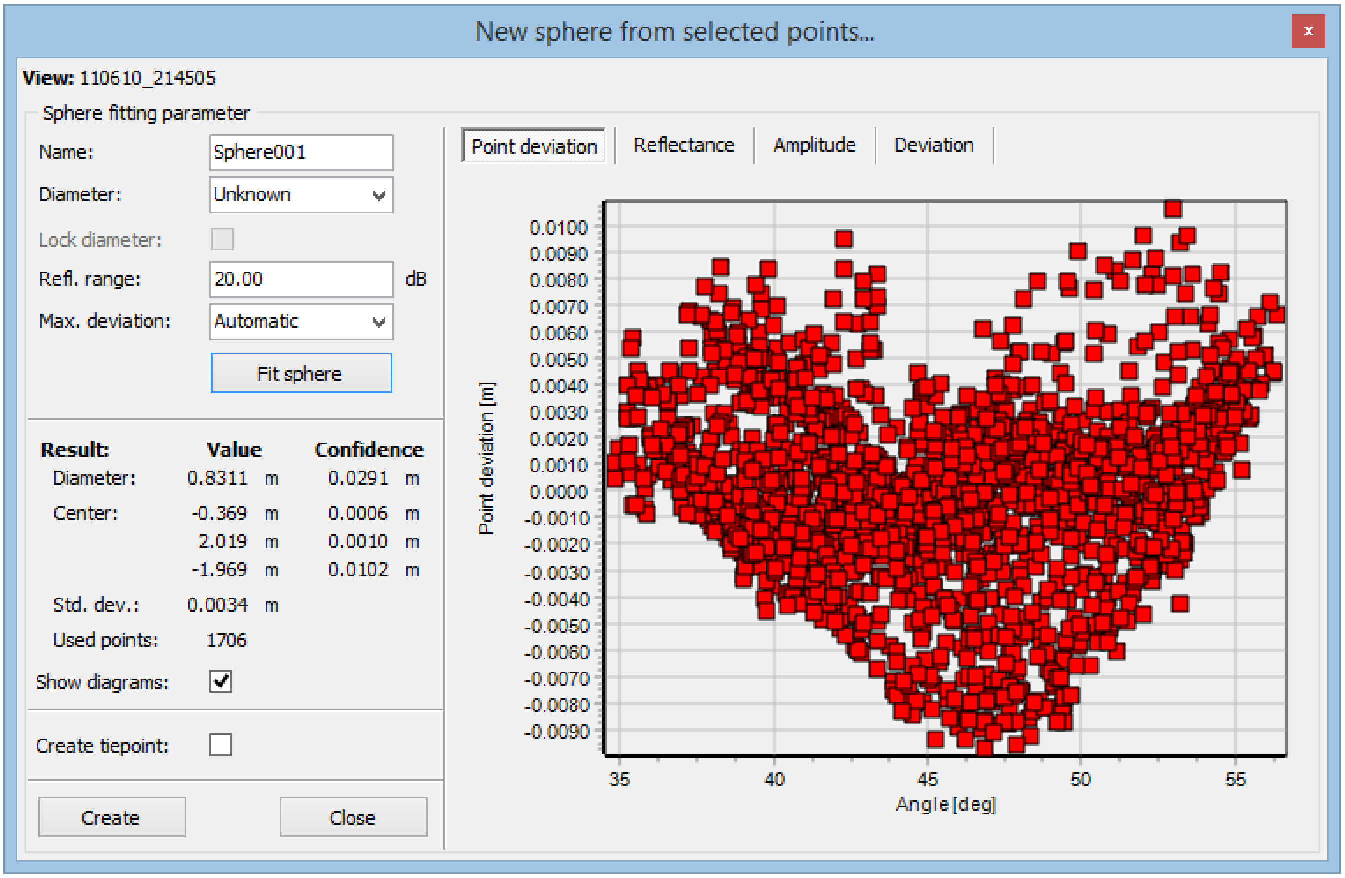
   In all modes the points are defined by either defining a point with the mouse 270 or entering the coordinates directly. If you enter the coordinates directly, click the button next to the coordinates in order to update the position of the sphere in the 3D scene.

3. To finally create (save) the sphere click the button "Create sphere" or press the "3" key. The sphere is saved in the folder "OBJECTS/SPHERES" and added to the current object view.

   Note:
   If "Modify radius" is activated the radius is modified every time you move the mouse. To be a able to click the button "Create sphere" you have to deactivate this option first. To do so press the "2" key.

7.5.2.4.1 From selected points

This tool fits a sphere into selected points from a 3D view and optionally creates a tiepoint at the sphere's center point.



Procedures

1. Start the tool by right clicking in the view window and choose "New object > Sphere > From selected points...".
2. Select points that belong to a sphere in the 3D view.
3. Enter a name and the diameter of the sphere you want to fit or choose "Unknown" if you do not know.
4. Constrain the number of points that will be used for sphere fitting by adjusting "Refl. range" and "Max. deviation".
5. Click "Fit sphere" to estimate a sphere into the selected points of the 3D view. The estimated sphere will appear in the 3D view.
6. If you are satisfied with fitting results click "Create" to permanently store the sphere object in the project.

Parameter description

- **Name:**
  Enter the name of the resulting sphere. If "Create tiepoint" is checked the resulting tiepoint will also be named with this name.

- **Diameter:**
  Enter the diameter of the sphere you want to fit. It serves as a initial value for the sphere fitting algorithm. If you do not know the diameter choose "Unknown" from the list and the diameter of the sphere will be automatically determined by the sphere fitting algorithm.

- **Lock diameter:**

Check "Lock diameter" if you want that the value entered for "Diameter" is compulsory for the sphere fitting algorithm. In this case the resulting sphere diameter will be exactly the entered diameter. If "Lock diameter" is unchecked the sphere fitting algorithm may adjust the diameter of the resulting sphere to best fit the selected point cloud.

- **Refl. range:**
  Constrains the number of points that will be used for sphere fitting. The upper reflectance bound is given by the highest reflectance value of the selected points. The lower reflectance bound is calculated by upper reflectance bound minus "Refl. range". Only points with an reflectance value between the upper reflectance bound and lower reflectance bound will be considered for sphere fitting.

- **Max. deviation:**
  Points with an deviation value above this "Max. deviation" will not be considered for sphere fitting. In case of "Automatic" the value for "Max. deviation" will be adjusted automatically to guarantee that at least half of the selected points will be used for sphere fitting.

- **Fit sphere**
  Click "Fit sphere" to fit a sphere into the pointcloud selected in the 3D view. The fit results will be displayed in the "Result" section. Furthermore a sphere will be shown in the 3D view on the estimated position and with the estimated diameter.

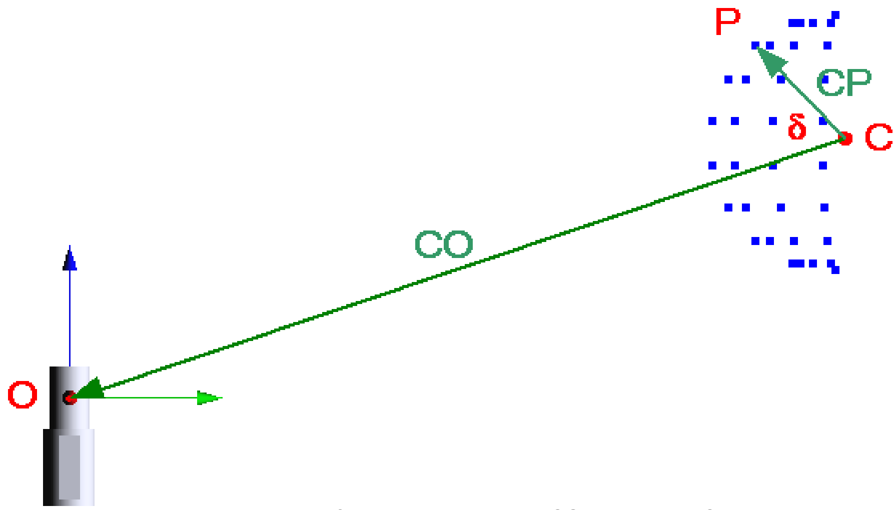
- **Result**
  - **Diameter Value/Confidence:**
    Shows the estimated diameter value of the resulting sphere. Confidence value shows the estimated deviation of the diameter value.

  - **Center Value/Confidence:**
    Shows the center of the resulting sphere in PRCS. Confidence value shows the estimated deviation of the center point.

  - **Std. dev.:**
    Shows the standard deviation of points to the fitted sphere.

  - **Used points:**
    Shows the number of points that have been used for sphere fitting.

  - **Charts:**
    Display results of sphere fitting. Chart bottom axis always shows the angle δ between the vector CO which points from estimated sphere center C to laser ray origin O and the vector CP which points from sphere center C to the data point P.



Angle delta is defined through vector CO and vector CP.

- **Chart - Point deviation:**
  "Point deviation" describes how well the estimated sphere fits into the data points and is defined by the difference between the length of the vector CP and the estimated sphere radius. Thus a point deviation of zero is best. A positive point deviation indicates that the data point lies above the estimated sphere surface whereas a negative point deviation indicates that the data points lies below the estimated sphere surface.

- **Chart - Reflectance:**
  Shows the reflectance value of each data point above angle δ. Usually the reflectance value is best for low δ values.

- **Chart - Amplitude:**
  Shows the amplitude value of each data point above angle δ.

- **Chart - Deviation:**
  Shows the deviation value of each data point above angle δ.

- **Show diagrams**
  Check to automatically display sphere fitting results in additional charts after sphere fitting.

- **Create tiepoint:**
  Check to automatically create a tiepoint at the spheres center point. The tiepoint will be added to the tiepoint list that belongs to the selected points. If the selected points come from different scan positions a tiepoint will be created in each corresponding tiepoint list.

- **Create:**
  Click "Create" to create a sphere object from fitting results. If "Create tiepoint" is checked a tiepoint will be automatically created at the spheres center point.

7.5.2.5 Plane

Create plane from geometry data:

To create a plane please proceed as follows:

1. Open or create an object view

2. Add the objects of interest

3. Right-click into the object view and select "New object/Plane" from the menu. As an alternative you can also use the corresponding button in the toolbar "3D - New object" 270. If you click on this button for the first time a menu is opened offering the functions described below. This menu can also be if you click on the small arrow next to the button. Once you have selected a function and you click the plane button the next time, the same function will be executed.

   - **Co-planar with the x-y plane**
     This will create a plane that is parallel to the x-y plane of the currently selected coordinate system. The origin will be set to the center of the bounding box of the scene.

   - **Co-planar with the x-z plane**
     This will create a plane that is parallel to the x-z plane of the currently selected coordinate system. The origin will be set to the center of the bounding box of the scene.

   - **Co-planar with the y-z plane**
     This will create a plane that is parallel to the y-z plane of the currently selected coordinate system. The origin will be set to the center of the bounding box of the scene.

   - **From 1 point**
     With this function you can create the plane by defining just one point. This point will be the origin of the plane. To define this point use the mouse 270 or enter the coordinates directly. If you enter the coordinates directly click the button next to the coordinate in order to update the plane in the 3D scene. The orientation of the plane is defined via the orientation of the virtual camera (the plane will be aligned perpendicularly to the direction of the virtual camera). If you want to navigate in the scene without modifying the orientation of the plane activate the option "lock plane normal". To tilt the plane by 180° deg activate the option "Negate normal vector". To finally create (save) the plane click the button "Create plane".

   - **From 2 points**
     This mode is only available if the camera is set to orthogonal mode 156.
     With this mode you can define a plane by defining two points. These points define an axis which lies within the plane. The rotation of the plane about this axis is determined by the orientation of the virtual camera (the plane normal will be perpendicular to the direction of the camera).
     As soon as you enter this mode the navigation is locked (you can not pan, rotate or zoom). To define the points of the axis left-click into the view. After you have defined the second point the plane will be created immediately.

     The dialog of this function offers some tools to make axis definition easier:
     Orientation
     - **Free** - the axis can be defined in any direction
     - **Horizontal** - the axis can be defined horizontally (referring to the screen) only
     - **Vertical** - the axis can be defined vertically (referring to the screen) only

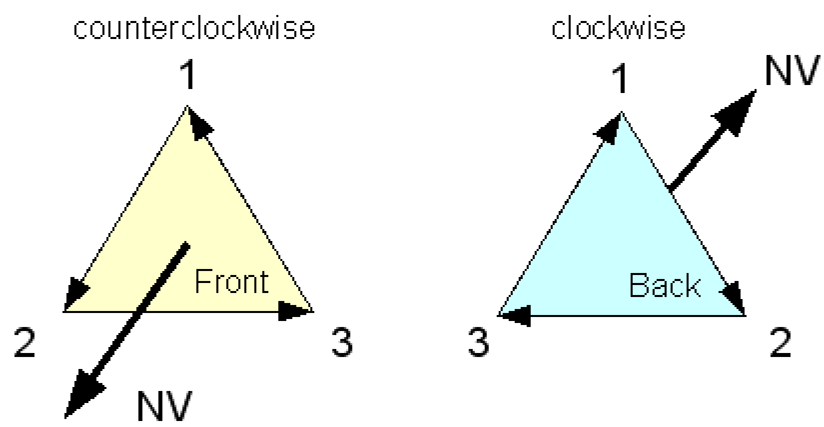
     Note: "Horizontal" and "Vertical" are related to the screen

     Orientation relative to previous
     - **Parallel** - the axis will be defined parallel to the previous
     - **Perpendicular** - the axis will be defined perpendicularly to the previous

     To leave this mode click the button "Close".

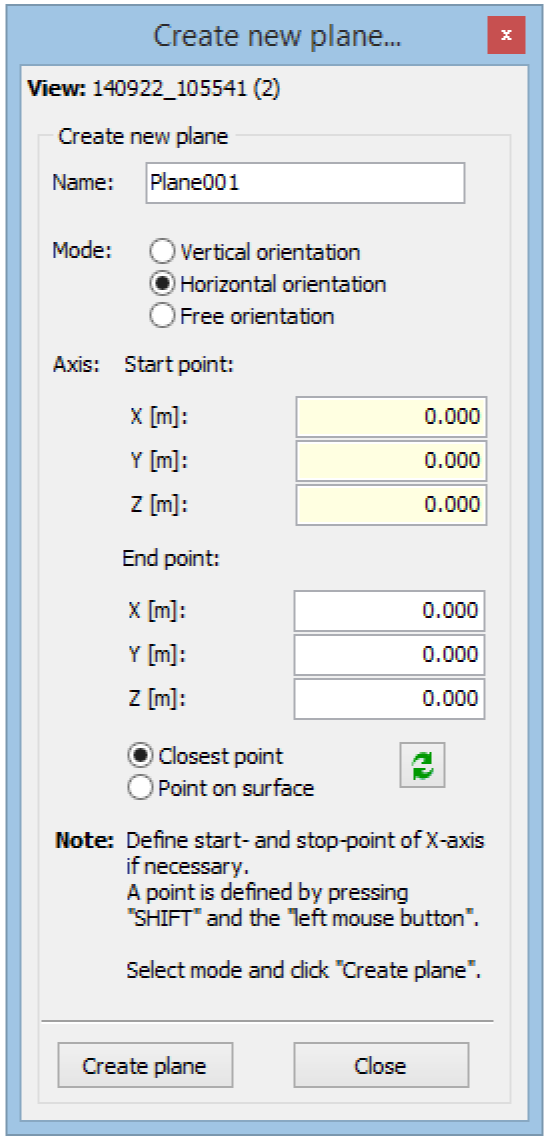
   - **From 3 points**
     With this function you can create a plane by defining three points. All three points lie on the created plane. In the accompanying dialog you can define the three points interactively with the mouse 270.
     You can use the "1", "2" and "3" keys on the keyboard as shortcuts to switch between definition of

point 1, 2 or 3. As an alternative you can enter the coordinates directly. In that case click the button next to the coordinates in order to update the point position in the 3D scene. You can modify each point as often as required. To finally create the plane click the button "Create plane".
The orientation of the plane (the direction of the surface normal) is defined by ordering the points clockwise or counterclockwise:



- **From selected area**
  Before you can use this function select some points 221 in the object view. The function will create an infinitely-sized plane that is calculated from the coordinates of the selected area using the least-squares-fit algorithm. The plane will be displayed limited only by the bounding box of the object view.

- **From selected area (limited)**
  Creates a plane like in the function described above. Additionally the orientation of the plane can be set:



- Vertical orientation

  Intended for generating orthophotos of facades. The plane is strictly parallel to the Z axis of the currently selected coordinate system 156.

- Horizontal orientation

  Intended for generating orthophotos of the floor or ceiling. The plane's surface normal is parallel to the Z axis of the currently selected coordinate system 156. The X axis has to be defined (see next mode: "Free orientation").

- Free orientation

  In this mode you have to define the X axis (bottom edge of the plane) with two points ("Start point" and "End point"). To do so click the button "Start point" (or press the "1" key) and click the corresponding point 270 in the 3D scene. Proceed this way with the second point ("End point", "2" key). Alternatively you can also enter the coordinates of the two points directly. In that case click the button next to the coordinates in order to update the axis in the 3D scene. To finally create the plane click the button "Create plane".

Note: All 3 modes always use the currently selected coordinate system 156 (either SOCS, PRCS or GLCS).

The created plane is saved in the folder "OBJECTS/PLANES" and will be added to the current object view.

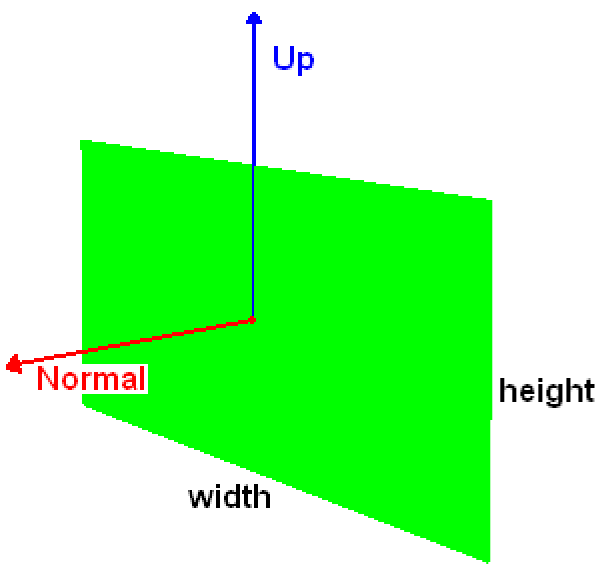
Create plane from tiepoints:

Open a tiepoint list and select some tiepoints. Then open the popup menu and select "Create geometry object…/ Plane".

Note:
At least 3 tiepoints must be selected in order to create a plane.

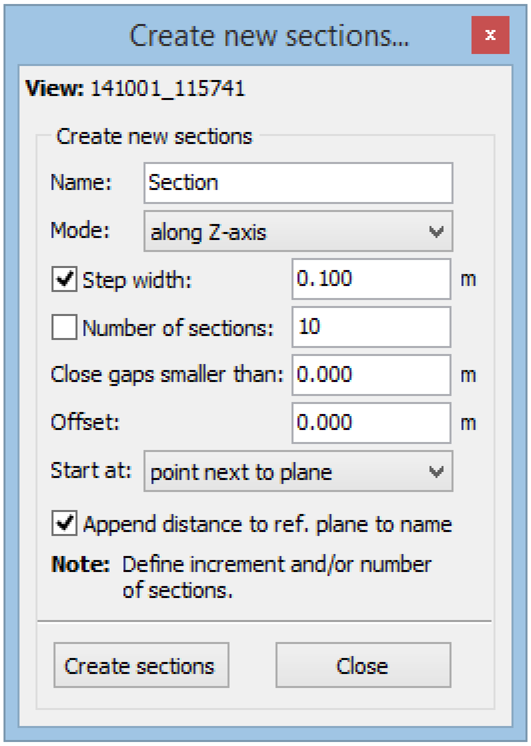
Definition of plane's width and height:

Every plane can either be unlimited (width and height set to zero) or can have a width and a height. These dimensions can be set in the plane's attributes or with the object inspector and are defined as follows:



7.5.2.6 Sections/Profiles

You can create cross sections from triangulated data (Polydata) by viewing the data of interest in an object view. You may also select only a part of this data. Then right-click into the object view and select "New object..." -> "Sections".



Mode:

Some modes to determine the orientation of the sections are available:

- **Along X, Y, Z – axis:**
  Create parallel cross section(s) along one of the three coordinate axes. The coordinate system is defined by the object inspector 156 (SOCS, PRCS, GLCS).

- **One plane:**
  Create cross section(s) parallel to one plane.

- **Two planes:**
  Create cross section(s) between two parallel planes.

Note:
The modes "One plane" and "Two planes" need additional information about the plane(s) to use. To define which plane(s) to use select them in the object inspector.

Step width:

Defines the increment between two sections.

Number of sections:

Defines the number of sections to generate

Close gaps smaller than:

You can close gaps within a section by defining this value larger than zero. The gap will be closed with a straight line connecting the two intersection points surrounding the gap.

Offset:

This value is used to determine at which level (counting from the reference plane) the first section should be created. The reference plane depends on the selected Mode. The modes using a coordinate axis use the plane that is perpendicular to the axis and starts at the bounding box minimum of the corresponding axis. The modes using planes use the specified plane for reference.

Start at:

With this option you can define where the first section should be placed.
"**Start at reference plane**" - the first section is created at the reference plane plus "Offset" added in the direction of the plane's normal vector.
"**Start at data point next to plane**" - the first section is created at the region that is next to the reference plane.

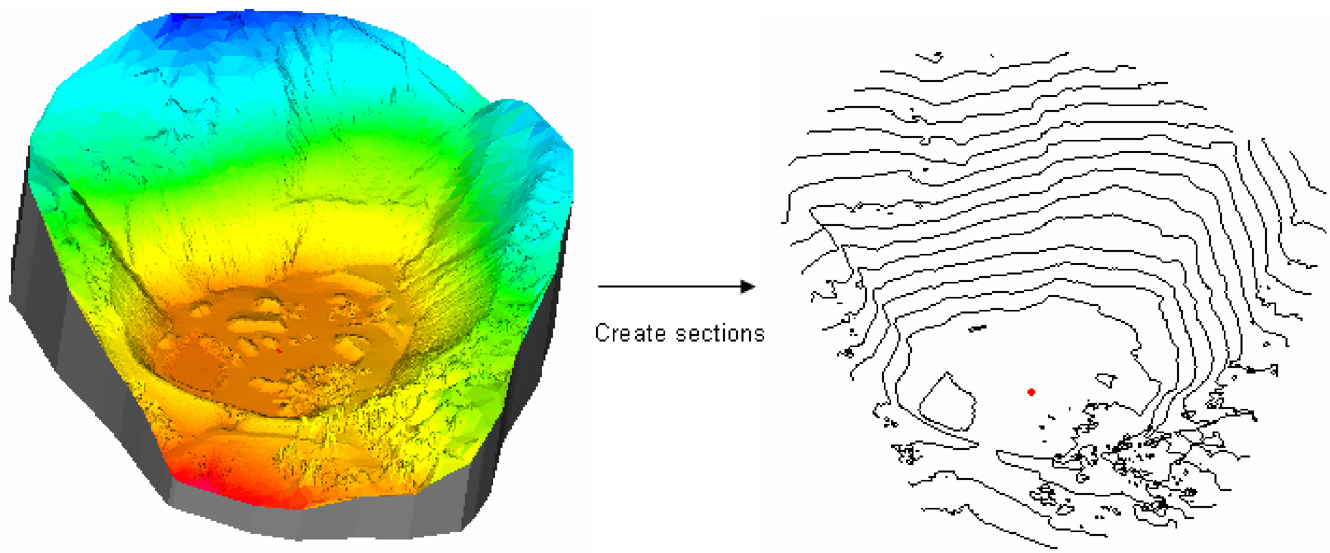
Example:

Mode is "along Z-axis (PRCS)", step width is 2 m, the lowest data point has a Z coordinate of 3.5 m.
In the case of "Start at reference plane", the sections will be at the following Z values: 4 m, 6 m, 8 m and so on.
In the case of "Start at data point next to plane", the sections will be at the following Z values: 3.5 m, 5.5 m, 7.5 m and so on.

Note:

At least one value for "Increment" or "Number of sections" must be defined. If you specify just one value the other one is calculated automatically (but not displayed) using the complete range given by the data.

Example: Cross sections with 7.5m increment



7.5.2.7 Tiepoint

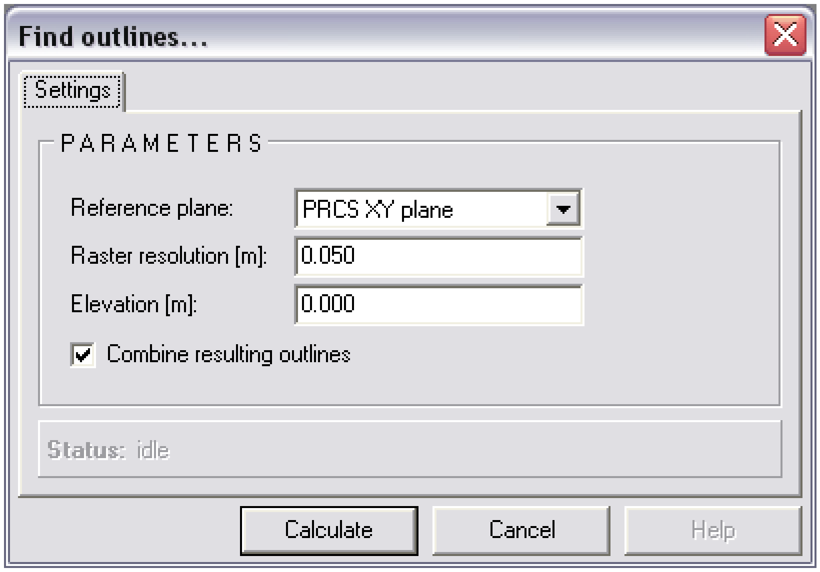
Creating tiepoints is similar to creating points 271.
In addition to the other parameters you can also define the reflector calibration 75 of the tiepoint. To do so select the calibration from the list "Type" before you create the tiepoint.

To finally create (save) the tiepoint click the button "Create tiepoint" or press the "3" key. The new tiepoint will be saved in the corresponding tiepointlist of the selected coordinate system 156 (that means either TPL GLCS, TPL PRCS or the TPL SOCS for the selected scan position).

7.5.2.8 Outlines

RiSCAN PRO allows you to find (extract) the outline(s) of any mesh from any desired point of view. The detected outlines are saved as polylines within a RiSCAN PRO section object which can be exported as DXF file for further processing in other programs.

How to extract outlines:
To start the function, right-click a polydata object and select "Find outlines..." from the menu. The following dialog appears:



- **Reference plane:**
  During the outline extraction procedure, the input mesh is projected onto a plane. The function accepts any user defined plane and also offers some frequently used default planes ("PRCS XY plane", "PRCS XZ plane" and PRCS "YZ plane").

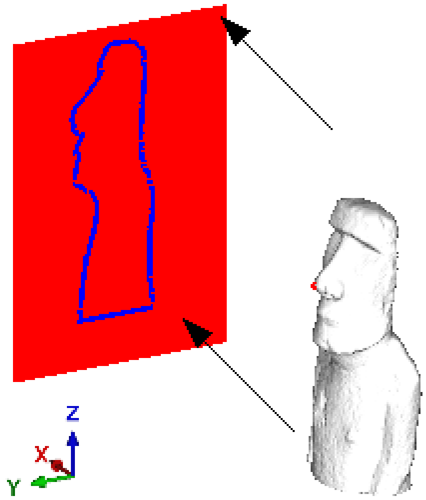
- **Raster resolution:**
  All mesh data is filled into a 2D raster that lies on the plane. Modify this value to adjust the raster resolution.

  Note: The range of this value is limited by the size of the object (mesh).

- **Elevation:**
  The created outline lies on the reference plane per default. To move the outline along the plane's surface normal modify the "Elevation" value.

- **Combine resulting outlines:**
  Enable this option to save all outlines to one single section object (otherwise one section object will be created for each detected outline).

Example:
The following example shows a sculpture and the outline created from the mesh. As reference plane the PRCS YZ plane was used.



7.5.2.9 Breakline extraction

This tool can be used to extract breaklines from a point cloud acquired in open-pit mining areas. A breakline may be classified as either "crest" or "toe" and is represented by a polyline. Each breakline has a quality attribute for itself and each of its vertices of either "high" or "low".
If modification of a polyline is desired, the polylines may be edited by the use of an interactive polyline editing tool optimized for ease-of-use.

Usage:

The input of this tool is a point selection (in the 3D view) and a reference plane (usually, the XY plane of the PRCS). The latter one is required since the algorithm uses a 2.5D approach.
Note: Although the algorithm can deal with a certain amount of outliers, it is recommended to apply the terrain filter to the input point cloud before (furthermore, an octree-filter should be used in order to avoid an unnecessary high point density, e.g. near a terrestrial scan position).

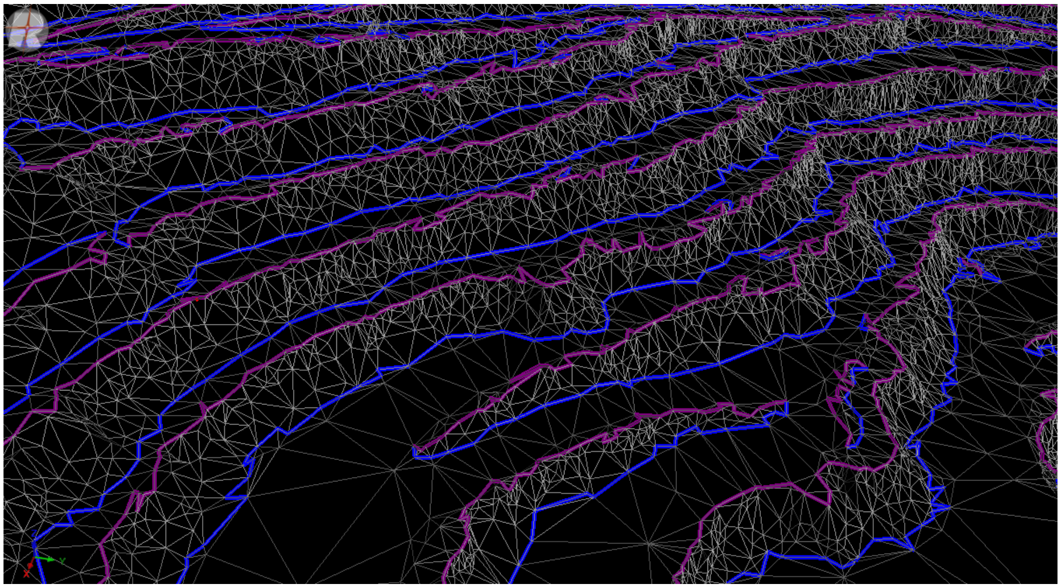
Step-by-step:

- Open a 3D view containing the (pre-filtered) input point cloud
- Select the points of interest (using the selection tools as usual)
- Click on the button "Create new edge" () in the tool bar "3D – New object".
- Select "Breakline extraction..." from the short menu that appears
- Define reference plane and parameters (for detailed description of parameters see below)
- Click on OK to start the breakline extraction process
- As result, up to two new section objects are created containing crest lines and toe lines respectively (a section object is created only if there is at least one line of the respective type)

Description of the breakline extraction method:

The following process is carried out:
In the first step, a triangular mesh is generated, which approximates the terrain's surface within a user-defined tolerance value. Based on this auxiliary mesh, a connected-component analysis is performed in order to find regions of "low-tilted" triangles within the mesh. Breaklines are assumed to be in the vicinity of the (closed)

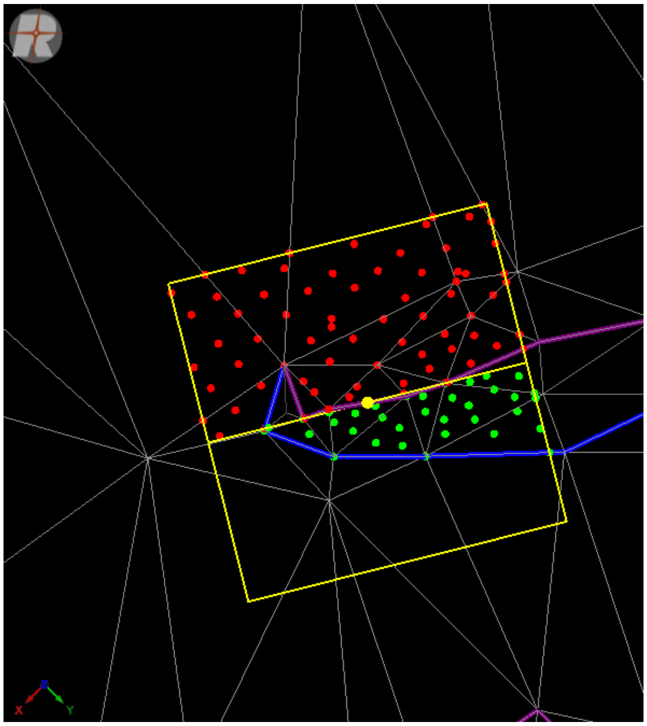
boundaries (cyclic sequence of mesh edges) of these regions. Hence, the point cloud near these boundaries is examined for breaklines. Before starting the actual breakline modeling process, the boundaries are split into parts, which are classified either as "crest" or "toe" parts. The screen shot below shows an example of these "toes" and "crests".

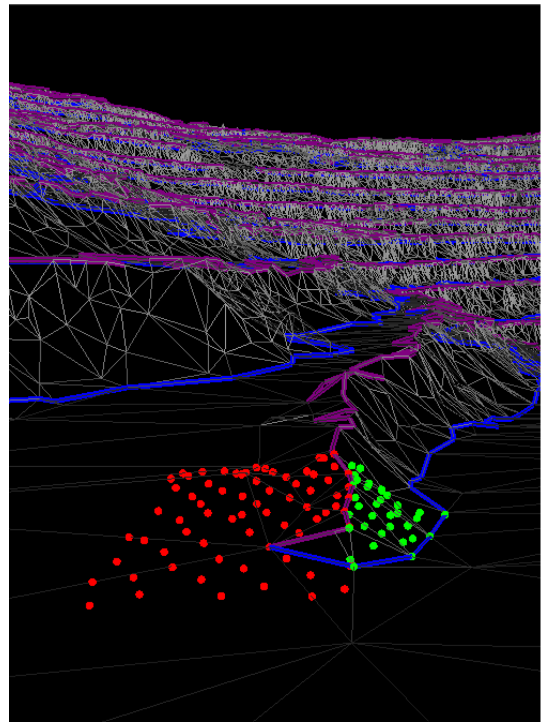


Classified boundary parts based on the auxiliary mesh

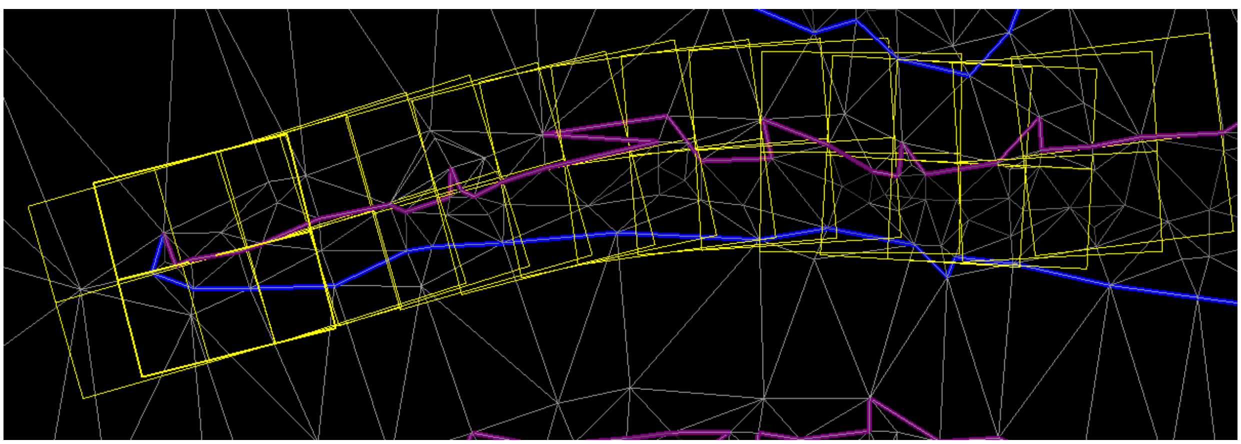
For each boundary part, a breakline is tried to be extracted:

Starting from a seed edge, the boundary part is traced both in backward and forward direction. This is done by successively intersecting two planes estimated through points on each side of the boundary within a pair of rectangles (2d boxes) sliding along the boundary. For each position of the box pair, a point on the resulting intersection line is added as vertex of the breakline. The center of the box pair's next position is obtained by extrapolation along the intersection line according to the parameter "box overlap" (for details see section "Description of the parameters"). Thus, the breakline is "growing" backward and forward until the respective end of the boundary part is reached or until another termination criterion is fulfilled (e.g. too low intersection angle of the two planes).
The screen shots below illustrate the breakline modeling process.





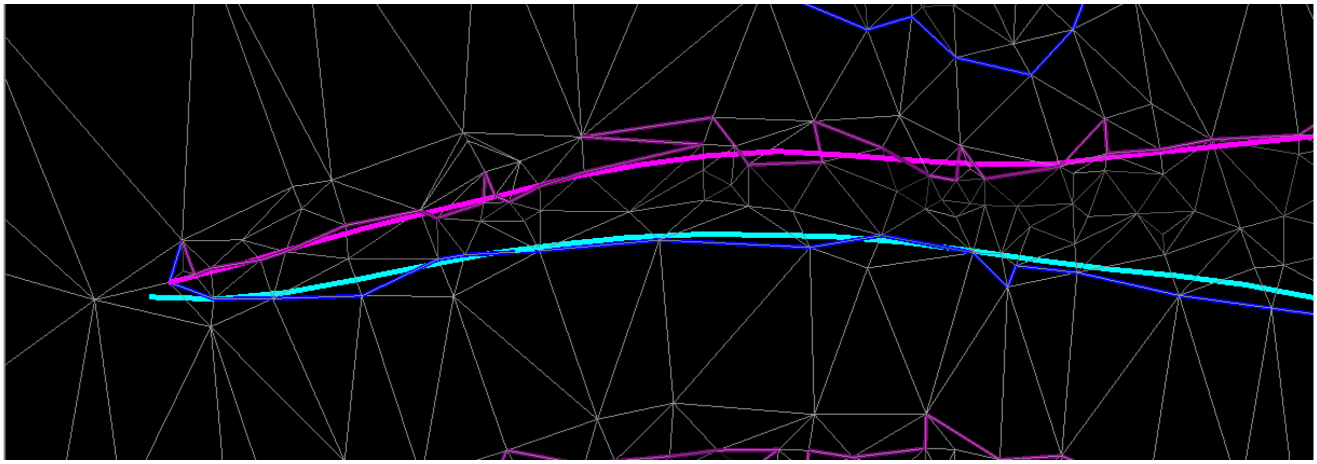
Points of left and right side of the boundary part inside the box pair (top+perspective view)



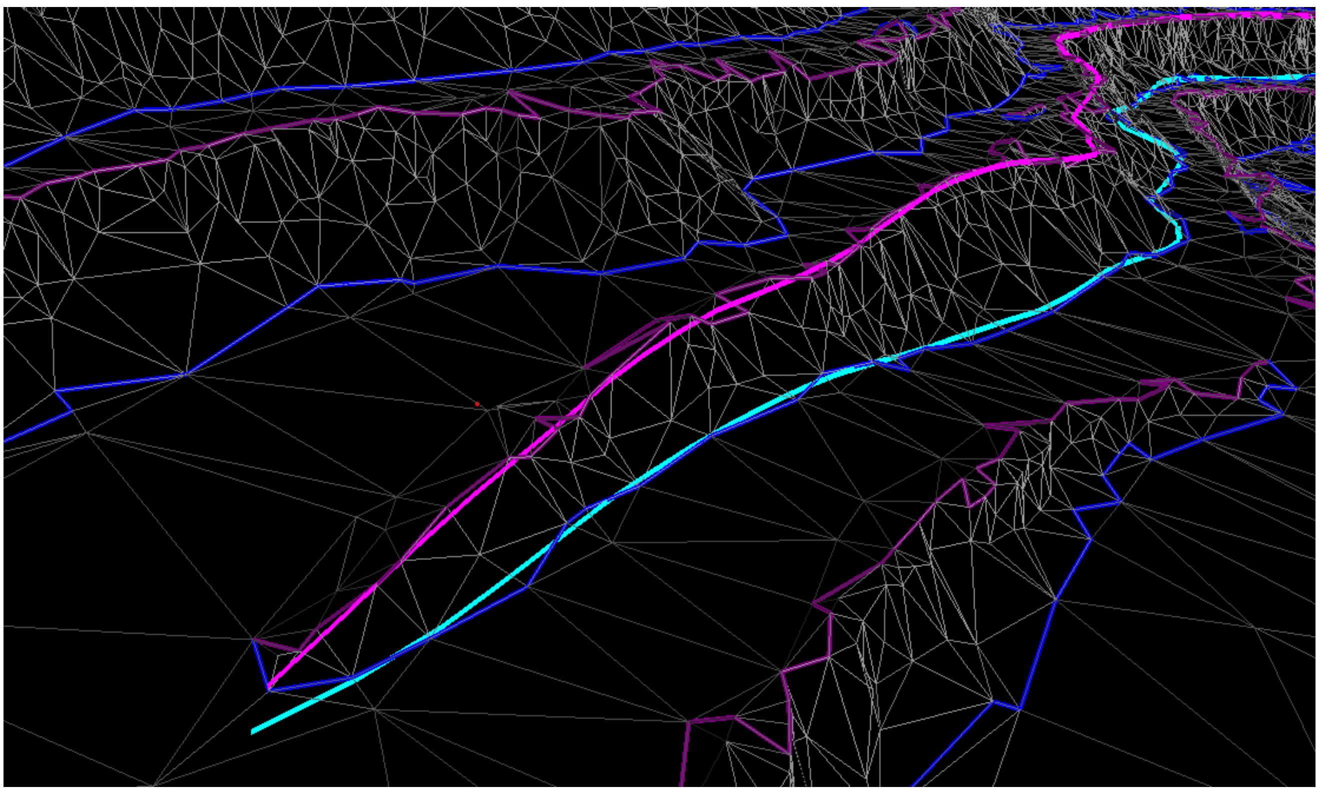
Box pairs used for breakline modeling in case of an overlap of 67% (top view)

Box dimensions and box overlap may be defined by the user. Depending on these parameters, a more or less smooth breakline is generated.

The screen shots below show a crest line and a neighboring toe line obtained by performing the above-mentioned process.

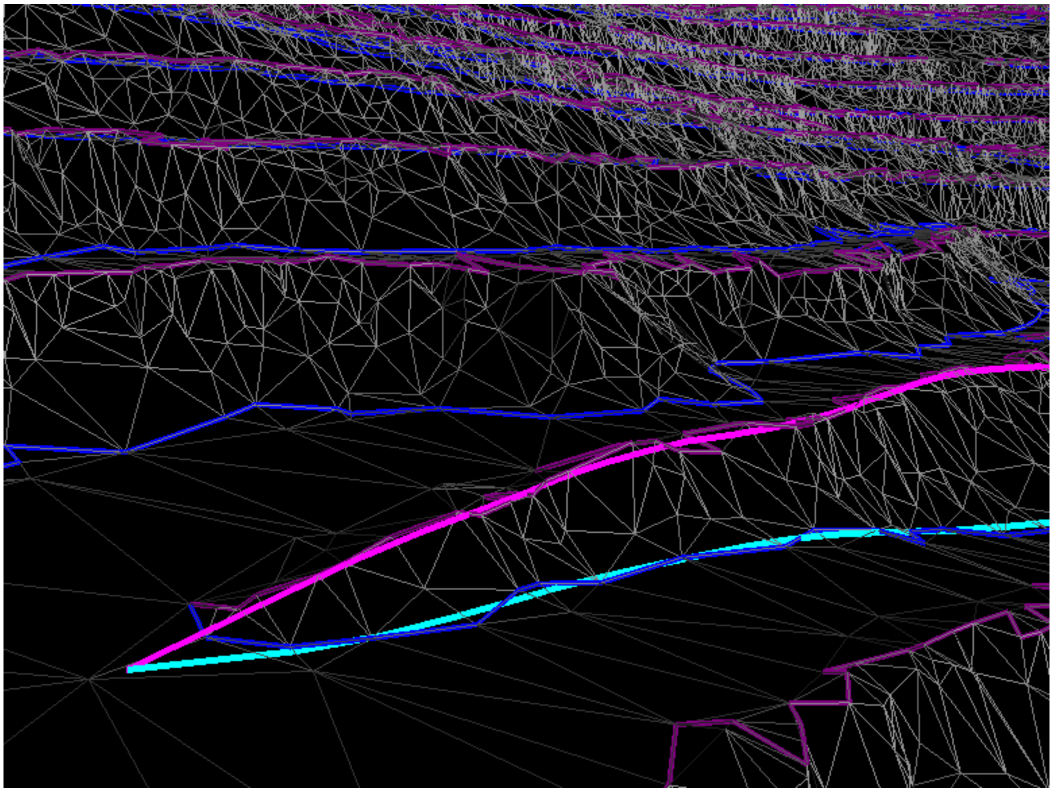


Crest line and toe line (top view)



Crest line and toe line (perspective view)

Finally, breaklines of different types are intersected/extended if their end vertices are close enough to each other in such a way that they share a common end vertex.



Crest and toe line after intersection (perspective view)

Description of the parameters:

- **Mesh tolerance value:**
  This parameter is responsible for the level of detail of the auxiliary mesh that is being generated. A coarse mesh is refined incrementally by inserting points to it. Therefore, the point with the maximum distance from the current mesh is determined and inserted. As soon as this maximum distance is below the mesh tolerance value, the process is stopped. Hence, the final mesh approximates the point cloud within this tolerance value (except outliers that are detected and eliminated afterward).
  The smaller the parameter value is chosen, the finer the mesh will be.
  Note: The processing time may increase considerably when reducing the parameter value (depending on the geometric characteristics of the terrain and on the point cloud size).
  If the tolerance value is too high, the mesh will be too coarse to represent the terrain's surface properly: consequently, narrow benches may be strongly smoothed and not considered in the final result.
  Note: A too small tolerance value (i.e. a too detailed representation of the terrain's surface) may deteriorate the quality of the result, too. The reason is the fact that the mesh is refined even in horizontal areas if they are rough compared to the tolerance value. Hence, such regions are represented by many small triangles having highly varying tilt angles. This leads to a high number of small "low-tilted" regions (instead of a few big ones), which may finally cause rather large gaps in the breaklines or even make the detection of some of them impossible.

- **Generate mesh output:**
  If checked, a polydata object containing the auxiliary mesh is generated.

- **Minimum bench height:**
  This parameter specifies the minimum bench height that is required at the seed vertex of a breakline. The bench height is estimated as the maximum (absolute) height difference between the center point and a point within the "right" box (representing the steep side of the boundary). If this value is below the parameter value, the seed edge candidate is considered as "not suitable" and the growing procedure is not

started.
Hence, this parameter may be used to avoid extracting irrelevant breaklines.

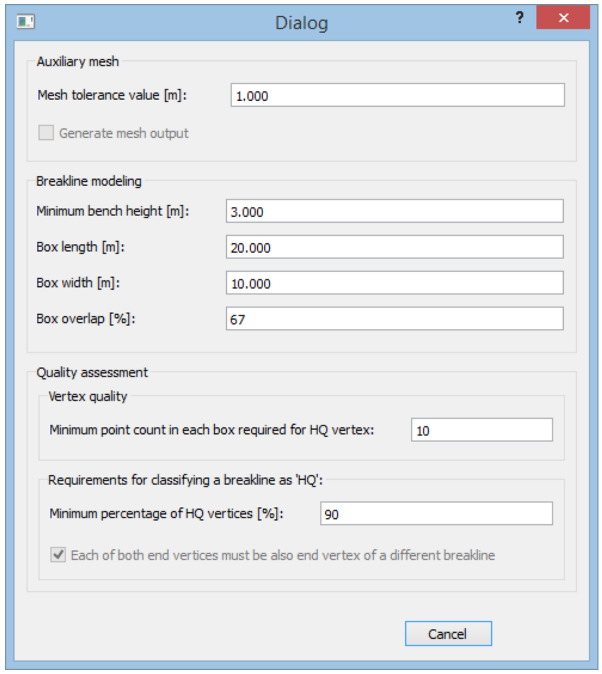
- **Box length and Box width:**
  These parameters specify the 2D box dimensions of the sliding box pair used for breakline modeling. Hence, they define the neighborhood used to determine a breakline's vertex. The bigger the box, the more neighboring points may be covered by it, i.e. the higher the redundancy for plane fitting. If the box is too small compared to the density of the point cloud, plane fitting may be not reliable (causing jags within the breaklines) or even not possible due to lack of points. Otherwise, if the box is too big, the result is obtained by averaging over a large area: the resulting breakline is smooth, but certain terrain details are not considered.
  The parameter Box length defines – together with Box overlap – the scheduled distance interval of successive vertices of the breaklines.
  Note: the parameter Box width may have a considerable influence on the breakline's position if the bench face's profile within the box deviates much from a straight line. In this case, the fitted plane is a too coarse representation of the actual surface and thus, the determined position of the vertex is not reliable. The algorithm tries to recognize such vertices by performing a profile analysis and sets their quality attribute to "low".

- **Box overlap:**
  This parameter is used for the breakline growing procedure: it specifies the longitudinal overlap percentage p of two successive box pairs if they were coaxial. Depending on p, the step width s is calculated by $s=(1-0.01 \cdot p) \cdot l$ where l is the parameter box length. The step width s is used to predict the position of the next breakline vertex. Hence, s is the scheduled distance between successive vertices (their actual distances may deviate more or less from this value). The higher the overlap, the more points on a breakline are generated but the more dependent they are from each other. Hence, increasing the box overlap without changing the box length yields more points on a breakline but does not increase its level of detail.
  Too low or too high values of this parameter (in the extreme cases: 1% and 99%) may cause abrupt changes of the breakline's direction or – in some cases – zigzag lines.

- **Minimum point count in each box required for high quality vertex:**
  This parameter is used to classify the quality of a breakline vertex. As already mentioned, the determination of a vertex is performed based on the intersection of two planes. Each of those planes is determined by fitting it to a set of points. Each point set consists both of original points and points generated by intersecting the box with the 2d projection of the mesh. If each of the two boxes contains at least the number of original points specified by the parameter, the spatial distribution of the points is analyzed for each box in order to assess vertex quality, otherwise the vertex is classified as "low quality" vertex.
  In case of a "high quality" vertex of a crest line, the above-mentioned profile analysis is performed which may change the vertex quality to "low".

- **Minimum percentage of high quality vertices:**
  By this parameter, a criterion for a high quality breakline is specified. Each breakline has a certain percentage of high quality vertices. If the percentage is at least as high as the parameter value, the criterion is met for the breakline.

- **Each of both end vertices must be also end vertex of a different breakline:**
  If checked, a further criterion for a high quality breakline is considered: only breaklines sharing both of their end vertices with a different breakline (of different type) meet this criterion. Hence, the criterion is met:
  - for a crest line if it is connected with a toe line at each end
  - for a toe line if it is connected with a crest line at each end



7.6 Modify geometry objects

You can modify the position and orientation of geometry objects with the tool described in Interactive coarse registration 197. You can also modify the properties of the geometry object by double clicking it's label it in the project manager.

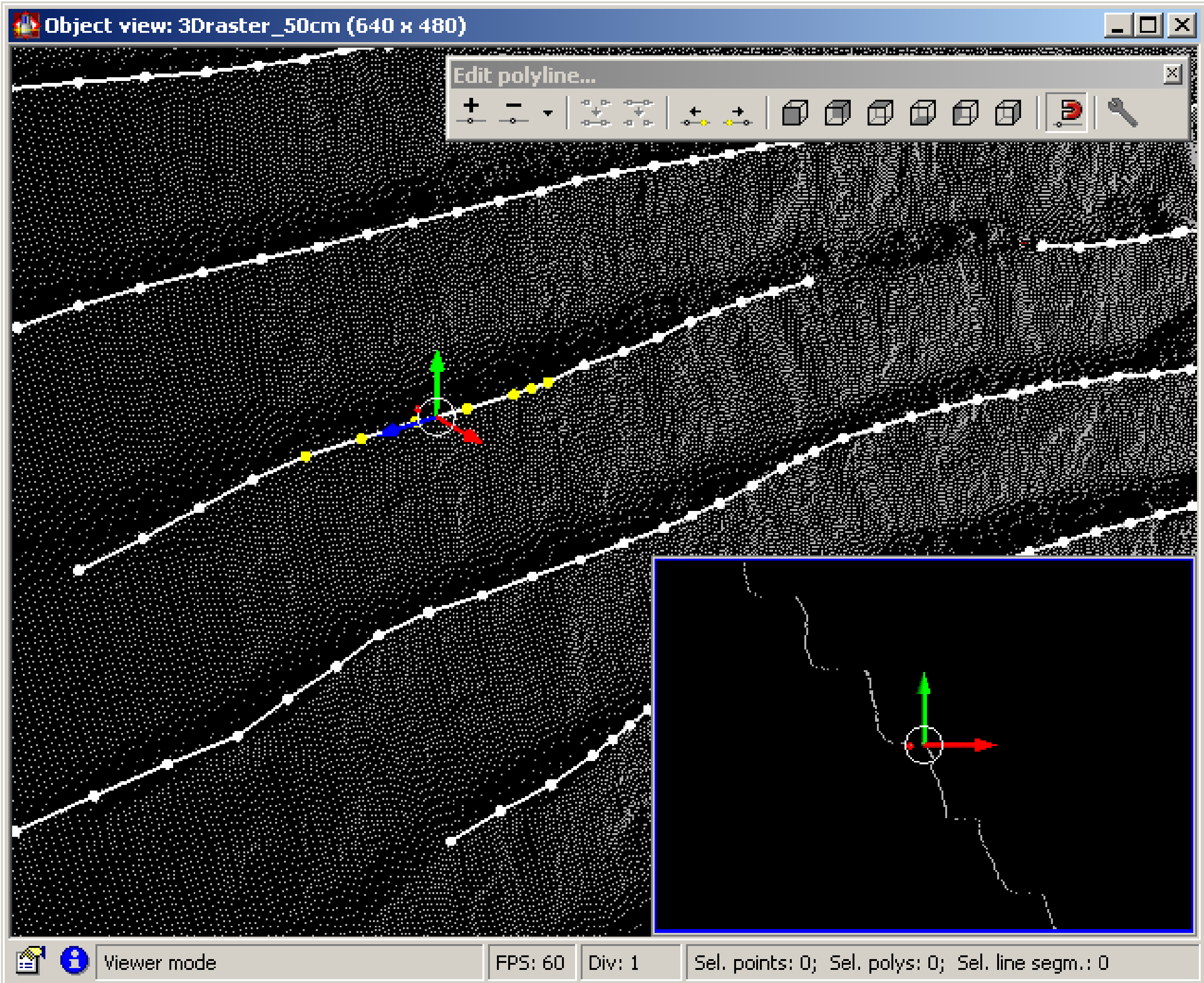
7.6.1 3D

7.6.1.1 Breakline/Polyline

Use the Edit polyline tool in order to edit polylines contained in polyline objects 271, section objects 285 and polydata objects.

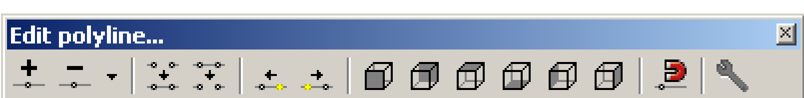
Start the Edit polyline... tool

1. Open/create an object view 144 and add the desired objects to the view.
2. Select/Multi select the desired polyline objects, section objects and polydata objects in the Object Inspector 156.
3. Right click the selected items in the Object Inspector and choose "Edit..." to launch the tool for the selected objects.



A 3D view showing polylines from a section object in edit mode. The tool window in the top right corner controls the editing. The yellow polyline nodes in the left are selected and can be modified interactively by the transform gizmo. The detail view in the bottom left corner shows the same scene from a different more detailed view.

Tool window description



Button description form left to right:
1. Add a new node between two selected non end nodes (**A**).
2. Remove selected node(s) without deleting the connected segments (**Del**). Delete selected node(s) and connected segments (**Shift+Del**).
3. Connect selected end nodes with a new segment (**C**).
4. Delete segment between two selected non end nodes (**S**).
5. Move selection backward (**Y, Shift+Mouse Wheel Down**).
6. Move selection forward (**X, Shift+Mouse Wheel Up**).
7. View front.
8. View back.

9. View top.
10. View bottom.
11. View left.
12. View right.
13. Snap to polyline node(s).
14. Settings: Enable clipping. Clipping size.

Additional keyboard shortcuts:
- Hold down **V** to temporarily hide all polyline nodes in the 3D view.

Select polyline nodes

- Select one polyline node by left clicking on the node. The clicked node will be selected and all other nodes will be deselected.
- Hold down Ctrl and left click a polyline node to toggle the selection state of the clicked node. The clicked node will be selected/deselected in addition to already selected nodes.
- Select one polyline node, then hold down Shift and select another polyline node on the same polyline to select all nodes in between of them.
- Use Ctrl+D to deselect selected nodes.

As soon as there is at least one polyline node selected a transform gizmo will be displayed at the center of all selected nodes.

Detail view

The detail view shows the same scene from a different, orthogonal camera. It is used to align the transformation gizmo. The X and Y axis of the transformation gizmo will be always parallel to the viewing plane of the detail view camera. Thus changing the detail view camera also changes the orientation of the transform gizmo in the 3D view.

Clipping:
- Click the settings button and tick/untick "Enable clipping" to enable/disable clipping of data in the detail view. If clipping is enabled all data before and after a certain slice which is centered at the transform gizmo origin and parallel to the viewing plane of the detail view is hidden.
- Click the settings button and choose "Clipping size" to adjust the size of the slice of visible data in the detail view.

Edit selected polyline nodes

- Translate selected polyline nodes by dragging one of the axes of the transform gizmo in the 3D view or the detail view. Transformation will be limited to the dragged axis.
- Translate selected polyline nodes by dragging the whole transform gizmo in the 3D view or the detail view by dragging the circle of the gizmo. Transformation will be limited to the viewing plane.
- Detail view only: Hold down Shift and left click anywhere in the detail view to directly translate the selected nodes to the clicked position. Transformation will be limited to the viewing plane.

7.7 Measurements

This chapter describes how to measure point coordinates, distances, volumes and surface areas in an object view 144.

- Create or open an object view
- Add the objects of interest
- Right-click into the view window and select the menu item "Measure" which offers a submenu with the following items:

- Point coordinate... 298
- Distance between two points... 298
- Volume and surface area... 300

As an alternative you can also click a button in the toolbar "3D - Measure" (use the view_menu 17 to show the toolbar):

(the functions described above are ordered from left to right in the toolbar)

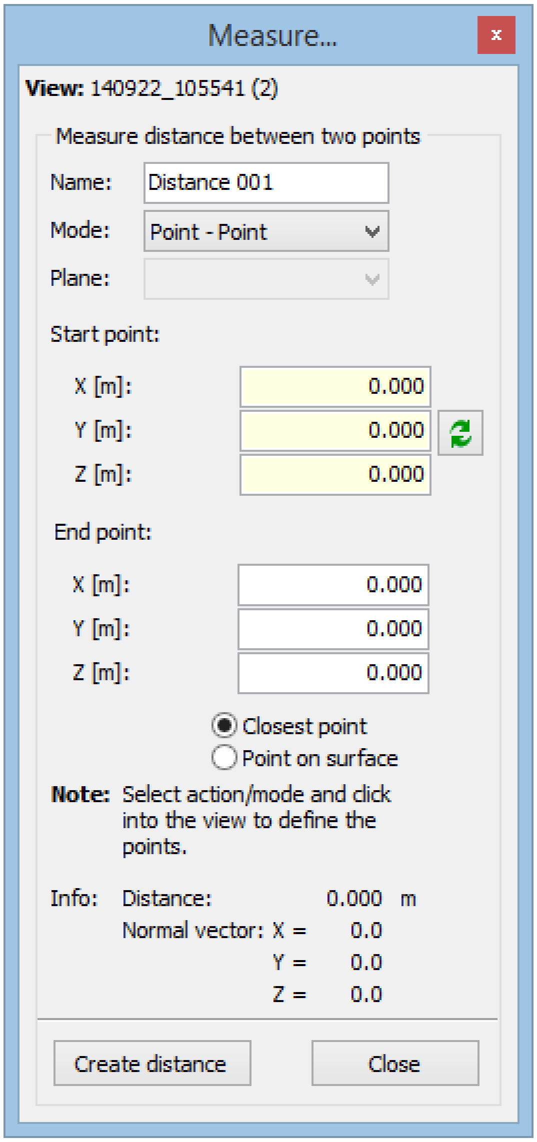
The functions are described in the subsequent sections.

7.7.1 Measure point coordinates

See Create geometry objects: Point 271.

7.7.2 Measure distance

- *distance between two points*



MEASURE DISTANCE BETWEEN TWO POINTS

Switch "**Mode**" to "**Point - Point**".

Point definition mode

- *Closest Point*

  the nodes will be defined by the coordinates from the closest point available

- *Point on surface*

  the nodes will be defined by the coordinates of the cursor when the mouse-button is pressed.
  Note: the mouse has to be positioned within a surface when the button is pressed!

Shortcuts (the focus has to be on the view, so the shortcuts can be applied during the definition of the points)

- press key 1 -> activate "Define start point"
- press key 2 -> activate "Define end point"
- press key 3 -> "Add distance"

To define the start point you can either press the key [1] on your keyboard or click with the left mouse button into one of the X, Y and Z fields of the start point in the tool window. Now you can either enter the coordinates manually or click on a point in the 3D view with the left mouse button while the [SHIFT] key is pressed. Then switch over to the end point (with key [2] or mouse click) and define the point coordinates the same way.

As soon as the parameters "**Start point**" and "**End point**" are defined the distance is displayed in the view by two points connected by a line. The line has a lable showing the distance between the start and end point. Now you can save the distance measurement by clicking on the button "**Add distance**" or pressing key "**3**" (there will be a new object within the folder "DISTANCE" in the object inspector window).

Note: If the created distance is not visible, select the distance-object from the Object-Inspector window and increase the "Line width" in the Properties window. The distance is only saved to the view in which it was created. You can not display the same distance object in another view.

- *distance between a point and a plane (normal distance)*

Switch "**Mode**" to "**Point - Plane**" (in this case "End point" is deactivated and you have to define a reference plane).
Select a plane from the list "**Plane**". As an alternative you can also use a temporary plane defined by selected points. In that case select some points and select "**<>**" from the list "Plane".
As soon as "Start point" and "Plane" are defined the normal distance between the point and the plane is displayed as "Distance" at the bottom of the window.

- *distance between two planes (origins)*

1. Open/create an object view and load the data you want to work with.
2. Select two planes in the object inspector.
3. Open the popup menu of one plane and select "Calculate->Distance between planes (origins)".

7.7.3 Measure volume and surface

RiSCAN PRO can calculate the volume of objects represented by point clouds (scan or polydata objects) or meshes (polydata objects only) in three different modes. Depending on the calculation mode, it is also possible to calculate the surface area of object.

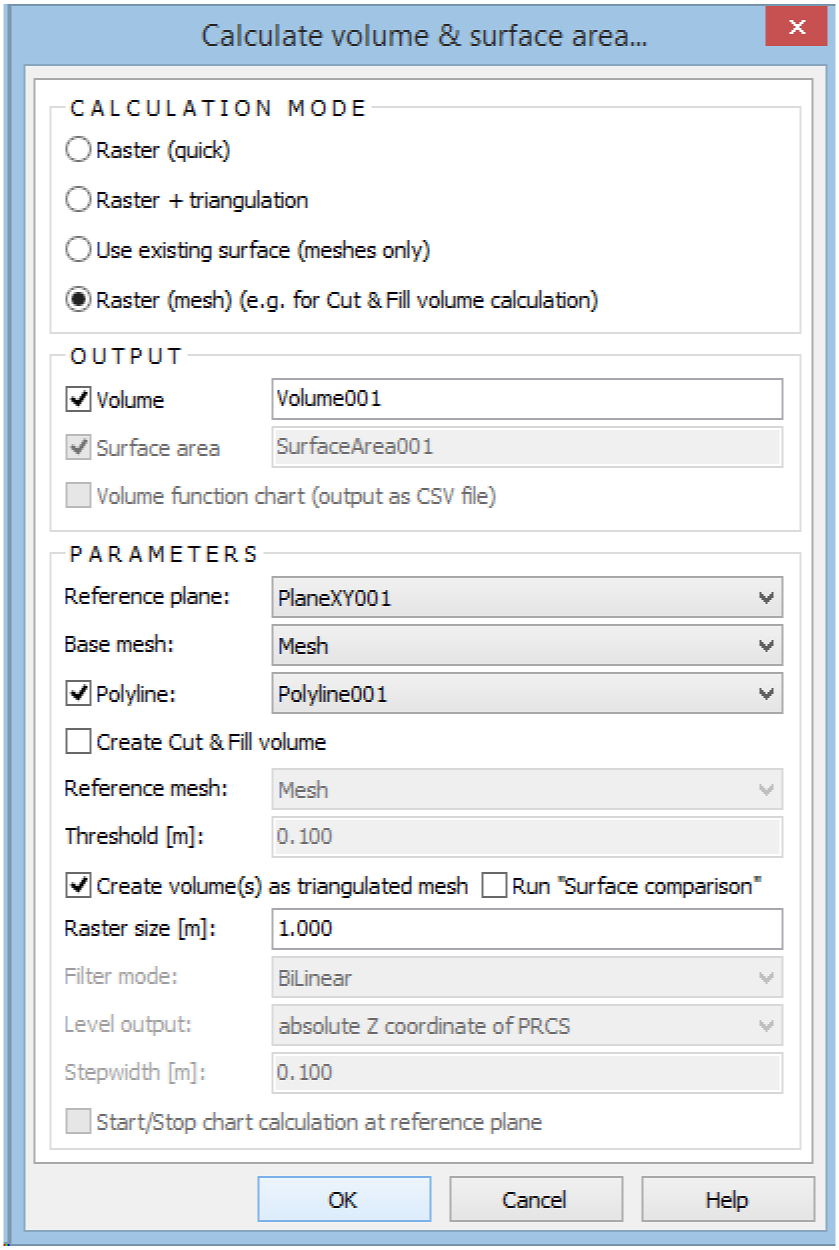
Prerequisites

To calculate the volume and/or surface area of an object, create a new Object View and load the desired data into the view. Now create a reference plane. RiSCAN PRO will calculate the volume between the surface (points or triangles) and the reference plane.

Note: Only points or triangles lying *above* the plane will be used for volume calculation, whereas *"above"* is the half-space on the side of the plane to which the plane's surface normal points.

Volume calculation

Now you have to configure the parameters fot the volume calculation. To do so, select the plane in the object inspector, right-click it and select "Calculate volume & surface area..." (alternatively you can right-click somewhere in the object view and select "Measure > Volume & surface area..."). The following dialog is displayed (the screenshot shows example settings):

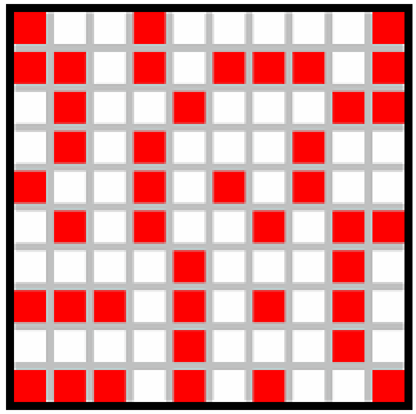


The subsequent sections explain the different calculation modes and their parameters.

Calculation mode "Raster" and "Raster + triangulation"

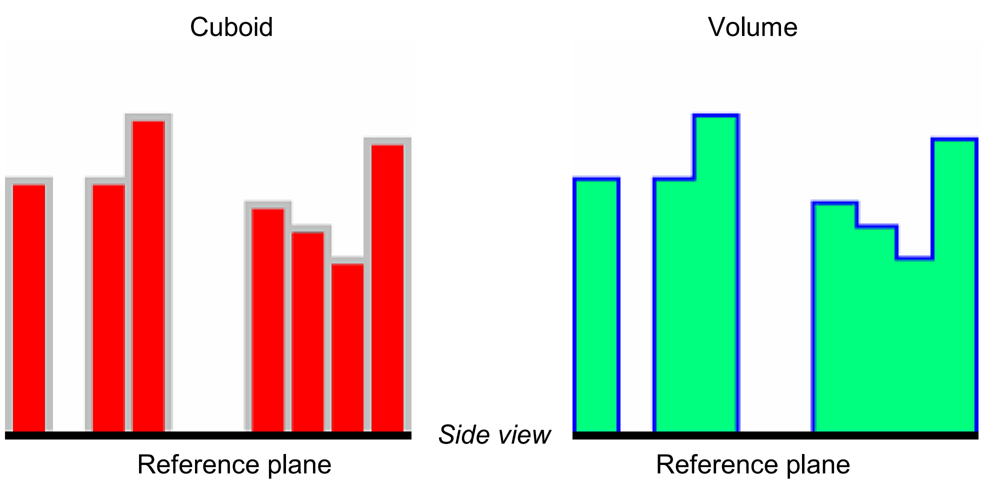
In both calculation modes the data is filled into a pattern, which is defined by the raster size.

Example pattern



- **Raster**

This is a fast way to calculate the volume, but the result is not very accurate.
For every cell the volume of the corresponding cuboid is calculated. The result is formed by all cell volumes added up. If a cell is empty no volume can be calculated for this cell. So you must adjust the raster size so that every cell is filled with a value.



Possible output values:

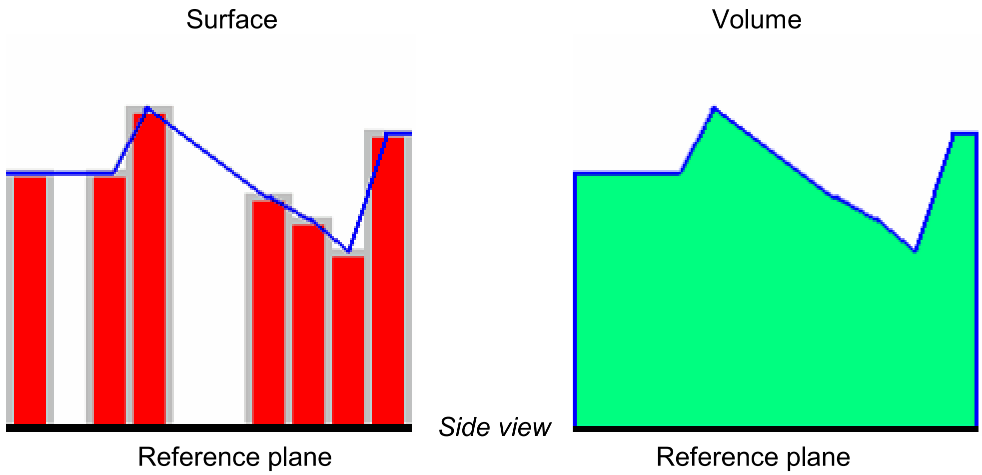
- Volume - save the volume of the model in the folder "COLLECTIONS / VALUES".

Parameters:

- Reference plane - the plane where all points are projected to
- Raster size - raster resolution
- Filter mode - either "Min", "Max" or "BiLinear". In "BiLinear" filter mode all input points will be averaged in every cell of the pattern. In the "Min" / "Max" filter mode only the point with the smallest/largest normal distance to the reference plane is used.

- **Raster + triangulation**

All raster points will be triangulated with a 2D-Delaunay triangulation algorithm. The Delaunay triangulation is computed from the 2D coordinates of the vertices mapped onto the reference plane. The volume is calculated between the plane and the resulting surface.



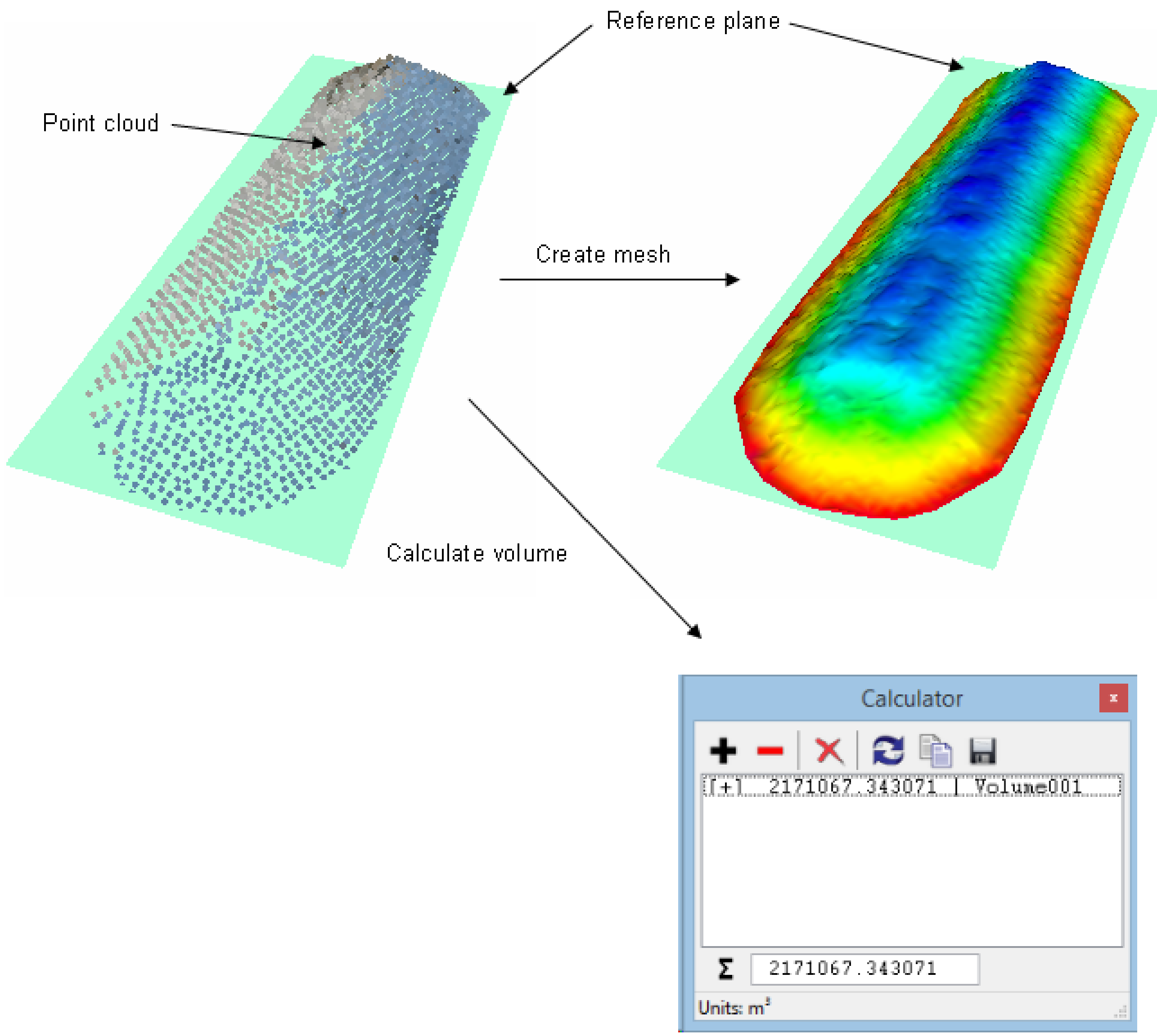
Possible output values:

- Volume - see output values of "Raster" mode 302
- Surface area - save the surface area of the model in the folder "COLLECTIONS / VALUES". The surface area is calculated as the sum of the area of all triangles. In addition the surface area of the model projected on the reference plane is saved.

Parameters:

- Reference plane - see parameters for "Raster" mode 302
- Raster size - see parameters for "Raster" mode 302
- Filter mode - see parameters for "Raster" mode 302
- Create volume as triangulated mesh - if this option is activated, the triangulation will be saved as a polydata object.

To finally start the volume calculation, click the button "OK". When the calculation has finished, the tool "Calculator 21" will be displayed showing the calculated volume.



Calculation Mode "Use existing surface (meshes only)"

In this calculation mode the existing surface (triangulation) is used for volume calculation. Each triangle of the mesh together with the reference plane forms a triangular prism. The sum of all prism volumes forms the total volume of the object. Triangles that are intersected by the reference plane are divided into three sub triangles and those above the plane contribute to the total volume.

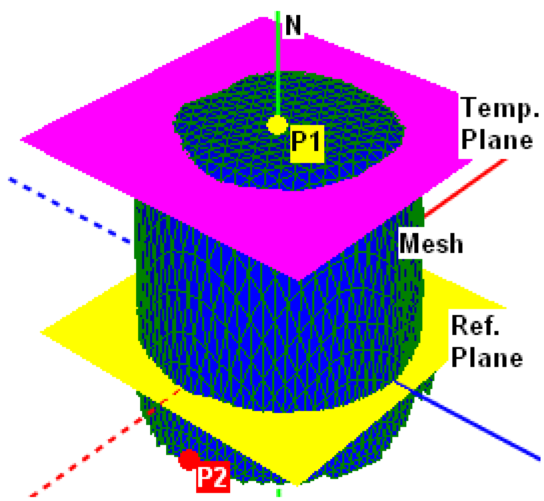
This mode has two sub-modes:

- **Calculate volume only**

  To calculate the volume between the surface and the reference plane only, activate the output "**Volume**" and select a **reference plane**.

- **Calculate volume function chart**

If the output "**Volume function chart**" is activated, RiSCAN PRO will create a comma separated file (csv) containing the volume in relation to the position of the plane. In that case the point with the largest normal distance above the reference plane is determined (P1). It's normal distance is decremented by the value "**Stepwidth**" and the reference plane is temporarily moved along it's surface normal (N) by this amount. Now the volume between the mesh and the temporary plane is calculated iteratively while the plane is moved by "**Stepwidth**" along it's negative surface normal. At each iteration the current level (see below) and the calculated volume is written to the result file. The iteration stops either if the reference plane is reached (option "**Stop chart calculation at reference plane**" activated) or if the point with the largest normal distance below the reference plane is reached (P2). The following figure shows an example mesh, the reference plane (Ref. Plane) the first temporary plane (Temp. Plane) and both end points P1 and P2.



The result file contains two columns ("Level" and "Volume") and one line per iteration step. The "level" value reflects the position of the plane at each iteration step and depends on the "**Level output**" option. This can be one of the following settings:

- **distance along normal vector of reference plane** - the level value represents the distance between the temporary plane and the reference plane along the normal vector (positive above the reference plane and negative below).
- **absolute X/Y/Z coordinate of PRCS** - the level value represents the absolute X/Y/Z coordinate of the temporary plane's origin in the PRCS

The information in the result file can be loaded into your favorite spreadsheet program in order to create a chart of the volume in relation to the plane position.

Calculation Mode "Raster (mesh)"

In this calculation mode an existing surface (base mesh) is used for volume calculation. The mesh is filled into a raster structure and the resulting raster points are triangulated. Each triangle of the resulting mesh together with the reference plane forms a triangular prism. The sum of all prism volumes forms the total volume of the object.

The base mesh can be limited by a polyline. This means that only the parts of the raster that are inside the polyline (raster cell center) are used for triangulation.

- **Create Cut & Fill volume**

You can also calculate the difference volume between two surfaces (base mesh, reference mesh). This is done by dividing the difference volume into a "Cut" volume and a "Fill" volume.

The two meshes are filled into a raster structure and the volume is calculated by summing up the raster cells volume (raster size Graster size Gdifference height). This is done only if the difference height of the two meshes is smaller than a specified threshold value. Parts of the base mesh that are below the reference mesh are added to the "Cut" volume and parts that are above the reference mesh are added to the "Fill" volume. The sum of both volumes is the total difference volume of the two meshes.

7.7.4 Measure angle

- *angle between two planes*

1. Open/create an object view and load the data you want to work with.
2. Select two planes in the object inspector.
3. Open the popup menu of one plane and select "Calculate->Angle between planes".

Note: The result is the smallest angle between the two surface normals of the planes.

7.8 Multiple Time Around

7.8.1 RiMTA 3D

RiMTA 3D is a plugin which enables automatic MTA Zone association between echoes and their source pulses. This process can be done manually by using the MTA Mover tool as well. To better understand what is being done by RiMTA 3D an explanation of the MTA problem is provided.

To measure a distance with a Terrestrial Laser Scanner requires a pulse of light to travel twice the distance of the measured range. For example, to measure an object 2km away from an instrument requires the pulse of light to travel 4 km; 2km to the object and 2km back. With this in mind, let’s consider a typical scenario: a VZ-4000 is measuring a slope at a distance of 3km at a laser pulse repetition rate (PRR) of 150kHz. With a pulse repetition rate of 150kHz, a pulse is transmitted every 1/150,000th of a second which, at the speed of light (299,792,458m/s) equals nearly 2km. Therefore it can be understood that each pulse transmitted is nearly 2km away when the next pulse is fired. However, the objective is to have each pulse echo off of a surface and return to the instrument. With this in consideration, each pulse may only travel 1km away from the instrument and then 1km back before the next pulse is transmitted. Which means that the maximum measurable range between each pulse (@50kHz) is 1km. This is the so-called “MTA Range”. If this pulse does not return to the instrument before a second pulse is transmitted, a condition called Multiple Time Around, or MTA exists. In the MTA condition, multiple pulses are “in the air” simultaneously.

In traditional TLS systems, the echoes of each pulse are returned to the scanner before the next pulse is transmitted, which makes association between pulse and echo very simple. Any echoes received belong to the “current” pulse. However, in MTA conditions, it is not as clear which echo belongs to which pulse! A first echo may belong to the “current” pulse, while a second echo can belong to a pulse which was transmitted 3 repetitions ago!

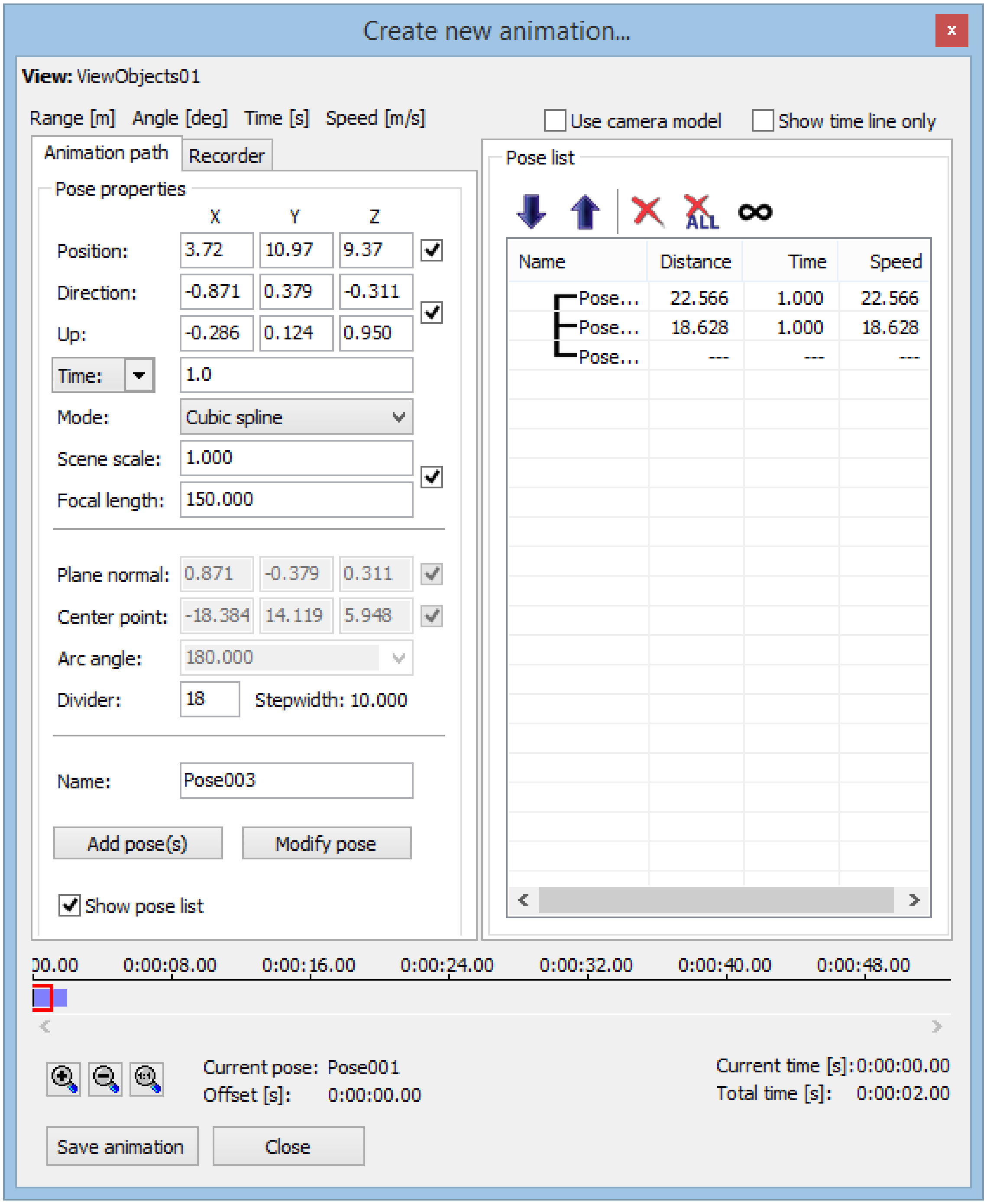
It is not a simple difference to calculate. In this case, the distance measured by the first pulse is less than 1km, yet the distance measured by the second pulse is over 3km. If either echo is assigned to the incorrect pulse, a range error of 1km will occur. To overcome this complexity, RIEGL LMS has developed a novel technique which enables laser scanners to operate at pulse rates which cause the scanner to exceed the MTA range threshold and still associate echoes with the correct pulse (with a confidence of better than 99.95%).

7.9 Animations

The object view in RiSCAN PRO has the ability to produce animations of the 3D scene it displays. The animation is based on user defined camera positions and camera orientations (called "poses"). The camera path between two poses is calculated by RiSCAN PRO in order to get a fluent camera movement. The created animation can be saved as an AVI file whereas all installed video codecs can be used to compress the video file.

Step by step description:

1. Open or create an object view. To get better results, make sure, that the parameter "Scene scale" of the camera of the view is set to 1.
2. Add all objects (scans, polydata, planes, polylines,...) of interest to the object view and configure their attributes (color, draw mode).
3. Right-click into the object view window and select "Create new animation..." from the menu. The following dialog will appear:



4. The next step is to define the animation path. The animation path may consist of several parts. Each part consists two poses, a travel mode and the duration.

The **two poses** define the start and stop position and orientation of the virtual camera. All parts of the animation path are stringed together. That means, that the stop pose of the previous part is the start pose of the current part.

The **travel mode** defines how the path between start and stop poses should be calculated. Following modes are available:

Linear interpolation
Start and stop pose will be connected by a straight line. No acceleration or deceleration of the movement will occur.

Cubic spline
This mode calculates a smooth curve which connects all poses of the animation. The speed of the flight will also vary.

Arc
With this mode you can configure a constant movement of the camera along an arc. The movement will be simulated by several subparts in "Cubic spline" mode.

To control the **duration** of the travel from start pose to stop pose you can either define the speed or enter the time directly.

How to define a "linear" or "cubic spline" camera movement

Navigate within the object view to the start point of this part of the animation (the pose properties "Position", "Direction", "Up", "Scene scale", "Focal length" will be updated automatically each time you move the virtual camera). As an alternative you can also enter the parameters directly.

Define the duration of the movement. This is done by either selecting "Time" or "Speed" and entering the speed of the movement or the time the movement should take.

Select "Linear interpolation" or "Cubic spline" mode.

Leave all other settings unchanged and click the button "Add poses(s)".

Splitter:
You can define splitters in order to split the animation path. This may be helpful when defining cubic spline movements, as all nodes of a cubic spline path have influence on the complete path and may lead to a weird movement of the camera. If you set a splitter the animation path is split into two (or more) paths. The movement of each path is calculated separately.

How to define a camera movement along an arc

Navigate to the start point of the arc. Alternatively you can enter the coordinates and vectors directly. To get better results the camera should be roughly aimed at the rotation center. Uncheck the checkbox after the pose properties "Position", "Direction" and "Up". This will leave the values unmodified when you move the virtual camera.

Now you have to define the **surface normal of the plane** the arc should lie in. The surface normal can be defined by the direction of the virtual camera. Example: If you want to "fly" around a vertically aligned object you may use the bird's eye view to define the surface normal of the plane. Uncheck the checkbox after the pose property "Plane normal" to avoid unwanted modification of this vector.

The next step is to define the **rotation center**. This is done by simply clicking into the scene. The rotation center will be marked with the pickpoint (default is a red pixel). Uncheck the checkbox after the pose property "Center point" to avoid unwanted modification of this point.

Define the **arc angle**. For a full rotation of the scene you have to enter 360 deg

As mentioned above, the movement will be built up by generating a number of poses lying on the arc with their mode set to "Cubic spline". With **Divider** you can decide how many poses are created. As a thumb rule you can set this value in a way, that the rotation between two poses is approximately 10 deg (a Divider of 18 for a 180 deg arc angle).

Define the duration of the movement. This is done by either selecting "**Time**" or "**Speed**" and entering the speed of the movement or the time the movement should take. Note, that the time parameter is set for each created pose and not for the complete arc!

Finally click the button "Add poses(s)".

How to edit the poses

Click the button "**Show pose list**" to show a list of all defined poses. To delete a pose select if from the list and click the button "Delete pose" with a red X on it.
To modify a pose double-click it in the list. The virtual camera position and orientation will be set according to the pose. Now you can modify the parameters either by moving the virtual camera or by entering the parameters directly. When all modifications are done click the button "**Modify pose**".

To change the camera orientation of some poses, select them and right-click. Choose "Change orientation" from the popup menu.
A new dialog will be opened and you can enter an angle to rotate around the three axes. You must also define the last pose where the rotation should end.

The complete camera path will be visualized in the scene by a white line. The poses will be represented by small red spheres along the line.
To save the animation path click the button "**Save animation**". You will be asked for a name. The animation path will be saved in the folder "COLLECTIONS/ANIMATIONS" within the project.

5. Animation playback (simulation)

Switch to the page "Recorder". To get an impression of the final animation click the button "**Simulate**" and select "**Simulate with camera**" from the menu. This will start the playback of the animation. Note, that the speed of this preview does not necessarily correspond to the speed of the final (recorded) animation. Especially if the object view contains a lot of data the speed of the preview is much slower than the speed of the resulting animation.
The speed of the complete animation (not of several animation parts) can be modified with the "**Time multiplier**". The default value is 1. To get twice the animation speed (and therefore half the animation time) set this value to 2.

6. Record animation

Modify the video settings to meet your requirements:

Dimension
Width and height of the movie in pixels. You can either enter a size directly or select a predefined size from the list.

Note:

If the selected dimension is smaller than the dimension of the object view window it's likely that the scene will not fit into the video. To solve this problem please adjust the parameter "Scene scale" of the virtual camera in the object inspector.

Frames per second

Default value is 25. A lower framerate will result smaller video files but the playback will be less fluent.

Compression

You can decide which compression should be used to create the video file. If you select "**Default**" the default video codec of the system will be used. To force the use of a particular video codec please select the entry "**Select...**". When the generation of the video file is started you will be asked for the video codec.

Define destination file

Now you can define the destination file. Normally the animation is saved to an avi file whose folder and filename can be entered by the user. As an alternative you can also decide to save the avi file directly into the project. In that case you have to create a document folder 316 in the project first. Then you can drag the folder from the project manager and drop it onto the box "Selected folder". To remove the folder again (to save the animation to an external avi file) right-click on the name of the folder in the animation window and select "Remove folder" from the menu.

Start recording

Finally start the generation of the video file by clicking the button "**Record**". If you defined a folder (as described above) you will be prompted to enter a name for the animation. Otherwise a dialog comes up where you have to enter the filename of the video file to create. The animation dialog disappears and a small window in the bottom left corner appears where you can watch the progress of the creation process.

Control recording

You can pause the record by clicking "**Pause**" in order to make changes to e.g. the draw mode of some objects or show/hide some objects. To continue recording click the button "**Record**" again. You can also tell RiSCAN PRO to **automatically pause recording** at a certain point of the animation. This is implemented by so called "**breakpoints**" which can be set at any pose in the poselist. To set or remove a breakpoint right-click a pose and select "breakpoint" from the menu. A small red dot in front of the pose name indicates that this pose is a breakpoint.

Note:

The breakpoints do not affect the "Simulate with object" mode (only "Simulate with camera" and "Record"). The animation is recorded as a sequence of many single frames which are recorded at positions derived from the user-defined animation path. The stepwidth between two frames depends on the selected animation speed and frame rate. Because of this fact it's not possible to pause the animation precisely at the given position. The animation will be paused at the very next frame after the breakpoint pose (which is very close in most cases).

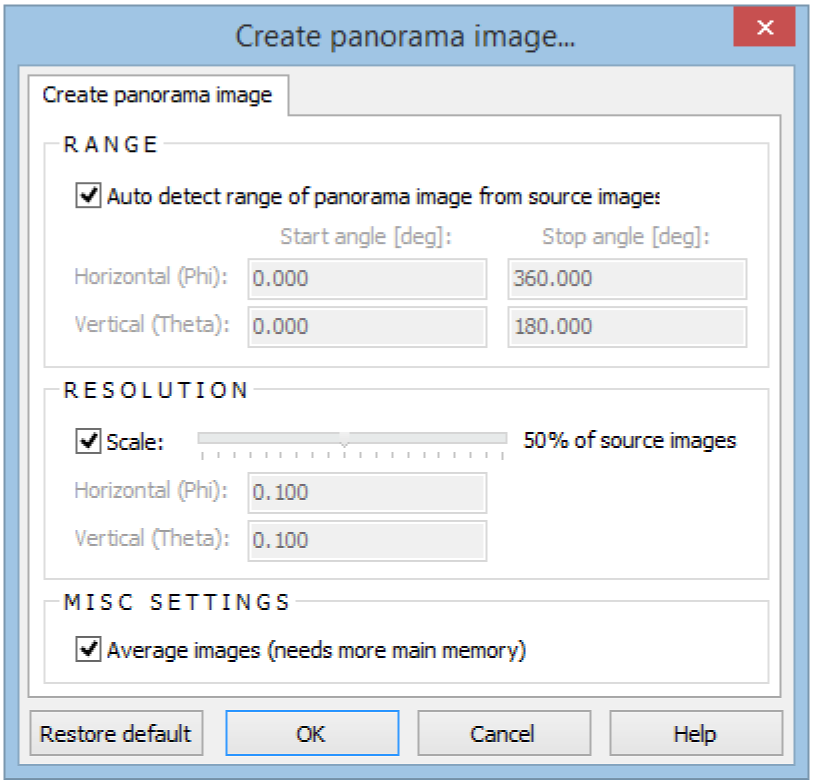
To completely stop the recording click the button "**Stop**".

7.10 Panorama images

RiSCAN PRO offers the possibility to create panorama images. These panorama images are generated by concatenating the images acquired at one scan position. This is done by projecting all images onto the inner surface of a virtual sphere.

Create panorama images

To create a panorama image, select the desired images of one scan position, right-click and select "Create panorama image…" from the menu. The following dialog appears:



Range

In this section you can define the angular extensions of the panorama image in phi (horizontal) and theta (vertical) direction. If you want to have these values determined automatically from the selected images, activate the option "Auto detect range of panorama image from source images".

Resolution

In this section you can define the angular resolution of the panorama image in phi (horizontal) and theta (vertical) direction. You can either enter these values directly or activate the option "Scale". In the latter case you can define the scale factor relative to the resolution of the source images.

Note: Be careful with setting the resolution! Too high a resolution (low values) will lead to an enormous main memory consumption and long calculation times.

Misc settings

Activate "Average images" in order to reduce nasty transitions between two neighboring images with different brightness. This is done by calculating the average of all relevant source pixels for the particular pixel of the panorama image.

Note: This function needs much more memory and is no guarantee to eliminate the effect. Please set the camera to use constant exposure time in order to avoid the effect.

To finally create the panorama image click the button "OK". You will be prompted to enter a file name for the panorama image. After that the calculation process starts.

Part VIII

Data exchange

8 Data exchange

8.1 Import

You can import different file formats. To do so simply right-click a "POLYDATA" folder and choose "Import..." from the menu. It is also possible to import objects located in the "OBJECTS" folder.

Select a file and the desired input format from the list.

Following objects can be imported:

- Polydata
  - ASCII 321 (GG)
  - Point cloud (G3pf)
  - Polyworks (Gpol) (triangles and polygons can be imported, whereas polygons are split into triangles)
  - PLY (Gply)
  - StereoLithography (Gstl)
  - Wavefront (Gobj)
  - Autocad (Gdxf) 315 (polygons are split into triangles)
  - Globally registered airborne laser data files (GSDW and GLAS)

- Point
  - Autocad (Gdxf) 315

- Polyline
  - Autocad (Gdxf) 315

- Section
  - Autocad (Gdxf) 315

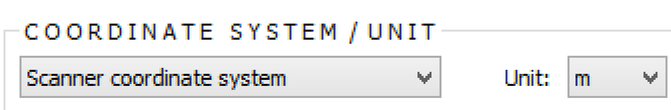
- Plane
  - Autocad (Gdxf) 315

- Documents 316

- Aerial views 316

For details about the input formats and their settings please refer to the specific chapters.

It is possible to define the source coordinate system and the source unit for every import (unit is not available for ASCII import).



Choose the type of coordinate system and unit:

- Scanner's own coordinate system (SOCS)
- Project coordinate system (PRCS)
- Global coordinate system (GLCS)

8.1.1 ASCII

The import dialog allows you to import a lot of differently formatted data files.

The settings you have to make in order to import an ASCII file are:

Skip lines (optional):
This causes the import function to ignore the first n lines from the file (e.g. if these contain comments or something else...).

Comment tag (optional):
Lines beginning with that character(s) will be ignored

Column separator:
You have to set the column separator to the correct character in order to recognize the data columns from the file. Normally this is the comma (","). If you don't know the column separator you can try clicking the button "Auto detect". This function attempts to find the correct character. Note, that this function may get wrong results in very "noisy" files.
You can check the correct setting for the column separator in the preview located on the bottom of the dialog.

Column association:
After the column separator was set and you got a correct preview you can associate the columns. This is needed in order to tell RiSCAN PRO which column of the file contains which data. Just drag the column from the list-box showing all columns and drop it on the corresponding column of the preview.

After all settings are made it is possible to save the settings. This provides faster import by simply selecting one of the pre-defined format settings from the drop-down list at the top of the dialog. To save the settings click the button with the plus ("+") on it. You will be prompted for a name. Enter a name (Info: Adding "Default" to one of the names will cause RiSCAN PRO to use these pre-defined format settings as default) and click "OK" .
Wrong or out of date pre-defined format settings can be deleted by selecting them one by one from the drop-down-list and clicking the button with the minus on it.

To finally import the ASCII file click the button "OK" at the bottom of the dialog.

8.1.2 DXF

Important: Only ASCII dxf files supported for import.

- **Polydata:**

  You can select which elements you want to import:

  - Import point data ... "POINT" elements will be imported
  - Import triangle data ... "3DFACE" elements will be imported (polygons are split into triangles)

- **Point:**
  Only "POINT" elements will be imported.
  Every element will create a new point object.

- **Polyline:**
  "LINE", "LWPOLYLINE" and "POLYLINE" elements will be imported.
  Every element will create a new polyline object.

- **Section:**
  "LINE", "LWPOLYLINE" and "POLYLINE" elements will be imported.
  Every layer will create a new section object.

- **Plane:**
  Only "3DFACE" elements will be imported.
  Every element will create a new plane object.

8.1.3 Documents

You can also import documents of any file type into a RiSCAN PRO project. To do, so please create a folder within the project first by right clicking on the project and selecting "New folder" from the menu. This will create new folder within the project.

Import documents:

To import documents right-click the folder and select "Import..." from the menu. Select the file to import. The file will be copied into the project. If you double-click the file in the project manager, the application registered to this file type is started and the file is loaded.

Create links:

You can also create links to files saved either locally or on the internet. To do so right-click the folder and select "New url..." from the menu. Either enter the url manually or drag and drop a file or link from the Windows explorer.

8.1.4 Aerial views

RiSCAN PRO offers the possibility to import aerial views and display them together with the acquired scan data.

To import an aerial view click with the right mouse button on the folder "OBJECTS / ORTHOPHOTOS" and select "Import...". Select the aerial view you want to import.

Note:
In addition to the image file a so called "world file 327" with the same name must be available. This file contains the position and orientation of the aerial view. The project has to be registered to the global coordinate system (GLCS) in order to import the aerial view correctly.

To view the aerial view just drag it from the project manager and drop it onto an open object view.

8.2 Export

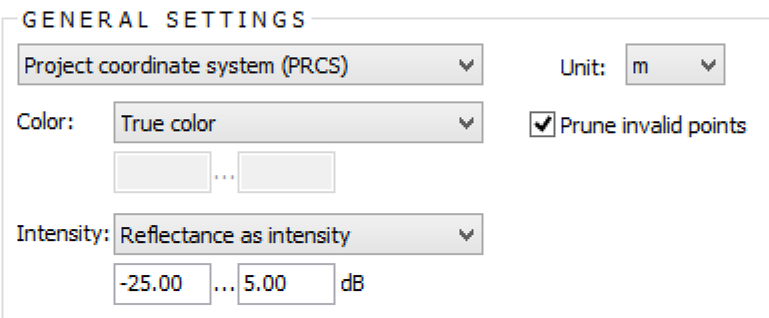
You can export some objects. To do so just right-click on it and choose "Export" from the menu.
Select a filename and the desired output format from the list.

For details about the output formats and their settings please refer to the specific chapters:

- ASCII 321 (GG)
- Crystalix 322 (Gasc)
- 3DD with SOP 321 (G3DD)
- point cloud 322 (G3pf)
- Autocad 322 (Gdxf)
- Polyworks 323 (Gpol)
- Wavefront 322 (Gobj)
- VRML 323 (Gwrl)
- PLY 323 (Gply)

- STL 323 (Gstl)
- LAS 323 (Glas)
- PointCloud for AutoCad (GPTC)
- Cyclone pts (Gpts)
- KMZ (Google Earth) 324
- RiALITY Quick Exchange 324 (Grqx)

It is possible to define the target coordinate system and the target unit for every export.



GENERAL SETTINGS

- **Choose the coordinate system and unit:**

  - Scanner's own coordinate system (SOCS)
  - Project coordinate system (PRCS)
  - Global coordinate system (GLCS)

  All data will be transformed into the desired coordinate system and scaled to the selected range unit before it is written to the exported file.

  Note:
  All supported export formats (except the formats based on text files) save point coordinates as single precision values with 7 significant digits. When points are transformed into an other coordinate system (PRCS or GLCS) the coordinates may consist of very large numbers (depending on the used SOP and POP matrices). Because of the single precision the point's position may have changed (the coordinates are rounded). Whenever possible it's recommended to export the data as-is (or in PRCS) and supply the POP matrix (e.g. as dat file) to the target software.

- **Prune invalid measurement points**

  This will ignore invalid measurement points for the export. **Note**: this option is only used when exporting scans of Z-series instruments (it does not apply to scans of V-line instruments or PolyData objects).

- **Color** source:

  Select the data source that will be written to the color channel of the exported file. Choose whether to export "Amplitude as color", "Reflectance as color" or "True color" to the color channel. In case of "Amplitude as color" or "Reflectance as color" you can specify the range that will be mapped to fit the color channel.

- **Intensity** source:

  Select the data source that will be mapped to the intensity channel of the exported file. Choose whether to export "Amplitude as Intensity" or "Reflectance as Intensity" to the intensity channel. In case of "Amplitude as intensity" or "Reflectance as intensity" you can specify the range that will be mapped to fit the intensity channel.

8.2.1 Coordinate export

The toolbar "Coordinate export" offers the possibility to export single data points to different export targets such as
- the Clipboard
- an ASCII-File
- AutoCAD

Data points can be exported from
- a 2D view of a scan
- a 2D image view with a pointcloud loaded
- a 3D view.

Data points are exported by pressing "Shift" and left-clicking into one of the previously mentioned views.
Note: You must be connected to the export target in order to export data points.

View the toolbar 17 "Coordinate export" by navigating to "View - Toolbars - Coordinate export" in the menu bar.

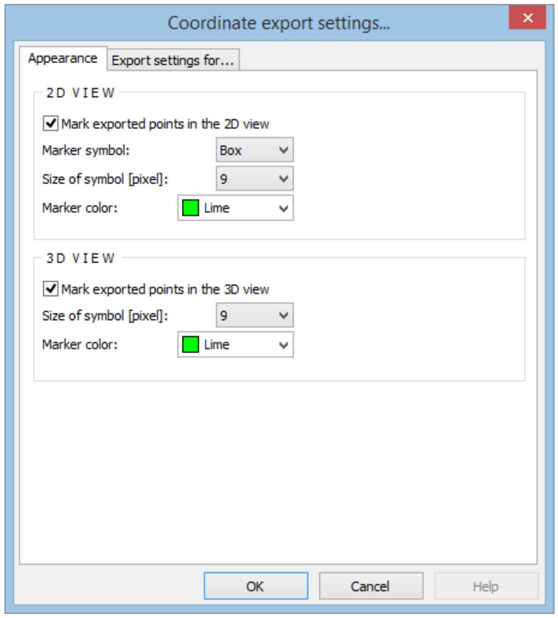
"Coordinate export" toolbar

1. **Select the export target** the coordinates will be exported to. The export target can only be selected if the toolbar "Coordinate export" is not enabled (not connected to the export target).
2. **Enable/Disable (connect/disconnect) the toolbar** "Coordinate export" to/from the selected export target.
3. Within a 3D view the **closest data point** to the clicked point will be exported.
4. Within a 3D view a **point on a surface** will be exported.
5. Export X and Y coordinates. This option is only available if coordinates are exported to AutoCAD.
6. Export X, Y and Z coordinates. This option is only available if coordinates are exported to AutoCAD.
7. **Select the target coordinate system.** The data point will be transformed to the selected target coordinate system before it is exported.
8. **Re-export exported points.** Re-exports all data points that have been exported up to now to the selected export target in the selected export coordinate system.
9. **Clear export list.** All data points that have been exported up to now will be removed from the export list.
10. **Coordinate export settings.**

Coordinate export settings

Appearance in the view

Exported data points can be marked in the views. To control the appearance of the markers open the "Coordinate export settings" by clicking the corresponding button in the toolbar and navigate to the tab "Appearance" in the settings dialog. Here you can adjust the marker appearance.



Export targets

Open the "Coordinate export settings" by clicking the corresponding button in the toolbar and navigate to the tab "Export settings for..." in the settings dialog. Here you can adjust the settings for the different export targets.

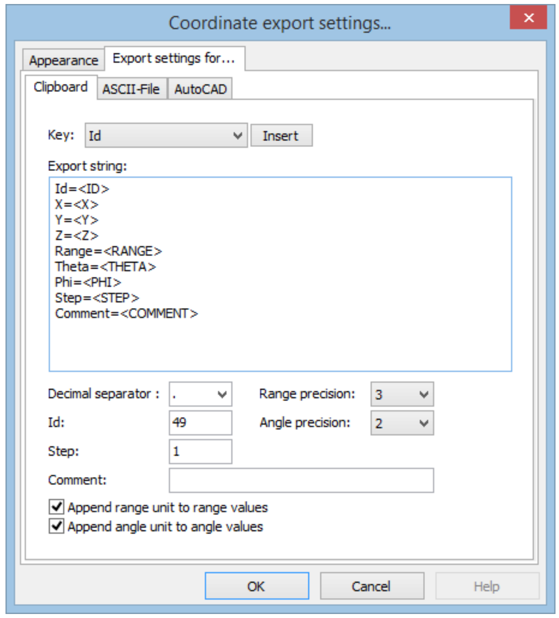
- **Clipboard**
  After the clicked point has been transformed into the selected target coordinate system it is copied to the clipboard.

  The string that will be copied can be adjusted in the text box "Export string:" of the clipboard export settings. You can input any text into text box. By selecting a keyword from the combobox "Key" and pressing the button "Insert" you can insert the corresponding keyword into the text box. Keywords will be replaced by the actual export data.

  The combobox "Decimal separator:" offers you the possibility to use a user defined decimal separator. Just select the the desired separator from the drop down list or enter a custom one.

  The comboboxes "Range precision" and "Angle precision" allow you to specify the number of decimal places for range values (X, Y, Z, range) and angle values (theta, phi).

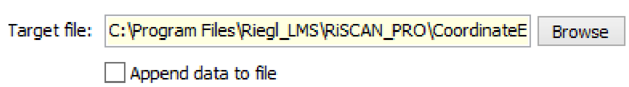
  The checkboxes "Append range units to range values" and "Append angle units to angle values" allow you to control whether range units will be added to range values (X, Y, Z, range) and angle units will be added to angle values (theta, phi) or not.



- **ASCII-File**
  After the clicked point has been transformed into the selected target coordinate system it is written into an ASCII-File.

  You can select the target ASCII-File by clicking the button "Browse" and specifying a valid file path and filename. If the file does not already exist it will be created. If the file does already exist it will be overwritten unless the checkbox "Append data to file" is checked.

  The "Export string:" for the coordinate export into an ASCII-File is defined similarly to the clipboard export string.



- **AutoCAD**
  After the clicked point has been transformed into the selected target coordinate system it will be sent to the AutoCAD plugins "PointCloud/FARO" or "TachyCAD". You can obtain these plugins from kubit GmbH.

  Currently supported AutoCAD versions are:
  - AutoCAD 2004-2006
  - AutoCAD 2007-2008
  - AutoCAD 2009-2011
  - AutoCAD 2010-2014

Note: In order to export coordinates to AutoCAD at least one of the mentioned plugins must be properly installed and licensed.

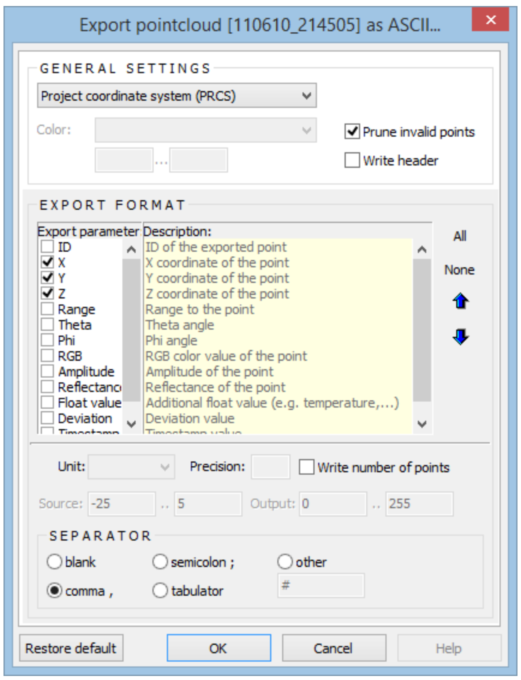
8.2.2 3DD

3DD with SOP

Saving a file with this format will export the SOP-Matrix to the file header.
Use this file type to import the registration into a post-processing program.

Note: The coordinate-value range of the 3dd file is limited to approximately -2 million to +2 million meters. This is especially important when you try to export in GLCS. Make sure that you do not exceed this limit or use another data export format.

8.2.3 ASCII



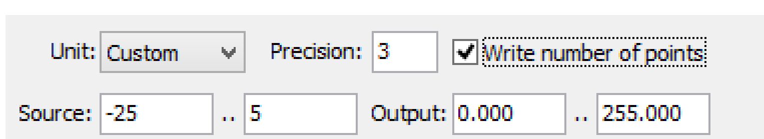
EXPORT FORMAT

Select the columns to export and arrange the order by clicking on the arrows.

- **Precision and Unit**

  select a column and choose the precision (digits after the decimal point) and unit (cartesian coordinates, polar coordinates, amplitude, reflectance or RGB values) for each column.

  The column "Reflectance" allows to select a "Custom" unit. This means that the source unit (eg. dB) will be mapped to a custom scalable output unit (eg. 0..255).



Select unit "Custom" and enter the desired output range to map values from one range to another.

Note:
ACI -> Auto Cad Color Index when selecting the color for RGB

- **Write header**

  This will cause the program to add a line with the names of the data exported (e.g. "Name, X, Y, Z")

SEPARATOR

select the character that will be used to separate the columns

8.2.4 ASC (Crystalix)

Crystalix contact:

Web: www.crystalix.de
Contact: Mr. Schieber

Note: It's recommended to only export approx. 50 to 75 thousand points (per glass cube)

8.2.5 3PF

Use amplitude as color
Select this to export amplitude information instead of color information.

Append to existing file
Select this to append the data to an existing file.

8.2.6 DXF

Following objects can be exported as DXF:

- Scans
- Polydata objects
- Points
- Polylines
- Sections
- Planes

You can export multiple objects at the same time. To do so select the objects you want to export and select "Export" from the popup menu.
Now enter a filename and decide if you want to create only one layer for all objects or a separate layer for each object.
The value "**Precision**" in the export dialog defines the number of decimal places to be written to the exported file (mainly for coordinates).

Note: Objects must all be of the same type.

8.2.7 OBJ

Only triangulated polydata objects can be exported in the OBJ file format.

Export with texture
If the polydata object is textured, you can select if you want to export texture information.

Use amplitude as color
Select this to export amplitude information instead of color information.

8.2.8 POL

Only triangulated polydata objects can be exported in the POL file format.

Export with texture
If the polydata object is textured, you can select if you want to export texture information.

Use amplitude as color
Select this to export amplitude information instead of color information.

8.2.9 VRML

Only triangulated polydata objects can be exported in the VRML file format.

Export with texture
If the polydata object is textured, you can select if you want to export texture information.

Use amplitude as color
Select this to export amplitude information instead of color information.

8.2.10 STL

Only triangulated polydata objects can be exported in the STL file format.

Select format:
- ASCII
- Binary

8.2.11 PLY

Only triangulated polydata objects can be exported in the PLY file format.

Select format:
- ASCII
- Binary (Little Endian, Big Endian)

Use amplitude as color
Select this to export amplitude information instead of color information.

8.2.12 LAS

The following objects can be exported as **LAS** files:

- Scans
- Polydata objects

Note: RiSCAN PRO exports **LAS** files conform to the "**LAS FORMAT VERSION 1.1**"
For further information visit the webpage www.lasformat.org

8.2.13 KMZ (Google Earth)

RiSCAN PRO offers a feature to export a simple project overview to Google Earth. The overview is stored as KMZ file and contains a location marker for each registered scan position of the project.

Usage: Right click on the "SCANS" folder in the project manager and select "Export to KMZ" from the menu. Afterwards, select the scan positions to export (only registered scan positions can be selected) and define the filename of the output file.

Note: This function requires the global coordinate system (GLCS) of the project to be WGS84 Cartesian (e.g. generated by the automatic registration feature 196 when V-Line scanners are used). Other coordinate systems are not supported.

8.2.14 E57

RiSCAN PRO offers a feature to export a complete project into an ASTM E57 data exchange file. You can find this feature in menu "Help > Wizard Export".

For more details on this data format, please visit http://www.astm.org/COMMIT/COMMITTEE/E57.htm

8.2.15 RQX

The following objects can be exported as **RQX** (RiALITY Quick Exchange) files:

- Scans
- Polydata objects

See RQX file format 332 description for details.

8.3 Fileformats

8.3.1 3DD

The 3DD files contain the raw data gained by a Z- or LPM-series instrument. The data format is the same as the data output of the instruments. To read 3DD files please refer to the RiSCANLIB 350.

Note: There's no format difference between 3DD and 4DD files. The file extension 4DD is used for files containing more than one scan frame.

8.3.2 3PF

The 3PF file format is a very simple format for unorganized point clouds. The point cloud is saved in an binary file of the following format:

<table>
<tr><th colspan="2">Field name</th><th>Field data (hexadecimal)</th><th>Data type</th><th>Byte offset (decimal)</th></tr>
<tr><td rowspan="20">Header</td><td rowspan="16">Identifier</td><td>63</td><td rowspan="16">16 bytes used to identify a 3PF file</td><td>0</td></tr>
<tr><td>59</td><td>1</td></tr>
<tr><td>B2</td><td>2</td></tr>
<tr><td>CC</td><td>3</td></tr>
<tr><td>21</td><td>4</td></tr>
<tr><td>A4</td><td>5</td></tr>
<tr><td>35</td><td>6</td></tr>
<tr><td>4C</td><td>7</td></tr>
<tr><td>84</td><td>8</td></tr>
<tr><td>C9</td><td>9</td></tr>
<tr><td>2E</td><td>10</td></tr>
<tr><td>E7</td><td>11</td></tr>
<tr><td>D5</td><td>12</td></tr>
<tr><td>EE</td><td>13</td></tr>
<tr><td>17</td><td>14</td></tr>
<tr><td>FD</td><td>15</td></tr>
<tr><td rowspan="4">Datasize</td><td rowspan="4">number of bytes following the header (= n * 24)</td><td rowspan="4">signed 32 bit integer value</td><td>16</td></tr>
<tr><td>17</td></tr>
<tr><td>18</td></tr>
<tr><td>19</td></tr>
<tr><td rowspan="19">Data</td><td rowspan="6">Data point 1</td><td>X [m]</td><td>32 bit float value</td><td>20</td></tr>
<tr><td>Y [m]</td><td>32 bit float value</td><td>24</td></tr>
<tr><td>Z [m]</td><td>32 bit float value</td><td>28</td></tr>
<tr><td>Red [0..1]</td><td>32 bit float value</td><td>32</td></tr>
<tr><td>Green [0..1]</td><td>32 bit float value</td><td>36</td></tr>
<tr><td>Blue [0..1]</td><td>32 bit float value</td><td>40</td></tr>
<tr><td rowspan="6">Data point 2</td><td>X [m]</td><td>32 bit float value</td><td>44</td></tr>
<tr><td>Y [m]</td><td>32 bit float value</td><td>48</td></tr>
<tr><td>Z [m]</td><td>32 bit float value</td><td>52</td></tr>
<tr><td>Red [0..1]</td><td>32 bit float value</td><td>56</td></tr>
<tr><td>Green [0..1]</td><td>32 bit float value</td><td>60</td></tr>
<tr><td>Blue [0..1]</td><td>32 bit float value</td><td>64</td></tr>
<tr><td colspan="4">...</td></tr>
<tr><td rowspan="6">Data point n</td><td>X [m]</td><td>32 bit float value</td><td>(n-1) * 24 + 20</td></tr>
<tr><td>Y [m]</td><td>32 bit float value</td><td>(n-1) * 24 + 24</td></tr>
<tr><td>Z [m]</td><td>32 bit float value</td><td>(n-1) * 24 + 28</td></tr>
<tr><td>Red [0..1]</td><td>32 bit float value</td><td>(n-1) * 24 + 32</td></tr>
<tr><td>Green [0..1]</td><td>32 bit float value</td><td>(n-1) * 24 + 36</td></tr>
<tr><td>Blue [0..1]</td><td>32 bit float value</td><td>(n-1) * 24 + 40</td></tr>
</table>

8.3.3 COP, SOP, POP

The COP, SOP, POP file format is used by RiSCAN PRO to exchange matrices. This format is already known from 3D-RiSCAN / LPMSCAN.

Example of a POP Matrix exported as .POP file:

```
[tiltmatrix]
c00=0.65922099
c01=0.69496346
c02=-0.28714722
c10=-0.72800934
c11=0.68545556
c12=-0.01237154
c20=0.18822891
c21=0.21720143
c22=0.95780659
[position]
x=1040.33007813
y=1142.82165527
z=1002.35168457
```

Whereas c00..c22 and x, y, z correspond to the following matrix values:

c00	c10	c20	x
c01	c11	c21	y
c02	c12	c22	z
0	0	0	1

Note: The offset is always in unit [m].

see also Fileformats: DAT 326

8.3.4 DAT

The DAT file format is used by RiSCAN PRO to exchange matrices. It is a very simple format using a text file. The matrix is written into the file "as is".

Example of a POP - Matrix exported as .DAT file:

```
 0.65922099    -0.72800934     0.18822891  1040.33007813
 0.69496346     0.68545556     0.21720143  1142.82165527
-0.28714722    -0.01237154     0.95780659  1002.35168457
 0.00000000     0.00000000     0.00000000     1.00000000
```

The columns are separated by at least one blank. The lines are separated by a sequence of CR (ASCII character 13) and LF (ASCII character 10).

see also Fileformats: COP, SOP, POP 325

8.3.5 RDB, RDS, RDX

Scans (as of August 2010, only pointclouds acquired with V-Line scanners) are organized within the project in the "RIEGL Laser Scan Database" (short RDB or lasdb). The data base provides fast, spatial-based access to the data and thus speeds up 2D and 3D visualization and data processing. The data base is stored in files with extensions RDS and RDX in the folder "project.rdb" inside the project folder (Project.RiSCAN). For a detailed description of the folder- and file-structure inside the data base, please refer to the document "lasdb.pdf" located in the installation folder of RiSCAN PRO.

8.3.6 ROT

The ROT file format is used by the Multiple SOP export 23 tool of RiSCAN PRO to save the matrices. The ROT file is a text file of following format:

```
Rotation about Z axis<CR><LF>
Rotation about X axis<CR><LF>
Rotation about Y axis<CR><LF>
<CR><LF>
Translation along X axis<CR><LF>
Translation along Y axis<CR><LF>
Translation along Z axis<CR><LF>
```

Units:
Rotation in [rad]
Translation in [m]

8.3.7 RSP (Project file)

The project is saved in a text file with XML syntax (project.rsp). For a description on how data is saved see "project.pdf" which is installed in the program folder of RiSCAN PRO. Please also refer to the comments in "project.dtd" to get a description of each XML-tag. The project.dtd file is saved to each project and can also be found in the program folder of RiSCAN PRO.

8.3.8 RXP

RXP files contain raw data produced by V-Line scanners. It is an undocumented binary file format that can be decoded and read using the software library RiVLIB 351.

8.3.9 UDA

The UDA file format is a very simple file format used by RiSCAN PRO to import position information from (D)GPS receivers. The file format is defined as follows:

```
NameOfPosition01,X,Y,Z<CR><LF>
NameOfPosition02,X,Y,Z<CR><LF>
...
```

The unit of the coordinates is defined by the unit set in the program settings 28.

8.3.10 VTP

RiSCAN PRO uses the XML based file format VTP out of the Visualization Toolkit (VTK) 352 which is open source, to save both point clouds and triangulated surfaces.

A detailed description of the VTP format can be found at: **http://vtk.org/VTK/pdf/file-formats.pdf**

RiSCAN PRO uses the standard arrays of the VTP format to save points and triangles (arrays "Points", "Verts", "Polys"). Additional information is saved in two more arrays within the tag "<PointData>". The arrays are named "intensity" and "color" and contain the amplitude and color information for each point.

8.3.11 World file

Aerial views 316 are stored as raster data, whereas each cell in the image has a row and column number. In order to display these images it is necessary to establish an image-to-world transformation that converts the image coordinates to real-world coordinates. This transformation information is typically stored in a separate ASCII file. This file is generally referred to as the world file, since it contains the real-world transformation information used by the image. World files can be created with any text editor.

World file naming conventions

It's easy to identify the world file which should accompany an image file: world files use the same name as the image with a "w" appended. For example the world file for the image file mytown.tiff would be called mytown.tiffw and the world file for redlands.rlc would be redlands.rlcw. For workspaces which must adhere to the 8.3 naming convention, the first and third characters of the image file's suffix and a final "w" are used for the world file suffix. Therefore, if mytown.tif were in a an 8.3 format workspace, the world file would be mytown.tfw. If redlands.rlc was in an 8.3 format workspace, its world file would be redlands.rcw. For images that lack an extension, or have an extension that is shorter than three characters, the "w" is added to the end of the file name without altering it. Therefore the world file for the image file terrain would be terrainw; the world file for the image file floorpln.rs would be floorpln.rsw.

World file contents

The content of the world file looks something like this:

20.17541308822119
0.00000000000000
0.00000000000000
-20.17541308822119
424178.11472601280548
4313415.90726399607956

The image-to-world transformation is a six-parameter affine transformation in the form of:

x1 = Ax + By + C
y1 = Dx + Ey + F

whereas

x1 = calculated x-coordinate of the pixel on the map
y1 = calculated y-coordinate of the pixel on the map

x = column number of a pixel in the image
y = row number of a pixel in the image

A = x-scale; dimension of a pixel in map units in x direction
B, D = rotation terms
C, F = translation terms
E = negative of y-scale; dimension of a pixel in map units in y direction
x,y = map coordinates of the center of the upper-left pixel

Note: The y-scale (E) is negative because the origins of an image and a geographic coordinate system are different. The origin of an image is located in the upper-left corner, whereas the origin of the map coordinate system is located in the lower-left corner. Row values in the image increase downward from the origin, while y-coordinate values in the map increase upward from the origin.

The transformation parameters are stored in the world file in this order:

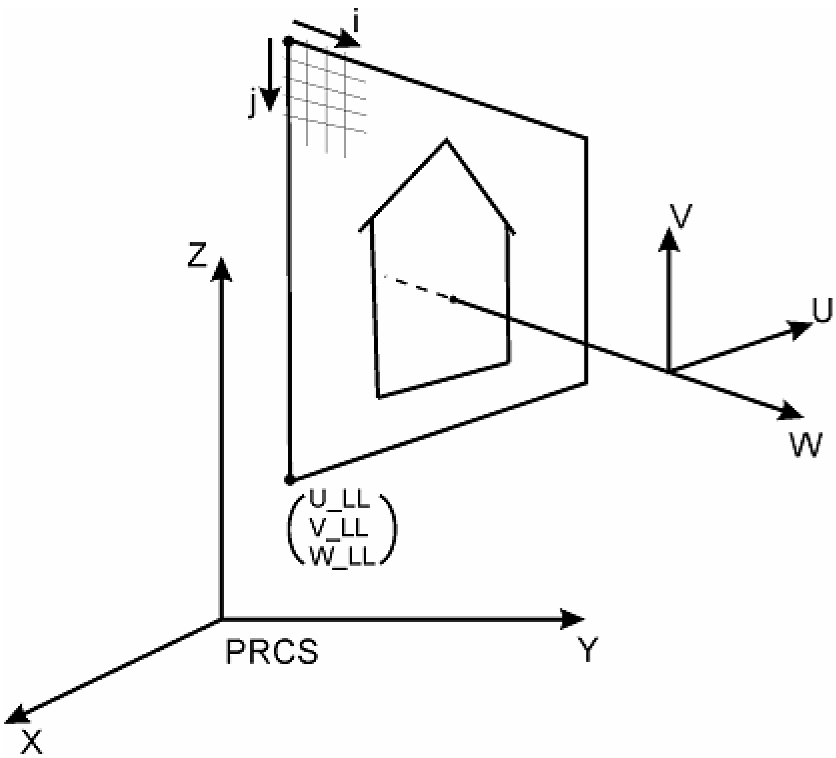
20.17541308822119 - A
0.00000000000000 - D
0.00000000000000 - B
-20.17541308822119 - E
424178.11472601280548 - C
4313415.90726399607956 - F

8.3.12 ZOP

The format is defined to describe true orthophotos with depth information. The true orthophoto is stored in a bitmap file (extension BMP) whereas the depth information is contained in a separate file with the extension ZOP.

The ZOP file contains the depth for every pixel of the bitmap as a signed 16 bit integer value. The ZOP file starts with a header containing the information where and how the orthophoto is positioned and orientated in the project coordinate system (PRCS) and additional information on the pixel size and data size.

The orthophoto is defined in a UVW coordinate system as sketched below:



The drawing plane of the bitmap is parallel to the UV plane.

The lower left corner of the orthophoto is specified in the header in the UVW system by U_LL, V_LL, W_LL. The origin of the UVW system in PRCS is specified by X0, Y0, Z0. The rotation matrix is specified by nine parameters r11 to r33.

Please note that the bitmap information is stored in the bitmap file starting at the upper left corner. The pixels are contained in a line-by-line order. Pixels in a line are contained from left to right and lines are contained from top to bottom. The depth information in the ZOP file follows the same order, left to right and top to bottom.

Given the pixel coordinates in the orthophoto i and j with i defined as increasing from left to right and j increasing from top to bottom, the coordinates in the UVW system are computed by

$$P_{UVW} = \begin{pmatrix} u \\ v \\ w \end{pmatrix} = \begin{pmatrix} (i + 0.5) \times \mathrm{PIX\_SIZE} \\ (\mathrm{B\_HEIGHT} - j - 0.5) \times \mathrm{PIX\_SIZE} \\ \mathrm{Z\_DEPTH}\left[i + j\,\mathrm{B\_WIDTH}\right] \times \mathrm{ZUNIT\_SIZE} \end{pmatrix} + \begin{pmatrix} \mathrm{U\_LL} \\ \mathrm{V\_LL} \\ \mathrm{W\_LL} \end{pmatrix}$$

By forming a rotation matrix RZOP and a translation vector

$$R_{ZOP} = \begin{pmatrix} r11 & r12 & r13 \\ r21 & r22 & r23 \\ r31 & r32 & r33 \end{pmatrix}, T_{ZOP} = \begin{pmatrix} X0 \\ Y0 \\ Z0 \end{pmatrix}$$

every point in UVW, i.e.

$P_{UVW} = (u, v, w)^T$,

is transformed into PRCS by

$$P_{PRCS} = (x, y, z)^T = R_{ZOP} P_{UVW} + T_{ZOP}$$

The ZOP file is organized in records of 2 byte length. When interpreting a record or a sequence of records, byte order is in low byte high byte order, also referred to as little endian notation.

Record Position	Type	Parameter	Remarks
0	Unsigned integer (16 bit)	H_LENGTH	Length of header in units of 2 bytes, i.e., 64
1	Signed integer (16 bit)	Z_INVALID	Value of z depth indicating that there is no depth value, usually –32767 in decimal notation
2	Unsigned integer (32 bit)	B_WIDTH	Bit map width in pixels
4	Unsigned integer (32 bit)	B_HEIGHT	Bit map height in pixels
6	Single precision float	U_LL	Lower left corner of drawing plane in UVW system, U coordinate
8	Single precision float	V_LL	Lower left corner of drawing plane in UVW system, V coordinate
10	Single precision float	W_LL	Lower left corner of drawing plane in UVW system, W coordinate
12	Single precision float	PIX_SIZE	Size of a pixel in UV direction in meters
14	Single precision float	ZUNIT_SIZE	Size of Z - depth unit in meters
16	Double precision float	X0	Origin of UVW system in PRCS
20	Double precision float	Y0	Origin of UVW system in PRCS
24	Double precision float	Z0	Origin of UVW system in PRCS
28	Double precision float	r11	Coefficient of rotational matrix
32	Double precision float	r12	Coefficient of rotational matrix
36	Double precision float	r13	Coefficient of rotational matrix
40	Double precision float	r21	Coefficient of rotational matrix
44	Double precision float	r22	Coefficient of rotational matrix
48	Double precision float	r23	Coefficient of rotational matrix
52	Double precision float	r31	Coefficient of rotational matrix
56	Double precision float	r32	Coefficient of rotational matrix
60	Double precision float	r33	Coefficient of rotational matrix
H_LENGTH	Signed integer (16 bit)	Z_DEPTH(0)	Depth value corresponding to upper left pixel of orthophoto
H_LENGTH + 1	Signed integer (16 bit)	Z_DEPTH(1)	Depth value corresponding to pixel neighbouring upper left pixel to the right, i.e., in the upper most line of image
…			

H_LENGTH + (B_WIDTH B_HEIGHT – 1)	Signed integer (16 bit)	Z_DEPTH(B_WIDTH B_HEIGHT – 1)	Depth value corresponding to lower right pixel of orthophoto

8.3.13 Image information

Some information about distorted and undistorted images can be saved in files having standard INI file format. The files can be exported with the tool "Multiple COP export" located in the "Tool" menu.

Example (lines starting with ";" are comments and are only inserted in this example for better clarity):

```
[GENERAL]
;
; This section contains general information about the image
;
Image=Panorama001
File=C:\Project.RiSCAN\SCANS\ScanPos02\SCANPOSIMAGES\Panorama001.jpg
Width=3008
Height=2000
CamCalib=NikonD100-Nr02_14mm
MountCalib=MountCalib01
Kind=scanposimage

[COP]
;
; This section contains the COP matrix of the image.
;
M[0][0]=0.890629866704642
M[0][1]=0.454728974812083
M[0][2]=0.000000153972128
M[0][3]=0.000000000000000
M[1][0]=-0.454728974812088
...
M[3][3]=1.000000000000000

[MOUNTING]
;
; This section contains the mounting matrix of the image.
;
M[0][0]=0.005636523000000
M[0][1]=-0.005813524000000
M[0][2]=0.999967216000000
M[0][3]=0.000000000000000
M[1][0]=0.001951305000000
...
M[3][3]=1.000000000000000

[SOP]
;
; This section contains the SOP matrix of the image if it
; is located at a scan position.
;
M[0][0]=0.158742809065264
```

```
M[0][1]=0.987184804388365
M[0][2]=-0.016336540477558
M[0][3]=0.000000000000000
M[1][0]=-0.986755942219543
...
M[3][3]=1.000000000000000

[POSITION]
;
; This section contains the coordinates of the principal point
; (project center).
;
X=6912.924890533076480
Y=182.893043077726016
Z=1289.756378852742720

[ORIENTATION]
;
; This section contains the orientation of the image described
; by four direction vectors. P1 represents the direction of the
; upper-left corner, P2 = upper-right, P3 = lower-right and P4
; the lower-left corner of the image.
; C is the direction of the image center.
;
P1_X=-0.563365025205855
P1_Y=0.533201089889953
P1_Z=-0.631123161806000

P2_X=-0.604866114464873
P2_Y=0.562348930858098
P2_Z=0.563826802948659

P3_X=0.150672350816607
P3_Y=0.798280860624787
P3_Z=0.583134212554076

P4_X=0.195360445868318
P4_Y=0.770283093871784
P4_Z=-0.607040567848714

C_X=-0.294363557454031
C_Y=0.955196385633329
C_Z=-0.030821427356407
```

All coordinates are exported in the selected coordinate system (either SOCS, PRCS or GLCS).
Each element of a matrix is stored separately. The name of the element includes the column- and row-numbers. The first index is the column number. The second one is the row number. In the example above some of the elements have been removed to shorten to example.

8.3.14 RQX

RQX stands for **R**iALITY **Q**uick **E**xchange file format. RQX files contain colored pointclouds that can be displayed by RiALITY on mobile devices.

Part IX

Appendix

9 Appendix

9.1 Frequently asked questions (FAQ)

This chapter can give you some hints about what's going wrong. It contains the most frequently asked questions from our support group.

9.1.1 General

The symbol is displayed next to scans or images in the project manager.

- This symbol means, that the required file was not found in the project folder (e.g. the file was renamed by RiSCAN PRO but the project was not saved properly or the file was deleted by another program).
- Check the names of the files in the corresponding folder (you can open this folder in an Explorer window by selecting it in the project manager and using the shortcut [CTRL]+[ENTER]).
- Make sure that the full file name (complete path and filename) is not longer than 260 characters. Otherwise problems may occur. Thus it's recommended to place all projects in a folder that is near the root of the drive (e.g. "C:\RIEGL SCANS", "C:\PROJECTS" or something like that).
- Also read the hints of the next section (save projects on a CD or DVD).

I want to save my projects on a CD or DVD. What do I have to keep in mind?

- Make sure that the used program does not modify file- or foldernames (sometimes the default value is to replace spaces by underlines or to change the characters to upper- or lowercase).
- It's not enough to copy only the project.rsp file. You have to copy the complete "Project.RiSCAN" folder including the folder itself (do not copy only the contents of the folder).
- When you copy the project back to the hard-disk make sure that the flag "readonly" is removed from the project folder and all contained files (and all files of subfolders too). Otherwise you will not be able to modify the project.

When I start RiSCAN PRO or a RiSCAN PRO plugin, a message like "no valid license key found" is displayed although I've entered a license key.

- Please check the license key(s) displayed in the license manager.
- License keys can be time limited. Please check the expiry date.
- If you have a license key which is bound to a USB Dongle please check that the proper dongle is installed.
- If you observe problems with the USB Dongle please close all RIEGL programs, detach the dongle, wait for some seconds and attach the dongle again. Now you can start RiSCAN PRO again. If there are still problems please repeat this procedure and plug the dongle on an other USB port.
- The USB Dongle must not be attached during the setup of RiSCAN PRO. If it was attached during the setup please detach it and reinstall RiSCAN PRO.

After some time working with RiSCAN PRO, I get the message "out of memory" when I try to open a scan/point cloud/polydata.

The reason for this problem is that RiSCAN PRO wants to load the complete dataset into a connected memory block. Right after starting the PC and/or RiSCAN PRO it's very likely that large datasets fit into a connected memory block. But after some time, when other programs have been started or some other functions of RiSCAN PRO are used, the main memory gets fragmented (many memory blocks spread over the complete main memory are used). Although the sum of all free memory blocks may be big enough, it's likely that the dataset does not fit completely into one of them.

That's a problem that all memory-intensive programs have to deal with. Unfortunately there's no solution for RiSCAN PRO.

9.1.2 Installation

What computer should I use to run RiSCAN PRO on?

- Please refer to the chapter "Installation > System requirements" 4 in the RiSCAN PRO help file.

When I start RiSCAN PRO the first time after installation the main window remains blank.

- Close RiSCAN PRO and check that you have sufficient access rights.You should be at least a member of the user group "**Power user**" (see also chapter Program installation 7).
- Restart RiSCAN PRO with proper access rights and restore the window configuration by switching on the desired windows via the "View" menu.

When I plug in the USB dongle for the first time, I am prompted to select a driver.

- Sometimes the driver for the dongle is not found automatically. In this case, please select the file "usbkey.sys" from the folder "C:\WINDOWS\system32\drivers" manually.

The USB dongle driver seems to be installed correctly but RiSCAN PRO does not recognize the dongle.

- In this case, please download and install the latest USB dongle driver directly from the Internet: http://www.keylok.com/downloads/Install.zip
- Make sure that the USB dongle is not attached and that no RIEGL software product is active during driver installation.

9.1.3 Data acquisition

I can not acquire a scan via TCP-IP (network connection).

- Check power supply of scanner.
- Check if the instrument is switched on and connected properly.
- Check the TCP-IP address and ports used in the RiSCAN PRO project 42. The default address is 192.168.0.234, port 20001 & 20002.
- Check whether RiSCAN PRO can reach the instrument. You can use the Connection tool 27 for that.
- Check the LAN link lamp on the instrument and/or the computer. If it is off check the network cabling and replace it if necessary.
- Check the type of network cable. For direct connection between the instrument and the computer you need a cross-over cable. If no direct connection is used (e.g. via a Hub or a Router) you may need a straight cable.
- Check the pins of the small round connector which is plugged into the instrument.
- Check the TCP-IP addresses: The IP address of the used network card (some computers have more than one card - don't mix them up) must be within the IP address range set in the instrument. By default the IP address of the instrument is 192.168.0.234 and the subnet mask is 255.255.255.0. Thus you have to set the IP address of the computer to an free address between 192.168.0.1 and 192.168.0.254 (except 192.168.0.234, of course). Please consult the help of the operating system to see how you can modify the IP address. Consult the instrument's manual to see how you can get and/or set the IP address of the instrument.
- Check the transmission rate (often also called "media type") of the network card. This can be found in the configuration dialog of the network card. The rate should be 100MBit (Full duplex if available).
- Make sure that no other user is accessing the instrument via the network (use a direct connection to avoid this).

I can not acquire a scan via serial and parallel connection. After I've configured the scan pattern (start-, stop- and resolution angles) the message "Can not open" (in German versions of Windows "Kann nicht geöffnet werden") is displayed.

- In that case the error message indicates a problem with the RiPORT settings and/or driver. The RiPORT driver is used for communication via the parallel port that carries the scan data.
- Please check the communication ports in the project attributes. By default "RiPort0" is used. If you apply the changes with the button "OK" RiSCAN PRO checks if the desired RiPORT is installed. If not, an error message is displayed and the RiPORT configuration dialog is opened.
- Make sure that at least RiPt0 is installed and configured correctly (that the correct LPT is used).
- More information about RiPort can be found in the chapter Appendix > RiPort 349.

I can not acquire an image with the digital camera.

- Check power supply of the scanner and the camera.
- Check if the instrument (scanner and camera) is switched on and connected properly.
- Check the camera settings in the project attributes 42 (Is the correct camera model selected?).
- Check if you have a connection to the scanner if you want to acquire images from a scan position.
- Make sure that the camera plugin is installed on your PC and you've entered a valid license key 10.
- Check if you can acquire an image with the program of the camera manufacturer. If not please check the camera device driver (sometimes it helps to disconnect and reconnect the camera).
- Make sure that the configuration and/or acquisition program of the camera manufacturer - or any other program - is NOT connected to the camera.
- Check the "USB protocol" setting of the camera. This value must be set to "PTP" for NIKON cameras and to "normal" for CANON cameras. To change this setting please refer to the product documentation of your camera.

Finescanning reflectors works fine but the TPL SOCS window is not updated and the name of the finescan is not displayed next to the corresponding tiepoint. What's wrong?

- In that case RiSCAN PRO is unable to detect the reflector in the finescan because of faulty program settings.
- Check the program settings: Menu "**Tool > Options**", Page "**General > Tiepoint scan**". It's recommended to activate the option "use auto-threshold". If you don't want to use this option, check the parameters "threshold detection" and "threshold calculation".
- Delete all tiepoints and restore them from the finescans with the shortcut [CTRL]+[R] in the TPL SOCS window.

I can not open scans during which the data acquisition was terminated for some reason

- If you acquire a scan with decreasing frame (phi) angles (triggered bidirectional mode, see Scan acquisition: Scan Mode 88) and you terminate data acquisition, the saved scan file can not be opened due to technical limitations.

If I try to start a new scan (singlescan or scansequence) a warning about the instrument's temperature is displayed. What's wrong?

- Before the scan is started RiSCAN PRO checks the **temperature** of the instrument's **range finder unit**. If the temperature is out of range (either too high or too low) an appropriate warning message is displayed. Usually this message will be displayed a few seconds after you power up the instrument and the instrument is still cold. In that case it's recommended to wait some time to give the built-in heating a chance to regulate the temperature. Of course you can ignore the warning and scan while the temperature is out of range but in the worst case you will not reach the measurement accuracy as specified in the data sheet.

The image acquisition of the camera calibration task "reflector column" suddenly stops with an error message like "calle to SC_ALIGN_F" failed.

- The problem with the camera calibration is that the scanner arrangement is not good. For image acquisition the scanner tries to turn left and right until the camera's entire field-of-view is covered. But in that case that's not possible because the scanner can not turn across 0 degrees. To solve the problem arrange the scanner with the backplate pointing roughly at the reflectors and start the camera calibration task from scratch.

9.1.4 Data registration

Registration of project images via tiepoints doesn't work properly.

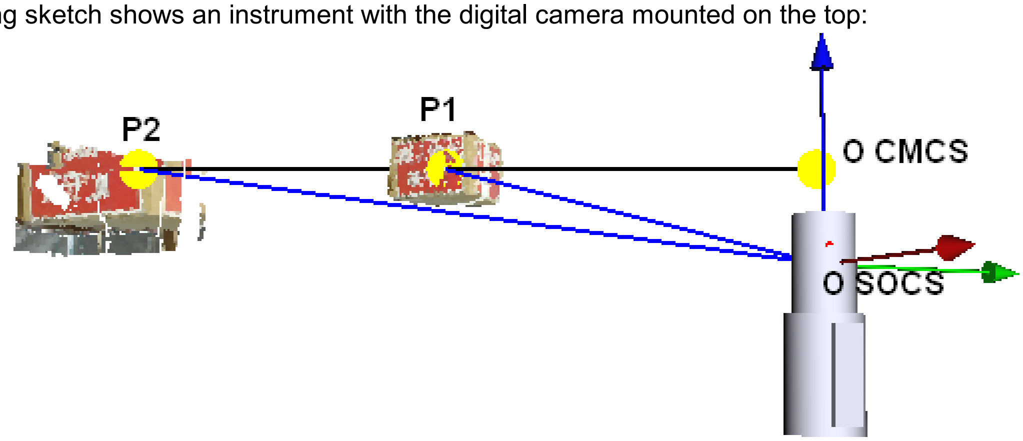
- If you use PRCS tiepoints to register the project image, please check that the coordinates of the tiepoints are correct and that they are marked as controlpoints before you link the image tiepoints to them.

9.1.5 Data postprocessing

When I process a scan with the function "Color from images" the same part of an image is mapped onto two different sets of points (double images).

The reason for this problem is the offset between the origin of the scanner coordinate system (SOCS) and the origin of the camera coordinate system (CMCS). Because of this distance the instrument may "see" (=measure) points which can not be seen in the high resolution photograph (this problem is also called "parallax"). The effect increases with decreasing distances between the scanner and the measured objects.

The following sketch shows an instrument with the digital camera mounted on the top:



The scanner (with the origin of SOCS at *O SOCS*) scanned the red box (point *P1*) which is very close to the scanner and the wall (point *P2*) which is farther away. The camera (with the origin of CMCS at *O CMCS*) took one photo which was used to color the points of the scan. What you can see in the sketch is, that the points of the wall are colored with the same color as the box, which is not correct. The blue lines demonstrate the rays of the instrument detecting the two object points (the lines start at *O SOCS* and end at *P1* and *P2*). The black lines start at *O CMCS* and also end at *P1* and *P2*. Both black lines overlap.

This problem is based on the principle of how the camera is mounted on the instrument and can not be solved completely. You can only minimize the effect with the following steps:

- Avoid data acquisition of near objects
- Take care of the instrument position (e.g. vary the height of the instrument)

Note:
This problem may also occur with invalid measurements (when no point was measured, e.g. if the laser points into the sky). All points are represented by two angles (theta and phi) and the range measurement. In the case of invalid points the range is set to a high value (about 100000m). Almost all functions of RiSCAN PRO detect and filter out such points. But the color function doesn't differ and thus invalid points get a color. This may cause double images which can only be seen in the 2D view. But you can deactivate the display of invalid points in the 2D view. To do so enter the program settings (Menu "**Tool > Options...**") and select "2D settings > Other settings". In this page activate the option "Use invalid point color". The next time you open a scan in the 2D view invalid measurements will be displayed with the selected color (instead of the real color).

9.1.6 Data visualization

I have troubles with 3D graphics output, what can I do?

- Make sure that you have installed the latest driver for your graphic card.
- Make sure that your graphic card meets the requirements as stated in chapter "Installation > System requirements 4".
- Depending on the graphic card and -driver, there might be an option named "Threading optimization" (or similar) in the driver settings. Please turn this option OFF.

9.2 Download information

RiSCAN PRO Download information:

At the following web page you'll find the latest version of RiSCAN PRO as well as RiSCAN PRO documentation, plugins and tools:

http://www.riegl.com/members-area/software-downloads/

If you have any further questions, please contact: support@riegl.com

9.3 Abbreviations

Abbreviations used by RiSCAN PRO and the documentation in alphabetical order:

- **ALS**
  Airborne laser scanning

- **CMCS**
  Abbreviation for "**C**a**M**era **C**oordinate **S**ystem". See "Coordinate systems used / CMCS 39" for more information

- **COP**
  Abbreviation for "**C**amera **O**rientation and **P**osition" (note that COP has different meaning when applied to images depending on whether the camera was mounted on top of a scanner or not - see "Embedding images into the project" 345).

- **CR**
  Character "carriage return" (ASCII character 13)

- **GLCS**
  Abbreviation for "**GL**obal own **C**oordinate **S**ystem". See "Coordinate systems used / GLCS 39" for more information.

- **LF**
  Character "line feed" (ASCII character 10)

- **POP**
  Abbreviation for "**P**roject **O**rientation and **P**osition" (Orientation and Position of PRCS within GLCS).

- **PRCS**
  Abbreviation for "**PR**oject **C**oordinate **S**ystem". See "Coordinate systems used / PRCS 39" for more information.

- **SOCS**

Abbreviation for "**S**canner's **O**wn **C**oordinate **S**ystem". See "Coordinate systems used / SOCS 39" for more information.

- **SOP**
  Abbreviation for "**S**ensor's **O**rientation and **P**osition" (within PRCS).

- **TLS**
  Terrestrial laser scanning

- **TP**
  Abbreviation for tiepoint. In RiSCAN PRO points of interest (e.g. reflector targets) are called "tiepoints". These points are managed in tiepoint lists 104 (see "The tiepointlist window" 104).

- **TPL**
  Abbreviation for tiepointlist. A tiepointlist holds a set of tiepoints.
  Related topics:
  - The tiepointlist window 104
  - Registration via tiepoints 187

9.4 Angle definition

- **Phi-, azimuth- and frame angles**

  have the same meaning and refer to the horizontal alignment.

- **Theta-, polar- and line angles**

  have the same meaning and refer to the vertical alignment.

- **Definition of angles of rotation**

  Within RiSCAN PRO the transformation from a scan position into the project's coordinate system (PRCS) is accomplished by a 4 x 4 matrix describing a rigid transformation which in turn can be split into a rotation (3 x 3 matrix) and a translation (3 x 1 vector). For interpretation of the rotational part of the transform it is often more convenient to describe the rotation by three angles of rotation. There are numerous different ways to derive a rotation matrix from three angles. The subsequent definition lends itself to the situation in **airborne laser scanning (ALS)**, where the three angles are described as

  - **roll** angle (rotation around the plane's roll axis)
  - **pitch** angle
  - **yaw** angle (rotation around the vertical axis or yaw axis)

  In ALS the rotations are applied sequentially to transform from the aircraft's body system into a body-fixed but rotated system with the axes parallel to the local east and north directions.

  For **terrestrial laser scanning (TLS)** the same approach is applied in the following. We modify the naming to have the three angles defined as

  - rotation about the scanner's **x-axis** = **roll** angle
  - rotation about the scanner's **y-axis** = **pitch** angle
  - rotation about the scanner's **z-axis** = **yaw** angle

  It is easy to calculate the rotation matrix from the angles:

$$R = \begin{pmatrix} R_{0,0} & R_{0,1} & R_{0,2} \\ R_{1,0} & R_{1,1} & R_{1,2} \\ R_{2,0} & R_{2,1} & R_{2,2} \end{pmatrix}$$

$$R = R_z(Y)R_y(P)R_x(R)$$

$$R_x(R) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & cos(R) & -sin(R) \\ 0 & sin(R) & cos(R) \end{pmatrix}$$

$$R_y(P) = \begin{pmatrix} cos(P) & 0 & sin(P) \\ 0 & 1 & 0 \\ -sin(P) & 0 & cos(P) \end{pmatrix}$$

$$R_z(Y) = \begin{pmatrix} cos(Y) & -sin(Y) & 0 \\ sin(Y) & cos(Y) & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

In order to calculate the angles from the rotation matrix follow the subsequent scheme:

1. **Case 1:** the x-axis of the scanner is **not** parallel to the z-axis of the project coordinate system (i.e. R_2,0 not equal 1):

   $$Y = atan2\left(R_{0,0}, R_{1,0}\right)$$

   $$R = atan2\left(R_{2,2}, R_{2,1}\right)$$

   1.1 Subcase 1.1: sin(Y) equal to 0

   $$P = atan2\left(R_{0,0}cos(Y)^{-1}, -R_{2,0}\right)$$

   1.2 Subcase 1.2: sin(Y) not equal to 0

   $$P = atan2\left(R_{1,0}sin(Y)^{-1}, -R_{2,0}\right)$$

2. **Case 2:** x-axis of the scanner is parallel to the z-axis of the project coordinate system (i.e. R_2,0 is equal 1):

   $$P = sign\left(R_{2,0}\right)\frac{\pi}{2}$$

   $$Y = atan2\left(-R_{1,1}, R_{0,1}\right)$$

$$R = 0$$

Note that the atan2 function if used as atan2(x, y) whereas x and y denote the x and y components of the vector respectively.

The interpretation of the angles R, P, and Y is straightforward. In the case that the scanner is mounted in an almost vertical position R and P give the same angles as the (optional) inclination sensors (if the PRCS is horizontally aligned), i.e., the tilts around the x and y axes of the scanner. The Y angle gives the angle between the x-axis of the scanner and the x-axis of the project coordinate system. Yaw can be interpreted also as the heading angle.

9.5 Object naming

In RiSCAN PRO you can rename objects such as scans, images, tiepoints, polydata objects to meet your requirements. Generally an object's name can consist of a combination of almost any characters. The following characters are not allowed:

- \
- /
- :
- G
- ?
- "
- <
- >
- |
- #
- @
- [(as the first character of the name, at other positions this character is allowed)

9.6 Program shortcuts

The following shortcuts are functional program-wide:

Note: Some functions may need an object reference (e.g. "F7 - New single scan" needs a scan position). The scan position is defined by setting the option "Activated" of the scan position before you use the shortcut (use the right mouse button on the scan position in the project manager). The last scan position is activated automatically.

General program shortcuts:

Action	Key	Comment
Show help file	F1	
Rename	F2	Rename currently selected item.
Create new scanposition	F6	A project must be opened.
New single scan	F7	The scan will be added to the activated scanposition.
Find reflectors	F8	Find reflectors of the currently selected scan.
Image acquisition	F9	The images will be added to the activated scanposition.
New project image	Ctrl + F9	A project must be opened.
Open project	Ctrl + O	
Open last opened project	Ctrl + Shift ⇧ + O	
Close program	Ctrl + Q	The currently opened project will be saved and closed.
Save project	Ctrl + S	A project must be opened.
Create new objectview	F12	A project must be opened.

Tool windows:

Action	Key	Comment
Show image browser	Ctrl + Alt + B	
Show data readout	Ctrl + Alt + D	
Show info window	Ctrl + Alt + I	
Show message list	Ctrl + Alt + M	
Show object inspector	Ctrl + Alt + O	
Show project manager	Ctrl + Alt + P	
Show thread list	Ctrl + Alt + T	
Show tiepoint display	Ctrl + Alt + V	

Window manipulation:

Action	Key	Comment
Close window	Ctrl + F4	
Next window	Ctrl + Tab	
Previous window	Ctrl + Shift + Tab	

9.7 Project cleanup

During a data acquisition campaign and data postprocessing the project is filled up with many different objects (scans, images, tiepoints,...). Some of the objects are not needed anymore after the end product has been created. To delete unnecessary objects RiSCAN PRO offers a cleanup wizard. The cleanup wizard can also import files that are located within the project folder but are not referenced by the project structure. The use of the cleanup wizard is described in the following section.

Cleanup wizard

To use the cleanup wizard, right-click either the folder ***OBJECTS***, a **scan position** or the **project** in the project manager and select "**Cleanup ...**" from the menu.

Note:
The cleanup wizard will always work only on the clicked object and its subobjects (i.e. if the project was clicked the complete project will be cleaned).

- **Step 1:** Options

  On this page you can define how an object or file should be processed:

  Unreferenced files
  In the case of files that are located within the project folder but are not referenced by the project structure you can decide whether you want to **import** or **delete** these files. Use the "**Filter...**" button to define a list of filter expressions (masks). Each file that matches any mask will not be processed by the cleanup wizard in any way. A valid mask consists of literal characters, sets, and wildcards. Wildcards can be used instead of unknown characters. Use the asterisk (*) as replacement for zero or more unknown characters. Use the question mark (?) as replacement for exactly one unknown character (Please refer to the documentation of the operating system for more information about file masks).

  Note:
  The list of file masks will be saved and restored the next time you use the cleanup wizard.

  Delete objects where files are missing
  Activate this option to delete objects that refer to one or more files but they are not found in the project folder.

  Delete <class> tiepoints
  Use this option to delete either **all** tiepoints or tiepoints that have **no link or are not referenced by other** tiepoints. If you activate the option "**Delete tiepoints**" all tiepoints of all classes (image, SOCS, PRCS, GLCS) are handled in a common way. If you want to delete tiepoints of a certain class only then activate "**Delete <class> tiepoints**" rather then "Delete tiepoints".

  Delete tiepointscans
  Use this option to delete either **all** tiepointscans or tiepointscans that **are not referenced by a tiepoint**.

  Delete singlescans/scansequences/images/undistorted images
  Use this option to delete scans or images. You can decide to either delete **all** objects or objects referring to files **bigger** or **smaller** than a given size.

  Delete polydata objects containing no points
  Use this option to delete polydata objects that do not contain points or triangles.

  Delete empty object views
  Use this option to delete object views that do not contain any object.

  Note:
  Object views that become empty because the cleanup wizard deleted objects in these views will not be deleted.

  Delete empty folders
  Use this option to delete folders that do not contain files.

  Note:
  Empty folders that belong to the project structure are not deleted.

Click the button "**Next**" to check the project structure for objects and files to be deleted/imported. **No object will be deleted and no file will be imported at this step!**

- **Step 2:** Summary

  This page shows a list of all objects matching the criteria defined on the previous page. You can activate or deactivate the actions on each single object by clicking on the box in front of the action. In the case of unreferenced files you can toggle the action between "Import" and "Delete" by right-clicking onto the action.

  Click the button "**Next**" to execute the desired actions.

- **Step 3:** Log

  This page shows a log of the performed actions and whether they succeeded or failed.

9.8 Project file description (XML)

The content was moved to chapter Data exchange / Fileformats / RSP (Project file) 327.

9.9 Embedding images into the project

RIEGL 3D imaging sensors can optionally be equipped with a high resolution digital camera. The images can be used to assign a color to the vertices of the point cloud data or to apply the images to a meshed surface as a texture.

In order to make use of the image data calibration data holding the intrinsic parameters of the camera has to be available. The calibration data is contained in the calibrations section of the project file. The calibration data has to be determined for every camera to be used and for every setting of the camera's focus and aperture to be used.

RiSCAN PRO knows two different kinds of images: images acquired when the camera was firmly mounted on the scanner (image type **Image@scan position**) and images acquired when the camera was not mounted on the scanner (image type **Image@ProjectLevel)**.
The first type (Image@scan position) of images are assigned to a scan position. With each image, RiSCAN PRO stores a transformation matrix (COP) holding the information about the orientation of the camera within the scanner's own coordinate system in relation to a reference orientation. Furthermore, a mounting matrix has to be available which transforms from the SOCS system into the CMCS in the reference orientation. This information is also contained in the calibrations section addressed as mounting calibration. The mounting calibration has to be updated after every mounting of the camera. In order to transform a pixel in the image into a ray in PRCS/GLCS the following transformations have to be applied:

- Distorted to undistorted pixel coordinates using the intrinsic parameters of the camera
- Reverse perspective projection to obtain a ray in CMCS
- Transformation of the ray with (mounting matrix)^-1 and with COP into SOCS
- Transformation of the ray with SOP into PRCS and if necessary with POP into GLCS

For the second type of images (Image@ProjectLevel) a single transformation matrix is stored (COP) which transforms from the camera's coordinate system into the project coordinate system. In order to transform a pixel in the image into a ray in the PRCS/GLCS the following transformations have to be applied:

- Distorted to undistorted pixel coordinates using the intrinsic parameters of the camera
- Reverse perspective projection to obtain a ray in CMCS
- Transformation of the ray with COP into PRCS and if necessary with POP into GLCS

In order to project a point in 3D in GLCS onto an image follow the subsequent procedure:

For Image@scan position:
- Transformation point with POP-1 into PRCS
- Transformation point with SOP-1 into SOCS
- Transformation point with COP-1 and by (mounting matrix) into CMCS
- Perform perspective projection to obtain pixel coordinates
- Perform undistorted-to-distorted transformation on pixel coordinates using the intrinsic parameters of the camera

For Image@ProjectLevel:
- Transformation point with POP-1 into PRCS
- Transformation point with COP-1 into CMCS
- Perform perspective projection to obtain pixel coordinates
- Perform undistorted-to-distorted transformation on pixel coordinates using the intrinsic parameters of the camera

9.10 Atmospheric correction and geometric scaling correction

Summary

Laser ranging is based on measuring the time-of-flight of short laser pulses. The range to the target is calculated from the measured time-of-flight. Carrying out this calculation with high accuracy requires very exact knowledge of the speed of the laser signal. However, the speed of light in air changes with temperature, pressure, and humidity. This section gives background information on how the air parameters impact laser ranging. Additionally an additional scaling correction has to be used to fit the data into an existing coordinate system which is not strictly metric in some applications. This geometric scaling correction is also addressed.

1. Atmospheric correction

1.1 Time-of-flight measurement and range calculation

Laser ranging is based on measuring the time-of-flight of a laser signal from the instrument's transmitter to the target and back to the receiver. For RIEGL instruments the laser signal is pulsed and thus the time-of-flight is evaluated by measuring the time interval between two short laser pulses, the transmitted pulse and the received pulse. The range to the target, R, is subsequently calculated from the TOF, τ, according to

$$R = c_g \frac{\tau}{2} = \frac{c_0}{n_g} \frac{\tau}{2}$$

(1-1)

whereas cg is the speed of light in the optical transparent medium the laser pulse is propagating in. To be precise, cg is the group velocity in the medium at the laser wavelength. This group velocity differs from the speed of light in vacuum by the factor ng, which is the group velocity index of refraction. To calculate the range with high precision exact knowledge of the group velocity is required.

1.2 Group velocity index of air

The group velocity index and thus the group velocity of air is a function of temperature, pressure, and humidity. For this reason, to perform highly accurate range measurement, the knowledge of these parameters is required.
The group velocity of air exhibits only small fractional changes with the change of the atmospheric parameters. Therefore, the fractional change is frequently described in the units of ppm, i.e., parts per million. For example if the condition of the atmosphere changes from state 1 to state 2 by a small amount, lets say

ng1 changes to ng2 by k=10 ppm, the time of flight changes accordingly:

$$\tau_2 = \frac{n_{g2}}{n_{g1}} \tau_1 = \left(1 + k10^{-6}\right)\tau_1$$

(1-2)

RIEGL instruments are calibrated at well-defined atmospheric conditions. These atmospheric parameters are given in Table 1-1.

Air temperature	12 °C
Air pressure	1000 mbar
Relative moisture	60 %

Table 1-1: Standard atmospheric conditions used for calibration of RIEGL instruments

The view graph below shows the variation of the group velocity index relative to the index at the standard conditions.

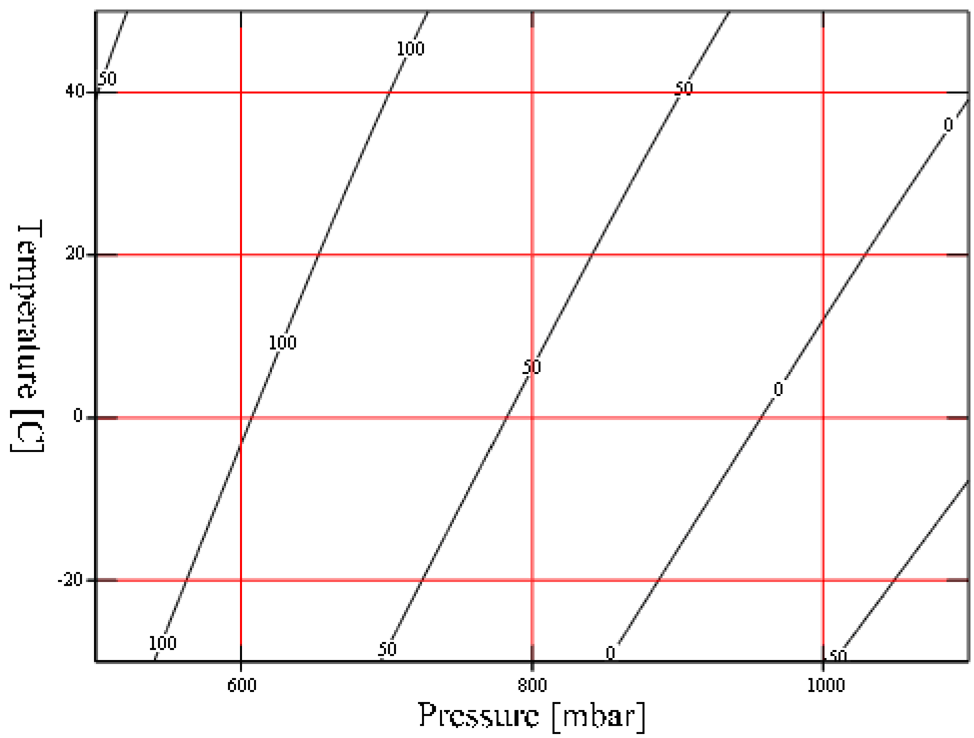


Figure 1-1: Variation of the group velocity at the laser wavelength with temperature and pressure.

For example, a change of 50 ppm in the index of refraction results in a change of the measured range of 50 mm at a target range of 1000 m, in case the change is not considered appropriately.

1.3 Handling atmospheric correction in 3D laser scanning

As the instrument is calibrated at the standard atmospheric conditions as stated in Table 1-1 at other conditions the raw data reading of the instrument has to be corrected. For the RIEGL 3D instruments providing a binary data stream of raw data this atmospheric correction is carried out within the software packages RiSCAN PRO or RiPROFILE.

Note: For other applications, the RiSCANLIB provides functions for ppm correction. See the documentation of RiSCANLIB for details.

The user has to provide the atmospheric data, i.e., temperature, pressure, and humidity to the software. As the software is project orientated, this data can be entered at a project level (see Project settings 45), but can be changed, if necessary, for every scan position (see Create new scanposition 46). Thus scans which were acquired under different atmospheric conditions can be combined.

Air moisture or humidity can be specified in three different ways: moisture pressure in mbar, relative moisture in percent, or dew point temperature in Celsius. Each of these values can be converted into the two other values for a given temperature and air pressure.

Taking a look at the sensitivity of the correction in ppm based on the three atmospheric parameters near the standard conditions reveals the following:

- a change in temperature of 1 °C yields a change in correction of +1 ppm
- a change in air pressure of 10 mbar yields a change in correction of –2.7 ppm
- a variation of relative moisture from 0 % to 100 % yields a change in correction of only 0.5 ppm

Consequently, to have an correction accuracy of ±5 ppm, the temperature has to be known with an accuracy of ±2.5°, the air pressure to within ±20 mbar, and the relative moisture doesn't need to be considered at all at this accuracy level and at a temperature of about 12 °C.

2. Geometric scaling correction

In some cases it is of advantage to have a geometric scaling correction to fit the data provided by the instrument to a coordinate system of a known scaling factor. For this purpose the software packages RiSCAN PRO or RiPROFILE allow you to also consider a geometric correction in addition to the atmospheric correction in ppm. With this correction all cartesian coordinates in the scanner's local coordinate system are scaled. For the polar coordinates only the range value is scaled, the angles remain unchanged.
The coordinate value after scaling, e.g., x, is derived from the unscaled coordinate xu by:

$$x = x_u\left(1 + sg10^{-6}\right)$$

(1-3)

whereas sg is the scaling correction value in ppm.

3. Formulas used for atmospheric correction

The following formulas are used for atmospheric correction in RiSCAN PRO and RiPROFILE:

Group refractivity Ng at 0 °C, 1013.25 mbar (hPa), and 0 % relative air moisture, and 0.0375 CO_2 content.

$$N_g = 287.6155 + \frac{4.88660}{\lambda^2} + \frac{0.06800}{\lambda^4}$$

(1-4)

λ being the laser wavelength in µm.

The group refractivity at ambient moist air for given temperature T in Kelvin, pressure p in mbar, and water vapor pressure e in mbar.

$$N_L = \frac{273.15}{1013.25}\frac{N_g p}{T} - \frac{11.27e}{T}$$

(1-5)

The group index of refraction ng is then given as

$$n_g = 1 + N_L 10^{-6}$$

(1-6)

To calculate the water vapour pressure in mbar from the dew point temperature the formula

$$e = 6.1\ 10^{\frac{7.45\ t_{dp}}{235\ + t_{dp}}}$$

(1-7)

is used, whereas tdp is the temperature in °C.

To calculate the relative moisture in %, from the water vapor pressure in mbar, e, and the temperature in °C, t, we use

$$e_{rel} = \frac{e}{6.1\,10^{\frac{7.45t}{235+t}}}$$

(1-8)

4. Using Scaling Correction in RiSCAN PRO

Once you start a new project or new scan position you must enter proper scaling correction values in the project or scan position settings. Please refer to chapters Project settings 45 and Create new scanposition 46 to see where you can define them.

The scaling correction (either atmospheric or geometric) is applied to the data every time you open a raw scan (3DD file). So the scans will still be valid after changing the PPM value. But you have to update other parts of the project:

A: Re-do the registration
B: Re-create colored- or resampled-Scans and PolyData objects (point clouds, meshes,...)

More detailed:

A: When your registration is based on fine scans, you need to recalculate the reflector positions after changing the PPM. This is done by opening the TPL SOCS and using the function "Tiepoint scan > Recalculate tiepoint positions > All listed". This will analyze the fine scans once more whereas the new PPM value is taken into account. As result, the tie points get new coordinates and you must restart the registration to get a new SOP matrix.

B: As mentioned above, the PPM value is only used when you load a raw (not modified) scan (e.g. for 2D/3D display or other post processing steps). Colored- or resampled-scans, PolyData objects or other geometry objects (like planes, spheres, polylines,...) will NOT be updated automatically, they must be re-created from scratch.

9.11 RiPort

The RiPort driver enables application interface to RIEGL-LMS high speed Laser-Distance sensors. The Laser Sensor is connected to the PC using an ECP (Enhanced Capabilities Port), which is usually used to connect printers and page scanner devices. Since almost every new PC is already equipped with this port this is a convenient interface comparable to the widespread serial RS-232 connection. However, the ECP port exceeds the data-transfer speed of the serial interface due to the parallel transmission of information.

The parallel port was originally only able to transfer data from the PC to a peripheral device (the printer). The port also had some control lines that could be driven by the peripheral (i.e. to signal "out of paper" condition).

Soon people used these lines to transfer information from the peripheral into the PC. A byte had to be split into 2 halves, which is known as NIBBLE mode. The next step was to allow a bi-directional use of the 8 data lines which is known as BYTE mode. The latest improvement has been the ECP and EPP modes which gained further speed improvements from a hardware supported handshake concept.

The ECP mode is expected to become a operating system supported feature. The full fledged ECP mode is standardized in the IEEE-1284 document, and also defines smooth interworking of the NIBBLE BYTE and ECP modes. Since the standard is not yet implemented by the operating systems (only a subset, the NIBBLE mode, already is) we decided to use the high speed features of the ECP mode without the interworking features and supply you with a driver which frees you from the need to know the details of the protocol. The interface is straight forward in use and allows us to implement more features in the future as the need arises without forcing you to rewrite your application.

9.12 RiSCANLIB

RiSCAN PRO uses the RiScanLib to communicate with the scanner devices.

Introduction of the RiSCANLIB

The Riegl LMS Scanner Library is a set of functions that will help you

- interface to a Riegl scanner via **parallel port, serial port** or **network**,
- read logged data from a **disk file**,
- decode data in a **scanner-independent** manner,
- set scanner **parameters**,
- integrate the scanner interface using your preferred programming environment using **COM** technology,
- convert geometry data to **cartesian** or polar coordinates (and apply corrections).

The library is packed as COM objects which are located in files named scannermod.dll and scancnfmod.dll. Once the library has been registered into your system, your compiler will be able to read its type library and generate the necessary interfaces. You can then call the functions as if they were native functions in your programming environment (e.g Visual C++, Delphi, ...). Since the library is coded in COM technology you will even be able to create multiple instances of interfaces, as you would when interfacing to more than one scanner at a time or when reading data files at the same time.

The library runs in a separate thread asynchronously to your application. This will ease your interface coding, since you will almost never be blocked when you call any of the interface functions, thereby avoiding the annoying hourglass cursor. To this end the library maintains an internal data buffer for storage of the scanner data, and controls access to it via a semaphore mechanism. The windows message passing system is used to inform you of the relevant events, such as start of a scan, receipt of a single scan-line or end of a scan.
A logging facility is also built into the library. You can use this feature to create files that will store any data the scanning unit is able to deliver, even if there is no interface function to directly access it. Storing the data in this native format will allow you to use an even more improved version of the library without compromising compatibility.

Geometry data can be retrieved in polar or cartesian coordinates. You can choose the amount of information you need to get in a single call. You may specify to get any number from a single point up to an entire scan per call. The same is true for amplitude, RGB (true color) or time data.

Error situations (such as end of file, wrong file or scanner types, ...) are also signaled via the windows message loop. The library even will give you a plain text message string, that can be used for display in your interface. This message string will automatically be translated to the language that is installed on your system. (english and german currently available).

The library is able to interface to the scanner data port either through a PC parallel port or a TCP/IP socket using the IB90-ETH box. On Windows NT/2000 interfacing is performed via the device driver RiPort, resulting in very low processor overhead because of the use of interrupts. On Windows95/98 there is no device driver available, resulting in the need to constantly poll the port, thereby incurring high processor load. On Windows 95/98 it is generally possible to use even an simple bidirectional (not ECP capable) port. This interface is, however, not recommended at all since only very low data transfer rates are obtainable.
Windows95/98 also needs a further precaution since none of the resource sharing functions for the parallel port are in use. (A simultaneous print attempt might crash the system.)

For detailed information about the RiScanLib and how to use it please refer to the documentation of the RiScanLib!

9.13 RiVLIB

The software library RiVLIB is intended for software developers and provides tools and classes to decode and read raw data files produced by V-Line scanners (RXP files). You can download the RiVLIB package containing the library, example source code and documentation from www.riegl.com, section "Downloads".

9.14 Rollei AIC P25

This chapter describes how to install and use the digital camera Rollei AIC P25 with RiSCAN PRO

Installation:

1. Install RiSCAN PRO (version 1.2.1b21 or higher) and the camera plugin (version 1.0.17 or higher)
2. Insert the installation CD of Capture One
3. Install Capture One (including the camera drivers)
4. Connect the camera to the PC (Power, Firewire and Serial)
5. Windows will automatically show the driver dialog for the new hardware.
6. Select the option to search for the driver automatically and finish the installation.

Usage:

1. Start Capture One and make sure that it can connect to the camera.
2. Start RiSCAN PRO and create a new project.
3. Create a new camera calibration (with the wizard) and mounting calibration.
4. Select the communication ports for the scanner and the camera (Rollei AIC P25 and COMx).
5. Go to "**Tool > Options**" and activate "**General > Image acquisition > Ask before taking image**".
6. Start the image acquisition as usual.
7. Before the camera is released a dialog box will be displayed. Click the button "OK" as soon as you are ready to take the image.
8. RiSCAN PRO releases the camera and the image will be transferred by Capture One.
9. RiSCAN PRO creates a new image object within the project structure. The corresponding image file is missing (see step 11) but the COP matrix is set properly.
10. Steps 7, 8 and 9 are repeated for all images.
11. When the image acquisition has finished, postprocess the images with Capture One and copy (and rename) the images into the corresponding folder of the RiSCAN PRO project.

9.15 Copyright remarks

9.15.1 VTK

RiSCAN PRO uses the Visualization Toolkit (VTK) which is open source.

VTK-License:

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9.16 Revision history

2015-02-20 Version 2.0.3

Changes:

Camera calibration method "Calibrate camera (flat check pattern)..." has been removed because it is not maintained any more.

The "Define POP-Matrix" dialog does not popup any more in case that the SOP/POP is calculated from a V-Line scan.

Bugfixes:

Fixed a bug that accidentally extracted User Coordinates from a V-Line scan from its house keeping information.

Updated RiMTATLS to version 2.2 to fix incorrect MTA resolution in case that the user requested MTA zone has been set to anything else than 1 during scan acquisition on the scanner.

Fixed "Access denied" error message when converting a scan in case that the project has been opened by double clicking on a Grsp file.

Fixed a bug that prevented Scan Positions from being automatically registered from V-Line scan in case of manual scan import.

2015-02-11 Version 2.0.2

Features:

New improved RiMTA TLS replaces RiMTA 3D as the MTA processing engine.

E57 export now additionally stores global georeferencing information in the exported file in case that GeosysManager 2 has been configured properly.

TPL (GLCS) feature "Calculate translation for POP" now allows to either setup a local ENU or a tangential ECEF project coordinate system.

Feature "Set scanner positions..." now allows to either setup a local ENU or a tangential ECEF project coordinate system.

3D view toolbar buttons for Perspective/Ortho, Constrained/Free and Fly/Walk now show the next state instead of the current state.

RiSCAN PRO project structure may contain an optional <guid> sub element in the <project> element to uniquely identify a project.

Added "Clone..." feature to right click context menu of Camera Mounting project node.

SDFSampleBlockChart chart plugin is now UAC aware.

Changes:

RiSCAN PRO reports are now stored in "REPORTS" project node instead of "PROTOCOLS" node.

Bugfixes:

Fixed G3dd file manipulation such as "Resample..." and "Color from images...".

Fixed "LOGIC ERROR!" and incomplete COP matrix import in image import.

Fixed GUI truncation of 3D view tool "Polar triangulation..." and occasional hang at 85% triangulation progress.

Fixed "Color from viewtype..." feature that colored whole pointcloud in single color when pointcloud coordinates were too big.

Removed unexpected popup menu that appeared when clicking 3D view toolbar "Delete" button.

Fixed an access violation that occurred under certain conditions during tiepoint finescan.

2014-12-17 Version 2.0.1

Features:

GeoSysManager 2 support added for export of Sections, Polylines, Planes, Points, Datamine STRINGS, RQX files.

Project .rsp and project.dtd are backed with a version number before updated to newer project structure version.

SOP Backsighting orientation now allows to use tiepoints that have not been finescanned.

Help -> Wizard 'Import' now offers automatic renaming options for resolving name conflicts.

Help -> Send support email... now includes important log, configuration and debug files.

Tool -> Options now offers Object inspector settings to prevent the Object inspector from automatically expanding sections when objects are added to the 3D view.

Multi Station Adjustment now offers an option to prevent the "Adjustment finished." popup.

Changes:

3D view toolbar restructured to make important features more easily available.

Bugfixes:

Fixed an access violation that occured when exporting Sections, Polylines, Planes and Points to e.g.: DXF.

Fixed "%1 is not a valid Win32 application." error message that occurred on certain systems when executing e.g.: MTA scan conversion.

Fixed a bug that led to very long project saving (verification) times. Saving large projects is now as fast again as it was in previous versions.

3dd files created by conversion from rxp to 3dd are now imported to the project file again after conversion.

Importing local licenses from a .lic file now works again without an access violation.

3D view selection mode flickering reduced.

Fixed dark gray Toolbar background when running RiSCAN PRO on a Windows with Windows classic style Desktop enabled.

Fixed missing Object inspector icons, corrupt tree view display and access violation errors that occurred when undocking the Object inspector.

Fixed ".Data = nil." error message that occurred when undocking the Object inspector and exporting some objects afterwards.

Fixed "Calculator not prepared." error message that occurred under certain conditions when opening a 3D view.

Microsoft Windows UAC awareness further improved by relocating log, temp and debug files to a central user accessible directory.

Open scan position images in the RiSCAN PRO Photo view now is again as fast as it was in previous versions.

Fixed stepped and perspective distorted selection results that occurred when selecting polydata or V-Line data in the 3D view by right clicking a polyline and choosing "Select data".

Fixed a bug where the Dongle was not recognized any more after RiSCAN PRO setup.

2014-10-07 Version 2.0

Features:

64 bit version of RiSCAN PRO released. 32 bit version of RiSCAN PRO is still available (only 32 bit version supports data acquisition with Z-Line scanners)

New Graphical User Interface (many improvements, new icons and layout)

Georeferencing support via GeoSysManager 2.0 now integrated

Ultra-High Definition (UHD) display support

Large Polydata File Support (>250 mio. points)

Rendering performance of 3D view pointcloud renderer improved

Russian Language Support

Render fallback mode for 3D view section rendering added

Single Color Sequence that is used to assign a single color to 3D view objects is predefined and high contrast now

3D view pickpoint is now set to some meaningful position when opening a 3D view

Info window now shows polar coordinates of the "i-clicked" data point if "Object inspector" coordinate system is set to SOCS

New color table "Rainbow Cycling 01" added.

The sequential point naming of the 3D view point creation tool "New object... - Create point" has been improved.

3D view function "Bird's eye view" added.

Wizard "Download and Conversion Wizard" now provides option to ignore "ZiSCAN" and "Backsight" files if "Main scans only" is selected.

Added additional "Filter data - 2.5D raster" modes. Additional modes are "Estimate plane - height at cell center" and "Estimate plane - height at cell COG".

Hold down "Ctrl" to change between "Select" and "Deselect" mode when the Selection Mode is active.

Changes:

Tool bars are cleaned up and more structured now

3D view view functions "Top view", "Bottom view", ... now do not zoom out to full extent any more automatically unless "Shift" is pressed

Default values of Scanner IP address changed to 192.168.0.125 to support default ethernet connections with VZ Instruments

3D view camera focal length length in program options changed for UHD display improvement

Tiepoint import file format "ASCII" is the very first in the import format list now

Export file format "PointCloud for Autocad (Gptc)" has been removed

Bugfixes:

Plotting Tool now saves the correct scale when plotting in PDF format

Conversion of VZ-4000, VZ-6000 scans into G3dd file format fixed (Only available in 32 bit versions)

E57 data export now supports Riegl database version 4.1

2014-06-26 Version 1.8.1

Features:

Added 10 new default color tables. Additionally user defined color table images can be loaded.

Selection Tool can select colored points by their Hue, Saturation and Brightness values now. Added a calculate bounds from selected points button.

Reflector finescan now lists all reflectors that failed to finescan in the message list at the end of the finescan.

Added function to sort objects like planes, spheres and polylines by name ascending.

3D view text is always on top now and has a black outline to increase readability on a low contrast background.

Color from images: added option to define a "region of interest" (i.e. only use a definable part of the images).

Changes:

When switching from a 2D view to a 3D view then the default coordinate system for the 3D view is SOCS now.

Camera Calibration: lens distortion model 2 added (suitable for wide angle lenses with severe radial distortion).

Update to RiSCANLIB 3.10

Rename objects: filter invalid characters

Short cut for creating a new project: "CTRL-N"

Create new mounting calibration each time the camera was detached from and attached to the V-Line scanner (requires current firmware version).

Connecting to a Z-Series scanner that is in error state, does no longer show the "No handler found for instrument type" error message.

Export planes to ASCII file also exports "Dip angle" and "Dip direction" values.

When importing scans while "Automatically register scans" is activated and configured to use UCS, the import uses WGS84 if the scan does not contain UCS coordinates.

Wizard Download and Convert: do not show thumbnail images.

Panorama viewer for scans (not the 2D/3D view) improved.

Bugfixes:

Change viewtype for all scans in object inspector failed if parent SCANS folder was collapsed.

Font scaling factor of 3D Text has not been applied correctly in create plot function.

Fixed a render error that occurred on some graphics cards during section creation/visualization in the 3D view.

Fixed an error that occurred under certain conditions when deleting polylines from a polydata object.

Fixed "not installed!" message when double clicking on a Grsp file in Windows Explorer.

Fixed 3D view freeze when loading a corrupt dataset.

Fixed Scan Position Label misplacement for Z-Line Scanner models in the 3D view.

Fixed inconsistent polydata data array when deleting points from a polydata in a 3D view with viewtype amplitude scaled or viewtype deviation scaled.

Fixed 3D camera navigation problem with big coordinates in perspective mode.

Fixed incomplete pointcloud visualization after SOP modification in a 3D view.

Fixed incorrect WORLD file interpretation when importing a Orthophoto.

Fixed a bug that may have lead to an access violation after Filter data operation.

Fixed a bug in 2D view that lead to an error message when the scan extents in theta, phi direction were very small.

Fixed installation bug where V-Line Scanner 3D models have not been installed correctly.

Export planes: normal vectors where not exported correctly when using PRCS or GLCS.

DXF import range unit conversion bug fixed.

Image view: sometimes the images were displayed upside down.

Release memory when loading a polydata object in the 3D view fails.

Using "Undelete" on a scan that was just imported (no points deleted yet), caused additional points to appear.

Renaming a project gave a strange error message in some cases.

ASCII Export did not export amplitude values if no amplitude unit has been selected.

Fixed "List index out of bounds(0)" error that occurred when selecting two or more polydata in the Object inspector and at least one of them was empty.

2013-12-17 Version 1.8.0

Features:

Export to RiALITY Quick Exchange format added.

Coordinate Export Tool now supports AutoCAD 2014.

Changes:

Polydata objects and 3dd scans now consider additional clipping planes like that from the Height Filter Tool for point selection.

Height filter tool now allows to select different reference coordinate systems and reference axes.

Bugfixes:

PTX and POD export: fixed bug that occurred when exporting colored point clouds.

3D view: Added security check to work with new NVIDIA drivers.

3D view: Fixed a memory leak that occurred when creating new poly data objects.

3D view: Grid labels were missing at certain zoom levels.

2013-09-06 Version 1.7.9

Features:

RiMTA 3D (resolving range ambiguities for VZ-4000/VZ-6000 instruments)

Export to Bentley Pointools POD format

Changes:

RiSOLVE and RiMINING: improvements of automated registration procedure

When creating a new project, a 10 cm cylinder reflector type is automatically created

Bugfixes:

Data export stoped without message when source point cloud or mesh did not contain amplitude values.

Edit view type sheet crashed when closed while calculate minimum and maximum thread was running.

3D view did not stop to refresh when removed a pointcloud that has not been fully loaded yet.

Object Inspector: Text "(not loaded)" next to a scan overlapped the scan position name [fixed].

GPS coordinates were not read correctly from RXP file in some cases.

Orthophoto: created world file was incorrect if image was rotated.

2013-06-25 Version 1.7.8

Features:

Volume & surface area...: Additionally calculate the surface area of the model projected on the reference plane.

ASCII export now offers point timestamp as an export column.

View Inspector: Edit view-type of all scan/polydata objects at once by right clicking the SCANS/POLYDATA node and choosing "Change view-type...".

New button "Configure camera..." in the scan acquisition window allows to configure camera settings.

3D view: Scans now have the new option "Point size mode" that allows to switch between "Fixed" size points and "Laser footprint" size points.

3D view: Absolute grid supports rotation now.

3D view: Virtual 3D view camera has 2 different navigation modes now: Free mode and Constraint mode.

Filter points based on their reflectance attribute upon import (see, "Tool > Options > General > Data acquisition").

Changes:

PLY import improved: supports point color and files without faces (triangles), i.e. pure point clouds, now.

Selection Mode with filter Outside now uses different cursors to make the modes better distinguishable.

Previously, temporary files and log files were stored in the RiSCAN PRO installation folder. Now they are stored in the user's profile folder. This is important for environments where the user is not allowed to create files in the program installation folder.

Improved compatibility with integrated camera of VZ-4000/6000 scanners.

Moved extraction of waveform data from a RXP file into a separate process to improve performance.

List of measurement programs (V-Line scanner) is now read from scanner (if supported by firmware).

3D view: Edit polyline tool has a fallback render solution now to cope with graphics card problems.

Bugfixes:

Multi Station Adjustment: GPS measurement uncertainty is used as a limit for shifting scan positions.

Scan acquisition crashed on Windows 8.

Image acquisition: Images could not be downloaded when "Ask before taking image" was active [fixed].

Program crashed on quit when 3D view was opened before.

Wizard 'Download and Convert' did not always recognize reflector fine scans.

Fixed an access violation that occurred when closing 3D view tool Edit Polyline directly via view window or application window close button.

Fixed an access violation that occurred when using the Terrain Filter and at least one polydata object has been unloaded in the 3D view.

Function "Filter Data", mode "All Data" produced invalid polydata objects when the source objects contained polylines (e.g. breaklines).

Function "Calculate Volume", mode "Use existing mesh" crashed when 3D view contained more than one mesh or point cloud.

Function "Calculate Volume", mode "Raster" gave a result of zero (0) when raster size was too small.

Network license keys were not recognized when used locally (not via LicenseServer).

Fine scanning many reflectors with a V-Line scanner sometimes stopped unintentionally.

Program crashed on quit after using "Network Scanner Search" tool.

RiSCAN PRO failed to start if DEP (Data Execution Prevention) was activated in Windows Control Panel.

RiSCAN PRO crashed when no valid license key was installed.

Offset between GPS antenna and SOCS origin was not correctly applied when UCS (user coordinate system) coordinates were used.

2013-02-21 Version 1.7.7

Features:

New view tool "Height filter" added to constrain 3D pointcloud with two horizontal planes.

New program option added to enable anti-aliasing for 3D views.

3D view tool "Waveform 3D" now also supports waveform display for MTA scans.

Export to RiDB for AVEVA PDMS Plugin.

Changes:

LAS import: added support for point records 6, 7, 8, 9 and 10.

Detect and repair faulty camera calibrations of images acquired with a VZ-4000/6000 laser scanner.

Reading GNSS position from RXP file improved.

Update to latest RiVLIB and RiWaveLib versions.

Bugfixes:

Importing LAS files of format 1.2 (or higher) sometimes caused an error.

Importing LAS files containing point records with "extra bytes" failed.

3D view: Viewtype "Falsecolor - Plane" now read locks the reference plane to prevent unexpected modification.

Fixed bug in E57 export routine.

2012-12-19 Version 1.7.6

Features:

Create Plot: Choose between various compression formats for TIFF images.

Changes:

RiVLIB updated to "rivlib-1_26-x86-windows-vc100".

Bugfixes:

3D view: Fixed an OpenGL related error that occurred when running RiSCAN PRO on Windows within Parallels Desktop on Mac OS.

3D view: Fixed an access violation error that occurred under certain conditions when closing the 3D view.

Online Preview Viewtype settings were not applied correctly when "Amplitude" was selected.

Reading scanner position (user coordinates) from RXP files (V-Line Scanners) was sometimes inaccurate.

Positions and number of "Readout" windows was not stored correctly.

2012-10-15 Version 1.7.5

Bugfixes:

MTA Mover Tool does not process points of polydata objects any more.

Image tie points where not displayed correctly when image was rotated counter clock wise.

V-Line scanners: between scan and image acquisition the scanner does no longer go to park position.

Closing a 3D view sometimes caused an error message - fixed.

Deleting all 3D views caused and error message - fixed.

Opening a project caused error message ("Element content is invalid according to...") - fixed.

Japanese and Finnish language pack problems fixed.

Filter data: amplitude gate: wrong amplitude unit displayed in GUI.

Set scanner positions: automatic linkage suggestion for GLCS tie-/control-points did not work.

Changes:

New viewtype "MTA confidence" is available for scans acquired by MTA capable V-Line scanner now.

Selection tool can select points by "MTA confidence" value and "Red", "Green", "Blue" true color components now.

Plane patch filter: maximum cube size can be defined now.

Animation: added option "Polar projection" to generate panoramic videos.

Export polylines to DXF: when multiple polylines are exported to the same layer, then the user can specify the layer's name now.

Multi Station Adjustment: column captions for X, Y, Z, Roll, Pitch and Yaw are left aligned now.

Mounting Calibration Adjustment: user can deactivate unwanted tie points now.

Minor adoptions for RiVIEWER.

When exporting a point cloud in ASCII format, user can select to export polar coordinates always in SOCS (no matter which export coordinate system is selected).

Feature "Calculate volume & surface area" can calculate the area of an existing mesh now (mode "Use existing surface (meshes only)").

Coordinate Export Toolbar: Additionally export an auto-increment custom point id number and a custom comment.

Wizard 'Download and Convert': added an option to go to 'legacy mode' (i.e. select .rxp file instead of .riproject folder).

V-Line scan data import: added an option to ignore all points closer to the scanner than a specified value.

Viewer license key updated.

2012-07-24 Version 1.7.4

Features:

"MTA Mover" tool added that allows to manually move points to a different MTA zone (VZ-4000 instrument only).

Bugfixes:

When using "Combine with" on a polyline with option "Delete points surrounding polyline" activated, some points were not deleted.

2012-07-20 Version 1.7.3

Features:

Support for VZ-4000 instrument added.

User can manually define MTA zone (or range gate) for processing scans of MTA capable scanners (e.g. VZ-4000)

Bugfixes:

Fixed 3D view error "Invalid value" that occurred if program option "Maximize windows on opening" was not ticked.

3D view camera pick point was set wrong and data readout did not work correctly on some graphic cards.

Number of highlighted polyline segments are now displayed correctly in the 3D view.

Create plot: The DPI information is now stored properly in TIFF images.

Working with selected points from a Z-Line scan (Show LSQ-plane info, New object -> Plane -> from selected area, ...) caused an access violation.

Data acquisition with Z-Series showed warning message about time synchronization problems although the feature was deactivated.

Wizard Download and Convert: size of files greater than 2 GB was not displayed correctly.

Bug in OBJ mesh export concerning large coordinate values (GLCS) fixed.

Processing of large RXP files failed sometimes.

Changes:

3D view memory management improved.

ASCII export of polydata objects can export normal vectors of plane patches now.

Cleanup Wizard: added an option to delete ALL or EMPTY polydata objects.

Filter data: "Triangulate with icosahedron": added option to use the origin of the object's scan position as center point.

Wizard Download and Convert: added option to ignore monitoring scan files.

Function "Smooth and Decimate" can handle larger meshes (more points/triangles) now.

Finnish language pack updated

Japanese language pack added

2012-05-14 Version 1.7.2

Bugfixes:

Create plot produced empty images when plotting from a newly created view.

Function "Filter data" produced invalid PolyData objects in some cases (e.g. using "Plane Surface Filter").

3D view function "Create new polydata object" from selected points caused an access violation.

The program settings (open windows, toolbars,..) were lost when starting RiSCAN PRO for the first time after installation on some computers (especially on Windows 7).

Changes:

RiSCAN PRO download link updated in manual.

Added a dialog window that allows to edit the links (URLs) of online map providers.

2012-05-04 Version 1.7.1

Features:

Automatic breakline extraction

Export to ASTM E57 exchange data format

New view tool "Edit polyline" to edit polylines contained in polyline objects, section objects and polydata objects.

Create plot: Select "3D view camera" or a limited plane object as viewport source.

Create plot: Added support for the Tagged Image File Format (GTIF) in order to plot images with huge dimensions.

User can select default viewtype for online views of V-Line scans.

Finnish language pack added.

Bugfixes:

3D view caused an "out of memory" error when creating a new empty view and dropping scans into it.

Import Wizard: importing V Line scans did not copy the point cloud data base - solved.

Filter "Octree" did not work correctly when option "Merge points closer than" was activated - solved.

Radial symmetric lens distortion model importer: calculated camera calibration parameters were wrong - solved.

"Find corresponding points" found no (or a wrong) solution in some cases when only four point pairs were used.

Changes:

V-Line scan import: instrument type, serial number and measurement program are read from scan file and stored in project now.

Combine polyline or section with polydata allows to define a border/buffer zone surrounding the polylines in which all points will be deleted.

Geographic project location can be set in project settings now.

ASCII Import supports comma as decimal separator now.

Radial symmetric lens distortion model importer: added a function to import the lens distortion table from a CSV file.

V-Line scan import (conversion): support for high resolution scans improved and made progress bar more accurate.

3D View - Absolute Grid: The "Absolute Grid" grid lines are now aligned to the grid reference coordinate system.

Wizard "Download and convert": main and monitoring scans are no longer coupled - they can be imported separately now.

Chinese language pack updated.

2012-03-06 Version 1.7.0

Bugfixes:

"Plane Patch Filter" did not work with polydata objects - solved.

Some filters in "Filter Data" were not selectable - solved.

Functions "Create plot", "Save scene to image" and "Record animation" produced incomplete images (points missing) when processing big scans - solved.

Export of point clouds to LAS format did not work when the point coordinates had big numbers (e.g. WGS84 Cartesian, or UTM map projection) - solved.

Changes:

Object names where the first or last character is a space (blank) are no longer supported.

User can define point coordinate resolution for LAS export now.

2012-02-29 Version 1.6.9

Features:

Export of meshes to SURPAC dtm+str format added.

Bugfixes:

Bugs in "triangulation" and "smooth and decimate" functions using point clouds that also contain polylines fixed.

Loading V-Line scans in a 3D view did not work or was very slow in some cases (depending on scan size) - solved.

Resizing dialog windows on Windows Vista/7 did not work sometimes - fixed.

Changes:

Documentation of "Plane Patch Filter" updated.

Old "Plane Surface Filter" of previous program versions reactivated (new "Plane Patch Filter" is recommended though).

Default dynamic point divider mode for new 3D views changed to "Target frame rate" and a desired frame rate of 8 FPS.

2012-02-23 Version 1.6.8

Features:

Chinese (Simplified, Traditional) translation for graphical user interface added.

Changes:

Datamine software is no longer required to be installed when exporting points, meshes, lines to Datamine file formats.

2012-02-17 Version 1.6.7

Features:

New algorithm for extracting plane patches from point clouds (used for registration with the "Multi Station Adjustment" feature).

Export sections and polylines to a DATAMINE strings file.

Bugfixes:

Camera calibration task: image acquisition stopped after first image when camera was directly connected to computer (not via VZ-Scanner).

Number of selected tiepoints was not displayed correctly in 2D view.

Reflector scan settings "Oversizing" and "Overlapping" were not saved correctly in program options.

Multi Station Adjustment: Outlier threshold was not correctly applied to observations when "Use measured scan positions" was used.

Using "Filter" function directly after importing scans (3DD files only) did not work in some cases.

"Surface Comparison" function did not work with very small scans (3DD files only).

Export of polylines/sections/planes in DXF and TXT file format ignored selected range unit - fixed.

Function "Analyze" for V-Line scans did not work correctly in some cases.

Function "Smooth and Decimate": mesh color was not correct in "True Color" mode.

Changes:

Multi Station Adjustment: improved support for externally measured scanposition coordinates.

Performance of "Smooth and Decimate" function increased for meshes also containing polylines.

3D view: selection mode is automatically deactivated when "Terrain Filter" is started.

2012-01-13 Version 1.6.6

Bugfixes:

Bug in ASCII export settings dialog window concerning unit selection solved.

Bug in ASCII export of planes solved.

Object inspector: vector properties (position, direction,...) were not displayed correctly in some cases.

Volume calculation: suffixes "CUT" and "FILL" were missing in names of generated meshes.

Changes:

Vertical scroll position of data readout window is preserved when the window is resized now.

Scanning and analysis of big reflectors (> 0.4 m) improved.

Added support for V-Line waveform scanners (see program options: General > Data acquisition > Scan Data Mode).

2011-12-20 Version 1.6.5

Features:

"Multiple SOP export" writes name of scanposition into CSV file now (first column).

Support for external GNSS receivers connected to a V-Line scanner added (requires latest firmware).

Bugfixes:

ASCII export: "Custom" unit for amplitude values did not work as expected.

Bugfix concerning out of memory error during animation recording.

Changes:

Support for latest firmware version of VZ scanners added.

Retro reflective targets bigger than 0.4 m were ignored - now there is no limit.

Reflector position calculation for cylindrical retro reflective targets improved.

2011-11-11 Version 1.6.4

Features:

Function "Create plot" (3D view) can directly export images to a PDF documents now.

Bugfixes:

Bug in warning message about soon expiring maintenance contract solved.

Registration: automatic conversion from left- to right-handed coordinate systems did not work - solved.

OBJ export did produce wrong error messages when exporting textured meshes created with option "Keep untextured triangles".

Function "Set Scanner Positions" did not display list of tie points correctly when "TPL GLCS" was selected.

Layout of some resizeable windows was not correct on some Windows 7 computers - solved.

Function "Color from viewtype" did not work with viewtype "False color > Plane" - solved.

2011-09-26 Version 1.6.3

Features:

Polydata import: Import amplitude values from an ASCII file in dB.

Surface comparison: more color bars added.

Added adjustable Pressure units (mbar, mmHg, inHg) and Temperature units (°C, °F, K).

Added adjustable reference coordinate system for viewtype "Falsecolor - height".

Scan data cleanup function added (to definitely remove deleted points).

Added feature "Terrain filter" for automatic terrain point classification.

Export of point clouds and meshes in Datamine file format (Gdm) added (requires Datamine Software to be installed).

Export of polylines and sections in Surpac file format (Gstr) added.

Note: Datamine and Surpac format exports are still under development.

Changes:

Export of colored VZ-Scan: if option "Prune invalid points" is activated, points without color information are not exported now.

Bugfixes:

Point cloud ASCII export: point index ("ID") was not written correctly - solved.

Panorama images were not created correctly when images have been acquired across the 0/360 deg margin of the phi angle (scanner's head rotation).

Export of camera calibration to .cam file did not work - solved.

Delete multiple point objects in project manager.

2011-05-02 Version 1.6.2

Changes:

Function "New single image" for V-Line scanners supports to acquire images at phi angles greater 360 deg now.

Image acquisition: added switch to program options to allow camera to be triggered by software directly instead of V-line scanner.

Function to repair incomplete 3dd files extended by support for 3dd files produced by LPM-scanners.

Update to latest version of RiVLIB.

Bugfixes:

Rectangular scan area definition did not work in "New single scan" function for V-Line scanners.

Multi Station Adjustment: Calculation of remaining error (std.dev.) was wrong when tie points were used.

2011-04-08 Version 1.6.1

Features:

Added a tool to set the position of scan positions from points inside the TPL PRCS or GLCS.

Function "Tile Data": added option "Combine data". If disabled, each scan will be processed separately.

Function to repair incomplete 3dd files (because scan acquisition was aborted) added.

Changes:

Template for name of newly created scan positions can be defined in program options now.

Function "Tile Data": tile indices in result names are padded with zeros according to total number of rows or columns now.

Holding down [Shift] opens a scan in an existing 3D view instead of opening a new one.

User can select default coordinate system for new 3D views.

3D view: color of polydata objects can be set the same way as for scans now.

Minor improvements of "Automatic scan registration" feature for V-Line scanners.

Resample function can be started for multiple scans at once now.

Wavefront (OBJ) export: color mode "No color" re-enabled.

Manual definition of reflectors in 2D view of a V-Line scan stores amplitude and reflectance now.

Default value of "Min. points" in reflector search settings window set to 2 (for V-Line scans only).

Bugfixes:

Calculation of normal distance between a point and plane object did not work - solved.

2011-03-11 Version 1.6.0

Features:

Edge modeling: Use "Ctrl + Shift + Left Mouse Button" to directly add the clicked data point to the edge line without any modeling operation.

Multiple scan positions can be unregistered with a single click now.

Changes:

Function "Improve matrix" enhanced and made available for POP matrix.

Point cloud export supports LAS 1.3 (without waveforms) now.

Export of Tiepointlist: support for amplitude units [0..65535] and [dB] added.

Bugfixes:

Function "Preprocess 3DD" did not work when started for multiple scans at the same time.

2011-03-03 Version 1.5.9

Changes:

Robustness of RXP data decoding improved (for V-Line scanners).

Robustness of camera image download (when camera directly connected to computer) improved.

Automatic registration based on GPS, inclination sensors and compass (V-Line scanners only) improved.

Bugfixes:

Wizard 'Project Overview': Overview area was cut in one direction.

Mesh texturing function deleted some triangles without reason - fixed.

2011-02-18 Version 1.5.8

Features:

3D view camera allows to scale up/down each of PRCS X, Y, Z axes separately.

LSQ Sphere Estimation: Choose "New object > Sphere > From selected points..." in a 3D view to estimate a sphere object into selected points and automatically create a tiepoint at the sphere's center.

Changes:

Light source behavior in "Camera" mode improved.

Bugfixes:

Export of TPL PRCS, columns delta X, Y and Z did not work - solved.

Calculation of distances between tie-planes was wrong in some cases - fixed.

Download of HDR images (V-Line scanner only) did not work in all cases - fixed.

2011-01-28 Version 1.5.7

Changes:

Adjust shining direction of the 3D view light source. Choose either "mounted on camera" or select predefined directions such as "North", "North-West", ... or manually enter direction of light.

Tool to convert RXP files (V-Line scans) to 3DD files (old scan data format) added.

Bugfixes:

Add-on images (used for HDR image generation) are now downloaded by Wizard 'Download and Convert'.

Conversion of small V-line scans failed in some cases.

Export of polydata objects to LAS 1.2 with color information failed - solved.

2011-01-19 Version 1.5.6

Changes:

Export: Choose whether to export point "Reflectance as Intensity" or point "Amplitude as Intensity" for export formats LAS 1.1 and LAS 1.2.

User can cancel single threads now (instead of all at a time).

User can enter name of view port directly when saving the view port in the 3D view.

Option "Auto Save Project" added to program options ("Tool > Options > Additional > Project manager").

Option "Automatically register scans" (for V-Line only) added to program options ("Tool > Options > General > Data acquisition").

Octree-Filter: option "Merge points closer than ..." added.

Coordinate Export toolbar supports point export to AutoCAD 2011.

Register scan based on GPS, inclination sensor and compass: scans without GPS position are located at PRCS origin now.

User can define a "default" reflector calibration which is automatically selected for new tie points.

Support for V-line scanner feature to acquire digital photographs at multiple exposure times added ("HDR images").

V-line scanners only: reflector fine scans are repeated automatically in case of bad quality.

Bugfixes:

3D view: Fixed access violation when deleting points.

Project overview KMZ export: Latitude and Longitude where not displayed correctly on western or southern hemisphere.

"Scanner detected / not reachable" messages were displayed without reason - fixed.

V-line scanners only: scan conversion did not work if file path contained Chinese characters - fixed.

2010-10-18 Version 1.5.5

Features:

Scans, image and polydata objects can be imported from other projects by reference now instead of really copying files.

New feature "POP Matrix Store" in the project attributes window allows to manage multiple POP matrices in a single project.

Changes:

Reflector height is no longer applied to displayed reflector coordinates (but is still used in calculations).

Multi Station Adjustment: observation class "measured position" is no longer displayed in result statistics (histogram and std.deviation).

2010-10-12 Version 1.5.4

Changes:

Support for new V-Line scanner firmware added.

Viewer License Key updated (key in version 1.5.3 is invalid).

Bugfixes:

When closing a 3D view, it sometimes crashed - fixed.

Readout of GPS position of V-Line scans did not work in some cases.

2010-10-04 Version 1.5.3

Changes:

Tool "Coarse registration" can be used with 2D views of scans now.

Tool "Coarse registration" can be limited to calculate origin of scan position only now.

Improvements on pose extraction (position and orientation) from V-Line scans.

Tool "Backsighting Wizard" can use external GPS and internal compass and inclination sensors (V-Line only) now.

Bugfixes:

Bug concerning calculation of std. deviation when control points with rod heights were used fixed.

2010-09-08 Version 1.5.3b13

Features:

Filter "Reflectance gate" and filter "Deviation gate" added to "Filter data..." function.

Project overview can be exported to Google Earth KMZ file now (requires project registered to WGS84/GPS)

Changes:

View Inspector displays object coordinates and vectors (plane origin, plane normal, ...) in active view coordinate system (up to now only PRCS was possible).

Added option "Store Reflectance as Amplitude" to filter function.

Bugfixes:

Bug in visibility check of texture function solved.

Bugfix concerning data visualization of Organized Pointclouds (OPC) with viewtype Amplitude-Scaled, Falsecolor-Range, Height and Plane.

Minor bug fix in "Plane selection" window (box "below" was not locked or unlocked correctly).

3D view: Access violation during rendering fixed.

TPL PRCS was not correctly locked when "Find corresponding points" was started.

Animation: New button to close an animation path. Bugfix concerning moving and copying of poses in the pose list.

Fixed access violation when using Selection Tool in 3D view with VBOs enabled.

True color mode for export to 3PF files enabled again.

Bug in "Find reflectors" for images fixed.

2010-07-09 Version 1.5.3b12

Bugfixes:

Bug in function "Create geometry object > plane" in tie point list window solved.

Function "Image acquisition" did not work with VZ-1000 instruments.

Changes:

Support for new 3D data structure (version 2.2) of RiPROCESS added.

2010-07-05 Version 1.5.3b11

Bugfixes:

Bug in PTS export concerning coordinate systems fixed.

Minor bug fixes concerning data acquisition with V-Line scanners.

2010-06-25 Version 1.5.3b10

Changes:

Data export option "Prune invalid points" is enabled by default now.

Bugfixes:

Bug in "Find Corresponding Points" (causing to fail in some cases) solved.

Error "Division by zero" occurred in 3D view in some cases.

Coordinates of a polyline node were not updated correctly (in 3D, when using "Modify node").

2010-06-09 Version 1.5.3b9

Features:

Support for compressed data stream of V-Line-Scanners (RXP files) added.

Tool "Project Checker" for simple project error checking added.

Changes:

Dongle driver updated to Version 2010.05.05

Bugfixes:

ASCII export did not work correctly when options "Write header" and "Write number of points" were activated.

ASCII export did not correctly write reflectance values.

Scan data base structure was damaged by "Undelete points" function in some cases.

2010-05-31 Version 1.5.3b8

Bugfixes:

Serious bugfix: links (e.g. between tie points, images and camera calibrations,...) were not saved properly.

2010-05-28 Version 1.5.3b7

Bugfixes:

Buttons "Ok" and "Cancel" were missing in all "Wizard-style" windows.

Object view: Bugfix concerning point deletion.

2010-05-21 Version 1.5.3b6

Features:

Added an (optional) sound alert to the end of each task.

Changes:

Data import supports LAS format 1.2, records 2 and 3 now.

View windows are closed now when Wizard "Download and Convert" is started.

Point cloud export to LAS 1.1 and 1.2 improved.

TPL PRCS: Deviation to (optionally) linked GLCS point is displayed now (last three columns).

Documentation of "Tile Data" added.

Bugfixes:

Names of created sections were not correct.

GPS coordinate readout failed with VZ-400 scanners having new firmware.

Scan conversion failed when two or more scans where converted in parallel.

Wizard "Download and Convert": bug concerning instrument type selection list fixed.

Minor bugfix in "Multi Station Adjustment" window.

Manuals of V-Line scanners were not displayed.

Opening manually renamed projects caused creation of an empty folder with the old name of the project.

View type dialog: "Calculate minimum/maximum" failed in case of True Color view type.

Invisible points were displayed again after points have been deleted.

Bug in import and export of camera calibration from or to V-Line scanner solved.

Point cloud database (of VZ-400 scans): point time stamp removed.

2010-04-30 Version 1.5.3b5

Features:

Data export:

- Support for export format LAS 1.2 added (including color information).
- Export amplitude scaled or reflectance scaled to all export formats.
- Possibility to restore default export settings.

Changes:

Memory management improved using up to 3 GB RAM on 32 bit and up to 4 GB RAM on 64 bit operating systems.

Bugfixes:

Problems with names of projects or scanpositions containing blanks or umlauts when using VZ-400 solved.

2010-04-10 Version 1.5.3b4

Changes:

Image acquisition is limited to a maximum field-of-view of 360 deg now.

Added option "Keep uncolored points" to filter function.

Bugfixes:

Bug in panorama image generation concerning images acquired at 0/360° border of phi angle fixed.

Preview of scan was not updated after functions "Convert" and "Color from images".

Bug in select and delete points in 3D view fixed.

Bug in Import Wizard fixed (scan data base files were copied to wrong folder).

Bug in coordinate readout of 2D image with 3D scan overlay solved.

2010-03-29 Version 1.5.3b3

Changes:

Function "Show LSQ Plane Info" uses selected coordinate system of 3D view now.

Bugfixes:

"Set tiepoint height" ignored negative values.

Show LSQ - plane info: Histogram charts axis range problem fixed.

Image acquisition: Bugfix concerning faulty image download.

2010-03-18 Version 1.5.3b2

Features:

New features "Split mounting calibrations" and "Clone mounting".

Changes:

Download of images and scans from VZ-400 improved.

Camera mode of 3D view can be changed by clicking on the camera in the inspector now.

Changing the Grid mode of the 3D view can be done by pressing key [G] now.

Distance between reference points of function "Calculate SOP via inclination sensors" is displayed now.

Bugfixes:

Window "Scanner orientation" did not close correctly.

Bug in scan import dialogs concerning rxp files solved.

Scan description was not loaded and saved correctly.

Displaying attributes of a scan caused RiPROFILE to crash.

Defining detail scans based on overview scans did not work correctly in RiPROFILE.

Bug in image import solved (wrong camera- and mounting-calibrations were assigned in some cases).

Image acquisition: Acquire images with a phi stop angle greater then 360 deg is possible now.

Value editing in "New single scan" did not work correctly.

Reflector scans imported from VZ-400 were not displayed correctly.

Multi Station Adjustment crashed in case of too little observations

2010-03-05 Version 1.5.3b1

Features:

Coordinate export (Kubit pointcloud) supports AutoCAD 2010 now.

Changes:

PTS export: amplitude is exported now as -2047..+2048

Number of parallel running color-, filter-, resample- and convert-tasks is selectable now.

Support for new firmware version of VZ-400 added

Bugfixes:

Bugfix in defining point on surface.

Bugfix in function "Create new polydata object".

Coordinate system transformation was missing in POL file import.

3D view: delete points of VZ-400 scans caused hidden points to appear again.

Bug in panorama image generation solved (camera orientation was not applied correctly).

2009-12-02 Version 1.5.2

Features:

Tiepoints in the TPL SOCS can be filtered by point distance now.

Data acquisition V-Line: Automatically color scans after acquisition.

Data acquisition V-Line: Acquire scans out of an image.

Changes:

Function "Remove isolated points" can be used on multiple scans at the same time now.

Animation files (AVI) are split automatically when they exceed 2 GB.

Bugfixes:

Volume calculation: Access violation when saving project after volume calculation fixed.

2D View: Mouse interactions with the view are less sensitive now (Rectangle zoom, Context menu).

3D View: Bugfix when picking single points.

Function "Color from images" did not work when more than one scan was selected.

Reading the inclination sensor values from a VZ-400 scan did not work while the scan is open in a view.

Scaling correction parameters were accidentally locked in the project settings.

2D View: Bug concerning wrong plane position and orientation in viewtype "Falsecolor-Plane" fixed.

Bugfixes concerning VZ-400 image acquisition.

Color information was lost when a PolyData object was created from selected points in a 3D view.

2009-11-03 Version 1.5.1b18 (Beta)

Features:

Selection tool: Select reference coordinate system (Object CS or View CS) for selection. Progress information.

PTS export: Export V-Line reflectance as amplitude.

Wizard download and convert: Import reflector finescans from a V-Line scanner.

Changes:

Animation paths are stored in an auxiliary file now. This reduces the size of the project file and speeds up project loading and saving.

"Multiple rename" tool improved (added name prefix and suffix)

Function "Tile data" improved.

Bugfixes:

Starting two "Color from images" tasks at the same time did not work -> solved.

Problem in "color from images" leading to arbitrary "color rings" solved.

2009-10-02 Version 1.5.1b17 (Beta)

Features:

Object view: New "Selection tool" to select points by certain filter criteria such as Range, Reflectance, Deviation, ...

Export data as Cyclone Gpts and Gptx files.

Bugfixes:

Bugfix in LAS-Export function concerning PolyData objects only.

Bugfix concerning AutoCAD Gptc export in combination with setting "Amplitude as color".

Calculation of reflector center failed in case of cylindric reflectors scanned with a VZ-400.

2009-09-18 Version 1.5.1b16 (Beta)

Features:

Object view: Model edges, create tieobjects and measure volumes from V-Line scans now.

Changes:

LAS Export and Import: handling of big coordinates (e.g. GLCS) improved.

LAS Import function now also accepts files containing less points than specified in the file header (possibly damaged or truncated files).

ASCII export: Select a custom output unit for reflectance now.

Bugfixes:

Selection tool: Outside filter now works properly on V-Line scans.

2009-09-08 Version 1.5.1b15 (Beta)

Changes:

Improvements on memory management of filter type "2.5D raster".

2009-09-04 Version 1.5.1b14 (Beta)

Features:

Registration - Multiple SOP export... supports export of the position vector of one or multiple scan positions to one or multiple files.

Show tiepoint from all scanpositions within a V-Line 2D view now.

Added a tool to split scans into tiles of definable size.

Changes:

Color thread is more tolerant concerning image alignment errors now.

Create Animation: added an option to load and unload scans with every new frame (useable for monitoring scans of e.g. land slides, glaciers,...).

Added an option "Max. diameter" to reflector search tool.

Bugfixes:

Bug in "Plane surface filter" concerning scans with phi angles > 360 deg solved.

Bugfix concerning the 2D view when showing V-Line scans with phi angles bigger than 360 degree.

Mounting matrix was not applied correctly directly after import.

Create Animations with resolution higher than screen resolution: not all points were rendered -> fixed.

2009-07-16 Version 1.5.1b13 (Beta)

Features:

Temporary support for images acquired with mobile systems added.

Changes:

Tiepoints of TPL SOCS show a preview image in project manager now.

Bugfixes:

Preview image of colored scans did not show correct colors.

2009-07-10 Version 1.5.1b12 (Beta)

Changes:

Function "Analyze scans" shows logarithmic charts now.

Bugfixes:

Bug in download of photo thumbnails from VZ-400 solved.

2009-07-06 Version 1.5.1b11 (Beta)

Changes:

Function "Color from images" for V-Line scans works now also for "2D" and "Panorama" views.

Panorama view has a camera history now (bound to key "Backspace").

It's now possible to combine sections-objects with PolyData-objects.

Camera configuration (V-Line): Exposure in fractions. Bugfix of the graytone histogram.

Backsighting Wizard can now read inclination sensor values from V-Line scans (offline).

Wizards for V-Line scanners ("Download and Convert", "Import camera calibration", "Export camera calibration") use an other file transfer protocol now. This increases performance and stability of file up- and downloads.

Bugfixes:

Major bugfix within the 2D view of a scan. Scans with a scan pattern over 360° are displayed correctly now.

Minor bugfix within the edge-modelling tool in combination with the draw polyline tool.

Multi station adjusment: Weights for points or planes had a bad influence on the calculated remaining error (Std. deviation) - solved.

Reflectance of points was not calculated correctly in some cases.

Versions 1.5.1b9 and 1.5.1b10 are NOT published.

2009-06-09 Version 1.5.1b8 (Beta)

Changes:

Acquired images are automatically selected in the project manager.

Colored V-Line scans are marked with an separate icon now.

Bugfixes:

Fixed problems after an image acquisition within the CamCalibTask (refector column) window.

2009-05-28 Version 1.5.1b7 (Beta)

Changes:

Improvements of LAN and WLAN connections to V-Line scanners.

Bugfixes:

Bug in precise estimation of reflector position solved.

2009-05-13 Version 1.5.1b6 (Beta)

Features:

Calculate standard deviation of a selected area within a 2D view.

Color from images: New filter added - "Color only first and single targets"

Draw polylines within a VZ-Line 2D view now.

Extended ASCII export: Export amplitude values in the scale of "0..65535" now.

Camera configuration tool used to adjust lens aperture and exposure time of the camera mounted on a V-Line scanner added.

Show/hide pointcloud overlay in a 2D view.

The "Plane selection" tool works now with new data set.

Surface comparison tool can export calculated distances to an ASCII (text) file now.

Changes:

Program option: Select whether finescans should be automatically deleted from the scanner or not.

Minor improvements of wizard "Download and convert".

Image acquisition: Select whether to download and erase acquired images or not.

Surface comparison: Support for new data type added.

Improvements in the 2D visualization of V-Line scans.

Rectangle zoom within the 2D visualization of Z-Line scans.

Create sections: The value of the cutting plane is now added to the name of the section

Changed view type selection sheet.

Find corresponding points between TPL PRCS and TPL GLCS works like between TPL SOCS and TPL PRCS now.

Bugfixes:

Determine SOP matrix from scans with inclination values (offline) did not work -> solved.

Selected units (range, scale, color,...) where not properly saved in the program options.

"Color from images" for a scan showed strange rings in some cases.

Camera calibration was not correctly used in some cases.

Fine scanning of reflectors out of images did not work with VZ-400 scanners.

Housekeeping toolbar: Connection problems after changing the scanner's ip address fixed.

Export as ASCII failed in some cases.

Reflector type was not applied correctly on VZ-400 fine scans.

Import of V-Line scans did not read scan dimension and resolution.

Reflector finescan for VZ-Line scanner does not abort unexpectedly any more.

Bugfix in selecting data of textured polydata objects.

Filter functions did not preserve color information of V-Line scans.

Versions 1.5.1b1 through 1.5.1b5 are NOT published.

2009-03-24 Version 1.5.0 (Release)

Features:

Support for new instrument series "**V-Line**" (especially **VZ-400**) added. This includes:

- New 2D/3D and panoramic view
- Database structure for fast point cloud access
- New scan data acquisition window
- Improved reflector search
- Wizard for downloading and importing data from the V-Line scanner's internal storage
- Miscellaneous tools to configure the scanner

Undo/Redo function for the Edge modelling tool.

Add support for Canon EOS 5D.

New surface comparison algorithm added, which is based on normal distances.

Surface comparison: New color table added for better color contrast "Rainbow (cropped)"

Camera and mounting calibration import and export wizards added.

Added new tool to adjust aperture and exposure time of Nikon and Canon cameras.

Changes:

Points of polydata objects can be colored from images now (sub-function of "Filter data")

Matrix import/export functions support .4x4 files now.

Texture function: Visibility check improved

ASCII import function can now also handle Range, Theta and Phi values.

ASCII export function can now scale the intensity to -2047..+2048 and write the number of points exported

Camera model enhanced (can handle lenses up to 10mm focal length "Fisheye")

Scanpositions are numbered with three digits per default now (e.g. "ScanPos001" instead of "ScanPos01" in older versions)

Backsighting tool: "Instrument height" value is restored to last used value at startup now.

Tool "Inclination chart" is no longer available.

Bugfixes:

The viewtype property dialog automatically loads the last settings.

Bugfix: Import of partly textured OBJ files.

Tool "Image registration" now closes properly and does not cause an access violation during further propgram execution any more.

Negative geometric scaling correction values had a bad influence on the detection of invalid points -> solved.

Minor bug concerning display of current measurement program of LPM-321 solved.

Dialog "Current scanner configuration..." displays the property "Beam widening lens is activated" correctly now.

RiPROFILE only: when making a detail scan of a LPM-321 scan, the "measurement programs"-list is enabled now.

Bugfix of predefined views in 3D.

Resolve some problems with ATI graphic cards, when displaying polydata objects.

2008-07-03 Version 1.4.3 (Release)

Features:

Scans can be (optionally) saved to disk during data acquisition now.

In newly created projects the RLMS logo is automatically imported and displayed in object views.

Tool "Multiple COP export" added.

Memory management improved.

Bugfixes:

Edge modelling tool bugfix. The bug occured when modelling on data with an assigned SOP matrix.

Frozen POP and SOP matrices can not be changed any more.

2008-06-13 Version 1.4.3b15

Features:

Edge modelling tool for extracting edges and breaklines from raw point clouds.

Multi Station Adjustment plugin is now able to adjust the geometric correction value (ppm) of scan positions

Changes:

For RiPROFILE only: name of LPM-321 measurement program is stored in scan attributes now.

2008-06-04 Version 1.4.3b14

Bugfixes:

Bugfix in toolbar "Coordinate export". Coordinates from scan positions are exported correctly now.

2008-05-29 Version 1.4.3b13

Changes:

Settings of "Find reflectors" tool are saved and restored per instrument type now (this allows to have different settings for different instrument types).

Bugfixes:

Bug in inclination sensor chart for angles greater than 10 deg. solved.

2008-05-21 Version 1.4.3b12

Bugfixes:

Bug in reflector search fixed.

Bug in display of inclination sensors (Window "Scanner orientation") fixed.

2008-05-21 Version 1.4.3b11

Features:

Polyline: Functions "Subdevide..." and "Combine with..." added.

ASCII export: Export of DIP-angle and DIP-direction of meshes.

New toolbar "Coordinate export". Export single data points from a 2D/3D view to the Clipboard, an ASCII-File or AutoCAD 2004-2008 (Pointcloud or TachyCAD plugin from kubit GmbH needed).

Changes:

Smooth and decimate is now capable of handling polylines. Polylines will not be modified by this process.

Plane and polar triangulation improved (using graphic card for better performance and accuracy now).

Tool "Create Sections..." extended: you can define now where the first section should be created.

Bugfixes:

3D view: Function "Select all" (Ctrl + A) now selects only visible objects.

Bugfix in functions "Remove selected triangles" and "Remove selected polyline segments".

Bug in "Modify Position and Orientation" concerning direction of X axis solved.

Bug in "Plane Selection" concerning mode "Set visibility state" solved.

Bug in animation window solved: animations containing pose splitters where not loaded correctly.

3D view: Bugfix in viewtype "Truecolor - Logscaled". The deletion of data points led to a uniform white mesh - Bug fixed.

Bugfix in function "Create new polyline object". Defined polyline nodes can be modified correctly now.

Settings of "Texture..." dialog where not saved and restored correctly.

Bug in "Goto frame" function of 2D view of scan sequences solved.

Bugfix in function "Calculate volume & surface area..."

2008-04-16 Version 1.4.3b10

Features:

3D view in orthogonal mode: you can decide between a relative and an absolute grid overlay now.

Changes:

3D view: default views (like top view, bottom view,...) take currently selected coordinate system into account now.

2008-04-07 Version 1.4.3b9

Features:

Added a function to create plots out of 3D views (in orthogonal mode).

Changes:

Volume calculation extended (mode 4).

Bugfixes:

Solved bug in Backsighting Wizard concerning left handed global coordinate systems.

Bug in export of normal vectors of meshes in ASCII format solved.

Solved bug in Backsighting Wizard concerning inclination sensors.

2008-03-13 Version 1.4.3b8

Changes:

Added support for instrument type Z620

Three new modes added to 2.5D filter: "True average", "True minimum" and "True maximum"

Bugfixes:

Bug in inclination chart solved (display of values of new inclination sensors was wrong)

Bug in loading/displaying scans in 3D view solved. In some cases this bug caused program crashes.

2008-02-19 Version 1.4.3b7

Features:

The triangulation tool (plane- polar- triangulation) is now capable of using polylines for mesh generation. Polylines that are visible in the view can be included into the triangulation. Their shape will appear unchanged in the resulting mesh.

Changes:

Activated state of tie points is not applied to all linked tie points anymore.

Bugfixes:

Own position of already registered scan positions was not displayed correctly in the backsighting wizard.

Solved bug in import wizard concerning deleted objects.

Bug in interactive movement/rotation of orthophotos solved.

Solved bug in connection tool (settings were not saved correctly).

Solved bug in inclination chart (it hung up directly after data acquisition)

2008-01-14 Version 1.4.3b6

Bugfixes:

Bug in Multi Station Adjustment fixed: Externally measured coordinates of scan positions where not used correctly.

Bug in Backsighting Wizard fixed: "Set SOP" did not work properly when the POP matrix was not the identity matrix.

2007-12-20 Version 1.4.3b5

Features:

Support for instruments with new inclination sensors added.

Changes:

For LPM-321 (RiPROFILE) only: User can modify parameters of measurment program now.

2007-11-30 Version 1.4.3b4

Features:

Display of estimated remaining scan time added.

Bugfixes:

Bug in backsighting function concerning left handed GLCS solved.

2007-11-12 Version 1.4.3b3

Features:

Scan sequence play back added.

2007-10-23 Version 1.4.3b2

Changes:

Acquisition licenses can be bound to an USB-Dongle now.

Recording or simulation of an animation is not compatible with walk mode of view, so the walk mode is turned off automatically now on start.

Bugfixes:

RiPROFILE: Bug in read out of instrument settings in the "New single scan..." window solved.

Bug in Inclination Chart solved (did not support scan cache files).

2007-10-04 Version 1.4.3b1

Features:

Multi Station Adjustment: Added 3D view of orientation of planes (tieobjects).

Changes:

Navigation information added to 2D/3D view and Multi Station Adjustment window.

GPS recorder enhanced (data string reader is less restrictive now).

Parameters for CityGRID Ortho plugin can be saved now.

2007-09-21 Version 1.4.2

Features:

The maximum tilt angle of the scanner during a scan process that leads to a warning is now adjustable in the program options (only available with optional inclination sensors).

Bugfixes:

Minor bugfixes and changes of license model.

Bugfix in the "Load user defined" and "Save user defined" functions of the the scan patterns (scan acquisition window).

2007-09-14 Version 1.4.2b8

Bugfixes:

Minor bugfixes and changes of license model.

2007-09-07 Version 1.4.2b7

Changes:

Changes to license key management (Import and Export to files is possible now).

Link tiepoints per Drag & Drop: You can directly link SOCS tiepoints together now.

You can export meshes as ASCII files now. In that case the center and normal vector of each triangle is exported.

RiSCAN PRO can open RiPROFILE projects (and vice versa) now.

Changes on license model (maintenance contract).

Image acquisition is not stopped when size of image can not be read from file now. RAW and NEF files (raw images) will be accepted but not processed.

Bugfixes:

Bugs in volume calculation window solved.

2007-07-12 Version 1.4.2b6

Changes:

Multi Station Adjustment extended: Detailed residue information is displayed after analysis or adjustment now.

Export "Scans" and "Polydata objects" as Glas (LAS FORMAT VERSION 1.1) files.

2007-06-15 Version 1.4.2b5

Features:

Backsighting function: Any scan can be used to read inclination sensor values from.

Scan acquisition: New parameter "Blur limit" added (please refer to instrument's manual)

Scan acquisition: New parameter "Measurement program" added (depends on instrument type).

Scan position preview added.

Toolbar for monitoring the houskeeping data of the scanner (supply voltage and temperature) added.

Tool "Image registration" added.

Changes:

Fullscreen viewer: Added a switch to program settings to allow usage of current instead of custom display mode.

Volume calculation extended: Volume can be limited by a polyline now.

Volume calculation extended: Cut and Fill volume between two surfaces can be calculated now.

Tool "Scanner search" improved.

Bugfixes:

Bug in display of GLCS coordinate axis in object view solved.

2007-03-21 Version 1.4.2b4

Changes:

Support for instrument LMS-Z390i added.

Bugfixes:

Bug in calculation of POP shift in Backsighting function solved.

Bugfix in color bar.

Version 1.4.2b3 - skipped (internal test version)

2007-02-21 Version 1.4.2b2

Features:

New function added for surface comparison.

Changes:

Object view: You can watch the animation path via a time line now.

Speed up "OBJ" file import.

Object view: New parameter for plane triangulation (Minimum triangle angle).

Triangulation algorithm improved.

Volume calculation improved.

Bugfixes:

Bug in polar triangulation concerning parameter "Max. angle" solved

Bug in filter function solved: Range gate was not correctly applied to polydata objects.

2007-01-17 Version 1.4.2b1

Features:

Function for finding outlines of meshes added.

Extraction of outer surface of closed meshes implemented.

New filter "Polar Triangulation" implemented.

Changes:

Animation: You can (have to) choose the "focal length" and the "scene scale" of the camera.

"Create new polydata/Filter data" accept section objects as input now.

Object view: It's possible now to change the properties of multiple objects, when the view attributes are edited (closed view).

Object view: New options for orthophoto visualisation (Scale, Load points, divider)

Object view: New triangulation parameters for polar triangulation (Center point, watertight)

New resample parameter added: Average theta/phi

When importing DXF files as section objects the name of the DXF file is now used as prefix for the section's name

Bugfixes:

Image acquisition task: The warning "Instrument head moved" was wrongly displayed in some cases.

Bug in license manager fixed.

CleanUpWizard: If more than one criteria was true, the object was added to the list several times.

Object view: The radius was not set correctly when creating a sphere object.

Precision of DXF and ASCII export of geometry objects improved.

Object view: The angle limits were set wrong in triangulation mode.

Object view: The custom viewport was not assigned correctly.

2006-11-10 Version 1.4.1

Changes:

TieObjects extended and import function added

SDW import: timestamp added

Bugfixes:

Bug in Import Threads fixed: Points were first transformed to proper coordinate system and then converted to meters

Bug in "find corresponding points" fixed: modes "by name" and "by link" did not work as expected

2006-11-09 Version 1.4.0

Changes:

"Color from viewtype" now supports all viewtypes.

Improvements on lincense model

Tiltmount: Removing the link to an other scanposition preserves the SOP matrix now.

Bugfixes:

Bugfix in octree filter: Octree resolution was twice of defined resolution.

When a project was closed when more than 1 view (2D) was opened, we got an access violation when opening a project and a view again [fixed]

2006-10-09 Version 1.3.0

Features:

Tool "License table" added.

Bugfixes:

Bugfix: Export of scan/polydata.

Bug in color coding of polydata objects fixed.

2006-09-29 Version 1.2.1b30

Changes:

New license model implemented.

2006-09-25 Version 1.2.1b29

Features:

New triangulation method for polydata objects: Polar triangulation.

New volume calculation method implemented.

Changes:

Registration based on inclination sensors extended.

Bugfixes:

Bug concerning all viewtypes that use intensity solved.

Colorbar min/max problem fixed.

2006-09-13 Version 1.2.1b28

Changes:

The image acquisition function saves and restores start angle, stop angle and overlapping factor values now.

Bugfixes:

Bug in filter thread fixed (points with large coordinates were deleted).

2006-08-09 Version 1.2.1b27

Features:

Support for new instrument LMS Z390 added.

Bugfixes:

Data import: Import process hang up when importing DXF as Polylines/Sections.

Bug in octree filter fixed (the result resolution was two times selected resolution).

Version 1.2.1b26 - skipped

2006-06-14 Version 1.2.1b25

Features:

It's now possible to color a scan/polydata with a new color defined by a view type.

Object view: New measerment function "Point - Plane"

Changes:

Image acquisition error message extended (in case when communication with scanner failed)

Modification of license model: licenses bound to USB dongles are not valid to acquire scan data anymore.

Bugfixes:

2.5D raster filter: The output data was wrong calculated when the "combine" flag was activated.

2006-05-30 Version 1.2.1b24

Features:

You can choose "filter data..." now for multi selection.

You can import SDW files now.

Changes:

You can activate triangulation now when using the "2.5D Raster" filter option.

You can select multiple input files now when you import data as polydata object.

Support for instruments Z210ii and Z210ii HT added.

Bugfixes:

Las file import failed, when importing as project polydata object.

Bug in Multi Station Adjustment fixed: Polydata objects of deactivated scanpositions where also used.

2006-05-12 Version 1.2.1b23

Features:

Object view: You can select data by a 3D polyline now.

You can display a color bar for falsecolor and intensity coloring now.

Changes:

Project images can be used to color scans now.

Object view: You can change the texture filter mode of an overlay item now.

Bugfixes:

Bug in "Save as..." function of project saved (some files where not found).

Bug in import of textured polydata files (index.pvtp) solved.

Bug in LicenseManager concerning HMSA licenses solved (Licenses were marked as invalid although they are valid).

2006-04-26 Version 1.2.1b22

Features:

New viewtypes added: "Falsecolor plane" and "Falsecolor plane intensity".

Added "custom camera" for image acquisition.

Object view: New grid overlay -> Rule

You can define image masks which can be used for texuring later (plugin CityGRID Ortho only).

Changes:

Also undistorted images can be used to color scans now.

Object view - Create new tiepoint: "Make controlpoint" property added (when PRCS tiepoint).

Registration of project images: Check of input parameters added.

Object view: You can select now how the forward/backward movement is performed (move along direction).

Program settings: Option "Use texture compression" moved to page "3D settings > General settings".

Bugfixes:

Object view crashed when an animation was defined while the walk mode was activated.

Textured state of polydata objects in an object view was not saved correctly.

Function "Tool > Scanner configuration" did not work.

Object View: Detailed readout of coordinates did not work when the view contained unloaded objects.

Timestamp information of scansequences was not read correctly.

Correction parameters (PPM) were applied to already corrected scans.

Cursor keys did not work as expected in and after full screen mode.

Object view: The animation crashed when simulation with object and close the action window.

The object view crashed when opening an organized point cloud without having a data file.

2006-03-22 Version 1.2.1b21

Features:

Added support for Rollei AIC digital camera.

Changes:

Temperature check failed if the parameter was unknown.

Bugfixes:

When watching the attributes of a scan, the "OK" button did not work properly.

Draw polyline and selection mode in 2D did not work properly in some cases.

2006-03-17 Version 1.2.1b20

Features:

Object view: You can display now the connection lines between a scan position and all tiepoints within this positon.

You can select the display settings for the fullscreen mode.

Object view: You can display now the simulated laser ray from a defined scan position to a valid data point.

You can now acquire data at one step: Scan -> Image acquisition -> Color scan from images

The temperature of the device will be checked now before data acquisition.

Changes:

You can import now the texture information from a POL file (if available).

Camera calibration based on reflector column: More detailed statistical information available now. Statistic can be saved to file now.

Tiepointscan: The tiepoints are ordered according to the current scanner position for fine scanning.

New picture transfer mode for Canon cameras.

Bugfixes:

Resample of scansequences with unknown frame count failed when option "Last target" was activated.

Object view and Data Readout Window: Bug concerning coordinate readout in PRCS fixed.

Drawing polylines in images of linked scanpositions (tiltmount calibration) did not work.

When filtering a scan with the "Create organized point cloud" filter the splat size was not calculated correctly.

Display of organized point cloud crashed when a required extension of the graphic card was not available

Camera calibration based on reflector column: Dialog did not close before "Cancel" was pressed two times.

Bug in Multi Station Adjustment concerning SOCS tiepoints with coordinates 0/0/0 fixed.

TPL window: Bug in calculation of standard deviation fixed (value was not correct after Multi Station Adjustment).

Bug in export of objects (planes, polylines,...) solved: Transformation to target coordinate system was not done correctly.

Bug in export as dxf fixed. Scans where not exported correctly.

Bug in dxf import fixed: Symbol of imported polydata point cloud was not correct.

Bug in plane estimation fixed (SOP matrices with big translational part caused wrong plane origin)

Bug in tiepoint display of images fixed: Program crashed when no camera or mounting calibration was assigned to the image.

Scan processing (such as resample, color, ...) caused program to crash when the scan was already opened in a 2D view.

Bug in Multi Station Adjustment fixed. SOCS tiepoints having a link to controlpoints caused error message during step "Remove outliers..."

2006-02-16 Version 1.2.1b19

Features:

Object view: Added "Max. divider" paramter in program options.

Added "Organized point cloud" object. This is an octree based point cloud renderer.

Object view: It is now possible to load/unload data of some objects without adding/removing them from the view.

Object view: Added "Use hardware acceleration" paramter in program options.

Changes:

Scanpositions where the flag "registered" is not set can be used for the Multi Station Adjustment now.

Multi Station Adjustment: Usage state of polydata objects is saved to project file now

Delete all objects definitely via trash window works faster now.

Create Orthophoto: The plane can be moved now by holding down one of the arrow buttons (action will be repeated until the button is released).

Multi Station Adjustment: Table of scanpositions redesigned in order to get smaller window size.

Bugfixes:

Installed program RiSYNC GPS was not correctly recognized

Installed plugin ORIENT was not correctly recognized

Bug in PTC export fixed: color and intensity are now scaled from 0..255

Bug in DXF export fixed: points of polydata objects where not exported correctly.

Bug in Multi Station Adjustment fixed: Deactivated polydata objects where used anyway.

Bug in scan naming function fixed: Prefix "BeamWidening_" was sometimes appended to scans of instruments which do not have a beam widening lens.

Object view: Some default values were not set correct.

Some scanparameters (such as "Scan Mode" and "Beamfocus") where not correctly initialized

Bug in image tiepoint attributes solved: modifications of the v coordinate were rejected.

Bug in SOP attributes solved: matrix was not correctly displayed when the scanposition was linked to an other scanposition (using a tiltmount calibration).

Bug in color and resample functions fixed: In some cases points with high range values (>1000m) were deleted.

2006-01-31 Version 1.2.1b18

Features:

Plugin "Multi Station Adjustment" for overall registration improvement based on tiepoints and surface data added.

Changes:

"New scansequence": User can decide whether the instrument should be stopped after data acquisition or not (when continous mode is selected, RiSCAN PRO only).

Bugfixes:

Bug in "Close holes" fixed: It's now possible to define plane points in freeform and rectangle selection mode

Bug concerning special characters (like ü, ö, ä) in TPL and TOL windows solved

Access violation when opening a TPL fixed

Image Browser did only display images having a camera and a mounting calibration. Now all images are displayed.

Closing the project was allowed while big files where imported. This caused program errors at the end of the copy procedure.

Selection mode in "Close holes" now works with rotated scans too

2006-01-26 Version 1.2.1b17

Changes:

Objectview: "Selection tools" and "Plane selection mode" can be used parallel now.

You can define animation "breakpoints" now

You can modify the properties of all objects that are within an object view without opening the view (click with right mouse button onto the object view item in the project manager).

Function "Close holes": It's now possible to make multiple selections with different parameters (plane, options)

Project folders "SCANPOSIMAGES", "TIEPOINTSCANS", "PROFILESCANS", "UNDISTORTED IMAGES" and "POLYDATA" are not optional anymore (the are always displayed in the project manager now).

Bugfixes:

Bug in create cross sections solved

The columns of the COP matrix were not displayed properly.

Bug in function "Close holes" fixed: It now also works when the scan is rotated

2006-01-18 Version 1.2.1b16

Features:

You can register now different scan positions via manually defined point pairs.

Export: It's now possible to export to PTC format (PointCloud for AutoCAD) too

Object view: You can now change visiblitiy/selection state by defining a plane and some parameters (Plane selection mode).

Object view: New option for dynamic divider added (Target frame rate).

Object view: Frames per second (FPS) and current divider are displayed in the status bar now.

Changes:

Object view: You can now add multiple images to the selected overlay at once.

Object view: The overlay item was not removed, when the corresponding image was deleted.

Function "Preprocess 3DD" improved.

Display of intensity in data readout window modified (unit "0..255" only)

When no reflector in a finescan was found a proper warning is displayed now.

Import threads improved: needed transformation matrix is calculated only once now (higher performance).

When TPL PRCS is registered onto TPL GLCS all linked PRCS tiepoints become controlpoints automatically.

Display of rotation angles Roll, Pitch and Yaw added for POP matrix.

Function "Close holes": option "Modify only points behind plane" added

Bugfixes:

Loading scan data from cache caused program chrash some times.

Bug in reflector calibration attributes fixed (wrong parameters where displayed).

Objectview: The color of the data was not updated after deleting some points.

Function for manual tiepoint definition in a 2D scan view did not use selected range unit (instead always [m] was used).

Some unit conversion problems fixed.

Bug in project image registration fixed: links to SOCS tiepoints were not properly evaluated

When object views were deleted the program crashed when the project was closed.

2005-12-22 Version 1.2.1b15

Changes:

Display of timestamp: Precision raised to 5 digits.

Bugfixes:

Online view: Timestamp data was not loaded correctly during data acquisition.

2005-12-22 Version 1.2.1b14

Features:

2D view: function "Draw polyline" added.

Object view: You can modify point objects now.

Object view: It's now possible to use a texture compression for polydata objects (Set in program settings)

Object view: The texture is disabled now in single color mode.

Changes:

Object view: Actions can be cancelled by pressing the ESC key now.

Object view: Change "Save screenshot" to "Save scene to image"
Following features can be set now:
- Pixel size
- Resolution (DPI)
- Real size

VRML export: You can export now also point cloud data (Scans, Polydata)

Plane create modes now take the current camera up vector as template for the plane up vector.

Some technical information added to bug report (and support email).

Support for extended raw data format implemented (Parameter ID 7.1)

Function "Close holes":
- It's now possible to close more holes simultaneously
- It's now possible to use parallel or user-defined planes for this function

Draw polyline in 2D: Shortcut for deleting all polyline nodes is now SHIFT + right mouse button

Bugfixes:

Select viewtype: When pressing "Calculate minimium/maximum" the program was hang up if the object was locked.

Polydata object: Normal vectors were used, although they were not available.

Inclination chart: Handling of scans containing no valid inclination information was not correct.

Object inspector: Docking problem fixed.

Smooth and decimate: Mode "Default settings" was not working because of missing file.

Camera calibration task "reflector column": Preparation of camera calibration was not started. Not prepared camera calibrations may have problems with the border area of images.

Bug in function "Cleanup and zip project" fixed: project is now saved before zipping

Bug in object inspector fixed: Right click on a distance objects caused error message

DXF Export (OBJECTS):
- The file extension is set correct now.
- The selected unit is saved and loaded now.
- An info is shown, when some objects could not be exported.

Las files can be imported now.

Object view: Hardware acceleration is used for creating images and animations.

Object view: Point/Tiepoint name was not updated during creation.

Bug in cleanup-wizard fixed: Convert-Exception on "delete undistorted images" was thrown

Cleanup wizard: "Delete empty folders" now only deletes non-project folders

2005-11-29 Version 1.2.1b13

Features:

It's now possible to define the camera position and orientation via two points in the object view.

Changes:

Cleanup wizard: function "Delete empty folders" added

Error messages include system error messages now (more informative)

The SOP matrix is now also represented by the rotational angles Roll, Pitch and Yaw.

Viewtypes "Falsecolor - Height" and "Falsecolor- Height - Int" for scans in 3D view are loaded faster now.

It's now possible to color a scan that is already colored (color from images).

Also SOCS tiepoints can be used to register project images now.

Bugfixes:

Image browser: Sometimes yellow planes were displayed instead of the real image

Image browser caused program crash when project or program was closed.

Wrong units were displayed for values "Phi resolution" and "Theta resolution" in the program options

Object inspector: When selecting the root node "OBJECTS" an access violation occured.

Some functions using a TCP/IP connection were unable to connect to the instrument

2005-11-17 Version 1.2.1b12

Features:

Tieobjects can be displayed now in object view.

Changes:

Function "Close holes": It's now possible to use an existing plane instead of calculating it from selection

You can now select a "color mode" for the OBJ export. (None, RGB, Intensity)

Improve DXF import for polylines/sections

You can now select the color mode (No Color, Truecolor, Intensity as color) for export in formats OBJ, POL, PLY and WRL.

You can now import POL and DXF files containing polygons. The polygons are splitted into triangles on import.

Menu "?" renamed to "Help ?"

Behaviour of "Activated" flag of tiepoints modified: This property is inherited from the linked tiepoint. If there's no link the value of this property is saved directly.

Bugfixes:

"Default Desktop Bug" after installation fixed.

When starting more than one undistorting thread, the main program was blocked.

Objectview: The default parameter for the "Grid overlay" was not used.

Objectview: New walk mode.

Bug in Launch.exe fixed: You can now open projects with blanks in file path

Open scan in 2D view while an other window was opened caused error message

ASCII Export: Coordinates where not formated correctly. Format precision is limited to 18 digits now.

Calculation of translation of of POP matrix: Backsighting function worked different than function of TPL GLCS window -> now both functions have a limit of 10000 meters.

2005-10-27 Version 1.2.1b11

Features:

DXF import/export improved and enhanced.
New:
- Polydata import
- Point object export
- Point object import
- Plane import
- Polyline import
- Section import

New shortcuts for object inspector.

- Strg + 1 ... Change lock state
- Strg + 2 ... Change visible state
- Strg + 3 ... Change color mode

Object view: The position object (scanner) will be highlighted when it is selected in the object inspector.

It's now possible to display point clouds (scans and polydata containing points) in an image

Project cleanup wizard added

2D View of a scan: function "Close holes" added.

Changes:

OpenGL min/max values (pointsize, linewidth, ...) are read out from GL context.

Window resize of objectview window is now disabled when selection mode is active.

Texture in PRCS: Visibility check of triangles can now be deactivated (higher processing speed)

ObjectView: Add "Show caption" property for point object

ObjectView: Add new cursors for selection mode.

Bugfixes:

Trash bug solved (links were not removed properly)

TPL Window: "Delete All": Wrong message was shown.

The viewtype min/max values are now displayed correct.

Bug in Launch.exe fixed: 2nd line of all entries is shown now correctly.

Bug in filter operation fixed: point filter was not processed

3D view: Function "Create new polydata object" did not take all data of the source objects.

Modifications of scans or polydata objects (like resample, color, filter,...) while the objects are displayed in 3D caused program crash.

Better logging of error messages

2005-09-29 Version 1.2.1b10

Features:

Object view: You can now define image overlays (COLLECTIONS/OVERLAYS).

Add ability to change normals of triangulated polydata objects.

Smooth and decimate: Added support for ini-files. You can smooth & decimate a polydata with predefined settings now with one single click.

It's now possible to define coordinates (actions started from an object view) by "Drag & Drop" some objects into the input fields.

Changes:

launch tool (for RiScan Pro and RiProfile) added

ASCII Export: Precision limited to 18 digits

Create new project: default values set to TCP: 192.168.0.234

Support for scans containing only one line improved

.rsp project files and project folders are now associated to the launch tool launch.exe

Data acquisition timeout removed (but user is still able to cancel the task at any time).

The scan modes "bidirectional" and "unidirectional" can be selected for "New single scan..." now.

Desktop Manager for loading and saving desktop settings added

3dd preprocessor (for rastering and interpolation) added

New modify orientation and position tool for objectview.

Context menu of scan: menu entries rearranged for better clarity

Function "Send support email..." added to "?" menu

Export functions extended: Now able to export all objects to GLCS too

Bugfixes:

Object view: Save screenshot problem fixed.

Name collision problems with file import (scan, images) fixed

Object view: The axes were displayed wrong in GLCS mode.

Missing registry entry needed for CityGRID Ortho added

Problem with image filter select box in image browser solved

Unlock of workstation while RiSCAN PRO/RiPROFILE is running caused error message.

Scanner connection tool was not properly working on Windows 2000

2005-09-12 Version 1.2.1b9

Changes:

Undistort of multiple project images is now possible

Bugfixes:

Some files (concerning CityGRID Ortho and USB Dongle) where missing in the setup

Version numbers of plugins where not correct

2005-09-09 Version 1.2.1b8

Features:

2D View: Tiepoint display (IMAGE, SOCS, PRCS, GLCS, Hide) can now be switched on/off via shortcuts (CTRL+0,CTRL+1,...)

2D View and Objectinspector: The shortcut CTRL+ENTER locates the displayed image/scan or the selected object in the project manager

You can drag and drop any TPL on a 2D view now (lists are managed by tiepointdisplay)

Tool added which allows to calculate the orientation of images which where taken while the camera was mounted on the instrument.

Fullscreen view of 2D-view implemented

Changes:

Info of Image: Number of tiepoints added

Memory statistics: Support for physical memory > 2GB added

After createing a scanposition the project will be saved now

License manager is now able to handle licenses for plugins too

Parameter "Reflector constant" for reflector type "Disc" reactivated.

Navigation 3D: Walk mode added.

Bugfixes:

Some serious bugs in Trash and Trash Window fixed

Bug in Function "Create polydata..." of a plane object solved. The parameters where not editable.

Bug in image import fixed

Bug in calculation of dimension information of large point clouds/meshes fixed

Bug in delete function of objects fixed

Update-bug in object inspector fixed

If unable to display the axes in the objectview, they are disabled

2005-08-02 Version 1.2.1b7

Features:

You can modify now also sphere and cylinder objects within the object view.

Changes:

New methods to define a sphere object:
- From center point + radius
- From center point + point on surface

- From two points on surface

Finescan image tiepoints: The window size is now two times reflector size

Bugfixes:

Move tiepoint to trash: Bug in linkage system fixed

2005-07-26 Version 1.2.1b6

Features:

Check RiPort settings after create/open a project and in project settings.

Double click an avi file opens the internal media player now. You can also use the standard program.

Creating animation files: You can integrate them directly into the project structure now.

New function: "Determine frame count" for scan sequences with undefined frame count.

New buttons in 2D view for scan sequences: "Goto frame" and "Last frame"

You can take a photo now directly from an image or a scan by holding down the "I" key down and clicking with the left mouse button in the 2D view of a photo/scan.

You can create a polydata from a sphere object.

Image browser: You can choose wheter you want to see the original image with a scale factor or the thumbnail of that image.

You can create a polydata from a cylinder object.

Multiple rename tool added

Bugfixes:

Object inspector: when changing XYZ values, the numbers behind the decimal point have been truncated.

2005-07-14 Version 1.2.1b5:

New features:

The distance of a "distance object" is displayed now direct within an object view.

You can create/edit cylinder objects now (project manager).

You can now define a plane object from 3 points.

Corner information of plane object is displayed now in info window.

Bug fixes:

Problem with camera plugin concerning CANON cameras solved.

2005-07-08 Version 1.2.1b4:

New features:

Acoustical feedback at the end of data acquisition added.

Viewtype dialog: Calc min and max values of color added.

Create new folder: The new folder will be selected automatically now.

DXF export: Also triangles can be exported now.

Changes:

Filter process is more stable and needs less memory now.

Objectview: Pointsize/Linewidth is displayed as floating point number (real number) now.

Help: F1 in dialogs modified.

Bug fixes:

Open project via doubleclick: Bug "InvalidOperation" fixed

Objectview - New point/tiepoint: Update button is working now.

Bug in repeated finescan fixed: newly estimated size was not used

2005-07-01 Version 1.2.1b3:

New features:

View 2D: You can modify the range gate and height gate via mousewheel and keys "R" and "H" now.

Data acquisition error handling enforced

OBJ import added

Color scale unit added: 0..1, 0..255, 0..65535

Raw color information panel added to the readout window

Image navigator added to 2D view

Bug fixes:

Bug in triangulate function solved: Polydata was not deleted correctly when the thread was cancelled

2005-06-23 Version 1.2.0:

New features:

Triangulation of arbitrary point clouds added

Create cross sections added

Object handling in object inspector improved

Object view: zoom with mouse wheel added

Image browser added

"Add clean polydata function (OP_CLEAN). This function removes duplicated points and unused points. If a polydata has only points, you can specify a tolerance."

Add 3D text to object view. You can see now the name of the scanposition right of the scanner object.

Add a position object in the object view. You can handle scanpostions separately now.

Add a new info window for info text.

Calculate SOP via inclination sensors implemented

Tiepointlist: Added function "Create polyline"

Tiepointlist: Added function "Create plane"

Tiepointlist: Added function "Create Center of gravity"

Add point object to "Geometry objects".

Intersection between a polyline (with 2 points) and a plane object ---> Result: Point object, automatically added to the object view.

Add STL import.

Object view: select object with key "S" and mouse click

Object view: increase and decrease navigation speed with keys "A" and "D"

Backsight: This function is now able to use the inclination sensors by extracting the inclination values from a finescan. For that the user selects a tiepoint (with a tiepointscan).

Chart to analyse the inclination values gained by the scanner

Object view: Added 2D grid in orthomode

Delete points from scan implemented (in object view)

Objectview: fullscreen mode added

Export of planes as DXF is now possible

Planes: Display if DIP Dir und DIP Angle added

Planes: Export as ASCII und DXF

Image acquisition: Instrument position before and after image acquisition is compared now -> warning!

Locked property of objects in an objectview will now be saved.

Added volume calculation

Add tiepoints to objectview.

Support for ParamID 7.0 added

Project manager: shortcut [CTRL]+[ENTER] added: Locate file/folder in windows explorer

Project manager: shortcut [ALT]+[ENTER] added: Show file/folder attributes dialog of windows

File size included into information of scans and imags

Add ability to change axes display settings for the objectview to the options.

You can now define point/tiepoint objects within the objectview. You can also measure point coordinates.

You can change now the viewtype of multiple objects in the objectview at once.

PanoramaThread redesigned

Trash can added. Objects will be moved to the trash can than deleted permanently (configureable).

Import of any files (documents) added

Aerial views added (airborne orthophotos)

Changes:

ImportFunctions deactivated when only the viewer-license is installed

The objectview is now able to view also jpg orthophotos

Old 3D view replaced by object view

Import/Export functions now offer range-unit-selection

Buttons 2D->3D and 3D->2D reactivated

Backsight: User can now select a TP GLCS as Own- and Targetposition

Behaviour of image selection box (Color from images) changed: The box will automatically scroll to the first selected item.

SOP & Linked positions (tiltmount): SOPs can NOT be imported/modified when the scanposition is linked to an other scanposition now.

Behaviour of Tiltmount attributes changed: If positions use the TiltMount you can not edit the it but display it's values.

Change render algorithm.

Object inspector: Remove separate "Position" - page and move it to objects.

Assignment of reflector types: The vector of a disc will now point to the scanposition.

Display of StdDev is now also functional for TPL PRCS

Matrix compare: Display more digits

Support for instrument Z360I_NF added

COP, SOP, POP: Translation is now displayed in selected range unit

Change display of axes in objectview.

ObjectView: Switching between perspective and orthogonal view mode improved.

Create Orthophoto: This modul can now also take PRCS polydata as input.

Animation: Add plane object in arc mode to visulise the arc.

2D view: Right mouse click to open the context menu is now more movement tolerant. (3 pixel radius)

A detailscan from an other scan now uses the raw coordinates for the angle readout

DXF export: Layer will now get his name from the corresponding object (only when "use separate layers" is checked)

Associate 3DD and 3PF disabled

New about box and splash screen added

RiSCAN PRO can now also be licensed onto a USB Dongle

Enlarged number of recently opened projects to 9

CTRL+A for TPL activated

ImageBrowser now memorizes it's settings (Registry)

xOP imports/exports in the selected range unit now

Objectview: When pressing "Shift" + DefaultView-button (eg. Bird's eye view) the distance from the camera to the pickpoint is the same.

UDA import now takes care of the selected unit (program settings)

New toolbars for objectview added: - New object - Measure

UI of filter propertysheet will now be saved/loaded.

Pressing "I" and click with the left mouse button into an objectview will display some information of the point closest to the line of sight in the "info window"

Bugfixes:

New single scans: Display of values is now common.

project.dtd: camcalibtask_freeimages: imageGwas missing

Upgrade of mesh: Error message "Can not rename ..." fixed

Bug fixed: Camera calibration free images failed when a lot of images where used

PLY and VRML exports improved

Error message "TraceStart" when the program was started several times simultanous solved.

Bug in TP's link and backlink system fixed

Bug in desktop-settings of Objectinspector fixed

Bug in TPL import fixed: Names will be imported correctly now.

Bug in TP link system concerning the trash solved

TPL2: GSI-Import modified: Now RTP is checked first

TPL2 import: Identical name bug fixed

Bug in tiepoint attributes solved: All values have been saved when User hits [OK]. Now only modified values are saved

Bug in import of scanpositions fixed.

Bug in tiepoint attributes solved (Name wasn't saved on Init)

Bug in Resample thread fixed (result was not saved)

TPL2: Bug in "Create plane" fixed: Up vector was not correct

Bug in finescan of image TP fixed (name collision)

convert union view bug fixed

Cancel bug fixed

Find reflectors is now more tolerant in "Use TPL SOCS" mode (Reflector size < 0.05m is set to 0.05)

Bug in triangulate dialog fixed: Some checkboxes were disabled

Objectview: After SOP update the cooresponding scanposition in the view was not updated.

Bug in project load fixed: Wrong project.dtd was used!

Bug in SOP Wizard concerning inclination sensors fixed.

Bug in color thread fixed: Wrong camera calibration was used when more than two images with different calibrations were used.

Bug in filter procedure fixed

Bug in ZOP attributes solved: The rotational part of the ZOP matrix was not displayed correctly - it was transposed

Bug in project.dtd concerning camera calibration task chessboard fixed.

project.rsp: "project.dtd" replaced by "./project.dtd", because the parser was not able to find the project.dtd file.

project.dtd problem fixed

Bug in TiepointDisplay fixed

Bug in ASCII import dialogs of polydata and tiepoints fixed: Column association was not correctly loaded from presets.

Bug in online view of scansequence fixed

TPL: Bug in StdDev calculation fixed (wrong values for links to TP GLCS)

Render: Problem with dynamic devider > 1 fixed

Bug in TP naming solved

ASCII Import improved

Bug in TPL import fixed: Empty lines caused errors.

Modify object: The rotation axis is not also updated.

scan acquisition: performance problems solved.

Bug in scan thread concerning inclination values and cache fixed.

TPL some update problems fixed

Bug in volume thread fixed: Question "Use all" was wrong evaluated

Fix problem when scan parameters was saved permanent.

ObjectView: Fix bug when defining a point in orthomode.

Improve triangulation in objectview.

Fix bug - Volumsberechnung: No points left for volume calculation.

Bug in CamCalibTaskScandataPropertySheet fixed: Wrong/No MountCalib was used

TPL PRCS: After registration to TPL GLCS the linked TP PRCS will NOT be modified anymore.

Improve rectangle filter in object view. Points behind the viewing camera was also selected.

Bug in Frame2D "Add point to TPL" fixed

OpenGL extensions for axes rendering are now checked during initialization of an objectview. If extensions are not available a warning will be displayed.

Bug in RiSCAN PRO startup fixed -> Doubleclick on rsp files produced some stange errors

2004-06-04 Version 1.1.1:

Changes:

Object view replaces UnionView

Object "Polydata" replaces "point cloud" (3PF is only supported as export and import format)

New/Improved data export functions: ASCII, 3PF, DXF-Points, 3DD with SOP, POL, OBJ, VRML, PLY, STL

New/improved data import functions: ASCII, 3PF, POL (as polydata)

Filterfunctions added (Rangegate, Intensitygate, Octree, Pointfilter); result is a "Polydata" object.

Wizard for a initial camera-calibration added.

Datareadout redesigned.

Usage of tiltmounts implemented

Hybrid Multi Station Adjustment (without using images) added

Image acquisition: pause implemented before the taking the image (user input - see options)

When an image is taken, it is checked if it has the same dimension as the selected camera calibration.

Now its possible to define a new scan from an single image (at the same position)

Added scanner control ("Tool"->"Scanner control")

Now its possible to rename the project folder (project.name is changed on opening the project)

Connection of camera is no saved to project (not program options)

Bug fixes:

Bug in Drag&Drop a TPL into a FormView solved (wrong display)

Reflector extraction based on TPL SOCS caused error when more images where selected and at least one image had it's TPL displayed.

When resampling a scan the threshold was ignored.

Bug in viewtypes fixed (intensity=0 was handled as invalid measurement)

Orient (HMSA) message window caused crash on saving [fixed]

Import CamCalib_OpenCV bug fixed

Some improvements on the registration

Some improvements on the camera server and camera client

2003-11-28 Version 1.1.0:

Changes:

Backsight-capability added

New camera-calibration based on reflector column added

New option for ASCII-Export added: ACI (AutoCAD-Color-Index).

Creation of orhtophotos (with depth-information)

Re-design of registration procedure

Bug fixes:

some general bug-fixes

2003-09-12 Version 1.0.2b30:

Changes:

The default coordinate system for the DataReadout is now PRCS!

Unionview-property-sheet redesigned

Font for "Message list" can be selected now (Options dialog)

Support for Z420I added

Added support for the Canon Powershot G3 and the Canon EOS-1 Ds.

Added a resample routine for single scans.

Added an ASCII export for single scans and point cloud

Added an Crystalix export for single scans and point cloud

Added the possibility to select several markers/tiepoints with a rectangle (Frame2D).

Two (selected) tiepoints of a 2D-view can now be linked (->context-menu) without showing the tiepointlist

UDA-Import added

Tiepointlist redesigned

"Find corresponding points:" added the possibility to clear the link (=results) before this process.

"Auto linker..." function added to Frame2D (automatical-link of a TP IMAGE and TP SOCS)

ZOP (Orthophoto) Export added

Bug-fixes:

Within the finescan of a reflector the reflector-constant was lost.

Selected TPs in a 2D-view where not allways selected in the tiepointlist

"Save as" function did not work correctly with Camera Calibration Tasks.

When use 2D filters in a view, the file reference was not set.

If during an image acquisition an error occurs, the thread got frozzen.

The export-functions of a scan/point cloud are also available now when the project is readonly.

The button "scan reflectors" in a 2D-View was shown for images also (now only for scans)!

Bug in UDA-Import fixed (to bottom-right cell of the SOP matrix was set to zero instead of 1)

The calculation of the preview image scale factor was wrong.

The calculation of the Frame2D image scale factor is wrong.

Re- Adjustment of mounting-calibration displayed (and used) to much tiepoints (also tiepoints of images, which have an other mounting-calibration assigned).

Bug in Wizard according the camera settings solved

When the attributes of an image were displayed a camera- and mounting-calibration were selected, although no calibration was assigned.

Bug in "Image acquisition" - PropertySheet: Cancel during SN-Check failed.

Bug in ReflectorCalibration W,H and D of a CUBE were not properly saved.

2003-05-30 Version 1.0.2b9:

Changes:

Added a legend panel for the unionview. Enables fast show/hide and coloring of a point cloud.

Added a new panel "Distance" to the "Readout"-window. The reference point can be set with key "D" and left mouse button in a 3D view.

Re-adjustment of mounting-matrix implemented

Position of the marker-labels can now be changed (top, middle, bottom, left, center, right). This provides better readability (two markers at same place...).

Added the scansequence functionality. Now you can acquire a series of scans. You can also calculate the average of the scansequence and convert them to one single scan.

Added a wizard: Wizard "Startup" - this will be called after the setup or by menu "?"

Add 2D filters to the 3D-view, unionview and point cloud-view. There are three filter methods: rectangle, circle and polyline. You can also invert the selection and undo the last filter action.

Readout-window: GLCS for Unionview added

The settings of the unionview propertysheet will now be saved in the project file.

Camera calibration based on flat check pattern added.

Undo function for all OP (SOP, POP, COP) added

Bug-fixes:

BoundingBox calculation was not correct, when creating a colored scan ("Color from images...").

Initial values of the 3D-view and the union-view was not set correct (e.g. "Show bounding box").

There were some navigation problems in the 3D-view and the union-view. This should now work correct.

Displaying TPL (PRCS) in 2D images of scan data raised error messages sometimes.

field of view of camera was calculated incorrectly in some cases.

Made the csv-import (TPL) more robust concerning text where no text should be.

The TPs of a SCAN were not correctly displayed when the scan-image was rotateted by 90° or 270°. Everything worked normal with 0° and 180°.

Hang-ups during "Find reflectors" twice on a scan solved.

Bug in extraction range selection during the image-reflector extraction. (when the image was rotated) solved.

Saving projects on japanese operating systems didn't work

2003-04-25 Version 1.0.1:

Bug-fixes:

Onlineview during scan hung up

Bug in file-naming convention

Selecting "Find Reflectors" when the corresponding scan was already opened caused RiSCAN PRO to hang up.

2003-04-16 Version 1.0.0:

Initial version

Index

- 2 -

- 3 -

- A -

- B -

- C -

- D -

- E -

- F -

- G -

- H -

- O -

- P -

- R -

- S -

- T -

- U -

- V -

- W -

- Y -

- Z -