TerraPhoto User's Guide

--- for the 32-bit version of TerraPhoto ---

Terrasolid Ltd *08.07.2016*

Trademarks

MicroStation®, MDL® and MicroStation stylized "M" are registered trademarks of Bentley Systems, Incorporated. Bentley Map PowerView, MicroStation PowerDraft, and MicroStation GeoOutlook are trademarks of Bentley Systems, Incorporated.

TerraBore, TerraGas, TerraLink, TerraMatch, TerraModeler, TerraPark, TerraPhoto, TerraPipe, TerraScan, TerraSlave, TerraStereo, TerraStreet, and TerraSurvey are trademarks of Terrasolid Limited.

Windows is a trademark of Microsoft Corporation.

Acrobat Reader is a trademark of Adobe Systems Incorporated.

OSTN02 is a trademark of Ordnance Survey, the national mapping agency of Great Britain.

Intergraph Raster File Formats - Copyright - 1994 Intergraph Corporation. Used with permission.

Copyright

Ordnance Survey®

OSTN02™ enabled

Table of Contents

Getting Started

1 Documentation ... 12
About the documentation ... 12
Accessing the documentation ... 12
Document conventions ... 12
MicroStation documentation ... 12

2 Introduction to TerraPhoto ... 13
Introduction ... 13
Terra application family ... 14

3 Installation ... 15
Hardware and software requirements ... 15
Installation media ... 15
Installation from zip file ... 16
Installation from CD/USB-Stick ... 16

4 Starting TerraPhoto ... 18
Starting TerraPhoto ... 18
Unloading TerraPhoto ... 19

Visualization Options

5 Viewing Images ... 21
Georeferenced raster files ... 21
Design file coordinate system ... 22
Top views ... 23
Fitting a view to show the location of the raster images ... 24

6 Creating Rendered Views and Movies ... 25
Rendered Views ... 25
Rotated Views ... 25
Camera Views ... 27
TerraPhoto Rendering ... 28
Flythru Movies ... 31
Definition of a camera path ... 31
Definition of target vectors ... 32
Creation of frames or movies ... 34
Creation of movies from frames ... 36

Project Workflow

7 Project Workflow Examples ... 39
Airborne orthorectification projects ... 39
Minimum effort project strategy ... 40
Maximum effort project strategy ... 41
Mobile system projects ... 42
Creating orthophotos and colored point clouds ... 42

Deriving TerraMatch correction values from images 43

8 Mission Setup 44

Mission directory structure 44
Camera calibration file 44
Mission definition 44
Image list 45
Thumbnails 45

9 Camera Calibration 46

TerraPhoto camera calibration parameters 46
Camera parameter groups 46
Starting values from scratch 49
TerraPhoto camera dialog 50
File / Open 53
File / Save 53
File / Save as 53
Tools / Solve parameters 54
Tools / Convert from 55
Tools / Import Mitsubishi cameras 57
Tools / Convert to 58
Tools / Assign poor polygons 59
Tools / Assign bad polygons 60
Airborne camera calibration 61
Calibration site 61
Flight pattern 61
Calibration workflow 62
Mobile camera calibration 64
Calibration site 64
Drive pattern 64
Calibration workflow 64

10 Color corrections 67

Define color corrections dialog 67
Display 69
Select by 70
Show and identify selected images 70
Color corrections 71
Changing the tie status of images 74
Changing the rectify status of images 75
Changing the quality value of images 75

11 Working with Tie Points 76

Tie point concepts 76
Tie point entry windows 77
Tie point types 78
Tie point values 78
Tie point distribution 79
Tie status 79
Tie point entry modes 80
File pulldown menu 81
New 82
Open 82
Save 82
Save As 82
Import known points 82

Import known lines ... 83
Recompute all ... 85
Output report ... 86
Draw pixel distribution ... 89
Draw residual vectors ... 90
Search points ... 91
Fix ground to air ... 93
Clean all ... 93
Renumber images ... 94
Image pulldown menu ... 95
Show active ... 96
Identify active ... 96
Identify secondary ... 96
Point pulldown menu ... 97
Add ground ... 98
Add air ... 99
Add depth ... 100
Add known depth ... 101
Add known xyz ... 102
Add known xy ... 103
Add line ... 104
Add known line ... 105
Add straight line ... 106
Edit information ... 107
Clean ... 107
Delete ... 108
Pixel pulldown menu ... 110
Enter position ... 111
Identify in image ... 111
Delete ... 111
Find worst ... 112
Find first bad ... 112
Find next bad ... 112
Filter bad ... 113
View pulldown menu ... 114
Setup ... 115
Save as default ... 116
Detail zoom ... 116
Fields ... 117

12 Improving Image Positioning ... 118

Adjust Camera Parameters ... 119
Airborne projects ... 119
Mobile ground-based projects ... 119
Adjust image positions ... 120
Airborne projects ... 120
Mobile ground-based projects ... 120
Ground Control Points ... 121
Airborne projects ... 121
Mobile ground-based projects ... 123

13 Color Points and Selection Shapes ... 124

Concept ... 124
Color points ... 124
Selection shapes ... 125

File pulldown menu 127
New 128
Open 128
Save 128
Save As 128
Recompute all 128
Search points 129
Filter bad 132
Renumber images 133
Point pulldown menu 134
Add 135
Add clones 136
Edit 137
Delete 139
Find worst 140
Find first bad 140
Find next bad 141
Equalize inside fence 142
Image pulldown menu 143
Assign selection polygons 144
Assign quality polygons 145
Assign smearing polygons 146
Assign shadow polygons 147
Paint selection 148
Place selection 149
Search seamlines 151
Update from design 151
View pulldown menu 152
Display mode 153
Zoom to 155
Show coverage 155
Correction points 156
Tool pulldown menu 157
Draw seamlines into design 158
Transform selection shapes 160
Derive image corrections 161

14 Orthophoto Production 162

Settings for quick orthophotos 162
Settings for final orthophotos 163

Tool Reference

15 Toolbox tools 165

TerraPhoto Settings 165
Coordinate transformations / Builtin projection systems 166
Coordinate transformations / Transformations 167
Coordinate transformations / US State Planes 173
Coordinate transformations / User projection systems 174
Reference images / Default visibility 176
Reference images / Raster references 176
Tie points / Automation 176
Tie points / Display 177
Tie points / Entry 177
Video / Display 178

Video / Misalignment ... 178
Angle systems ... 179
Attitude computation ... 180
Color points ... 180
Define Color Corrections ... 180
ECW compression ... 180
Exterior orientation formats ... 181
Histogram adjustment ... 182
Laser points ... 182
Memory usage ... 183
Mobile rectification ... 183
Operation ... 183
Selection shapes ... 184
TFW and JGW files ... 184
Tile naming schemes ... 185
Trajectory formats ... 186
General tool box ... 187
Settings ... 188
Define Coordinate Setup ... 189
Define Camera ... 191
Manage Raster References ... 192
Set References By View ... 192
Set Reference ... 192
Convert Raster Files ... 193
Manage Camera Trajectories ... 195
Display Video ... 196
About TerraPhoto ... 198
Help On TerraPhoto ... 198
Render tool box ... 199
Define Rendering Settings ... 200
Display Rendered View ... 201
Save Rendered View ... 202
Create Flythru Movie ... 204
Build Movie From Frames ... 206
Place Rpc Tree ... 207
Fix Building Normals ... 208
Change Texture Image ... 209
Export City Model ... 210
Color Points tool box ... 212
Add Color Point ... 213
Add Clone Color Points ... 213
Edit Color Point ... 213
Delete Color Point ... 213
Paint Selection Shape ... 213
Place Selection Shape ... 213
Change Image Rectify Setting ... 214
Tile tool box ... 215
Place Tile ... 216
Place Tile Array ... 216
Move Tile ... 216

16 Main Window Menu Commands ... 217

Mission pulldown menu ... 217
New mission ... 218
Open mission ... 221
Edit mission ... 221
Save mission ... 221

Save mission As ... 221
Import Lynx Survey ... 222
Import Pictometry Survey ... 223
Exit ... 224
Points pulldown menu ... 225
Load from TerraScan ... 226
Load from file ... 226
Images pulldown menu ... 227
Load list ... 228
Compute list ... 229
Close list ... 232
Save list ... 232
Save list As ... 232
Define color corrections ... 233
Transform positions ... 235
Adjust to geoid ... 236
Convert angles ... 237
Convert time stamps ... 238
Define tie points ... 239
Adjust positions ... 240
Add ... 243
Edit ... 244
Delete / Selected images ... 245
Delete / By camera ... 245
Delete / Inactive images ... 246
Delete / Closeby images ... 246
Delete / Overlapping images ... 247
Delete / Inside fence ... 248
Delete / Outside fence ... 248
Delete / Outside ground ... 249
Delete / Non-tower images ... 250
Delete / Missing file images ... 251
Rectify pulldown menu ... 252
Define color points ... 253
Place tile array ... 256
Rectify mosaic ... 259
Rectify wall rasters ... 262
View pulldown menu ... 264
Minimal dialog ... 265
Small dialog ... 265
Large dialog ... 265
Fields ... 266
Sort images ... 267
Create camera view ... 268
Remove camera view ... 270
Fit view ... 270
Utility pulldown menu ... 271
Draw footprints ... 272
Draw projections ... 274
Analyze images ... 274
Adjust images ... 275
Assign groups ... 277
Deduce line numbers ... 278
Create thumbnails ... 279
Compute depth maps ... 280
Compute shadow maps ... 282
Export orientation ... 283

Transfer images 284
Rectify images 285
Adjust image angles..... 287
View images 288
Settings 290
Help pulldown menu..... 291
Help / Contents 291

17 Manage Trajectories 292

TerraPhoto Trajectories window..... 292
File pulldown menu 293
Set directory..... 294
Import files 295
Import directory..... 297
Merge from GPS and INS 297
Import accuracy files 298
Trajectory pulldown menu..... 299
Edit information..... 300
Set accuracy..... 302
Delete..... 302
View positions 303
Display pulldown menu 304
Verticle video 304
Forward video..... 304
View pulldown menu..... 305
Small dialog..... 305
Large dialog..... 305
Sort..... 305
Fields 306
Tools pulldown menu 307
Split..... 308
Transform 309
Adjust to geoid..... 310
Convert angles 311
Convert time stamps 312
Draw into design..... 313

18 Commands for Raster References 315

Manage Raster References window..... 315
File pulldown menu 316
Attach files..... 316
Attach directory 317
Attach list..... 317
Save list As 317
Save list to design 318
Create thumbnails..... 318
Detach / Selected 319
Detach / Inside fence 319
Detach / Outside fence..... 319
Detach / All..... 319
Edit pulldown menu..... 320
Modify attachment..... 321
Enter position..... 323
Transform positions..... 323
Display pulldown menu 324
Fit..... 324

Zoom to 324
Send to back 325
Bring to front 325
Send backward 325
Bring forward 325
View pulldown menu 326
Small dialog 326
Medium dialog 326
Large dialog 326
Fields 327
Utility pulldown menu 328
Retile images 329
Create roof materials 331
Convert references 333

Programming Interface

19 MDL Public Functions 335
Calling Method 336
Structure definitions 337
Function prototypes 338

20 File formats 343
Mission file format 343
Image list file format 344
Camera calibration file format 345

Additional Information

21 Technical Details 347
Rotation Computation 347

22 Installation Directories 348

23 Configuration Variables 349

Getting Started

1 Documentation

About the documentation

This document serves as a user's guide for two 32-bit versions of TerraPhoto. The entry-level version, TerraPhoto Lite, is functionally a subset of the full version, TerraPhoto. Tools available in TerraPhoto and TerraPhoto Lite work identically in the two versions. Tools that are not available in TerraPhoto Lite are marked as "*Not Lite*" in the documentation.

This User's Guide is divided into several parts:

- **Getting Started** - general information about TerraPhoto and instructions on how to install and run the application.
- **Visualization Options** - information about viewing raster images in the background and a description of the creation of rendered views and flythru movies.
- **Project Workflow** - general advice on steps to take when processing a project.
- **Tool Reference** - detailed descriptions of the tools and menu commands in TerraPhoto main toolbox and main window.
- **Programming Interface** - a list of public functions as well as a description of file formats.
- **Additional Information** - information about the installation configuration.

Accessing the documentation

The documentation is accessible as an Acrobat Reader PDF document which serves the role of online help. Accessing the electronic format of the documentation has the following advantages:

- You can conduct automated searches for keywords in topic names or body text.
- You can click hypertext to "jump" to related topics.

Document conventions

The following conventions and symbols appear in this guide:

- **Data click** - click on the data mouse button, usually the left button on a right-hand mouse.
- **Reset click** - click on the reset mouse button, usually the right button on a right-hand mouse.
- **< >** - angle brackets used for keybord keys, for example, <Return>.
- **Key in** - type a command in the key-in line of MicroStation and then press <Return>.
- **OR** - alternate procedures or steps in a procedure.
- **C:/TERRA** - paths to directories of files on a hard disk are written with capital letters.
- Icons used to introduce special information:

Icon:	Appears next to:
✍	Notes and Hints
➢	Procedures

- When no distinction between MicroStation versions is necessary, this document refers to the CAD environment simply as "MicroStation".

MicroStation documentation

This document is written under the assumption that the reader knows how to use basic MicroStation features. You should refer to the printed documentation or online help of MicroStation whenever you need information about using the CAD environment.

2 Introduction to TerraPhoto

Introduction

TerraPhoto is widely used for the production of orthorectified images from airborne imagery. It is specifically written for handling images taken during a laser scanning mission and using the laser data for an accurate ground model. The complete orthorectification process can be performed without having any known points at the site. However, known points can be used to improve the absolute accuracy of the image positions.

TerraPhoto's approach to orthorectification is simple and accurate. The rectification routine has the following advantages:

- Straightforward workflow which directly creates a mosaic of orthorectified rasters.
- Triangulated laser ground model follows all terrain features accurately. The software computes an elevation value for each pixel in the ortho image.
- Automatic smoothing of color transitions between images as well as several correction methods for color issues in the raw images.

TerraPhoto can further create wall textures automatically from oblique images taken during a flight. The 3D building models required for wall texture rectification have to be available as design file elements in MicroStation. They can be produced, for example, by TerraScan building vectorization tools.

Images from mobile systems can be used to calibrate multiple-camera systems, to improve the positioning of the images from several cameras of a system, to rectify images on the ground surface, and to create source data for coloring MLS point clouds.

TerraPhoto can serve as an application for displaying raster images in the background of MicroStation views. The supported file formats include ECW, GeoTIFF, TIFF, BMP, CIT, COT, RLE, PIC, PCX, GIF, JPG, JP2, and PNG raster files. Furthermore, the software is able to produce rendered views and images, as well as fly-through movies. It can also be used to display videos that are taken during a flight or drive session and assigned to the trajectory files.

TerraPhoto is fully integrated with MicroStation. The CAD environment provides a huge number of useful tools and capabilities in the areas of view manipulation, visualization, vector element placement, labeling, and plotting.

TerraPhoto Lite

TerraPhoto Lite is a light version of TerraPhoto and provides a subset of the functionality of the full version. It can be used to display raster images in the background. It supports all the same raster formats and can convert raster files between some of the formats. It is also able to create rendered views and images.

TerraPhoto Lite provides all the necessary tools for color balancing and for seamline editing as preparations steps for ortho mosaic creation. It does not include the orthorectification tools.

Terra application family

Terrasolid developes a full family of civil engineering applications. Almost all Terra applications are tightly integrated with MicroStation presenting an easy-to-use graphical interface to the user.

TerraBore is a solution for reading in, editing, storing and displaying bore hole data. You can triangulate soil layers with the help of TerraModeler.

TerraMatch fixes mismatches between laser points from different data strips automatically. It can be used for the calibration of a laser scanner system and for fixing project data.

TerraModeler creates terrain surface models by triangulation. You can create models of ground, soil layers, or design surfaces. Models can be created based on survey data, graphical elements, laser data, or XYZ text files.

TerraPhoto rectifies digital photographs taken during laser scanning survey flights and produces rectified ortho images.

TerraPipe is used for designing underground pipes. It gives you powerful tools for designing networks of drainage, sewer, potable water, or irrigation pipes.

TerraScan processes laser scanning data. It reads in laser points from text or binary files and lets you view the point cloud three dimensionally, classify the data, and create vector data based on the points.

TerraSlave is a stand-alone application that processes TerraScan macros. It enables distributed processing and scheduling tasks to gain optimal time and working performance.

TerraStereo is a stand-alone application for viewing very large point clouds in mono and stereo mode. It utilizes advanced point rendering techniques and the graphics card memory in order to display huge amounts of points.

TerraStreet is an application for street design. It includes all the terrain modeling capabilities of TerraModeler. The street design process starts with the creation of horizontal and vertical geometries for street alignments.

TerraSurvey reads in traditional survey data and creates a three dimensional survey drawing. The application recognizes a number of survey data formats automatically.

3 Installation

Hardware and software requirements

TerraPhoto is built on top of MicroStation. You must have a computer system capable of running this CAD software.

To run TerraPhoto, you must have the following:

- Pentium or higher processor
- Windows 8, 7, Vista, XP, or 2000 (64-bit version recommended)
- mouse
- 1024*768 resolution display or better
- 512 MB RAM or better
- MicroStation V8, MicroStation V8i (Select Series 2 or higher) or Map PowerView. Check Terrasolid's web pages for a more detailed overview of compatible MicroStation versions.

Installation of TerraPhoto requires about 2 MB of free hard disk space.

Installation media

TerraPhoto may be delivered on a CD/USB-Stick or as a zip file.

A **zip package** only contains the actual software - it does not include the PDF User's Guide.

A **Terra Installation CD/USB-Stick** includes the software and the online documentation. When you install from the CD/USB-Stick, the software and the documentation are copied to your hard disk. The CD/USB-Stick may include versions for multiple environments. You should locate the directory which corresponds to your operating system and MicroStation version.

Directory on CD/USB	For operating system	For MicroStation
\setup\eng	Windows	V8 or V8i

Installation from zip file

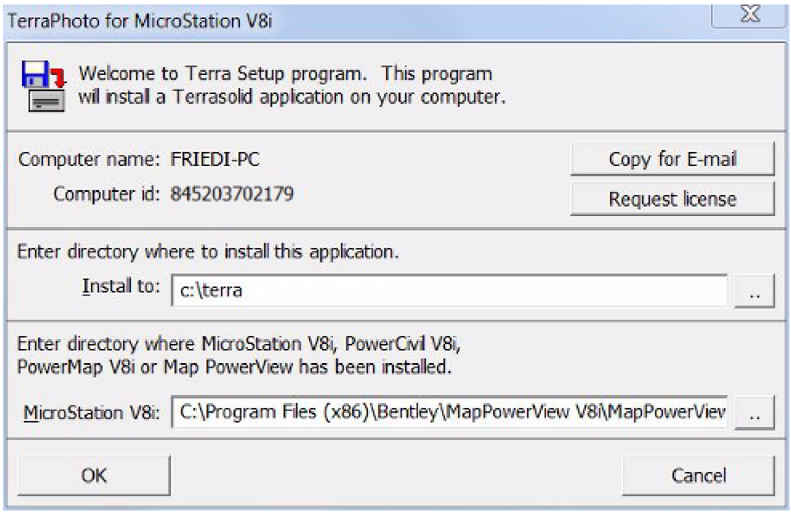
➢ **To install TerraPhoto from a zip file:**

1. Unpack the zip archive with any zip file manager.
2. Start **SETUP.EXE** which is part of the zip archive.

   This may open a dialog confirming the execution of SETUP.EXE and/or prompting for the administrator password.

   The installation program needs to know where MicroStation has been installed. It automatically searches all local hard disks to find the MicroStation directory.

   The installation dialog opens:



3. Enter the directory where to install TerraPhoto.

   The default path is C:\TERRA. You may change this to another location. The specified directory is created automatically if it does not exist.

4. Check the MicroStation directory. Replace the path if the correct location was not found automatically.
5. Click OK to start the installation.

   When the installation is finished, a message is displayed.

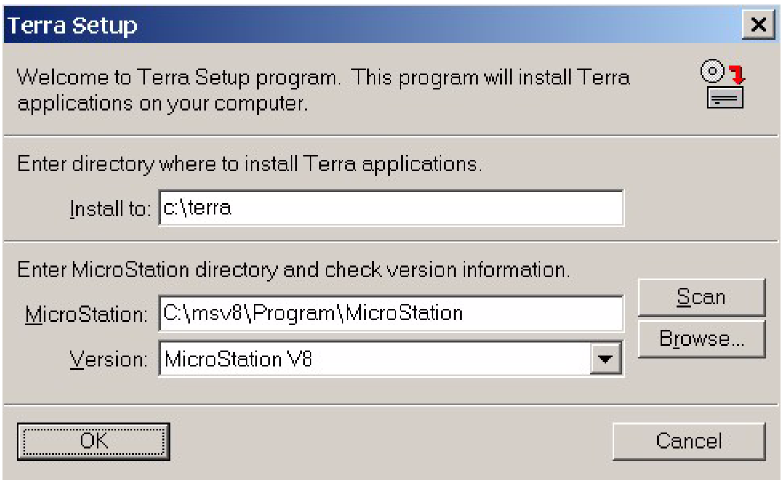
✍ See Chapters **Installation Directories** on page 348 and **Configuration Variables** on page 349 for additional information.

Installation from CD/USB-Stick

➢ **To install TerraPhoto from CD/USB-Stick:**

1. Insert the **Terra Installation CD/USB-Stick**.
2. Locate the correct directory which corresponds to your computer configuration.
3. Start **SETUP.EXE** from that directory.

   The installation program tries to determine where MicroStation has been installed and opens the **Terra Setup** dialog:



4. Enter the directory where to install the application(s).

   The default path is C:\TERRA. You can change this to another location. The specified directory is created automatically, if it does not exist.

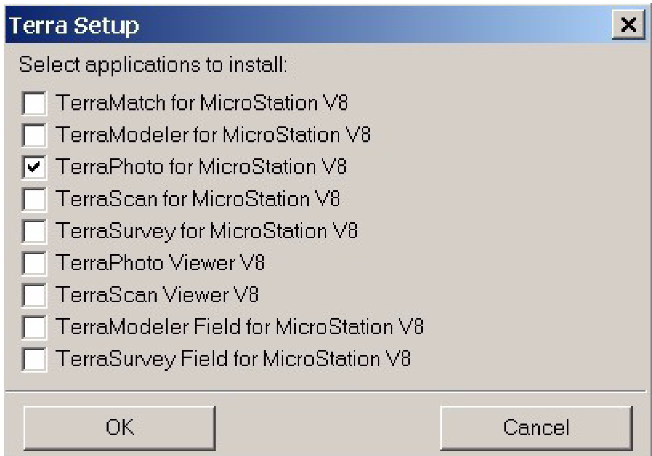
5. Check the **MicroStation** directory. Replace the path if the correct location was not found automatically.

   Alternatively, you can use the **Scan** button to automatically search the hard disk for the MicroStation installation or you can use the **Browse** button to locate the MicroStation executable yourself.

6. Check the MicroStation version information in the **Version** field. Select the correct version if it was not detected automatically.

7. Click OK to continue.

   This opens another **Terra Setup** dialog:



8. Select the **TerraPhoto for MicroStation** item in the dialog.

   You may select other applications as well for which you have installation files.

9. Click OK to start the installation.

   A message is displayed when the installation is finished.

✍ See Chapters **Installation Directories** on page 348 and **Configuration Variables** on page 349 for additional information.

4 Starting TerraPhoto

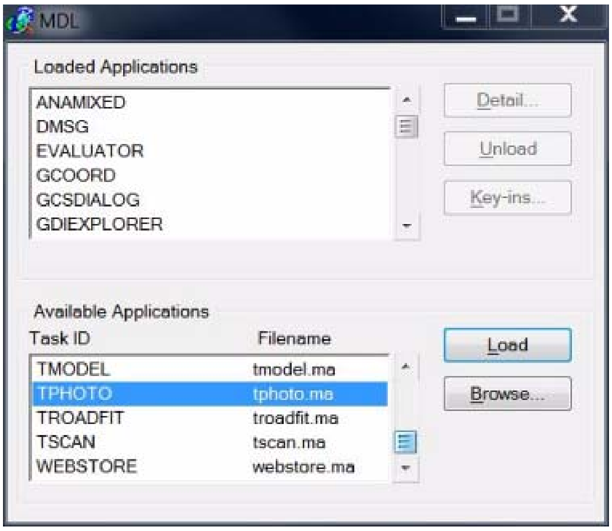
Starting TerraPhoto

TerraPhoto is an MDL application that runs on top of MicroStation.

➢ **To start TerraPhoto:**

1. Select **MDL Applications** command from the **Utilities** menu in MicroStation.

   The **MDL** dialog opens:

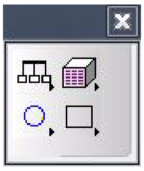


2. In the **Available Applications** list, select TPHOTO.
3. Click the **Load** button.

   OR

1. Key in MDL LOAD TPHOTO.

When the application is loaded, it adds an **Applications** menu to the MicroStation menu bar and opens the **TPhoto Main window** and **Main tool box**:



✍ The **Available Applications** list shows all MDL applications that MicroStation is able to locate. MicroStation searches for MDL applications in the directories listed in the MS_MDLAPPS configuration variable. If MicroStation can not find TPHOTO.MA, you should check the value assigned to this configuration variable. Make sure the directory path of the TPHOTO.MA file is included in the variable. To view configuration variables, select **Configuration** command from the **Workspace** pulldown menu in MicroStation. See also Sections **Installation Directories** on page 348 and **Configuration Variables** on page 349 for additional information.

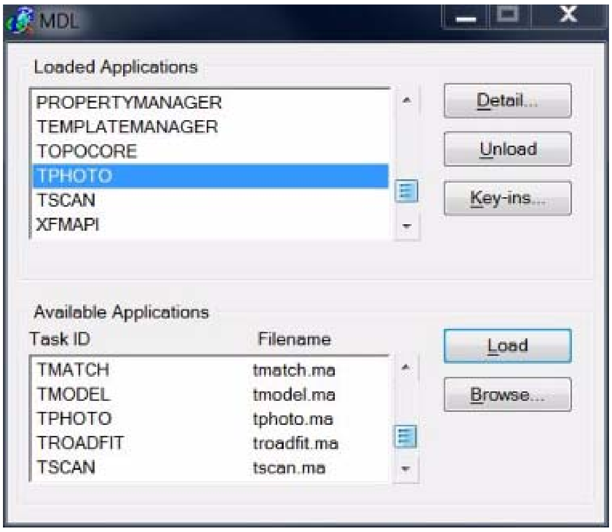
Unloading TerraPhoto

TerraPhoto is unloaded automatically when you exit MicroStation. Sometimes you may want to unload the application while continuing to work with MicroStation. This frees up the memory reserved by TerraPhoto.

➢ **To unload TerraPhoto:**

1. Select **MDL Applications** command from the **Utilities** pulldown menu in MicroStation.

   The **MDL** dialog opens:



2. In the **Loaded Applications** list, select TPHOTO.
3. Click on the **Unload** button.

   OR

1. Key in MDL UNLOAD TPHOTO.

   This unloads the application and frees the memory allocated for it.

Visualization Options

5 Viewing Images

This chapter serves as an introduction to the concepts of viewing raster images in the background.

The basic requirements for viewing raster references are listed below:

- Raster files must have a known geographical position. Some raster file formats contain the georeferencing information in the file header (for example, GeoTIFF and ECW). Alternatively, the georeferencing information can be stored in external files specific for raster file formats (for example, .TFW files for TIFF, .JGW files for JPG).
- The design file must provide the appropriate coordinate range for the position of the raster files.
- Raster references are displayed only in top views or rendered views.

Georeferenced raster files

TerraPhoto can load georeferenced raster files in multiple formats. The two most commonly used formats are GeoTIFF, JPEG or ECW.

If your raster files do not have georeference information, you may still attach those files and assign the position interactively.

Design file coordinate system

MicroStation design files use a coordinate system which can incorporate only a limited coordinate range. You should make sure that the raster image coordinates fit inside your design file coordinate system.

If you regularly work in the same geographical area and use the same coordinate system, your seed files are probably configured correctly.

As an alternative, you may want to create a new design file using a seed file that is provided with the TerraPhoto installation. The SEED3DCM.DGN file has working units defined as follows:

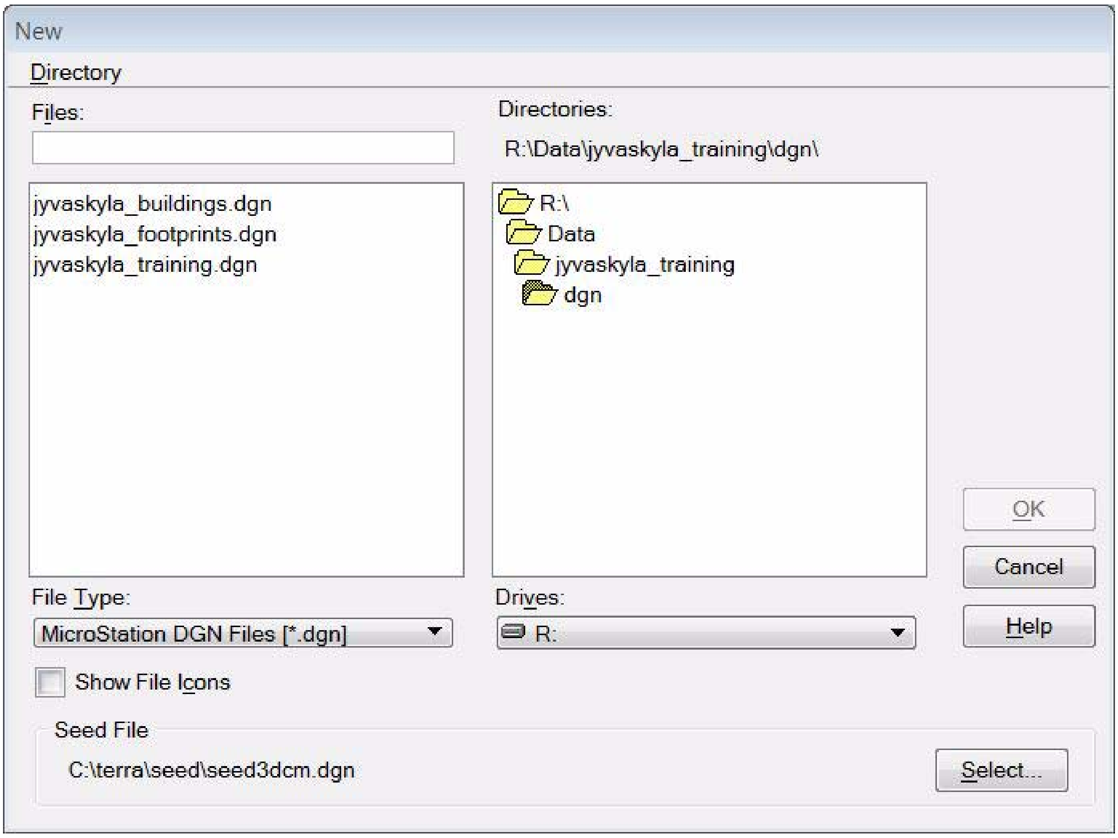
- Master units: **m**
- Sub Units: **cm**
- Resolution: **100** cm per m
- **1** Pos Units per cm

This seed file can include coordinate values between -21 474 836 and +21 474 836.

➢ **To create a suitable empty design file:**

1. Select **New** command from the **File** pulldown menu in MicroStation.

   The **New** dialog opens:



2. Type a name for the file to be created in the **Files** text field.
3. Click **Select** to select the seed file to be used.

   The **Select Seed File** dialog opens.

4. Locate SEED3DCM.DGN seed file.

   If you installed TerraPhoto in the default directory C:\TERRA, you can find this file at C:\TERRA\SEED\SEED3DCM.DGN. Alternatively, you can type in the full path of the seed file in the **Files** text field.

5. Click OK to accept the seed file.
6. Click OK to accept the creation of a new design file.

   This creates a new design file and opens it.

Top views

TerraPhoto displays raster images only in top views. A top view is an orthonormal view where usually, the north axis points upward on the screen. However, a top view can also be rotated around its z-axis.

➢ **To rotate a view to top rotation:**

1. Select the *Rotate View* tool from the MicroStation *View* tool box.

   The **Rotate view** dialog opens.
2. Select **Top** in the **Method** list.
3. Place a data click inside the view.

   This changes the view to a top view where north direction points upward on the screen.

You can use the same tool to rotate the view around its z-axis. The method described below is especially handy when you have a corridor-like project area which you would like to run horizontally across the screen.

➢ **To rotate a view around the z-axis:**

1. Select the *Rotate View* tool from the MicroStation *View* tool box.

   The **Rotate view** dialog opens.
2. Select **3 Points** in the **Method** list.
3. Place a data click inside the view to define the start point for a direction line.
4. Place a data click inside the view to define the end point for a direction line.

   The direction line defines the horizontal direction of the rotated top view.
5. Place a data click inside the view to define the upward direction on the screen.

   This rotates the view so that the given direction line runs from left to right on the screen.

Raster references in TerraPhoto

The **Manage Raster References** window is used to view raster images in TerraPhoto. The commands of the window are described in detail in Chapter **Commands for Raster References** on page 315.

➢ **To attach raster references in TerraPhoto:**

1. Load TerraPhoto. See chapter **Starting TerraPhoto** on page 18 for instructions on how to load TerraPhoto.
2. Select the *Manage Raster References* tool.

   This opens the **Manage Raster References** window.
3. Select **Attach files** command from the **File** pulldown menu.

   This opens a standard dialog for opening files.
4. Select all files to be opened.

   TerraPhoto inspects the selected files and opens the **Reference Visibility** dialog. This dialog allows you to change the visibility of the images in MicroStation views 1 - 8 and for rendered views.
5. Click OK.

   The raster images are attached and are displayed in the selected views if they are top views.

Fitting a view to show the location of the raster images

In order to see the raster images, it may be necessary to move the view to the right geographical location.

You can primarily use MicroStation tools for manipulating the views, such as *Pan*, *Zoom*, etc.. However, TerraPhoto offers a few tools which are handy in locating the raster images. One possibility is to fit a view to the area of all or selected attached raster images.

➢ **To fit a view to show all attached images:**

1. Select an option of **Fit** command from the **Display** pulldown menu in the **Manage Raster References** window.
2. Place a data click inside a top view.

   This fits the view to display all or selected reference images.

6 Creating Rendered Views and Movies

This chapter describes the creation of 3D rendered views and movies with MicroStation and TerraPhoto tools.

In the first part, the concept of rotated views and camera views is introduced. Afterwards, rendering views including different objects is explained. The second part describes the workflow for the creation of flythru movies.

To create nice 3D visualizations, not only tools from TerraPhoto are used, but also tools and functions from TerraScan and TerraModeler. Those tools are included in the following descriptions but not further explained. See TerraScan and TerraModeler User's Guides for more information.

Rendered Views

Rendering is a process which is used to generate an image of a geometric model of an object. The calculation of a rendered image includes besides geometry also a viewpoint, lightning, shading, and texture information. The process is done by a renderer that can be part of larger programs like MicroStation or TerraPhoto.

Rendered views are nice and demonstrative representations of geographic data used for 3D visualization purposes, in the field of geo-visualizations, for example, for 3D city or landscape models. They are also required as frames for the creation of flythru movies.

To display rendered views, it makes sense to rotate a view which means to change the orientation from a top view to another orientation. Another possibility is to create so-called camera views which offers the opportunity to define more precisely the location of the observer (= camera) and the target. These view settings can be manipulated by MicroStation *View Control* tools and are described in the following Sections **Rotated Views** on page 25 and **Camera Views** on page 27. As mentioned before, rendered views are calculated from geometric models of objects. Examples for such objects and their usage in TerraPhoto rendering are described in Section **TerraPhoto Rendering** on page 28.

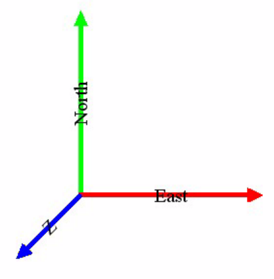
Rotated Views

Rotated views are views that are rotated around the east axis. As a result, the z axis points in an upward direction which is the usual case for geospatial 3D visualizations. Depending on an additional rotation around the z axis, the north and east axes point into different directions. In MicroStation, there are some predefined settings for certain view orientations:

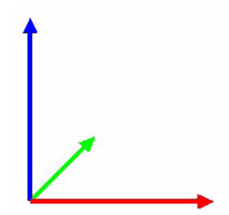
- **Front** – north axis points into the screen, east axis points to the right, z axis points straight upwards.
- **Back** – north axis points towards the observer, east axis points to the left, z axis points straight upwards.
- **Left** – north axis points to the left, east axis points into the screen, z axis points straight upwards.
- **Right** – north axis points to the right, east axis points towards the observer, z axis points straight upwards.
- **Isometric** – Front setting rotated 45° counterclockwise around the z axis and towards the observer around the east axis.
- **Right isometric** – Front setting rotated 45° clockwise around the z axis and towards the observer around the east axis.

The following sketches illustrate the different view orientations. The first image shows the orientation of the coordinate axes in a top view while the other images show the orientation in the above described rotated views.

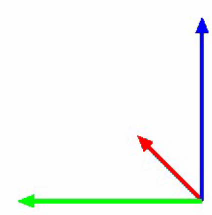
Top view orientation



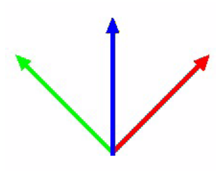
Front



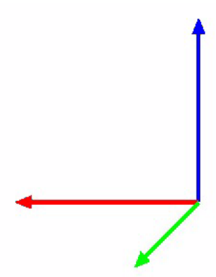
Left



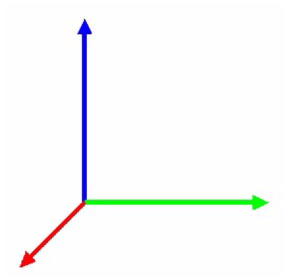
Isometric



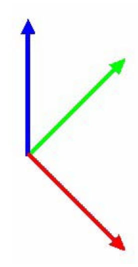
Back



Right



Isometric Right



Orientation of coordinate axes for different view rotation settings in MicroStation. Colors of axis: red = east, green = north, blue = z

➢ **To rotate a view to a certain orientation:**

1. Select *Rotate View* tool from the MicroStation *View Control* tools.
2. Select an option in the **Method** field.
3. Click inside a view in order to apply the selected orientation.

Besides these predefined orientations, views can be rotated dynamically to get individual displays from other directions.

➢ **To rotate a view dynamically:**

1. Select the *Rotate View* tool from the MicroStation *View Control* tools.
2. Select **Dynamic** option in the **Method** list.
3. Place a data click inside a view.
4. Move the mouse to rotate the view.
5. Place another data click inside the view to accept the new orientation.

   OR

3. Click the data mouse button and move the mouse pointer while the mouse botton is pressed.
4. Release the mouse botton in order to accept the new orientation.

Camera Views

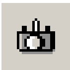
Camera views are perspective views where the location of the observer (= camera) and the target are defined. This can be useful, for example, to analyze the visibility of objects from a certain location. Camera views are created using the camera settings of MicroStation.

Note, that camera views described in this section do not serve the same purpose as camera views of TerraPhoto, which are used as a first step to solve camera parameters. See **Create camera view** for more information.

➢ **To create a camera view:**

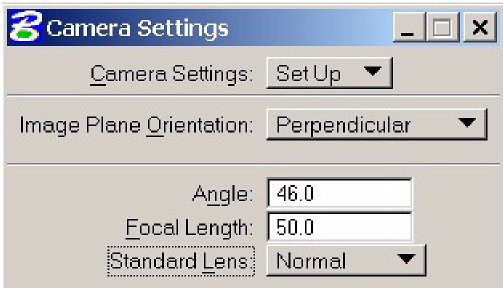
1. Select **View Control** command from the **Tools** pulldown menu in MicroStation.

   This opens the **View Control** menu.



2. Select the *Camera Settings* tool.

   This opens the **Camera Settings** dialog:



3. Place a data click inside a view to define the view for camera view display. The settings in the lower part of the dialog become active.
4. (Optional) Change settings for the camera. For more information about camera settings refer to the MicroStation documentation.
5. Place a data click inside the view to define the target point of the camera.
6. Place a data click inside the view to define the camera location.

   This displays the camera view.

It might be helpful to start the camera view creation from a top view that shows, for example, orthophotos. To define exact coordinates for the camera location and the target point, MicroStation’s *AccuDraw* can be used to set absolute coordinate values.

Another possibility is to set the height of camera location and target point based on a ground model. The ground model can be represented by laser points loaded into TerraScan or by a surface model loaded in TerraModeler.

➢ **To create a camera view using a ground model:**

1. Load laser points representing the ground into TerraScan.

   OR

   Create a surface model with TerraModeler.

2. Select *Camera Settings* tool as described above.
3. Place a data click inside a view to define the view for camera view display.
4. Select *Mouse Point Adjustment* tool from the **Drawing** tools in TerraScan.

   OR

   Select *View elevation* tool from the **Draw using Surface** tools in TerraModeler.

5. In the **Mouse Point Adjustment** dialog, lock **Adjust elevation** and set a value for **Dz**. The value defines the height above the laser points for each mouse click. Select also a laser point

class in the **Class** field.

OR

In the **View elevation** dialog, lock **Points on surface** and set a value for **Dz**. The value defines the height above the surface model for each mouse click. Select also a surface model in the **Surface** field.

6. Place a data click inside the view to define the target point of the camera.
7. (Optional) Change the value for **Dz** in the **Mouse Point Adjustment** dialog or **View elevation** dialog to set another height for the camera location.
8. Place a data click inside the view to define the camera location.

TerraPhoto Rendering

TerraPhoto is able to render vector models of objects in a design file. Rendered views can also include elevation models previewed in TerraModeler, images that are attached as TerraPhoto references, as well as laser data loaded in TerraScan.

Buildings and other vector models

To include buildings into rendered views, vector models of the buildings have to be created. This can be done, for example, by using the building vectorization tools in TerraScan, which enable the (half-)automatic creation of building models based on classified laser data. The resulting models consist of a roof top, roof sides, roof bottom, and walls.

However, 3D vector models of any objects that have been created by other methods can be included in TerraPhoto rendered views.

Orthophotos or other georeferenced images can be draped on 3D shapes of objects, such as building roofs or bridge surfaces. The usage of such 3D elements is defined by the *Define Rendering Settings* tool in the **Render** tools of TerraPhoto.

The walls of 3D building models can be textured by raster files. The wall textures have to be produced by the **Rectify wall rasters** command in TerraPhoto.

RPC cells for trees

An option to visualize trees in 3D scenes is the use of RPC cells. RPC cells are purchased by Archvision (www.archvision.com). These cells include texture maps of an object from different directions and angles. They can be used to render objects like trees, cars, road furniture etc. in a realistic way no matter from which direction the object is viewed.

To use RPC trees in a rendered view, cell elements have to be placed for the trees. This can be done, for example, by using the automatic tree detection tool in TerraScan, which detects trees from classified laser data. It utilizes predefined tree shapes for tree recognition in the point cloud. It places either cells or RPC cells which are both MicroStation cell elements. RPC cells include a link to the corresponding RPC file on a hard disk. The tree shape definitions, RPC file storage settings, and cell definitions are managed in TerraScan **Settings**. The default directory for RPC file storage is C:/TERRA/RPC where TerraPhoto looks for the cells if a view is rendered.

Another possibility is to use TerraPhoto's *Place Rpc Tree* tool in order to place RPC cells for trees manually based on laser and image data.

Digital elevation model

A digital elevation model (DEM) is usually the basis of 3D city or landscape models. In TerraModeler, a DEM is created from traditional survey data or from laser points of the ground and can be visualized using different methods. See TerraModeler Users' Guide for more information.

An representative way to use the DEM in a rendered view is to drape orthophotos on it. The orthophotos (or any kind of other georeferenced images, e.g. maps) have to be attached as TerraPhoto references with the setting **R** for ‘Rendered views’ switched on. See chapter 17, **Commands for Raster References** on page 315 for information about how to manage raster references in TerraPhoto. In addition, the DEM in TerraModeler has to be displayed as raster triangles, a specific display method for surface models.

Laser data

Laser points loaded in TerraScan can be included in rendered views as well. They are always rendered with the same point size and colored according to the display settings in TerraScan’s **Display Mode** dialog.

Usa the data in rendered views

To use all the above mentioned options in a rendered view, tools from TerraPhoto (Lite), TerraModeler (Lite), and TerraScan (Lite) are required.

➢ **To create a rendered view using a DEM, vector models, and orthophotos:**

1. Create a surface model using the *Create Editable Model* tool in TerraScan or using tools of TerraModeler.
2. Create raster triangles by using the *Display Raster Triangles* tool from the **Display Regions** tools in TerraModeler.

   The raster triangles are not drawn as elements in the design file but only displayed temporarily. Therefore, the level set for triangle display appears to be empty in the **Level Display** dialog of MicroStation. However, the level must be switched on in order to display the surface model in rendered views.
3. Attach raster files as TerraPhoto raster references. See commands of the **File pulldown menu** for a description of how to attach images in TerraPhoto’s **Manage Raster References** window. It is essential, that the view setting **R (= Render)** for the reference images is switched on.
4. Switch on all design file levels that contain vector models of buildings, RPC cells for trees, or other objects. These objects are only included in rendered views if the level display is switched on for the respective MicroStation view.
5. Attached raster references can be draped on one or more design file levels which consist elements like building roofs or bridge surfaces. Define such levels by using the *Define Rendering Settings* tool in the **Render** tools of TerraPhoto.
6. Select *Display Rendered View* tool from the **Render** tools in TerraPhoto.
7. Click inside the view to display the rendered view.

✍ Rendered views are created by TerraPhoto tools *Display Rendered View*, *Save Rendered View*, and *Create Flythru Movie*.

Examples

Rendered view including orthophotos draped on a DEM and building roofs, wall textures referenced on 3D building models, and RPC trees.

Rendered view without any imagery. Building models and RPC trees are displayed on top of a DEM that is colored by elevation and stored in TerraModeler.

Flythru Movies

Flythru movies are created in TerraPhoto from a set of frames. The frames are rendered views along a camera path that determines the path, viewing direction, and other settings of the camera. All above described elements in rendered views can be part of frames for movies. Flythru movies are saved as .avi files.

The process of flythru movie creation includes the following steps:

- **Definition of a camera path** – creation of a 3D path for the camera.
- **Definition of target vectors** – defines camera viewing direction and distance.
- **Creation of frames or movies** – frames are rendered and saved as image files, or a movie is created directly without saving image files before.
- **Creation of movies from frames** – frames are recorded as movie file.

The next Sections describe these steps in detail.

Definition of a camera path

The camera path defines the flight path of the camera. It is created from a line string element digitized in the design file. To set the height of the camera path relative to the ground, the *Mouse Point Adjustment* tool from TerraScan or the *View elevation* tool from TerraModeler can be utilized. Additionally, settings for line digitalization in MicroStation are useful to create a smooth camera path.

➢ **To define a camera path:**

1. Load laser points of the ground into TerraScan.

   OR

   Create a surface model with TerraModeler.

2. Select *Mouse Point Adjustment* tool from the **Drawing** tools in TerraScan.

   OR

   Select *View elevation* tool from the **Draw using Surface** tools in TerraModeler.

3. In the **Mouse Point Adjustment** dialog, switch on **Adjust elevation** and set a value for **Dz**. The value defines the height above the laser points for each mouse click. Select a laser point class in the **Class** field.

   OR

   In the **View elevation** dialog, switch on **Points on surface** and set a value for **Dz**. The value defines the height above the surface for each mouse click. Select a surface in the **Surface** field.

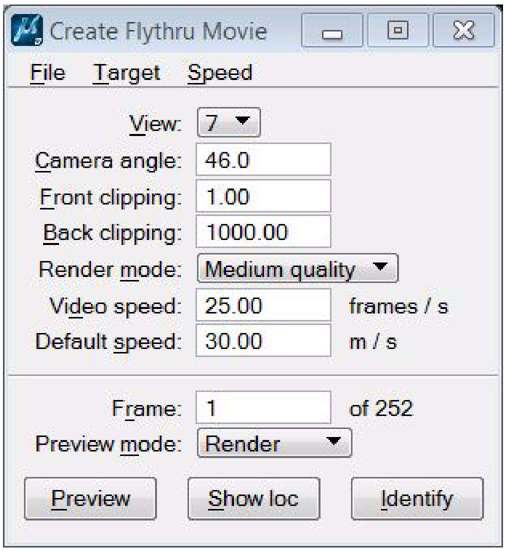
4. Select *Place SmartLine* tool in MicroStation. Select **Rounded** in the **Vertex Type** field, define a **Rounding Radius**, and switch on **Join Elements**.
5. Digitize a line string. The height above ground and the rounding radius settings can be changed during the digitalization process. The final 3D line string can be checked by rotating the view.
6. Select the line string using *Selection* tool in MicroStation.
7. Select *Create Flythru Movie* tool from the **Render** tools in TerraPhoto.

   This defines the line string as camera path and opens the **Create Flythru Movie** dialog.

✍ 3D line strings from other sources may be used as camera path as well, for example, trajectories that are drawn into the design file.

Definition of target vectors

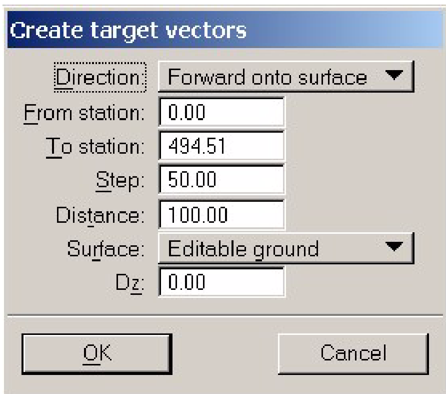
Target vectors determine the viewing direction and distance of the camera from the camera path to the target. They are attached as line elements to the camera path using tools from the **Create Flythru Movie** dialog:



➢ **To define target vectors:**

1. Select **Create vectors** command from the **Target** pulldown menu in the **Create Flythru Movie** dialog.

   This opens the **Create target vectors** dialog:



2. Define settings and click OK. If direction is set to **Fixed point**, the target point has to be defined by a data click inside a view.

   This attaches the vectors to the camera path. The result can be checked by rotating the view.

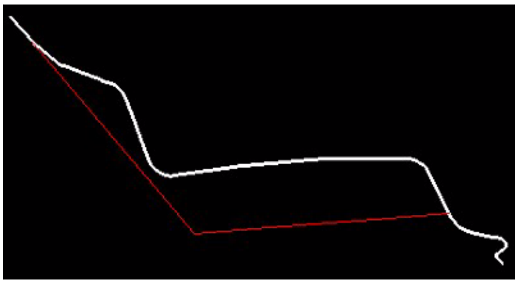
3. (Optional) Besides using the predefined settings, target vectors can be modified manually using, for example, *Modify Element* tools of MicroStation.
4. After manual modification, use **Update from design** command from the **Target** pulldown menu in the **Create Flythru Movie** dialog to apply the changes to the camera path definition.

Setting:	Effect:
Direction	Camera viewing direction: • **Fixed point -** the camera is directed towards one point during the whole flythru. • **Forward onto surface -** the camera is directed forward towards a surface model stored in TerraModeler. • **Forward horizontal -** the camera is directed in a forward horizontal direction independently of the camera path direction. • **Forward -** the camera is directed in a forward direction relative to the camera path. • **Down -** the camera is directed vertically down.
From station	First location of a target vector along the camera path.
To station	Last possible location of a target vector along the camera path.
Step	Distance between two target vectors along the camera path. Determines the distance between camera direction changes. This is only active if **Direction** is not set to **Fixed point**.
Distance	Length of a target vector. This is only active if **Direction** is not set to **Fixed point**.
Surface	Surface model used as reference. This is only active if **Direction** is set to **Forward onto surface**.
Dz	Vertical elevation difference between the reference surface and the target vector's end point. This is only active if **Direction** is set to **Forward onto surface**.

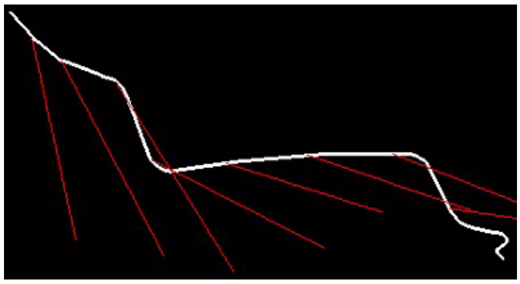
✍ The automatic placement of target vectors can be undone be using MicroStation's **Undo** command. Existing target vectors are replaced by choosing another setting for direction in the **Create target vector** dialog as long as they are not manually modified.

The following figures illustrate the differences of direction settings provided by the tool. The white line is the camera path and the red lines are the target vectors in 3D perspective views.

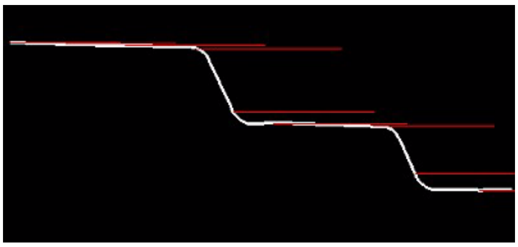
Fixed point



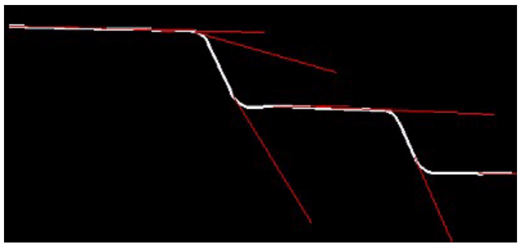
Forward onto surface



Forward horizontal



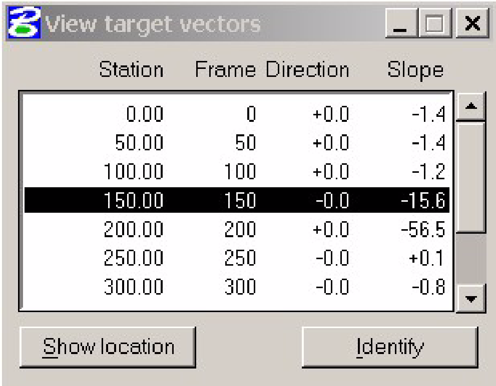
Forward



➢ **To view the current target vector settings:**

1. Select **View list** command from the **Target** pulldown menu in the **Create Flythru Movie** dialog.

   This opens the **View target vectors** information window:



   The window shows a list of all stations along the camera path, and for each station the frame number, the direction, and the slope of the target vectors.

   To show the location of a vector, select a line in the **View target vectors** window. Select **Show location** and move the mouse pointer into a view. This highlights the selected target vector.

   To identify a vector, select **Identify** and click next to a vector in a view. This selects the corresponding line in the **View target vectors** window.

Creation of frames or movies

The **Create Flythru Movie** dialog offers the possibility to safe frames as image files (.tif) for later movie creation, or to safe a movie directly as .avi file. Saving frames has the advantage that frames from different creation processes can be combined in one movie. Additionally, frames can be edited by other software before they are included in a movie. For example, text can be added to one or more frames using image processing software.

General settings for the movie/frame creation regarding clipping, quality and speed are defined in the **Create Flythru Movie** dialog and explained in the *Create Flythru Movie* tool description.

Before starting the movie or frame creation, check the following points:

- The MicroStation view for creating rendered views must be open and set to a suitable size. The view size determines the size of the frames/movie. All frames of a movie must have the same size.
- All design file levels containing vector data must be switched on for the respective view in order to display the data in the frames/movie.
- If raster images are used for the ground model, the setting **R (= Render)** in the **Manage Raster References window** must be switched on for the reference images. Also, a surface model in TerraModeler has to be available and displayed as raster triangles. For draping the raster images on objects, such as building roofs, check the level setting in *Define Rendering Settings* tool.
- If laser points are included, display settings for the respective view have to be set in TerraScan’s **Display Mode** dialog, and classes have to be switched on.

✍ The suitability of settings and display options can be tested using the preview options offered in the **Create Flythru Movie** dialog.

➢ **To save a flythru movie directly:**

1. Select **Save movie** command from the **File** pulldown menu in the **Create Flythru Movie** dialog.

   This opens the **Save movie** dialog, a standard dialog for saving files.

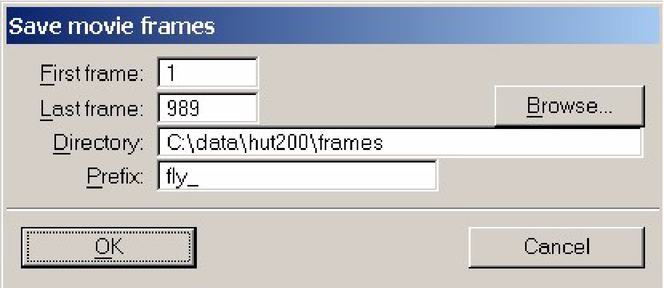
2. Select a directory and type a name for the movie file.
3. Click **Save**.

   TerraPhoto starts the recording of the movie.

➢ **To save frames:**

1. Select **Save frames** command from the **File** pulldown menu in the **Create Flythru Movie** dialog.

   This opens the **Save movie frames** dialog:



2. Define settings and click OK.

   This starts saving the frames as TIFF files.

Setting:	**Effect:**
First frame	First frame number that is saved.
Last frame	Last frame number that is saved.
Directory	Directory on a hard disk where frames are saved.
Prefix	Text that is added in the beginning of the image file names. The frame number is automatically added to the file name.

For both saving methods, frames are previewed in the MicroStation view that is defined for showing rendered views. The information bar at the bottom of the MicroStation application window shows the number of processed frames out of the number of all frames. Depending on the number of frames and the amount of elements that have to be rendered, the process may take a while.

Creation of movies from frames

A movie can be created from previously saved frames using the *Build Movie From Frames* tool from TerraPhoto **Render** tools. The **Build Movie From Frames** dialog shows a list of all frames used for movie creation and a preview of the images. It further provides commands for importing single image files or all files from a directory, for saving a movie as .avi file, as well as for copying or removing frames.

➢ **To import individual image files:**

1. Select **Import files** command from the **File** pulldown menu in the **Build Movie From Frames** dialog.

   This opens the **Movie frames** dialog, a standard dialog for importing files.

2. Define the image files for import.

   The software checks the files and adds them to the list of frames.

➢ **To import all image files from a directory:**

1. Select **Import directory** command from the **File** pulldown menu in the **Build Movie From Frames** dialog.

   This opens the **Movie frame directory** dialog, a standard dialog for selecting a directory.

2. Define the directory for import.

   The software checks the files in the directory and adds them to the list of frames.

➢ **To remove all image files from the list of frames:**

1. Select **New** command from the **File** pulldown menu in the **Build Movie From Frames** dialog.

   This removes all frames from the list.

Imported images can be cut, copied, and pasted using menu commands from the **Edit** pulldown menu in the **Build Movie From Frames** dialog. This is useful to remove single images from the list or to change the order of images. A copied image is pasted before a selected image in the list.

Copy and paste can be used, for example, to lengthen the display of a certain frame. This may be useful for a title frame which is then shown for a longer time than other frames in the final movie. To achieve that, copy the image for the title frame and paste it several times at the beginning of the list.

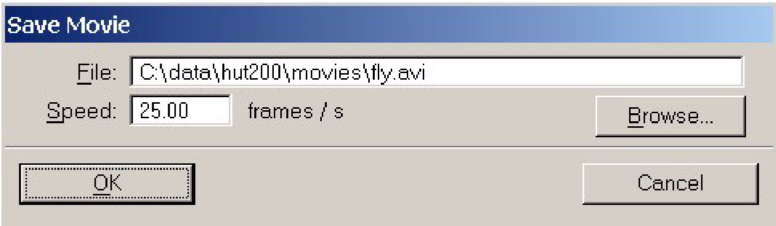
The images can be previewed in a fast way using the <Arrow up> and <Arrow down> keys.

If frames from different camera paths or saving steps are combined in the same movie, make sure that the size of the frame images is equal. Only frame images with the same size can be combined in one movie. The **View Save/Recall** option of MicroStation can be used, for example, to save the view size for creating the frames.

➢ **To save a movie from frames:**

1. Select **Save As** command from the **File** pulldown menu in the **Build Movie From Frames** dialog.

   This opens the **Save Movie** dialog:

2. Define a directory and file name for the movie in the **File** field. You can use the **Browse** button or type the paths manually into the field.
3. Set a **Speed** value in order to define the display speed of the movie in frames per second.
4. Click OK.

   This starts the movie creation. The information bar at the bottom of the MicroStation application window shows the number of recorded frames out of the number of all frames.

✍ As frames are already rendered images, the recording using the *Build Movie From Frames* tool is faster than creating a movie directly from the **Create Flythru Movie** dialog. However, depending on the amount of images, the import of the frame images, and the recording process may take some time.

Project Workflow

7 Project Workflow Examples

Airborne orthorectification projects

Depending on the characteristics of the camera system and the desired quality level of the final orthophotos, a rectification project can require a large amount of effort or nearly no operator work at all.

Some of factors affecting the project workflow include:

- How good is the raw positioning?
  - How good is GPS/IMU trajectory?
  - Is the image timing accurate?
- How stable and well known is the camera?
  - Is the internal geometry of the camera known beforehand?
  - Is the camera misalignment known beforehand?
- How good are the raw images visually?
  - Have light conditions been uniform during the flight session?
  - Is there a color cast or other coloring problems in the images?
- What are the requirements for the final orthophotos?
  - Reasonable positional quality only or best achievable positional quality?
  - True orthophotos or normal orthophotos?
  - Does the orthophoto mosaic need to be visually high quality without any detectable seamlines?

This chapter outlines two possible strategies for an orthorectification workflow. These two strategies represent two extreme cases: the minimum effort and the maximum effort possibility. You will probably choose a strategy which is somewhere in between these two extremes.

Minimum effort project strategy

This workflow outline is based on the following conditions:

- Reasonable positional accuracy is enough for the orthophotos.
- Image timing and raw positioning is accurate.
- The camera system is stable and the internal geometry of the camera is known beforehand.
- Final orthophoto does not have to be high quality - it is acceptable to have some detectable seamlines.

These circumstances make it possible to choose a quite automatized workflow with very little operator time spent on the job. The project workflow may proceed with the following steps:

1. Create a TerraPhoto camera calibration file using values from a previous calibration.
2. Define a mission with **New mission** command.
3. Import trajectories using *Manage Camera Trajectories* tool.
4. Create an image list with **Compute list** command.

   OR

3. Define an exterior orientation file format in **Exterior orientation formats** of TerraPhoto **Settings**.
4. Create an image list by importing exterior orientation files with **Load list** command.

✍ If you use data from a Pictometry system, the camera calibration files, the mission file, and the image list can be created automatically by importing the Pictometry survey file. See **Import Pictometry Survey** command.

5. Create thumbnail versions of raw images with **Create thumbnails** command.
6. Enter tie points with **Define tie points** command in a few (5-10) images. You should choose images from a couple of different locations. Choose places which have clearly identifiable objects on the ground (such as paint markings on asphalt) and have a good overlap pattern (crossing flight lines if possible).
7. Create an **Output report** to make sure that the starting mismatch of the tie points is at an acceptable positional level and that the camera misalignment angles match the camera parameters.

   If the camera misalignment is not valid, apply new values given in the report. Make sure that the tie point mismatch is small after applying the new misalignment angles.
8. Search for automatic color points with **Search points** command from the **Color points** menu for balancing color differences between neighbouring images.
9. Create tile rectangles with **Place tile array** command.
10. Run orthorectification with **Rectify mosaic** command using the image list based on raw positioning and color points.

Maximum effort project strategy

This workflow outline is based on the following conditions:

- You want to produce the best possible positional accuracy for the orthophotos.
- Image timing is accurate.
- Raw positioning is decent but not necessarily the highest accuracy.
- Some of the camera parameters are unknown or inaccurate for the project.
- Seamlines and coloring changes are not acceptable in the final orthophotos.

1. Create a TerraPhoto camera calibration file using known values from a previous calibration.
2. Define a mission with **New mission** command.
3. Import trajectories using *Manage Camera Trajectories* tool.
4. Create an image list with **Compute list** command.

   OR

3. Define an exterior orientation file format in **Exterior orientation formats** of TerraPhoto **Settings**.
4. Create an image list by importing exterior orientation files with **Load list** command.

✍ If you use data from a Pictometry system, the camera calibration files, the mission file, and the image list can be created automatically by importing the Pictometry survey file. See **Import Pictometry Survey** command.

5. Create thumbnail versions of raw images with **Create thumbnails** command.
6. Use **Define color corrections** command to check the overall coloring of the raw images and apply color adjustments if necessary.
7. Enter enough tie points with **Define tie points** command to validate and fine tune camera parameters. This part of the workflow is described in detail in Section **Adjust camera parameters** for **Airborne projects** on page 119.
8. Produce an adjusted image list with **Adjust positions** command. You would typically adjust heading, roll, and pitch angles of each image in the list.
9. Check the image list against control points. Apply an xy transformation if necessary.
10. Create color points with **Search points** command from the **Color points** menu to balance color differences between neighbouring raw images.
11. Modify seamlines between neighbouring images with commands from the **Color points** menu.
12. Create tile rectangles with **Place tile array** command.
13. Run orthorectification with **Rectify mosaic** command using the adjusted image list, color points, and seamline shapes.

Mobile system projects

This chapter outlines typical processing workflows for images from mobile systems. Usually, mobile systems include several cameras, such as down-looking and side-looking cameras. The first part in the processing workflow is to check the calibration of the camera system and possibly improve the camera parameter values using tie points. Images from down-looking cameras can then be used to create orthophotos of the ground (e.g. of the road surface). The images from side-looking cameras may be utilized to assign color values to laser points.

Furthermore, images of the road surface allow the collection of specific tie point types that can be utilized by TerraMatch for the derivation of corrections values. This supports the correction of the trajectory drift for high-accuracy work.

Creating orthophotos and colored point clouds

1. Create TerraPhoto camera calibration files for each camera using the commands in the **TerraPhoto camera dialog**.
2. Define a mission with **New mission** command.
3. Import trajectories using *Manage Camera Trajectories* tool.
4. Create an image list with **Compute list** command.

OR

3. Define an exterior orientation file format in **Exterior orientation formats** of TerraPhoto **Settings**.
4. Create an image list by importing exterior orientation files with **Load list** command.

✍ If you use data from a Lynx system, the camera calibration files, the mission file, and the image list can be created automatically by importing the Lynx survey file. See **Import Lynx Survey** command.

5. Create thumbnail versions of raw images with **Create thumbnails** command.
6. Use **Define color corrections** command to check the overall coloring of the raw images and apply color adjustments if necessary.
7. Enter enough tie points with **Define tie points** command to validate and fine tune camera parameter values. This part of the workflow is described in detail in Section **Adjust camera parameters** for **Mobile ground-based projects** on page 119.
8. Reduce the image list to images from a camera that sees the ground with the **Delete / By camera** command.
9. Adjust **Position** and **Rectify center** parameters in the **TerraPhoto camera dialog** in order to reduce edge effects along image seamlines.
10. Create color points using commands from the **Color points** menu to balance color differences between neighbouring raw images.
11. Create selection shapes using commands from the **Color points** menu in order to remove artifacts from moving objects.
12. Create tile rectangles with **Place tile array** command.
13. Run orthorectification with **Rectify mosaic** command using the reduced image list, color points, and seamline shapes.
14. Reload the complete image list. Reduce the image list to images from side-looking cameras.
15. Use TerraScan commands in order to assign colors from raw images to laser point classes above the ground.
16. Attach the orthophotos of the ground with commands from the **Manage Raster References window**.
17. Use TerraScan commands in order to assign colors from the orthophotos to laser points on the ground.

Deriving TerraMatch correction values from images

Images of the road surface can be used to define tie points from which TerraMatch corrections values can be derived. The tie points can be created from control points drawn into the design file (absolute control) or by placing them in images of different drive paths (relative control). The tie points are of **Tie point types** “Known depth” or “Depth”. These tie points at regular distances along the road allow the derivation of fluctuating correction values for TerraMatch.

The workflow involves TerraMatch functionality which is not described here. For more information refer to the **TerraMatch User’s Guide** available at www.terrasolid.com.

1. Create TerraPhoto a camera calibration file for the camera that sees the ground best (downward-looking camera) using the commands in the **TerraPhoto camera dialog**.

   For the present workflow, only images that see the road surface as vertical as possible are needed. However, it is also possible to create the camera calibration files and image list for all cameras of the system and then reduce the image list to images captured by a downward-looking camera.

2. Define a mission with **New mission** command.
3. Import trajectories using *Manage Camera Trajectories* tool.
4. Create an image list with **Compute list** command.

   OR

3. Define an exterior orientation file format in **Exterior orientation formats** of TerraPhoto **Settings**.
4. Create an image list by importing exterior orientation files with **Load list** command.

✍ If you use data from a Lynx system, the camera calibration files, the mission file, and the image list can be created automatically by importing the Lynx survey file. See **Import Lynx Survey** command.

5. Create thumbnail versions of raw images with **Create thumbnails** command.
6. Define tie points for adjusting the images to the laser data and for deriving TerraMatch correction values. This part of the workflow is described in detail in Section **Ground control points** for **Mobile ground-based projects** on page 123.

8 Mission Setup

This chapter describes the basic steps required to setup a project in TerraPhoto. TerraPhoto refers to a project with the term ‘mission’.

The task of setting up a mission includes the following steps:

1. Create a suitable directory structure on the hard disk for storing the data.
2. Create or copy an initial camera calibration file.
3. Create a mission definition.
4. Create an image list.
5. Create thumbnails (optional).

✍ The production of rectified images or ortho photos, as well as the placement of certain types of tie points require a ground model. The ground model can be loaded into TerraPhoto either from laser points loaded in TerraScan or directly from a laser point file. Most often it makes sense to load the ground model as one step of the mission setup workflow, for example, after defining the mission.

Mission directory structure

You probably want to create a master directory for each TerraPhoto project. This master directory would contain all the data for that project.

The list below shows an example directory structure:

c:\data\hut200	master directory of HUT200 project
🗀 camerapath	raw camera trajectory files
🗀 dgn	design files
🗀 images	raw images
🗀 laser	classified laser data and/or the ground model file
🗀 laserraw	raw laser point files (not used inTerraPhoto)
🗀 mission	mission, camera calibration, image list, tie point, and color point files
🗀 ortho	orthophotos
🗀 temp	temporary files required for TerraPhoto processing
🗀 trajectory	imported TerraPhoto trajectories

Camera calibration file

The camera calibration file is created by one of the options described in Chapter **Camera Calibration** on page 46. Alternatively, a camera calibration file of a previous project may be used if the data was collected with the same and unchanged system.

Mission definition

TerraPhoto uses a mission definition to link all necessary pieces of information that belong to a project. This includes the following:

- Descriptive information about the mission, such as project name, location, and date.
- Output directories for rectified images and temporary files.
- List of cameras used in the mission. For each camera, the directory and name of a camera calibration file, the format and storage directory of the raw images, and a numbering scheme

are defined.

A mission is created, modified, and saved by using the commands from the **Mission pulldown menu** in the **TPhoto Main** window. See **New mission** for a description of mission settings and the workflow of creating a mission.

TerraPhoto provides commands for the automatic creation of mission, camera calibration, and image list files for certain camera systems. More precisely, TerraPhoto is able to import the output files of those camera systems which provide the information necessary for creating the TerraPhoto files. The following system output files are supported:

- Lynx system index files - see **Import Lynx Survey** command.
- Pictometry system files - see **Import Pictometry Survey** command.

Image list

An image list stores position and orientation information for each raw image. Further, it can contain additional information for each image, such as color correction values, quality and accuracy tags. TerraPhoto stores an image list as a text file with the extension .IML.

There are two common ways of creating an image list:

- Link image timing file(s) with trajectory information. This requires that the time stamps of the trajectories in TerraPhoto match with the time stamps stored for each raw image in an image timing file.

  The process includes two steps:

  1. Import trajectories into TerraPhoto using the commands **Set directory** and **Import files** of the TerraPhoto **Trajectories** window. See **Manage Camera Trajectories** for detailed information.
  2. Compute an image list from the image timing file(s) using the **Compute list** command of the **TPhoto Main** window.
- Import exterior orientation files. This requires that the format of the exterior orientation files is defined in **Exterior orientation formats** of the TerraPhoto **Settings**. The files are imported and converted into a TerraPhoto image list using the **Load list** command of the **TPhoto Main** window.

✍ If the data was collected with a Lynx system or a Pictometry system, the image list can be created automatically from the system output files. See previous Section **Mission definition** for more information.

Thumbnails

Thumbnails are images of reduced resolution and used for a faster display of the raw images. They are created by **Create thumbnails** command from the **Utility** pulldown menu in the **TPhoto Main** window. Thumbnails for multiple resolution ratios can be created in one processing step.

Thumbnails are used by:

- **Define color corrections** display
- **Active full** view in tie point mode
- **Define color points** display

It is strongly recommended to create thumbnails at the beginning of the processing workflow, bacause they speed up the image display for these processes essentially.

9 Camera Calibration

The best method of getting camera calibration parameters for TerraPhoto is to derive the parameters from a calibration data set using TerraPhoto itself. When the calibration data set is captured, the camera is operated in conditions similar to the actual project data collection. In addition, the calibration task serves as good verification of the overall accuracy of all system components.

Calibration data sets are usually collected at specific locations. These calibration sites should provide optimal conditions for the data collection. They are described in Sections **Calibration site** on page 61 for airborne systems and **Calibration site** on page 64 for mobile ground-based systems.

If you do not have any calibration document to start from, you need to derive initial values for the calibration parameters yourself. This is outlined in Section **Starting values from scratch** on page 49.

Another way is to convert system-specific calibration parameters into a TerraPhoto calibration file. There are several common system calibration formats implemented in TerraPhoto that enable the conversion. The conversion is done by using the **Tools / Convert from** command in the **TerraPhoto camera dialog**. It is usually required to improve the converted calibration values with the normal calibration workflow in TerraPhoto.

The result of the camera calibration is a set of calibration values that work nicely from one project to another. It is still expected that you have to fine tune misalignment angles for each mission as the IMU initialization offset probably causes a small systematic error.

TerraPhoto camera calibration parameters

The TerraPhoto camera model specifies the following dimensions and parameters of the camera:

- **Resolution of images -** this is defined by **Image width** and **Image height**.
- **Dimensions of the image plate -** this is defined by **Plate width** and **Plate height**. For digital cameras the values are the same as for **Image width** and **height**.
- **Timing offsets -** timing corrections to add to the camera event times when computing an image list. They are defined by **Timing offset** and **Exposure**.
- **Lever arm -** an offset vector to add to trajectory positions when computing an image list. The offset vector points from trajectory positions to the focal point of the camera and is defined by **Lever X**, **Lever Y**, and **Lever Z**.
- **Camera misalignment -** orientation difference between IMU and camera. Defined by **Heading**, **Roll**, and **Pitch** misalignment angles.
- **Principal point position -** position of the focal point relative to the image center. This is defined by **X**, **Y**, and **Z** image coordinates.
- **Lens distortion -** a function that models the difference between the lens and a perfectly spherical shape. There are different models available whose constant parameters depend on the type of the function.

Camera parameter groups

TerraPhoto adjusts camera parameters in groups instead of solving all parameters at the same time with a single routine.

The **Misalignment angles** form one group that you can solve separately. This makes sense as the misalignment angles depend on the camera mount and thus, they change every time the camera is removed and reinstalled.

The second parameter group deals with the internal geometry of the camera. This group includes the **Principal point and lens distortion**. These parameters should not change as long you do not disassemble the camera and there is no internal movement of the parts inside the camera.

The third parameter group relates to **Timing and Exposure** problems. TerraPhoto provides some basic capabilities for solving timing issues manually but it is primarily written for data sets where image timing and raw positioning is good.

Misalignment angles

Heading, roll, and pitch misalignment values define the difference between the values reported by the inertial measurement unit (IMU) and the true camera orientation. These values represent how the camera is mounted into the aircraft and are not dependent on the internal structure of the camera as most of the other camera parameters.

If the values are completely unknown, you should try to derive initial values with the help of **Camera Views**. It is possible to achieve about 0.1 degree accuracy with this method.

To improve the misalignment values, you need to enter some tie points. See Chapter **Working with Tie Points** for detailed information. As soon as you have entered a few points, you can use the **Output report** command in the **Tie points** window in order to create a report which contains the optimal values. The application determines what misalignment values produce the smallest mismatch distances for the tie points and writes these values in the report.

The adjustment of the misalignment angles to optimal values is an iterative process. As soon as you have a handful of images well-defined with tie points (e.g. 5-6 ground tie points per image for airborne data), you should achieve fairly good misalignment angles. The more images are well-defined, the more stable the misalignment angles become until they do not change any more unless you make changes to other camera parameters.

Roll and pitch misalignment angles correlate highly with principal point x and y parameters for airborne data sets collected from one altitude above ground. For cameras in landscape orientation, a small change of the roll angle has almost the exact same effect as moving the principal point x position slightly. A small change of the pitch angle has almost the exact same effect as moving principal point y position.

✍ For corridor projects, if images have been collected in only one survey direction, tie points provide a reliable solution only for the heading misalignment angle. Roll and pitch misalignment angles have a very small effect on the tie point matching in such data sets. In this case, camera views are the only way to verify roll and pitch misalignment angles.

Principal point and lens distortion

Principal point and lens distortion define how much the lens differs from a perfect spherical shape and what is the position of the CCD plate compared to the lens. The parameters define the internal geometry of the camera.

The values of the parameters should remain pretty stable from one mission to another. You should use a good calibration data set for deriving these values. An ideal data set is collected at a suitable calibration site, includes close to 100% overlap between images of different strips, and provides many clearly identifiable objects for placing tie points.

In order to solve principal point and lens distortion, you need to collect a good number of tie points that are well distributed over the raw images. In airborne missions, if the flight pattern is optimal with 100% overlap, **Ground** tie points for 20 images should be enough. If the images are captured with smaller overlap, tie points are needed in more images.

In mobile missions, tie lines of the type **Straight line** are best suited for solving the principle point z and the lens distortion with a **Zero radius function**. Good tie lines are placed along image edges and as long as possible. There should be a few **Straight lines** close to all four image edges.

The optimal values for principal point and lens distortion are computed by the **Tools / Solve parameters** command of the **Camera** dialog.

Lens distortion models

The lens distortion can be modeled as **Zero radius function**, **Function** or **Balanced function** which are very similar to each other. All three models include equations for radial distortions and for tangential distortions.

Radial distortion of the **Zero radius function** model:

$$dx = -rx * ((A * (d^2 - R^2)) + (B * (d^4 - R^4)))$$
$$dy = -ry * ((A * (d^2 - R^2)) + (B * (d^4 - R^4)))$$

Radial distortion of the **Function** model:

$$dx = -rx * ((A * d^2) + (B * d^4) + (C * d^6))$$
$$dy = -ry * ((A * d^2) + (B * d^4) + (C * d^6))$$

Radial distortion of the **Balanced function** model:

$$dx = -rx * (K0 + (K1 * d^2) + (K2 * d^4))$$
$$dy = -ry * (K0 + (K1 * d^2) + (K2 * d^4))$$

Tangential distortion of all three models:

$$dx = P1 * (d^2 + 2.0*rx*rx) + 2 * P2 * rx * ry$$
$$dy = P2 * (d^2 + 2.0*ry*ry) + 2 * P1 * rx * ry$$

In all of the above equations:

dx	is shift from original pixel to correct location
dy	is shift from original pixel to correct location
rx	is pixel coordinate relative to focal point
ry	is pixel coordinate relative to focal point
d	is pixel distance to focal point

A	is **Radial A3** setting
B	is **Radial A5** setting
C	is **Radial A7** setting
R	is **Zero radius** setting
K0	is **K0** setting
K1	is **K1** setting
K2	is **K2** setting
P1	is **Tangential P1** setting
P2	is **Tangential P2** setting

In addition to the three model above, the lens distortion can also be modeled as **Homogenous function**. The function does not include equations for radial distortions.

Finally, the lens distortion can be modeled as a **Grid** of xy shift vectors. The correction vectors are expressed as 1/100th of a pixel.

Timing and Exposure

The timing offset parameters take effect when you use **Compute list** command from the **Images** pulldown menu for creating a TerraPhoto image list. The values are zero if the time stamps in image timing files do not have a constant error.

There is no tool in TerraPhoto for directly solving timing offset problems. If you suspect a constant time offset, you can use a manually-driven strategy to find the best offset value. This simply involves that you test different timing offset values and determine what value results in the smallest mismatches for tie points. Whenever you change the timing offset, you have to optimize the pitch misalignment angle at the same time in order to compensate for the change.

Starting values from scratch

In most cases, you start with an existing camera calibration file that was used for a previous project. This reduces the effort of the calibration significantly because most of the camera parameters should be stable or very close to previous values.

If the camera is used for the first time with TerraPhoto, you need to create a new camera calibration file. Some system providers deliver calibration values from a system calibration that can be converted into TerraPhoto calibration values. See **Tools / Convert from** command from the **Camera** dialog for more information.

If system calibration values can not be used, you need to start the calibration in TerraPhoto from scratch. There are a few calibration parameters for which you have to define initial values before you start with the actual calibration work:

- **Image width** and **Image height** (image size in pixels)
- **Plate width** and **Plate height** (= image size in pixels for digital cameras)
- **Orientation**
- **Timing offset** (usually 0.0)
- **Lever arm XYZ** fields
- **Principal point z**
- **Zero radius**

You should set all other fields to zero.

Lever arm

The lever arm vector is one of the parameters which correlates highly with other parameters. It is best to measure the lever arm vector separately and not try to solve it from an airborne calibration data set.

The lever arm vector defines the offset from the input trajectory information to the focal point of the camera. Depending on the exact position for which the trajectory is computed, the lever arm vector describes the offset between the camera and the IMU, the GPS receiver, or the laser scanner. If the trajectory is computed for the camera, all lever arm components are zero.

An accuracy level of about 1 centimeter is sufficient for the lever arm information. If you fine tune the misalignment angles for each flight session, you can compensate a small inaccuracy of the lever arm vector.

Principal point z

You can compute a reasonable initial value for the **Principal point z** if you known the approximate focal length of the camera in millimeters and the CCD pixel size. The equation is:

```
Principle point z = -FocalLength / PixelSize
```

For example, if focal length is 50 mm and pixel size is 0.0068 mm, the principle point z value is:

```
-50 / 0.0068 = -7353
```

Zero radius

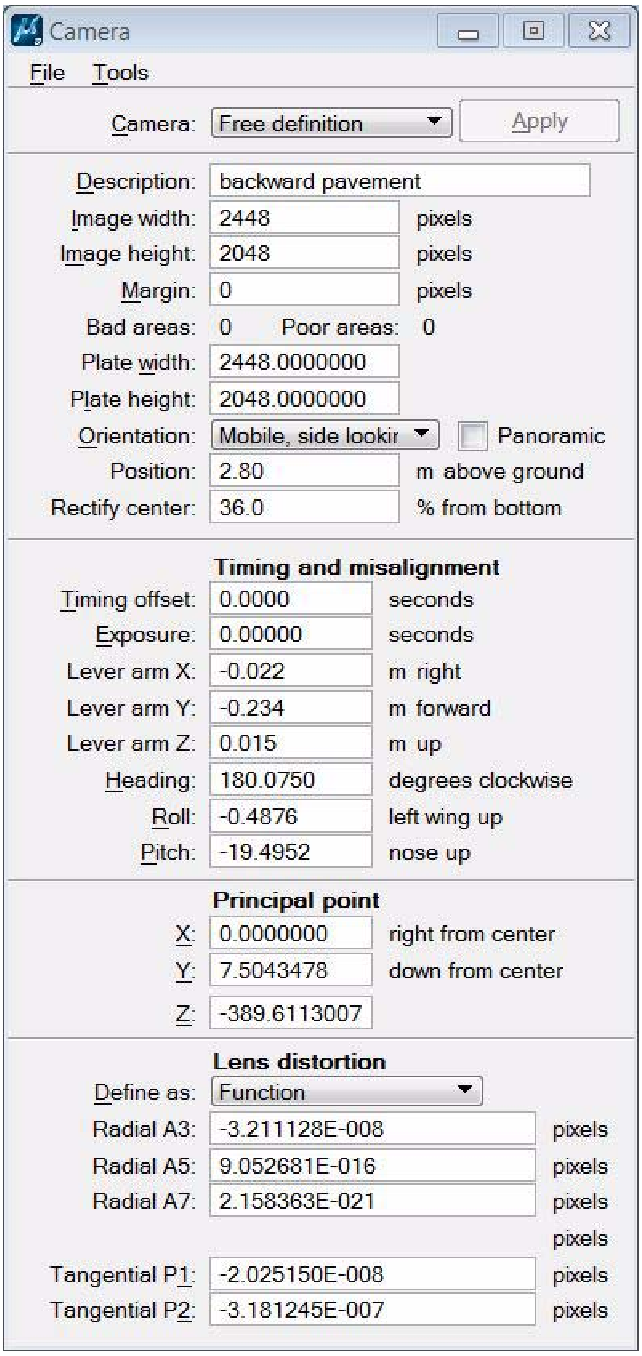
The **Zero radius function** is the preferable model for radial lens distortion. The initial value for the **Zero radius** should fit inside the image and can be calculated by taking slightly less than half of the image width or height, whatever is smaller.

Examples:

- Image size is 7228 * 5428 pixels, use 2500.
- Image size is 3056 * 2032 pixels, use 1000.

TerraPhoto camera dialog

The camera calibration values are defined in the **Camera** dialog of TerraPhoto that is opened by the *Define Camera* tool. Additionally, the dialog contains pulldown menu commands for opening and saving the camera calibration into a file, for solving camera parameters, converting from and to system-specific calibration files, and assigning bad and poor polygons to cameras.



Setting:	**Effect:**
Camera	Name of the camera for which the parameters are shown in the dialog. The camera names are available if a mission is loaded into TerraPhoto. For creating a new camera file, select **Free definition**.
Description	Description of the camera.
Image width	Width of an image in pixels.
Image height	Height of an image in pixels.
Margin	Distance from image boundaries that are ignored for processing. Given in pixels.

Setting:	Effect:
Plate width	Width of the CCD plate or film. Same value as **Image width** for digital cameras.
Plate height	Height of the CCD plate or film. Same value as **Image height** for digital cameras.
Orientation	General orientation of an airborne camera relative to the flight direction: • **Top forward** - the top edge of images points forward. • **Bottom forward** - the bottom edge of images points forward. • **Right forward** - the right edge of images points forward. • **Left forward** - the left edge of images points forward. • **Mobile, side looking** - setting for all cameras of mobile ground-based systems.
Panoramic	If on, the calibration values are for a panoramic camera. This removes input fields for principle point **X** and **Z**, and for lens distortion from the camera dialog. This is only active if **Orientation** is set to **Mobile, side looking**.
Position	Defines the center of a rectified image for mobile system cameras. The value highly correlates with the **Rectify center** value. This is only active if **Orientation** is set to **Mobile, side looking**.
Rectify center	Defines the center of a rectified image for mobile system cameras. The value is expressed in percent from the bottom edge of an image. The value highly correlates with the **Position** value. This is only active if **Orientation** is set to **Mobile, side looking**.
Timing offset	Time value in seconds that is added to the time stamps of raw images if an image is computed with the **Compute list** command.
Exposure	Timing difference between xyz position and attitude in **Compute list** menu command. Zero value means that xyz position and attitude are interpolated from the same position on the trajectory. Positive value means that attitude is computed from a later position on the trajectory.
Lever arm X	Lever arm vector component. A positive value points to the right. Given in meter.
Lever arm Y	Lever arm vector component. A positive value points forward. Given in meter.
Lever arm Z	Lever arm vector component. A positive value points up. Given in meter.
Heading	Heading misalignment angle. A positive value indicates clockwise rotation. Given in degree.
Roll	Roll misalignment angle. A positive value indicates left wing up rotation. Given in degree.
Pitch	Pitch misalignment angle. A positive value indicates nose up rotation. Given in degree.
X	Principal point x position relative to the image center.
Y	Principal point y position relative to the image center.
Z	Principal point z position as a negative value.
Define as	Function type that models the lens distortion. See **Lens distortion models** for more information.
Radial A3, A5	Constants for radial lens distortion functions.
Zero radius	Radius at which the lens distortion of a **Zero radius function** is 0.
Radial A7	Constant for the radial lens distortion model of type **Function**.
K0 ... K4	Constants for lens distortion models of types **Balanced function** and **Homogenous function**.

Setting:	**Effect:**
Tangential P1, P2	Constants for lens distortion functions.
Columns	Number of columns used for solving lens distortion by a **Grid**.
Rows	Number of rows used for soving lens distortion by a **Grid**.

✍ The measurement unit for **Plate width**, **Plate height** and principal point **X**, **Y**, **Z** coordinates can be pixel or millimeter or some other unit but the same must be used for all these parameters. Pixel is the recommended unit as it is easiest to understand.

File / Open

Open command reads previously saved calibration values from a file on the hard disc.

File / Save

Save command saves the calibration values to the same file from which they have been opened before.

File / Save as

Save As command saves the calibration values into a new file. TerraPhoto stores the calibration values in a text file with the extension .CAL.

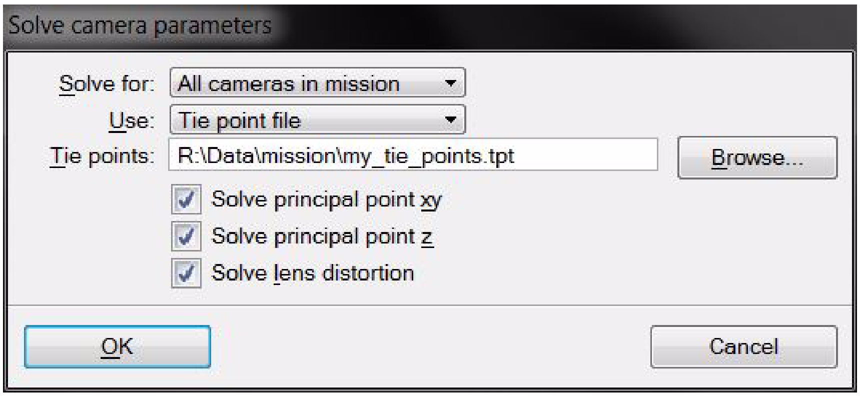
Tools / Solve parameters

Solve parameters command computes optimal values for principle point coordinates and lens distortion functions. The computation is based on tie points. The process can use active tie points or tie points saved into a file.

➢ **To solve principal point and lens distortion parameters:**

1. Collect a good number of tie points.
2. Select **Solve parameters** command from the **Tools** pulldown menu.

   This opens the **Solve camera parameters** dialog:



3. Select settings and click OK.

   The software computes the values for the selected parameters. It updates the values in the **Camera** dialog.
4. Select **File / Save** or **File / Save as** commands from the **File** pulldown menu in order to save the calibration values into a file.
5. If active tie points were used for solving the parameters, click the **Apply** button in the **Camera** dialog in order to recompute the tie points.

Setting:	**Effect:**
Solve for	Camera(s) for which parameter values are computed: • **Active camera** - camera that is set in the **Camera** field of the **Camera** dialog. • **All cameras in mission** - all cameras that are defined for the active mission.
Use	Source of tie points used for the computation: • **Active tie points** - tie points that are active in TerraPhoto. • **Tie point file** - tie points saved in a file on the hard disc.
Tie points	Directory and name of the file storing the tie points. This is only active if **Use** is set to **Tie point file**.
Solve principle point xy	If on, the software computes the optimal value for the principle point **X** and **Y** coordinates.
Solve principle point z	If on, the software computes the optimal value for the principle point **Z** coordinate.
Solve lens distortion	If on, the software computes the optimal values for the lens distortion parameters.
Using	Source tie points/lines for computing the lens distortion values: • **Tie points** - tie points are used. • **Straight lines** - only tie lines of type **Straight line** are used. This requires that the lens distortion is defined as **Zero radius function** and **Straight lines** must be available in the tie point file.

Tools / Convert from

Convert from command is used to convert system-specific calibration values into TerraPhoto calibration values. Many system providers deliver a document for their camera system that includes the values of the system calibration.

TerraPhoto implements the conversion of several common types of system calibrations:

- DiMAC
- iWitness
- Leica RCD
- Matlab
- Riegl VMX
- Rollei
- Trimble MX8
- US / Applanix

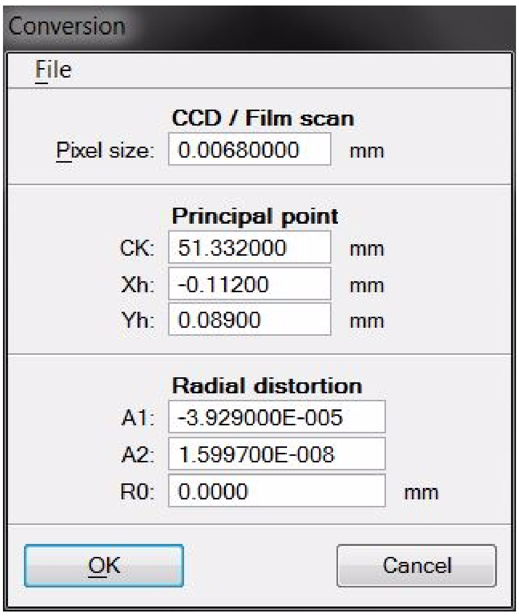
Sometimes the calibration of other systems contain the same parameters as one of the implemented conversions. Therefore, it is recommended to check the implemented conversions even if the system is from another provider.

The conversion does usually not include the size of the images and the overall orientation of the camera in the system. Only some calibration documents contain a lever arm vector. These values must be set manually in the **Camera** dialog.

➢ **To convert camera values from a system-specific calibration document:**

1. Open the **Camera** dialog.
2. Select **Free definition** in the **Camera** field.
3. Define the image size in pixels in the **Image width** and **Image height** fields.
4. Define the same values for **Plate width** and **Plate height**.
5. Select the camera orientation in the **Orientation** field.
6. If necessary, define the lever arm vector in **Lever arm X**, **Lever arm Y**, and **Lever arm Z** fields.
7. Select **Convert from** command from the **Tools** pulldown menu and choose the correct system calibration type.

   This opens the **Conversion** dialog:



   The settings in the dialog depend on the selected calibration type. They should be explained in the calibration document delivered by the system provider.

8. Define values and click OK.

This converts the calibration values into TerraPhoto equivalents. The converted values usually need to be improved by following the normal TerraPhoto calibration workflow.

9. Select **File / Save** or **File / Save as** commands from the **File** pulldown menu in order to save the calibration values into a TerraPhoto .CAL file.

✍ The system-specific calibration values can be saved into a text file. Use the **Save as** command from the **File** pulldown menu in the **Conversion** dialog. This creates a file with the extension .CSV. The text file can be opened by the **Open** command from the **File** pulldown menu.

For certain camera systems, there is another option for the automatic creation of the camera calibration file(s). More precisely, TerraPhoto is able to import the output files of these camera systems which provide the information necessary for creating the TerraPhoto files. The following system output files are supported:

- Lynx system index files - see **Import Lynx Survey** command.
- Pictometry system files - see **Import Pictometry Survey** command.
- Mitsubishi system files - see **Tools / Import Mitsubishi cameras** command.

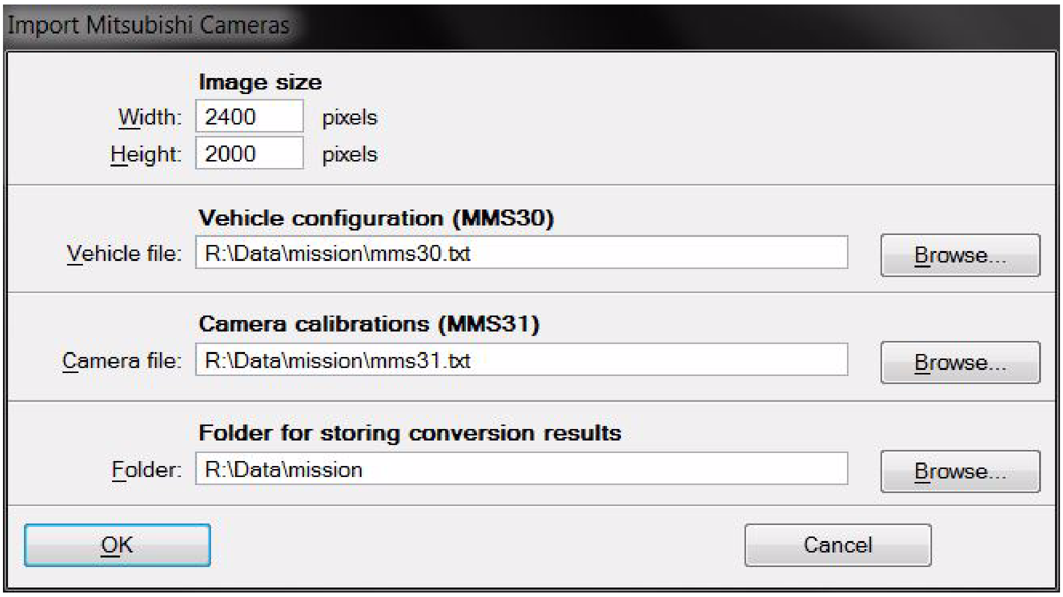
Tools / Import Mitsubishi cameras

Import Mitsubishi cameras command can be used to create a TerraPhoto camera calibration file for Mitsubishi Mobile Mapping Systems (MMS). The system provider delivers two text files, one for the configuration of the system on a vehicle, and the other for the actual camera calibration values.

➢ **To import Mitsubishi MMS cameras:**

1. Select **Import Mitsubishi cameras** command from the **Tools** pulldown menu.

   This opens the **Import Mitsubishi Cameras** dialog:



2. Define values and click OK.

   This converts the calibration values into TerraPhoto equivalents. The .CAL files are saved in the given folder.

Tools / Convert to

Convert to command is used to convert TerraPhoto calibration values into system-specific calibration values. TerraPhoto implements the conversion into several common types of system calibrations:

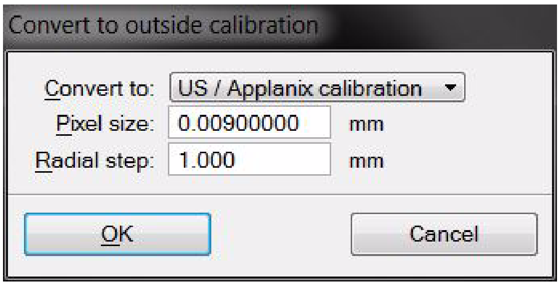
- iWitness
- Leica RCD
- Rollei
- US / Applanix

The lens distortion model used in TerraPhoto determines if the calibration values can be converted into a specific system calibration or not. The converted values can be save into a text file.

➢ **To convert camera values into system-specific calibration values:**

1. Select **Convert to** from the **Tools** pulldown menu.

   This opens the **Convert to outside calibration** dialog:



2. Select a calibration to which you want to convert.
3. Define settings and click OK.

   This opens the **Camera calibration** window that shows the converted calibration values. From this window, a text file can be saved or printed by using commands from the **File** pulldown menu. The commands in the **View** pulldown menu can be used to change the size of the window.

Setting:	Effect:
Convert to	Target calibration system. The availability in the list depends on the lens distortion function in the **Camera** dialog.
Pixel size	CCD or film pixel size. Required to convert pixels into millimeters.
Radial step	Interval for writing the radial lens distortion table. This is only active if **Convert to** is set to **US / Applanix calibration**.

Tools / Assign poor polygons

Assign poor polygons command is used to define areas in images of one camera that should be avoided in rectification processes. Such areas may be caused, for examples, by dust on the camera lens or by other small artefacts which lead to small flaws at the same location in all images.

Such areas are marked in one raw image by a polygon. Then, the polygon can be defined as “poor polygon” for a camera in the **Camera** dialog. Areas inside poor polygons are excluced from automatic tie point and color point searches. In rectification processes, they are filled from other images whenever possible.

The polygons are stored in the camera calibration files. The coordinates of the vertices of the polygons are listed for each polygon separately in the calibration file of the effected camera.

➢ **To assign a poor polygon:**

1. Select *Manage Raster References* in order to open the **Manage Raster References window** of TerraPhoto.
2. Attach a raw image as raster reference using **Attach files** command from the **File** pulldown menu.
3. Select **Modify attachment** command from the **Edit** pulldown menu.
4. In the **Modify attachment** dialog, define the following values:
   - **Easting origin** = 0.0000 Pixel size = 1.00000
   - **Northing origin** = 0.0000 Pixel size = 1.00000
5. Select **Fit / Selected** command from the **View** pulldown menu. Place a data click inside a MicroStation top view in order to display the image.
6. Digitize a polygon around the area that should not be used from the images of the camera. Any MicroStation tool for creating shape elements can be used.

   You may create several polygons that can be defined as poor polygons in one step.
7. Select the polygon using any MicroStation *Selection* tool.
8. Select *Define Camera* tool in order to open the **Camera** dialog.
9. Select the correct camera name in the **Camera** field.
10. Select **Assign poor polygons** command from the **Tools** pulldown menu.

    This defines the selected polygon as poor polygon. The number of **Poor areas** is displayed in the **Camera** dialog.
11. Select **File / Save** or **File / Save as** commands from the **File** pulldown menu in order to save the polygons into a camera calibration file.

Tools / Assign bad polygons

Assign bad polygons command is used to define areas in images of one camera that are unusable for TerraPhoto processes. Such areas may occur, for examples, if a camera always sees a part of the aircraft or car on which the system is mounted.

Such areas are marked in one raw image by a polygon. Then, the polygon can be defined as “bad polygon” for a camera in the **Camera** dialog. Areas inside bad polygons are excluced from automatic tie point and color point searches, from rectification processes, and from the extraction of RGB colors for laser points.

The polygons are stored in the camera calibration files. The coordinates of the vertices of the polygons are listed for each polygon separately in the calibration file of the effected camera.

➢ **To assign a bad polygon:**

1. Select *Manage Raster References* in order to open the **Manage Raster References window** of TerraPhoto.
2. Attach a raw image as raster reference using **Attach files** command from the **File** pulldown menu.
3. Select **Modify attachment** command from the **Edit** pulldown menu.
4. In the **Modify attachment** dialog, define the following values:
   - **Easting origin** = 0.0000 Pixel size = 1.00000
   - **Northing origin** = 0.0000 Pixel size = 1.00000
5. Select **Fit / Selected** command from the **View** pulldown menu. Place a data click inside a MicroStation top view in order to display the image.
6. Digitize a polygon around the area that can not be used from the images of the camera. Any MicroStation tool for creating shape elements can be used.

   You may create several polygons that can be defined as bad polygons in one step.
7. Select the polygon using any MicroStation *Selection* tool.
8. Select *Define Camera* tool in order to open the **Camera** dialog.
9. Select the correct camera name in the **Camera** field.
10. Select **Assign bad polygons** command from the **Tools** pulldown menu.

    This defines the selected polygon as bad polygon. The number of **Bad areas** is displayed in the **Camera** dialog.

1. Select **File / Save** or **File / Save as** commands from the **File** pulldown menu in order to save the polygon into a camera calibration file.

Airborne camera calibration

Calibration site

Any site with easily identifiable features on the ground is a good choice for airborne camera calibration. You would normally choose an urban area with roads and parking lots or an airfield where there are a lot of paint markings on asphalt.

If the actual project area includes such a place that fulfills the requirements of a calibration site, it is possible to use data from this place for calibration purposes. It just requires that the place is covered by the recommend **Flight pattern** in order to collect suitable calibration data.

TerraPhoto needs a ground model of the calibration site. Therefore, you should collect laser data during the same flight. However, you can also use a ground model from another flight.

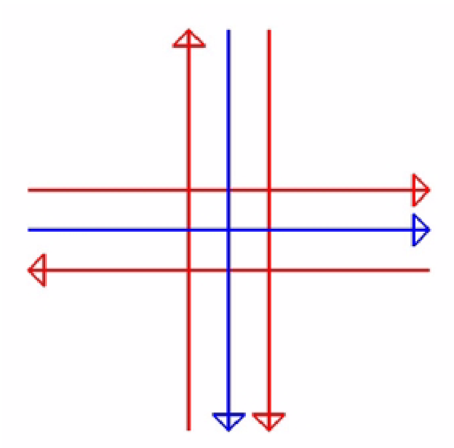
It is beneficial but not required to have some ground control measurements from the site. They can be utilized to eliminate any systematic elevation shifts in the ground model before it is used in TerraPhoto.

Flight pattern

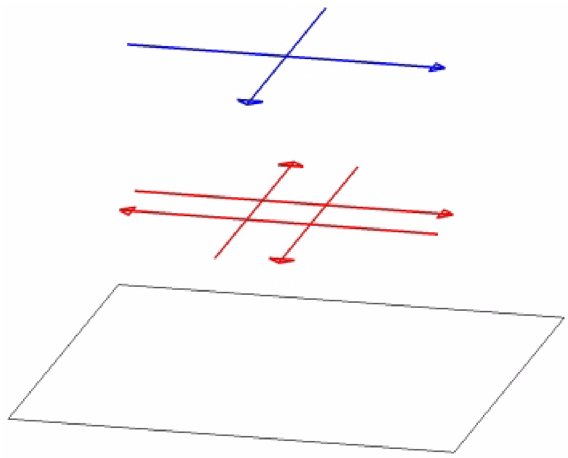
For calibration, it is easiest to cover one small area with multiple crossing flight lines. This results in nearly 100% overlap between some of the images.

The same location needs to be captured from at least two different flight altitudes. This helps to differentiate some of the camera parameters from each other. The camera parameters highly correlate with each other if images from only one altitude are available.

The following figures illustrate the minimum flight pattern:



Flight pattern in a top view.



Flight pattern in a perspective view.

An ideal data set can be produced by flying the same site at three different altitudes, for example 500 m, 1000 m, and 2000 m.

Calibration workflow

The calibration process can be devided into three phases. The aim of the first phase is the rough positioning of the images based on reference data. In this phase, mainly the correct geographical location of the images and the overall orientation of the camera are checked. The second phase involves the manual and half-automatic placement of tie points. They are used to calibrate the misalignment angles and the principle point z value. In the third phase, the final calibration values are fixed by solving all possible camera parameters based on the tie points.

Phase 1: Camera view

A camera view makes it possible to derive reasonable values for the camera misalignment angles and the principal point z. A camera view is basically a perspective view that shows the world as seen through a camera when it was recording an image. You can compare a single raw image with laser points or 3-dimensional vector data. If the image does not match the reference data, you can change the camera parameters in order to reach a better visual match.

If the images are not even close to the reference data, you should check if the geographical position of the images in the image list is correct. Camera views are also an option for validating that all data of a project covers the same geographical location and that no errors occured in coordinate transformations.

Camera views are described in detail in Section **Create camera view** on page 268. In this phase you may achieve an accuracy level of about 0.1 degree for misalignment angles.

Phase 2: Tie points for solving misalignment angles and principle point z

Tie points provide a method for calibrating most of the camera parameters. This is an iterative process. Some of the parameters can be adequately solved with a very small number of tie points while other parameters require a larger number of tie points and a data set suitable for the task. A higher number of tie points achieves a more accurate and a more reliable solution.

In the beginning, it is more laboursome to enter tie points as the positioning of the images is bad. If more tie points are available, the calibration values can be gradually improved which in turn makes it faster to collect more tie points and to filter out bad tie points. The quality of the tie points is crucial to the reliability of the calibration. Therefore, it is essential to remove bad tie points during the calibration process.

As soon as you have entered a few ground tie points, it is possible to solve some of the camera parameters. You should start with the misalignment angles and then move to the principal point z. The other parameters have a much smaller effect on positional accuracy.

1. Enter tie points, enter more tie points, or filter out bad tie points.

   Enter **Ground** tie points whenever possible. Use **Air** tie points only if there is no way to place **Ground** tie points.

   Start with the manual tie point entry mode. See **Tie point entry modes**.

   For detailed information about placing tie points see Chapter **Working with Tie Points** on page 76, especially commands from the **Point pulldown menu** and the **Pixel pulldown menu**.
2. Solve and apply misalignment angles using **Output report** command in the **Tie points** window.
3. Go back to step 1 and continue until the modification of misalignment angles does not improve the average mismatch of the tie points anymore.
4. Solve principal point z using **Tools / Solve parameters** command in the **TerraPhoto camera dialog**.
5. Recompute the tie points by using the **Apply** button in the **Camera** dialog.
6. Go back to step 1 until images are well-defined by tie points. See **Tie point values** and **Tie**

point distribution.

If the mismatch distances for tie points become smaller (about 2-3 * pixel size of the raw images), try to switch to half-automatic tie point entry mode. See **Tie point entry modes**.

Continue with steps 1 to 5 until the values for the misalignment angles and principle point z do not change significantly anymore. The second phase should result in reasonably good mismatch distances in tie points (about pixel size of the raw images).

Phase 3: Solve misalignment angles, principle point xyz, and lens distortion

The third phase of the workflow solves all camera parameters that can be calibrated with tie points.

1. Solve and apply misalignment angles using **Output report** command in the **Tie points** window.
2. Solve all other solvable parameters using **Tools / Solve parameters** command in the **TerraPhoto camera dialog** and apply the changes to the tie points.

   The application adjusts roll and pitch misalignment angles if it modifies principal point x and y values. The adjustment of the misalignment angles compensates the modification of the other parameters.

   You may still check for bad tie points using the **Find worst** command from the **Tie points** window.
3. Go back to step 1 and continue until there is no more improvement and the values are stable.

   The third phase produces the final calibration parameters.

Mobile camera calibration

Calibration site

Any site with large buildings on two or more sides is a good choice for mobile camera calibration. The buildings should have a plane wall with easily identifiable features (such as windows, facade paintings, etc.) facing the road without obstacles in front of the wall. Long sharp edges in the images are especially useful for calibrating principle point z and lens distortion of mobile cameras.

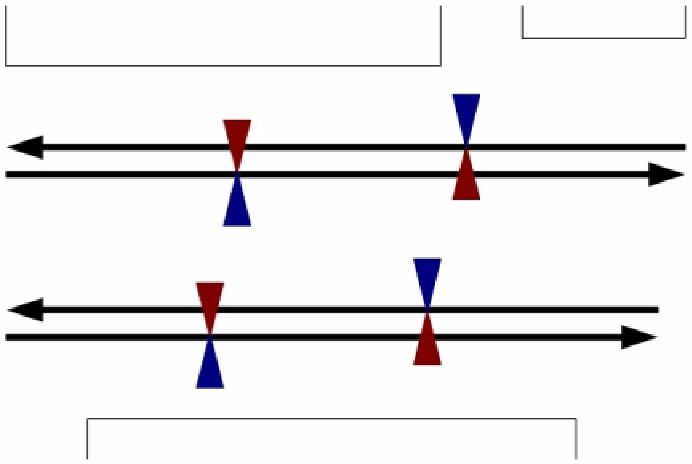
Paint markings on asphalt add another valuable features for the calibration task. There should be enough space on the calibration site to turn around, drive back and forth, and maybe even drive crossing paths.

If the actual project area includes such a place that fulfills the requirements of a calibration site, it is possible to use data from this place for calibration purposes. It just requires that the place is covered by the recommend **Drive pattern** in order to collect suitable calibration data.

Drive pattern

For calibration, it is easiest to cover one small area with multiple drive paths. This results in nearly 100% overlap between some of the images. The same building walls should be captured by each camera from at least two different distances.

The following figure illustrates an example drive pattern for a system with two side-looking cameras:



Drive pattern in a top view. Blue and red triangles indicate the views of two side-looking cameras.

Calibration workflow

The calibration process can be devided into three phases. The aim of the first phase is the rough positioning of the images based on reference data. In this phase, mainly the correct geographical location of the images and the overall orientation of the cameras are checked. The second phase involves the manual placement of tie points. They are used to calibrate the misalignment angles. In the third phase, further tie points and straight tie lines are placed in order to solve principle point z and lens distortion parameters in addition to fine tuning the misalignment angles.

Phase 1: Camera view

A camera view makes it possible to derive reasonable values for the camera misalignment angles and the principal point z. A camera view is basically a perspective view that shows the world as seen through a camera when it was recording an image. You can compare a single raw image with laser points or 3-dimensional vector data. If the image does not match the reference data, you can change the camera parameters in order to reach a better visual match.

If the images are not even close to the reference data, you should check if the geographical position of the images in the image list is correct. Camera views are also an option for validating that all data of a project covers the same geographical location and that no errors occured in coordinate transformations.

Camera views are described in detail in Section **Create camera view** on page 268. In this phase you may achieve an accuracy level of about 0.1 degree for misalignment angles.

Phase 2: Tie points for solving misalignment angles

Tie points provide a method for calibrating most of the camera parameters. This is an iterative process. Some of the parameters can be adequately solved with a very small number of tie points while other parameters require a larger number of tie points and a data set suitable for the task. A higher number of tie points achieves a more accurate and a more reliable solution.

In the beginning, it is more laboursome to enter tie points as the positioning of the images is poor. If more tie points are available, the calibration values can be gradually improved which in turn makes it faster to collect more tie points and to filter out bad tie points. The quality of the tie points is crucial to the reliability of the calibration. Therefore, it is essential to remove bad tie points during the calibration process.

1. Enter tie points, enter more tie points, or filter out bad tie points.

   Enter **Air** tie points first. The calibration becomes more reliable if you also enter some **Known** tie points, for example, based on objects detectable in the laser point cloud.

   For detailed information about placing tie points see Chapter **Working with Tie Points** on page 76, especially commands from the **Point pulldown menu** and the **Pixel pulldown menu**.
2. Solve and apply misalignment angles using **Output report** command in the **Tie points** window.
3. Go back to step 1 and continue until the modification of misalignment angles does not improve the average mismatch of the tie points anymore.

   If the calibration is started with values of a system-specific calibration, around 20 **Air** tie points and 5 - 10 **Known** tie points should be enough to get reasonable values for the misalignment angles.

Phase 3: Solve misalignment angles, principle point z, and lens distortion

The third phase of the workflow solves lens distortion and principle point z values. It also fine tunes the misalignment angles.

1. Place a good number of **Straight** tie **lines** for each camera. See **Add straight line** command.
2. Check the distribution of tie points and lines by using the **Draw pixel distribution** command. If necessary, add more tie points/lines.

   The **Straight lines** should be placed close to the image boundaries along edges of objects (for example building edges). The edges, which are straight in the real world, are curved in the images due to the lens distortion. Long and curved edges are best for solving the lens distortion.
3. Open the **Camera** dialog and set the lens distortion model to **Zero radius function**.

4. Set **Radial A3** and **A5**, and **Tangetial P1** and **P2** to zero. Set the **Zero radius** to approximately half of the image height or width, whatever is smaller.

   Example: if the image size is 1624 x 1236, set **Zero radius** to 600.

5. Solve the lens distortion using **Straight lines** for all cameras of the mission with **Tools / Solve parameters** command in the **TerraPhoto camera dialog** and apply the changes to the tie points.
6. Solve principal point z for all cameras of the mission using **Tools / Solve parameters** command in the **TerraPhoto camera dialog**.

   This recomputes the tie points and saves the camera files automatically.

   You may still check for bad tie points using the **Find worst** command from the **Tie points** window.

7. Solve and apply misalignment angles using **Output report** command in the **Tie points** window.
8. Go back to step 6 and continue until there is no more improvement and the values are stable.

   The third phase produces the final calibration parameters.

10 Color corrections

Color corrections in TerraPhoto are an option to improve the overall coloring of raw images. They include RGB color balance, intensity, saturation, and contrast modifications that are unique for a single raw image. In addition, a grid-based intensity correction can be applied to a raw image in order to adjust brightness differences between image corners and center. The correction values are stored in the image list. TerraPhoto applies the corrections for different processes on-the-fly:

- tie point mode
- color point display
- perspective views
- rectification

The **Define color corrections** dialog uses thumbnails for image display if those are available in the /TEMP folder of the mission. See **Create thumbnails** for more information.

Color corrections are useful to correct systematic coloring issues that affect a larger number of raw images. Examples are systematic color casts in images of one or more cameras, brightness differences between different parts of a project area, saturation and contrast issues in images of one or more strips, etc.

Define color corrections dialog

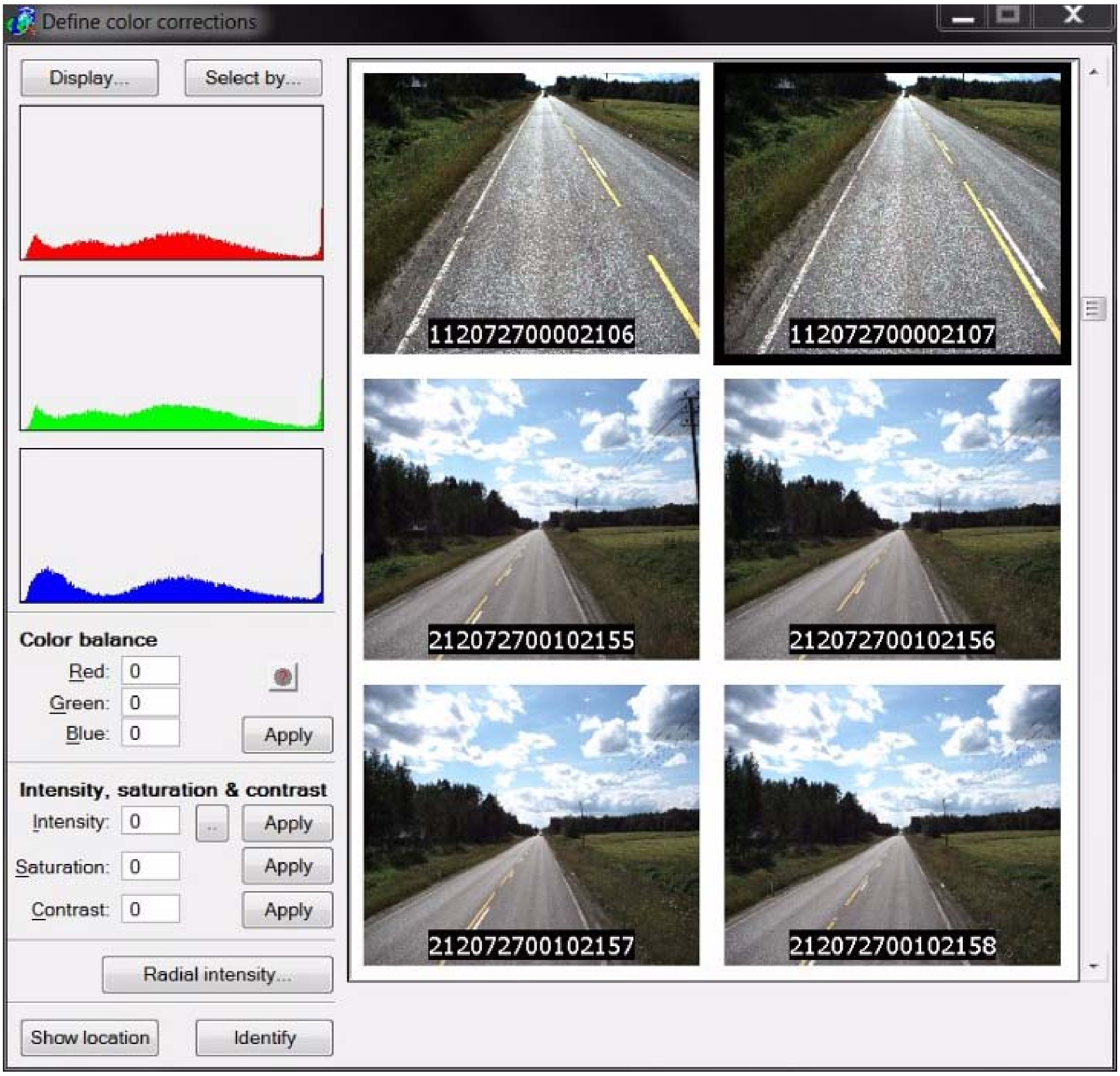
Color corrections are usually applied to the unadjusted image list, especially if the coloring issues affect the (half-) automatic placement of tie points. However, color corrections can be applied at any time in the processing workflow.

Before starting with color corrections, images can be analyzed using **Analyze images** command from the **Utility** pulldown menu in the **TPhoto Main** window. The command results in a report of average color, intensity, saturation, and contrast values for each image as well as an average value for all or selected images. Therefore, it can be used to get an idea about coloring issues that possibly need to be corrected.

The color corrections are defined in the **Define color corrections** dialog which is opened by the **Define color corrections** command from the **Image** pulldown menu in the **TPhoto Main** window.

On its left side, the dialog contains controls for displaying the thumbnails of the raw images, for selecting images, and for adjusting color values. In addition, the histogram for each color channel of a selected image is shown. On the right side, the thumbnails of all images of the active image list are displayed.

Color corrections are always applied to images that are selected in the list of thumbnails in the dialog. An image can be selected by a data click on the thumbnail. Several images are selected in the common way by pressing the <Ctrl> or the <Shift> key while clicking on the image thumbnails. Images can also be selected by certain criteria, such as the camera name, the group number, a time stamp interval, or inside a fence.


Define color corrections
Display...
Select by...
112072700002106
112072700002107
212072700102155
212072700102156
212072700102157
212072700102158
Color balance
Red: 0
Green: 0
Blue: 0
Apply
Intensity, saturation & contrast
Intensity: 0
Apply
Saturation: 0
Apply
Contrast: 0
Apply
Radial intensity...
Show location
Identify

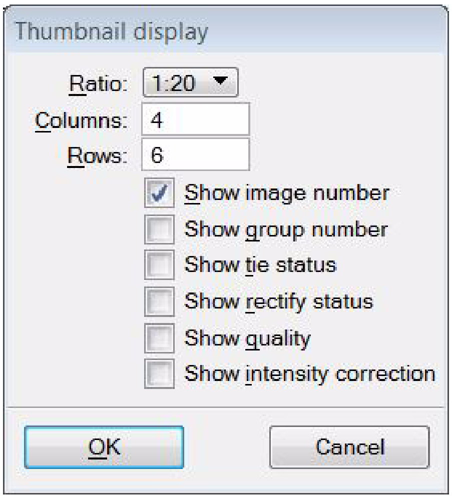
Display

Display button is used to modify the appearance of the thumbnail list on the right side of the dialog.

➢ **To change the display of the thumbnails:**

1. Click on the **Display** button in the **Define color corrections** dialog.

   This opens the **Thumbnail display** dialog:



2. Choose settings and click OK.

   The optimal display settings depend mainly on the screen size and resolution. It is recommended to select a resolution ratio for which thumbnails have been created.

Setting:	Effect:
Ratio	Resolution ratio for thumbnail display.
Columns	Number of columns in the thumbnail list.
Rows	Number of rows in the thumbnail list.
Show image number	If on, the image number is shown on the bottom of each thumbnail.
Show group number	If on, the group number is shown on the bottom of each thumbnail.
Show tie status	If on, the tie status is shown on the bottom of each thumbnail. In addition, the buttons for **Changing the tie status of images** appear at the bottom of the left side of the dialog.
Show rectify status	If on, the rectify status is shown on the bottom of each thumbnail. In addition, the buttons for **Changing the rectify status of images** appear at the bottom of the left side of the dialog.
Show quality	If on, the quality value is shown on the bottom of each thumbnail. In addition, the user controls for **Changing the quality value of images** appear at the bottom of the left side of the dialog.
Show intensity correction	If on, the grid-based intensity correction values are shown as overlay of each thumbnail.

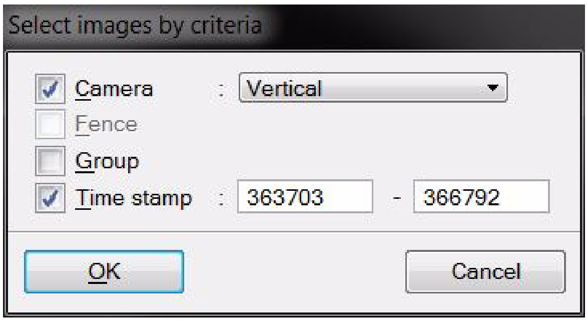
Select by

Select by button is used to select images for color corrections automatically. The button opens a dialog which lets you set specific criteria for image selection.

➢ **To select images automatically by criteria:**

1. Click on the **Select by** button in the **Define color corrections** dialog.

   This opens the **Select images by criteria** dialog:



2. Define settings and click OK.

Setting:	Effect:
Camera	If on, images captured by the given camera are selected for color corrections. The list includes all cameras of the active mission.
Fence	If on, images **Inside** or **Outside** a fence are selected for color corrections. This is only active if a MicroStation fence is drawn or a shape is selected.
Group	If on, images that belong to the specified group are selected for color corrections. The group number is stored for each raw image in the image list.
Time stamp	If on, images captured within the specified time stamp interval are selected for color corrections.

Show and identify selected images

➢ **To select a single image from view:**

1. Click on the **Identify** button in the **Define color corrections** dialog.
2. Move the mouse pointer inside a MicroStation view.

   The footprint of the image closest to the mouse pointer is highlighted.

3. Place a data click in order to select the highlighted image in the thumbnail list of the **Define color corrections** dialog.

➢ **To show the location of selected images:**

1. Select one or more images in the **Define color corrections** dialog.
2. Click the **Show location** button in **Define color corrections** window.
3. Move the mouse pointer inside a MicroStation view.

   The footprints of the selected images are highlighted. Place a data click inside the view in order to center the view to the highlighted images.

Color corrections

There are six values which can be modified in order to correct coloring issues in the raw images: red, green, blue color channels, intensity, saturation, and contrast.

➢ **General process to apply color corrections:**

1. Select one or more image thumbnails for which you want to apply color corrections.
2. Fill in values you want to change.
3. Click on the **Apply** button next to each setting to see the affect in the thumbnail display and to write color correction values to the image list.
4. Continue until all color corrections are applied.
5. Save the image list using **Save list** or **Save list As** commands from the **Images** pulldown menu in the **TPhoto Main** window in order to save the color corrections into an image list file.

✍ You can check the result of color corrections by choosing **Define color points** command from **Rectify** pulldown menu in **TPhoto Main** window. This creates a preview of the ortho mosaic using the color corrections on-the-fly. Use *Update view* tool for MicroStation views in order to apply changes to the preview.

Color balance

Red, **Green**, and **Blue** add the given correction values to the red, green, and blue channels of an image. The values may range between -255 (no red/green/blue) and +255 (full red/green/blue).

The *Gray balance* tool button next to the RGB fields can be used to derive correction values for the color channels automatically. The software computes correction values for the color channels that result in gray coloring at the location selected by the mouse pointer.

The *Gray balance* tool is especially useful if there is a color cast in images. Then, the tool should be used in a part of the image that should be gray but clearly shows the color cast (e.g. a gray road surface).

➢ **To derive color corrections for gray balance adjustment:**

1. Activate the *Gray balance* tool next to the RGB fields with a data click on the button.
2. Place data clicks in thumbnails at several locations where there are gray objects/surfaces.

   This displays correction values next to the RGB fields.

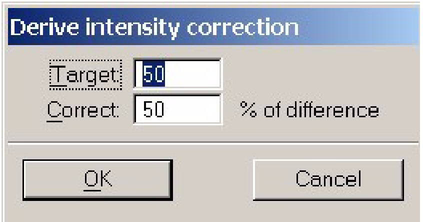
3. Continue until you get an impression of good correction values that result in a balanced gray coloring for a number of images.
4. Deacitvate the *Gray balance* tool with a data click on the button.
5. Select the images for which to apply color corrections.
6. Type the correction values in the **Red**, **Green**, and **Blue** fields and click **Apply**.

   This applies the color corrections to the selected images. Gray objects/surfaces should now appear with gray coloring.

Intensity

Intensity multiplies the given value with the *Value* in the HSV color model. It is expressed as percentage and makes the image brighter or darker. A setting of +40 multiplies the *Value* with 1.40, a setting of -25 with 0.75. The possible values range from -100 to +500.

Correction values for intensity can be derived automatically. The **..** button next to the intensity field opens the **Derive intensity correction** dialog:

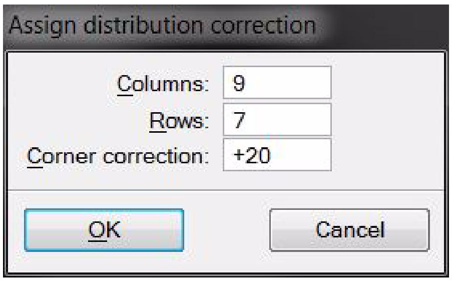


Setting:	Effect:
Target	Target intensity value to move images towards. This is expressed as a number ranging from 0 to 100.
Correct	Percentage of difference to correct. For example, if an image has an intensity value of 36, **Target** is set to 60 and **Correct** to 50, the image would end up with intensity 48.

If several images are selected, the intensity correction is derived individually for each image.

Radial Intensity Correciton

In addition to the unique intensity correction for an image, a grid-based correction can be applied as well. Then, local correction values are distributed over an image in a grid structure. The distribution of the correction values is defined in the **Assign distribution correction** dialog which opens from the **Radial intensity** button:



Setting:	Effect:
Columns	Number of columns in the correction value grid. Numbers can range from 3 to 9.
Rows	Number of rows in the correction value grid. Numbers can range from 3 to 9.
Corner correction	Maximum correction value applied to the image corners. Expressed as percentage value.

If the corner correction is positive, the corners of the image(s) become brighter while the center becomes darker. If the corner correction is negative, the corners become darker and the center becomes brighter. All correction values average to zero.

Saturation and Contrast

Saturation multiplies the given value with the *Saturation* in the HSV color model. It is expressed as percentage and makes the colors of the image stronger or weaker. A setting of +40 multiplies the *Saturation* with 1.40, a setting of -25 with 0.75. The possible values range from -100 to +200. The minimum value -100 multiplies with 0.00 and results in a grayscale image.

Contrast moves the RGB values away from the center value, which means that the histogramm for each channel is stretched from the center value 128 (positive values) or tightened towards the center value 128 (negative values). The possible values range from -100 to +200.

The histogram display on the left side of the **Define color correction** dialog gives an indication, how the changes effect the color value distribution for each color channel. The gray graphs show the original color distribution while the red, green or blue graphs display the distribution with the current settings.

Changing the tie status of images

The tie status of image refers to the tie points that are defined for a raw image. The status is either '*Check*' or '*Approved*'. Images with status '*Check*' need more tie points or better distributed tie points, while images with status '*Approved*' have a good number and distribution of tie points. See Chapter **Working with Tie Points** on page 76 for more details about tie points.

The tie status of images can be changed quickly in the **Define color corrections** dialog.

➢ **To change the tie status of images:**

1. Use the **Display** button in order to switch the **Show tie status** setting on.

   The buttons **Tie approve** and **Tie check** appear at the bottom of the left side of the **Define color corrections** dialog.

2. Select the image(s) for which to change the tie status.
3. Click on the respective button in order to change the status to *Approved* or *Check*.

✍ The tie status of images can be changed using a key-in command defined in MicroStation. The syntax of the key-in command for changing the status to *Approved* is:

```
tie set status approved
```

If the key-in command is defined, for example, for the <F8> key, it can be used to change the status of selected image to *Approved* by just selecting the images and pressing the <F8> key.

✍ The tie status of images can also be changed by selecting the the images in the image list and using the **Edit** command of the **TPhoto Main** window.

Changing the rectify status of images

The rectify status of image refers to the usage of images in orthophoto production. The status is either '*Rectify*' or '*No rect*'. Images with status '*Rectify*' are used for creating orthophotos, while images with status '*No rect*' are ignored. See Chapter **Orthophoto Production** on page 162 for more details about orthophoto production.

The rectify status of images can be changed quickly in the **Define color corrections** dialog.

➢ **To change the rectify status of images:**

1. Use the **Display** button in order to switch the **Show rectify status** setting on.

   The buttons **Rectify on** and **Rectify off** appear at the bottom of the left side of the **Define color corrections** dialog.

2. Select the image(s) for which to change the rectify status.
3. Click on the respective button in order to change the status to *Rectify* or *No rect*.

✍ The rectify status of images can also be changed by selecting the the images in the image list and using the **Edit** command of the **TPhoto Main** window.

Changing the quality value of images

Each image has a quality value stored in the image list. By default, the value is 0 for all images. Some processing steps require that images are separated by quality. The quality value of images can be changed quickly in the **Define color corrections** dialog.

➢ **To change the quality value of images:**

1. Use the **Display** button in order to switch the **Show quality** setting on.

   The **Quality** field and an **Apply** button appear at the bottom of the left side of the **Define color corrections** dialog.

2. Select the image(s) for which to change the quality value.
3. Type a value in the **Quality** field.

   Values from 0 - 255 are accepted in the field. The lower the number, the higher the quality of an image.

4. Click on the **Apply** button in order to change the quality value.

✍ The quality attribute of images can be changed using a key-in command defined in MicroStation. The syntax of the key-in command for changing the value :

```
quality set <value>, for example, quality set 3
```

If the key-in command is defined, for example, for the <F8> key, it can be used to change the value of selected image to <*value*> by just selecting the images and pressing the <F8> key.

✍ The quality attribute of images can also be changed by selecting the the images in the image list and using the **Edit** command of the **TPhoto Main** window.

11 Working with Tie Points

Tie point concepts

Not Lite

Tie points play a key role in TerraPhoto data processing workflows. Tie points provide a method for solving camera parameters and improving the positional accuracy of images. They are used for camera calibration at the beginning of the processing workflow and later, for internal and external positional improvements of the actual project data. See Chapters **Camera Calibration** on page 46 and **Improving Image Positioning** on page 118 for detailed information.

Tie points are differentiated into different types. They can occur as point or line features but, for reasons of simplicity, the term ‘tie points’ is used for both in this documentation if no separation is necessary.

The software handles and uses tie points differently for airborne and mobile ground-based missions. For airborne missions, the tie point mode is only available if a ground model is loaded in TerraPhoto. For mobile missions, a ground model is not required for working with tie points. However, there are a few tie point types which are only available for airborne or mobile missions. Finally, there are differences in the aims for which tie points are collected.

Airborne missions:

- Collect a small number of tie points for all cameras of a mission and distributed over the whole project area for adjusting misalignment angles in the camera calibration file.
- Collect more tie points until as many images as possible are well-defined by tie points. Improve the misalignment angles, principle point coordinates, and lens distortion parameters iteratively while working with tie points.
- Collect a big number of tie points for images in order to adjust the positioning for each image individually.

Mobile missions:

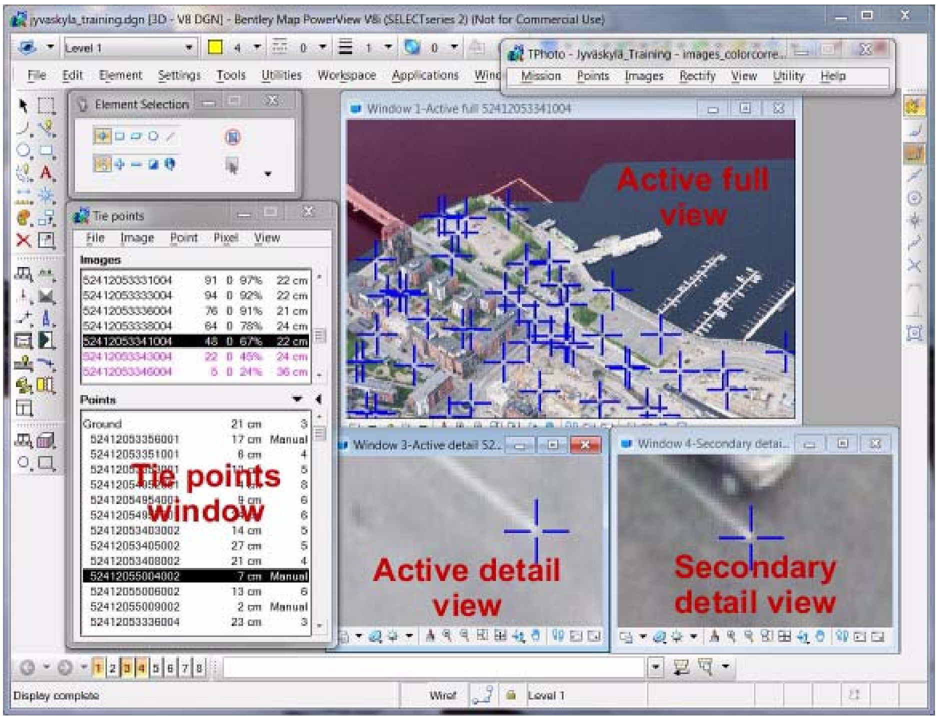
- Collect a small number of tie points for all cameras of a mission and distributed over the whole project area for adjusting misalignment angles in the camera calibration file.
- Collect tie lines of type **Straight line** for solving the lens distortion values in the camera calibration file.
- Collect tie points of types **Known depth** and/or **Depth** at regular distances in order to derive fluctuating corrections of the trajectory drift in TerraMatch.

✍ *TerraPhoto Lite* does not have any of the tie point tools.

Tie point entry windows

If the **Define tie points** command from the **Images** pulldown menu in the **TPhoto Main** window is selected, the application changes into the tie point mode. The application makes sure that relevant windows are open on the screen. The following windows are needed for working with tie points:

- **Tie points -** window that contains pulldown menus and two list boxes. The upper list box displays the active image list and tie point-related attributes for each image. The row selected in the upper list box determines the active image. The lower list box displays the list of tie points entered for the active image. Each tie point includes one or more tie point pixels, one pixel in each image in which the tie point is defined. The list also shows mismatch and reliability values for each tie point pixel. The visibility of attributes in the **Tie points** window can be defined by the **Fields** command.
- **Active full -** MicroStation view displaying a full raw image. The view uses thumbnails of images if they are available in the /TEMP folder of the mission.
- **Active detail -** MicroStation view displaying a rectified raster from the active image at the pixel location of the selected tie point.
- **Secondary detail -** MicroStation view displaying a rectified raster from a secondary image.



Tie point types

TerraPhoto distinguishes between different types of tie points/lines:

- **Ground point -** a common point seen in multiple images. The software does not know the coordinates of the point but it knows that it is on the ground or very close to the ground elevation. This type is only available for aerial imagery missions.
- **Air point -** a common point seen in multiple images. The coordinates of the point are not known and it may be off from the ground elevation.
- **Known xyz point -** the coordinates of the point are known. The point is visible in one or multiple images.
- **Known xy point -** easting and northing coordinates of the point are known. The point is visible in one or multiple images. This type is only available for aerial imagery missions.
- **Depth point -** a point seen in multiple images. The depth from the camera position of the point is known. This type is only available for mobile imagery missions.
- **Known depth point -** the coordinates and the depth from the camera position of the point are known. The point is visible in one or multiple images. This type is only available for mobile imagery missions.
- **Line -** a common line seen in multiple images. The software does no know the exact position of the start and end points of the line but it knows that it is on the ground or very close to the ground location. A perpendicular correction to each line is calculated.
- **Known line -** the easting and northing coordinates of one point along the line are known and the line is located on ground elevation. The line is visible in one or multiple images. A perpendicular correction to each line is calculated.
- **Straight line -** a line that represents a straight linear feature in an image of a mobile side-looking camera. This type is only available for mobile imagery missions.

The availablity of tie point types depend on the system that captured the data: airborne or mobile ground-based system.

Ground tie points are typically the most common type of tie point used in TerraPhoto workflow for aerial orthorectification projects. **Air** tie points are most often used to improve the internal positioning of mobile imagery. **Depth** and **Known depth** tie points can be utilized for deriving TerraMatch correction values for trajectory drifts of mobile system projects. **Straight lines** are used for calibrating the lens distortion of mobile side-looking images.

Tie point values

TerraPhoto can adjust the positioning of the images in a way that tie point objects seen in different images fall more accurately at the same location. The adjustment process is only reliable if each image has a sufficient number of tie points. If an image does not have enough tie points, the adjustment process does not necessarily make an improvement. It can even worsen the positioning in those parts of the project area where images do not have any tie points.

TerraPhoto computes a sum of tie point values for each raw image in order to indicate if an image has enough tie points (i.e. is well-defined) or not. The positional value of a tie point depends on its type and is a measure of how fixed the position of the tie point is. TerraPhoto uses the following value system:

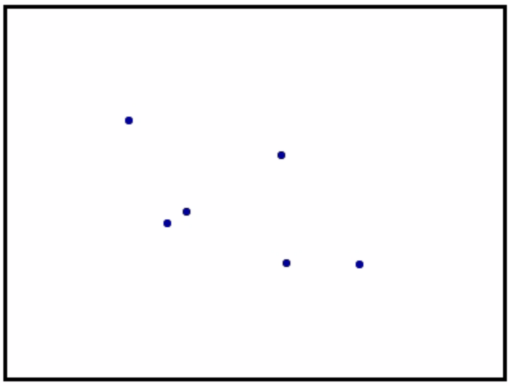
- Air point, Line 1
- Ground point, Depth point, Known line 2
- Known xyz point, Known xy point, Known depth point 3
- Straight lines do not have a tie point value.

Air points and **Lines** are the least valuable types as they have the biggest degree of freedom. Their position is always computed as an average of the tie point rays and the solution point can move freely. **Ground** points, **Depth** points, and **Known** lines provide more value. Their position is computed as an average of the tie point rays but it is also fixed on the ground surface. **Known** point types are most valuable as their position is fixed.

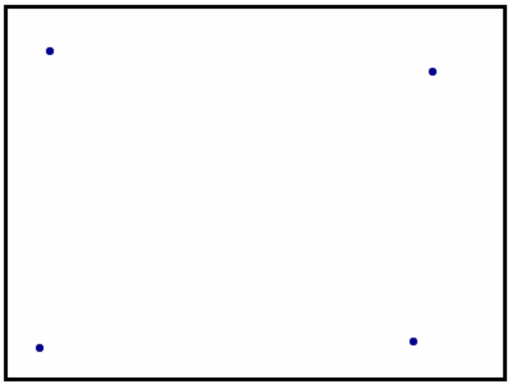
Tie point distribution

The number of tie points and the sum of their values is not the only criterion which should be considered when evaluating how well an image is defined by tie points. The distribution of tie points within the image is an equally important factor. Tie points close to the corners of the image provide the best positional control. Tie points close to the center of the image provide less control.

The ideal case for airborne images is to enter one **Ground** tie point close to each corner of the image. This would create good positional control using only four tie points.



Poor distribution



Good distribution

The distribution of tie points within an image is reflected in the coverage value which can be displayed in the **Tie points** window. The coverage is expressed as percentage value. Well-defined images have a percentage value bigger than at least 50 % and close to 100 %.

Tie status

The tie status of an image indicates whether more tie points should be entered to this image or not. It is an attribute which is stored for each image in the image list. The tie status can be '*Check*' (default) or '*Approved*'. The status *Approved* indicates that an operator has checked the image and decided that no more tie points can or need to be added to this image. Thus, approved images can be images that already have a good number of well-distributed tie points, or they are images where no tie points can be entered (for example, they are completely covered by dense forest or water).

The tie status of images can be changed in different ways:

- In the **Define color corrections dialog** - see **Changing the tie status of images** on page 74 for more information.
- In the **Tie points** window - use function key commands to change the status for a selected image. The key commands are:
```
tie set status approved
tie set status check
```

The tie status can be used to **Sort images** in the image list in order to display images with tie status *Check* at the beginning of the list.

Tie point entry modes

Tie points are defined by using different levels of automation. These different levels can be described as three entry modes:

- **Manual -** you enter the tie point manually in all images. The application just displays each raw image the sees the tie point location automatically in the detail views.
- **Semi-automatic -** you enter the tie point manually in the active image. The application finds matches in other images automatically. This mode is active if **Find matches automatically** is switched on in **Tie points / Automation** of the TerraPhoto **Settings**. This mode applies to **Ground** tie points only.
- **Automatic -** the application searches for tie points automatically. You start the search by selecting **Search points** command from the **File** pulldown menu in the **Tie points** window. The automatic search enters only **Ground** tie points.

Whenever you start working on a new project, you normally start with the manual mode. If mismatch distances become relatively small (about 2-3 * pixel size of the raw images), you may change to the semi-automatic mode. If that mode is successful in finding correct matches and if the camera parameters are stable, you can run the automatic search.

➢ **General workflow of entering a tie point**

1. Select an image in the upper list box of the **Tie points** window.

   The image is displayed on the **Active full** view.

2. Select a tie point type from the **Point** pulldown menu of the **Tie points** window.
3. Define an appoximate location with a data click in the **Active full view**. Select a location where you think you can place a tie point of the selected type.

   For **Known** tie point types, the known point location must be entered first instead of the approximate tie point location.

   The selected location in the active image is displayed in the **Active detail** view.

4. Search for a good location for the tie point in the **Active detail** view. Place the tie point in the **Active detail** view with a data click.

   The tie point is created and displayed in the lower list of the **Tie points** window. It is defined in the active image while all secondary images have empty pixels for this tie point.

   The tie point location is displayed in the **Secondary detail** view.

5. Enter the tie point in all other images in the **Secondary detail** view. The images are displayed one after one in the **Secondary detail** view whenever the tie point has been entered.

   In semi-automatic entry mode, **Ground** tie points are placed automatically in all secondary images after they have been entered in the active image. If a tie point location can not be found automatically in an image, this image is displayed in the **Secondary detail** view for manual entry. However, the setting for **Bad matches** in **Tie points / Automation** of the TerraPhoto **Settings** determines the handling of situations, where tie points can not be found semi-automatically.

Alternatively to the mouse pointer, you can navigate in the lists of the **Tie points** window by using the <Arrow-up> and <Arrow-down> keys. The key commands select the previous/next image in the list of images or points. A selected tie point pixel can be deleted by using the <Delete> key. The usage of keys is automatically focussed on the tie point list if the setting **Focus point list automatically** is switched on in **Tie points / Automation** of the TerraPhoto **Settings**.

✍ A detailed description of entering tie points of different types is provided in Section **Point pulldown menu** on page 97.

File pulldown menu

Commands in the **File** pulldown menu are used to open and save tie points, import known point files, recompute all tie points, output a report, draw tie point distribution and residual vectors, search tie points automatically, modify tie point types, clean undefined pixels, and modify the image numbers.

To:	Choose menu command:
Erase currently defined tie points	**New**
Open a previously saved tie points file	**Open**
Save tie points to an existing file	**Save**
Save tie points to a new file	**Save As**
Import known point coordinates from a text file	**Import known points**
Import known line coordinates from a text file	**Import known lines**
Recompute solution points for tie points	**Recompute all**
Output a report about tie points	**Output report**
Draw the distribution of tie points for a camera	**Draw pixel distribution**
Draw residual vectors for all tie points of a camera	**Draw residual vectors**
Search new tie points in automatic mode	**Search points**
Convert ground into air tie points automatically	**Fix ground to air**
Remove all undefined pixels from all tie point	**Clean all**
Change the image numbering in the tie point file	**Renumber images**

New

New command erases the active tie points and thus, lets you start the creation of a new tie point file. It frees the memory that is occupied by active tie points.

Open

Open command reads previously saved tie points from a file on the hard disc.

Save

Save command saves the tie points to the same file from which they have been opened before.

Save As

Save As command saves the tie points into a new file.

Import known points

Import known points reads points from a text file and inserts them as **Known xyz** tie points. You need to go through the list of images and enter the tie point positions in each image that sees a known point location.

The command recognizes space-delimited text files where each line stores the coordinates of one known point as:

- Easting Northing Elevation
- Identifier Easting Northing Elevation

➢ **To import known points and enter them as tie points:**

1. Select **Import known points** command from the **File** pulldown menu.

   This opens the **Import known points** dialog, a standard dialog for opening a file.

2. Select the known point text file and click **Open**.

   This reads the known point coordinates from the text file and adds the points as **Known xyz** tie points to the active tie points. The points are added as empty tie point pixels at the end of the tie points list.Images that see the known point locations are marked with the asterisk character (*) behind the image number in the list of images in the **Tie points** window.

3. Scroll through the list of images in the **Tie points** window until you find an image with an asterisk behind the image number. Select the image.

   This displays the tie points for the selected image in the lower list box of the **Tie points** window.

4. Select a **Known xyz** tie point in the active image in the tie points list.

   The location of the tie point in the active image is displayed in the **Active detail** view and in a secondary image in the **Secondary detail** view**.**

5. Select **Enter position** command from the **Pixel** pulldown menu.
6. Enter the tie point location with a data click in the active image in the **Active detail** view.
7. Enter the tie point location with a data click in all other images in the **Secondary detail** view. Use the <Arrow-down> key or the mouse pointer to select the next secondary image in the tie points window after placing a tie point in one image.
8. Repeat steps 3 to 7 for all known tie points.

Import known lines

Import known lines reads coordinates of points on linear features from a text file and inserts them as tie lines of type **Known lines**. There is an option for automatic placement of the lines. Alternatively, you need to go through the list of images and enter the tie line positions in each image that sees a known line location.

The command recognizes space-delimited text files where each line stores the coordinates of one known line as:

- Easting Northing Elevation
- Identifier Easting Northing Elevation

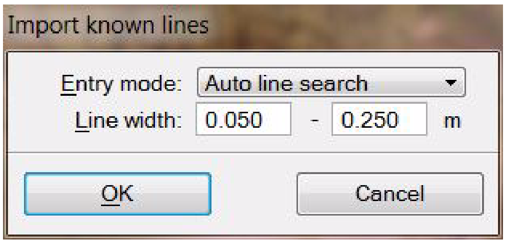
➢ **To import known lines and enter them as tie lines:**

1. Select **Import known lines** command from the **File** pulldown menu.

   This opens the **Import known lines** dialog, a standard dialog for opening a file.

2. Select the known lines text file and click **Open**.

   Another **Import known lines** dialog opens:



3. Define settings and click OK.

Setting:	Effect:
Entry mode	Method of **Known line** placement: • **Manual -** lines need to be entered manually. • **Auto line search -** lines are placed automatically.
Line width	Distance from the tie line within which the software tries to place tie line pixels automatically. Values can be determined, for example, from the width of paint markings on a road.

   This reads the known line coordinates from the text file and adds them as **Known lines** to the active tie points.

   If the **Entry mode** is set to **Auto line search**, the software starts the automatic search for tie lines and adds them to the tie points list. Otherwise, the known lines are added as empty tie line pixels to the tie points list and you need to continue with step 4.

   Images that see locations of empty known lines are marked with the asterisk character (*) behind the image number in the list of images in the **Tie points** window.

4. Scroll through the list of images in the **Tie points** window until you find an image with an asterisk behind the image number. Select the image.

   This displays the tie points for the selected image in the lower list box of the **Tie points** window.

5. Select a **Known line** in the active image in the tie points list.

   The location of the tie point in the active image is displayed in the **Active detail** view and in a secondary image in the **Secondary detail** view**.**

6. Select **Enter position** command from the **Pixel** pulldown menu.
7. Enter the start and end points of the tie line with two data clicks in the active image in the

Active detail view.

8. Enter the start and end points of the tie line in all other images with two data clicks in the **Secondary detail** view. Use the <Arrow-down> key or the mouse pointer to select the next secondary image in the tie points window after placing a tie point in one image.
9. Repeat steps 4 to 8 for all known lines.

Recompute all

Recompute all command recomputes internal variables of each tie point. This includes projecting pixel vectors to the ground and computing the solution point.

The command is not used very often as the application recomputes tie points automatically after the most typical actions which invalidate tie point information. It recomputes automatically after the following actions:

- Applying changes to camera parameters using **Apply** in the **Camera** dialog.
- Adjust image positions using **Adjust positions** command.
- Open a new image list.

Recompute all must be used after the following actions:

- Modify images using the **Edit** command.
- Change **Positions** setting for any of the cameras in the mission definition.

Output report

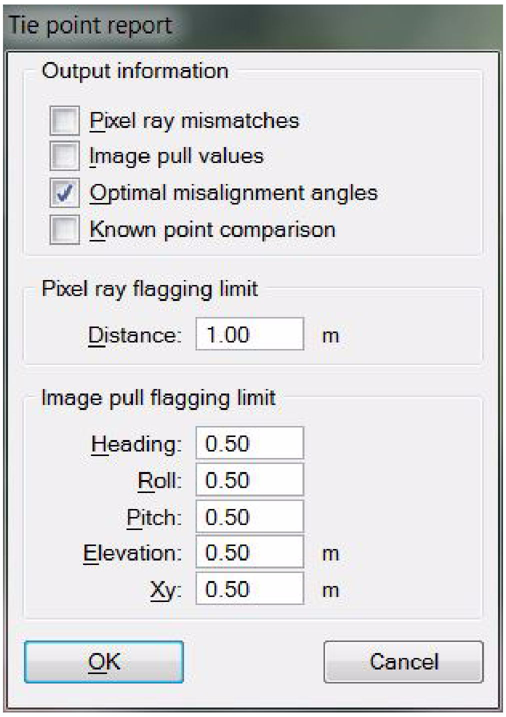
Output report command creates a report based on the active tie points. You may use this command to accomplish the following:

- Find out how many images have enough tie points and how many do not.
- Find tie points or images with large mismatch distances.
- Find and apply the best misalignment angles for camera(s).
- Find out how well known tie points match to know point coordinates.

➢ **To output a tie point report:**

1. Select **Output report** command from the **File** pulldown menu.

   This opens the **Tie point report** dialog:



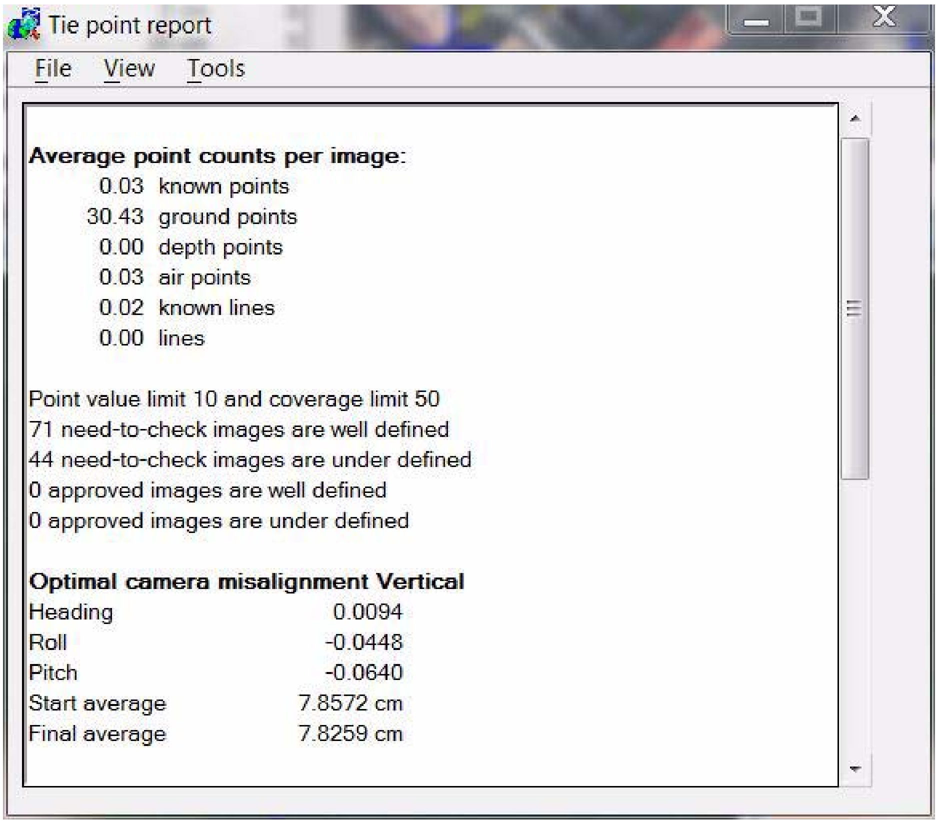
2. Define settings and click OK

   This computes the report values and opens the **Tie point report**.

Setting:	Effect:
Pixel ray mismatches	If on, the report contains mismatch distances for each tie point pixel.
Image pull values	If on, the report contains the pull direction for each image translated into heading, roll, and pitch changes.
Optimal misalignment angles	If on, the report includes camera misalignment values which produce the smallest tie point mismatches using raw image positions.
Known point comparison	If on, the report includes a comparison of how well pixel rays of known tie points match the known point coordinates.
Distance	Writes pixel ray mismatch in red if it exceeds this value.
Heading	Writes heading pull value in red if it exceeds this value.
Roll	Writes roll pull value in red if it exceeds this value.
Pitch	Writes pitch pull value in red if it exceeds this value.
Elevation	Writes elevation pull value in red if it exceeds this value.
Xy	Writes xy pull value in red if it exceeds this value.

Tie point report

The tie point report is displayed in the **Tie point report** window. The window contains pulldown menus and the report information:



Use commands from the **File** pulldown menu to save the report as a text file and to print the report directly. Commands from the **View** pulldown menu can be used to change the size of the report window.

Apply misalignment command from the **Tools** pulldown menu applies the optimal camera misalignment values to the camera calibration file(s) for each camera of the mission. Further, the command automatically saves the camera calibration file(s) and recomputes the tie points. This should be done if the **Final average** value in the report is smaller than the **Start average** value, which means that the optimal camera misalignment values improve the image positioning.

Depending on the selected settings in the **Tie point report** dialog, the report includes the following information:

Average point counts per image lists the average number of tie points per image for each tie point type. Further, it displays the number of images with tie status *Check* that are well-defined and under-defined according to the given tie point value and coverage limits. The same is shown for images with tie status *Approved*.

Pixel ray mismatches shows a list of all tie points, their geographical coordinates, and the mismatch distances in centimeters of each tie point pixel. The tie points are sorted by tie point type. The list ends with the average mismatch distance.

Image pull values are reported in a table which lists all images. For each image the number of tie points per type and changes in values for heading, roll, pitch, elevation, and xy are displayed. The table ends with the average change for each value.

Optimal camera misalignment provides the optimal misalignment angles for each camera of the mission. **Start average** and **Final average** values allow the comparison between the average mismatch with the current camera misalignment angles and with the optimal camera misalignment angles. If the value for **Final average** is smaller than the value for **Start average**, the new misalignment angles should be applied to the camera calibration files.

Known point comparison lists all known points, their geographical coordinates, and the mismatch distances for x,y, and z (if available) between the known points and the **Known** tie points/lines. The table ends with the average values for the mismatch distances. Further, the report gives a recommendation for a linear transformation in xy. It shows values that should be added to eastings and northings of the image coordinates in order to match the images better to the known points. These values can be used to **Transform positions** of the image list and thus, improve the absolute accuracy of the image list. Finally, the **Average** and **Worst mismatch** distances between known points and **Known** tie points/lines are shown.

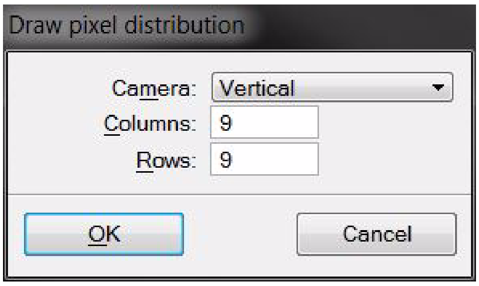
Draw pixel distribution

Draw pixel distribution command draws a grid into the design file that contains all tie point pixels for a camera. The drawing illustrates how well tie points are distributed and points out areas where tie points are missing. Thus, it helps to decide whether the lens distortion can be solved with the current tie points or not.

➢ **To draw the tie point distribution:**

1. Select **Draw pixel distribution** command from the **File** pulldown menu.

   This opens the **Draw pixel distribution** dialog:



2. Select a **Camera** for which you want to see the tie point distribution.
3. Define the number of **Columns** and **Rows** of the grid.
4. Click OK.

   The grid is shown temporarily at the mouse pointer location.

5. Place the grid in a MicroStation view with a data click.

   This draws the grid as cell element into the design file using the active level and symbology settings of MicroStation.

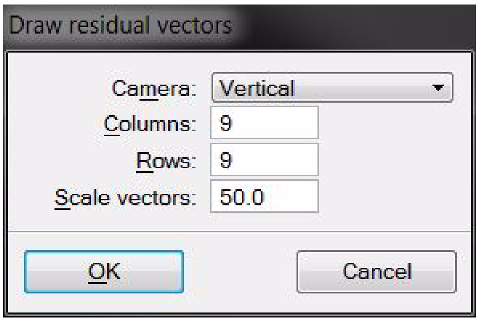
Draw residual vectors

Draw residual vectors command draws a grid into the design file that shows the residual pull vectors for a camera. The grid illustrates whether the lens distortion is regular or not. Thus, it helps to decide if the lens distortion in the camera calibration file can be corrected by a **Grid** model.

➢ **To draw the residual vectors:**

1. Select **Draw residual vectors** command from the **File** pulldown menu.

   This opens the **Draw residual vectors** dialog:



2. Select a **Camera** for which you want to see the residual vectors.
3. Define the number of **Columns** and **Rows** of the grid.
4. Define a scale factor in the **Scale vectors** field for enlarging the arrows that represent the pull vectors in the grid drawing.
5. Click OK.

   The grid is shown temporarily at the mouse pointer location.

6. Place the grid in a MicroStation view with a data click.

   This draws the grid as cell element into the design file using the active level and symbology settings of MicroStation.

Search points

Search points command searches for **Ground** tie points automatically by comparing overlapping parts of rectified images.

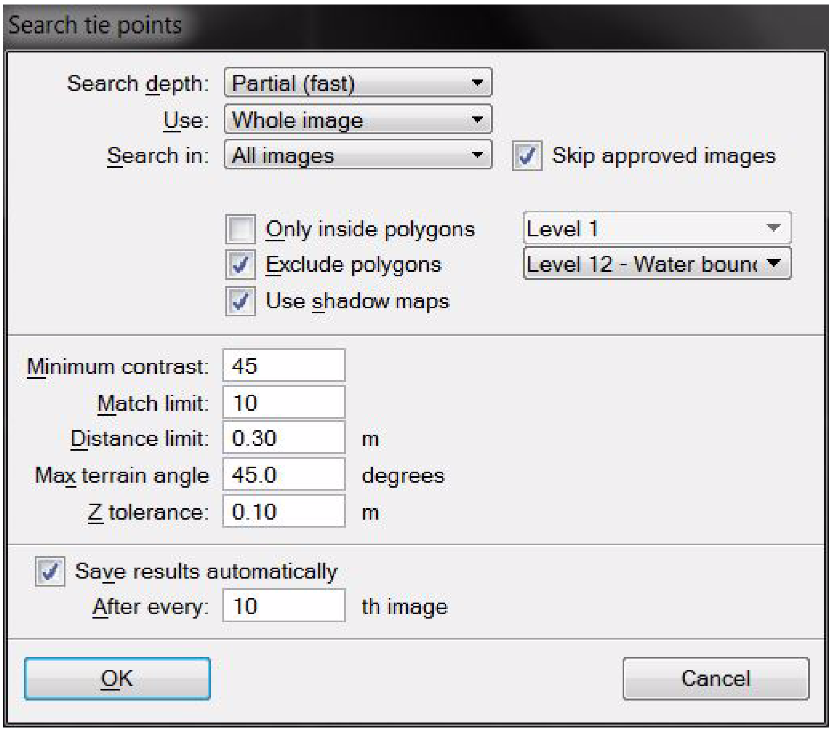
The process is only successful if the positioning of the images is fairly good. This requires that good stable camera parameters are established and mismatch distances for tie points are relatively small.

The automatic tie point search typically results in a large number of tie points. The majority of those tie points are good but there is also a small percentage of tie points which do not really see the same position on the ground. Therefore, bad tie points must be filtered out after the automatic search process. Use **Filter bad** command in order to perform the task automatically with a pretty good success rate. Additionally, you can filter out bad tie points with a more manual approach using **Find worst**, **Find first bad** or **Find next bad** commands.

➢ **To search tie points automatically:**

1. Select **Search points** command from the **File** pulldown menu.

   This opens the **Search tie points** dialog:



2. Define settings and click OK.

   The application starts searching for tie points. A progress window indicates how many images have been searched and how many tie points have been found.

   The tie point search on a large data set can take a very long time. The speed of the search is primarily effected by how well tie points can be found. The more tie points are found, the faster the search runs as it does not need to attempt finding new points close to the already collected ones. If the routine does not find many points, you probably need to restart the process with a higher **Match limit** setting or establish better camera parameters.

Setting:	Effect:
Search depth	Depth of the search. This partially effects how many tie points the application searches for each image: • **Full (slow) -** largest amount of tie points. • **Medium** - medium amount of tie points. • **Partial (fast)** - smallest amount of tie points.
Use	Area within an image where the software searches for tie points: • **Whole image -** within the whole image. • **Selected parts -** only in selected parts of an image. The parts can be selected for each image separately by using the **Define** button.
Search in	Images to search in: • **All images** - all images. • **Underdefined image -** all images lacking tie points. • **Active image** - active image only. • **Given image range** - images in a given range of image numbers.
Skip approved images	If on, images with tie status *Approved* are not included in the tie point search.
Images	Image numbers that define the range for searching tie points. This is only active if **Search in** is set to **Given image range**.
Only inside polygons	Tie points are searched only inside shape elements on the given design file level.
Exclude polygons	No tie points are searched inside shape elements on the given design file level.
Use shadow maps	If on, the routine uses shadow maps stored in the /TEMP directory of the mission. See **Compute shadow maps** for more information.
Minimum contrast	Minimum contrast required at a location where the software tries to enter a tie point. The contrast is the difference between the maximum and the minimum gray scale value within the comparison raster. Normally set to a value between 30 and 100.
Match limit	Required match rating for accepting a tie point. A higher value allows the application to accept worse matches where the rasters from different raw images do not match each other so well. Normally set to a value between 6 and 12.
Distance limit	Maximum allowed mismatch distance for a tie point pixel to be accepted.
Max terrain angle	Maximum allowed terrain angle at a tie point location.
Z tolerance	Elevation variation in ground model points. Used in slope computation.
Save results automatically	If on, the routine saves the tie points at regular intervals into a tie point file on a hard disc.
After every	Interval after which to save points automatically. This is only active if **Save results automatically** is switched on.

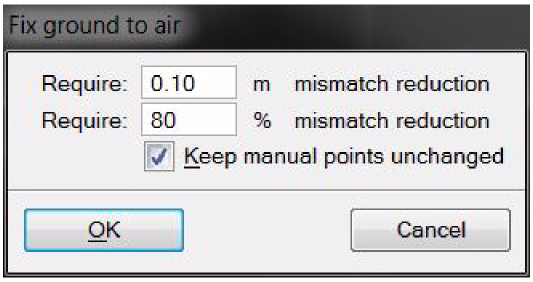
Fix ground to air

Fix ground to air command changes the type of a tie point from **Ground** to **Air** if a given mismatch reduction is achieved by the conversion. This is useful, for example, after an automatic tie point search where many tie points have been placed on objects above the ground, such as bridges.

➢ **To change ground tie points into air tie points:**

1. Select **Fix ground to air command** from the **File** pulldown menu.

   The **Fix ground to air** dialog opens:



2. Define settings and click OK.

   The software performs the conversion. An information dialog shows the number of points that were changed into **Air** tie points.

Setting:	**Effect:**
Require	Mismatch reduction in meter that is required for converting a tie point.
Require	Mismatch reduction in percent that is required for converting a tie point.
Keep manual pixels unchanged	If on, manually placed tie point pixels are not affected by the conversion.

Clean all

Clean all command removes undefined pixels from all tie points.

It performs the same action as the **Clean** command from the **Point** pulldown menu, just for the complete tie point file.

➢ **To remove undefined pixels from all tie points:**

1. Select **Clean all** command from the **File** pulldown menu.

   An alert dialog requests a confirmation for the process.

2. Click OK in order to remove the undefined tie point pixels.

   An information dialog shows the amount of removed tie points and tie point pixels.

Renumber images

Renumber images command renumbers all or a given range of images in the tie points file. It adds a constant number to the existing image numbers or converts 32-bit image numbers into 64-bit numbers.

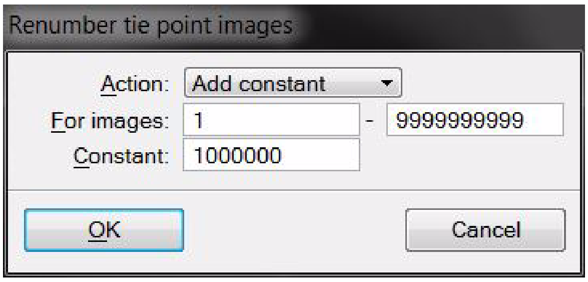
TerraPhoto requires a unique number for images in the active image list which is derived from the image file names. These image numbers are stored in the tie point file. If it is necessary to rename the image files, the numbers in the image list change. Therefore, it might be necessary to change the image numbers in the tie point file as well in order to ensure that tie points still work for the renamed images.

The update of image numbers is also required if an old tie point file with image numbers stored as 32-bit values is used for a new image list file with image numbers stored as 64-bit values (TerraPhoto version 010.014 or later).

➢ **To renumber images:**

1. Select **Renumber images** command from the **File** pulldown menu.

   This opens the **Renumber tie point images** dialog:



2. Define settings and click OK.

   The new numbering is applied for the tie points. An information dialog shows the amount of images that have been renumbered.

3. Save the tie points using **Save** or **Save As** commands from the **File** pulldown menu in order to save the tie points with renumberd images into a file.

Setting:	Effect:
Action	Method of renumbering images for tie points: • **Add constant** - a constant value is added to each image number. • **Convert to 64 bit** - the image numbers are converted into 64-bit values.
For images	Range of image numbers for which the renumbering is applied.
Constant	Value that is added to current image numbers. Negative values can be used. This is only active if **Action** is set to **Add constant**.

Image pulldown menu

Commands in the **Image** pulldown menu are used to show the geographical location of the active image and to select the active image or the secondary image by geographical location.

To:	Choose menu command:
See the geographical location of the active image	**Show active**
Select the active image by geographical location	**Identify active**
Select the secondary image by geographical location	**Identify secondary**

Show active

Show active command shows the geographical location of the active image.

➢ **To see the geographical location of the active image:**

1. Select an image in the upper list box of the **Tie points** window.
2. Select **Show active** command from the **Image** pulldown menu.
3. Move the mouse pointer inside a MicroStation view.

   The application displays the footprint shape of the selected image.

✍ Place a data click inside the view in order to center the view to the xyz position of the active image.

Identify active

Identify active command lets you select a new active image. The image is selected by its geographical location.

➢ **To select an active image by geographical location:**

1. Select **Identify active** command from the **Image** pulldown menu.
2. Move the mouse pointer inside a MicroStation view.

   The image footprint of the image closest to the mouse pointer is displayed dynamically.

3. Select an image with a data click inside the view.

   This selects the image closest to the mouse pointer as new active image in the **Tie points** window. The image display in the **Active full** view is updated.

Identify secondary

Identify secondary menu command lets you select a new secondary image. The image is selected by its geographical location.

➢ **To select a secondary image by geographical location:**

1. Select **Identify secondary** command from the **Image** pulldown menu.
2. Move the mouse pointer inside a MicroStation view.

   The image footprint of the image closest to the mouse pointer is displayed dynamically.

3. Select an image with a data click inside the view.

   This selects the image closest to the mouse pointer as new secondary image.

Point pulldown menu

Commands in the **Point** pulldown menu are used to add new tie points and to modify, clean, or delete the selected tie point.

To:	Choose menu command:
Add a ground tie point	**Add ground**
Add an air tie point	**Add air**
Add a depth tie point	**Add depth**
Add a known depth tie point	**Add known depth**
Add a known xyz tie point	**Add known xyz**
Add a known xy tie point	**Add known xy**
Add a tie line	**Add line**
Add a known tie line	**Add known line**
Add a straight tie line	**Add straight line**
Modify information of the selected tie point	**Edit information**
Remove all undefined pixels from the selected tie point	**Clean**
Delete the selected tie point	**Delete**

Add ground

Add ground command lets you enter a new tie point of type **Ground**. **Ground** tie points can be placed manually or in semi-automatic entry mode depending on the setting in **Tie points / Automation** of the TerraPhoto **Settings**.

➢ **To enter a new ground point:**

1. Select **Add ground** command from the **Point** pulldown menu.

   The **Tie Add Ground** dialog opens:

   If **Display position hint** is switched on, the software indicates the approximate location of the tie point in secondary images by a small red cross.

2. Identify an approximate location with a data click in the **Active full** view where you intend to enter a **Ground** point.

   The application updates the **Active detail** view in order to show the selected location as an orthorectified image.

3. Enter the tie point position with a data click in the **Active detail** view. You may move or zoom the image in the view in order to find a good tie point location.

   The application adds the tie point to the list in the **Tie points** window. The tie point is manually defined in the active image. In semi-automatic entry mode, the software tries to place the tie point in all other images automatically. If all tie point pixels are found automatically, you can continue with step 2 in order to place the next **Ground** tie point.

   The tie point pixels in the other images are undefined at this stage if you are using the manual entry mode or if the semi-automatic entry mode did not find an acceptable match. The software selects the next image with an undefined tie point pixel in the list and updates the **Secondary detail** view in order to show the tie point position.

4. Enter the tie point position with a data click in the **Secondary detail** view.

   The application recomputes the solution point for the tie point and displays the current mismatch for each image. It selects the next image with an undefined tie point pixel in the list and updates the **Secondary detail** view in order to show the tie point position.

5. Continue with step 4 until all tie point pixels are defined.
6. After entering the last pixel of a tie point, you can continue with step 2 if you want to place the next **Ground** tie point.

✍ If the tie point position can not be defined in one of the secondary images, you should select the next undefined pixel for this tie point and continue entering the tie point pixels. Use the **Clean** command from the **Point** pulldown menu in order to remove undefined pixels from a selected tie point.

Add air

Add air command lets you enter a new tie point which may be above the ground. **Air** tie points can be entered manually only.

➢ **To enter a new air point:**

1. Select **Add air** command from the **Point** pulldown menu.

   The **Tie Add Air** dialog opens:

   If **Display position hint** is switched on, the software indicates the approximate location of the tie point in secondary images by a thin red line.

2. Identify an approximate location with a data click in the **Active full** view where you intend to enter an **Air** point.

   The application updates the **Active detail** view in order to show the selected location as an orthorectified image.

3. Enter the tie point position with a data click in the **Active detail** view. You may move or zoom the image in the view in order to find a good tie point location.

   The application adds the tie point to the list in the **Tie points** window. The tie point is defined in the active image.

   The tie point pixels in the other images are undefined at this stage. The software selects the next image with an undefined tie point pixel in the list and updates the **Secondary detail** view in order to show the tie point position.

4. Enter the tie point position with a data click in the **Secondary detail** view.

   The application recomputes the solution point for the tie point and displays the current mismatch for each image. It selects the next image with an undefined tie point pixel in the list and updates the **Secondary detail** view in order to show the tie point position.

5. Continue with step 4 until all tie point pixels are defined.
6. After entering the last pixel of a tie point, you can continue with step 2 if you want to place the next **Air** tie point.

✍ If the tie point position can not be defined in one of the secondary images, you should select the next undefined pixel for this tie point and continue entering the tie point pixels. Use the **Clean** command from the **Point** pulldown menu in order to remove undefined pixels from a selected tie point.

Add depth

Add depth command lets you enter a new **Depth** tie point. **Depth** tie points are used for deriving trajectory drift corrections in data sets from mobile systems. Therefore, the tie points are collected in TerraPhoto but used in TerraMatch for finding fluctuating corrections. The derived corrections can then be utilized to improve the positioning of images and laser data collected during the same survey.

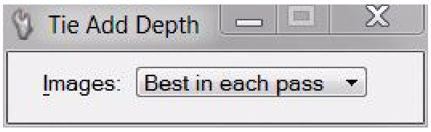
Depth tie point should be entered at regular distances along roads, railroads, or other linear objects in order to provide a good source for correcting the drift in the trajectory. You may place a tie point, for example, in every 5th or 10th image if the images were captured at a constant driving speed. The point is entered only in those images that see a tie point location best.

Depth tie point require depth maps in the /TEMP directory of the mission. See **Compute depth maps** for more information.

➢ **To enter a new depth point:**

1. Select **Add depth** command from the **Point** pulldown menu.

   The **Tie Add Depth** dialog opens:



2. Select **Images**, in which you want to place the tie point: **All possible** or **Best in each pass**. The latter option causes that only those images from each drive path are displayed for tie point placement that see the tie point location best.
3. Identify an approximate location with a data click in the **Active full** view where you intend to enter a **Depth** point.

   The application updates the **Active detail** view in order to show the selected location.

4. Enter the tie point position with a data click in the **Active detail** view. You may move or zoom the image in the view in order to find a good tie point location.

   The application adds the tie point to the list in the **Tie points** window. The tie point is defined in the active image.

   The tie point pixels in the other images are undefined at this stage. The software selects the next image with an undefined tie point pixel in the list and updates the **Secondary detail** view in order to show the tie point position.

5. Enter the tie point position with a data click in the **Secondary detail** view.

   The application recomputes the solution point for the tie point and displays the current mismatch for each image. It selects the next image with an undefined tie point pixel in the list and updates the **Secondary detail** view in order to show the tie point position.

6. Continue with step 5 until all tie point pixels are defined.
7. After entering the last pixel of a tie point, you can continue with step 3 if you want to place the next **Depth** tie point. Typically, you would select another image before you place the next tie point.

✍ You can check the distribution of tie points along the survey area in another MicroStation top view. Make sure that the setting **Draw points in all top views** is switched on in the **Tie point view setup** dialog. The dialog is opened by the **Setup** command from the **View** pulldown menu. New tie points are displayed in top views after redrawing the view.

Add known depth

Add known depth command lets you enter a new **Known depth** tie point for which the x, y, and z coordinates are known.

Known depth tie points are used for deriving trajectory drift corrections in data sets from mobile systems. Therefore, the tie points are collected in TerraPhoto but used in TerraMatch for finding fluctuating corrections. The derived corrections can then be utilized to improve the positioning of images and laser data collected during the same survey.

Known depth tie points are entered based on points for which the x, y, and z coordinates are known, for example, control points on signal markers, paint markings, etc. on the ground. The control points should be measured at regular distances along roads, railroads, or other linear objects in order to provide a good source for correcting the drift in the trajectory. The known points must be drawn into the design file and should be displayed in a top view for tie point entry. Each tie point is entered only in one image that sees the known point location best.

Known depth tie point require depth maps in the /TEMP directory of the mission. See **Compute depth maps** for more information.

➢ **To enter a new known depth point:**

1. Select **Add known depth** command from the **Point** pulldown menu.

   The **Tie Add Known Depth** dialog opens:

2. Define a number for the tie point. The number increments automatically.
3. Select **Images**, in which you want to place the tie point: **All possible**, **Best in each pass**, or **Best one**. The latter two options cause that only image(s) from each drive path or one drive path are displayed for tie point placement that see the known point location best.
4. Enter the position of the known point with a data click in a MicroStation view. You can snap to a vector element drawn in the design file in order to get the exact coordinates of the known point.

   The software adds the point to the list in the **Tie points** window. All tie point pixels are undefined at this stage. The software updates the **Active detail** view in order to show the location of the known point.

5. Enter the tie point position with a data click in the **Active detail** view. You may move or zoom the image in the view in order to find the correct tie point location.

   The software computes and displays the mismatch between the tie point and the known point coordinates. If the tie point is only entered in one image, you can continue with step 4 in order to enter the next **Known depth** tie point.

   If the tie point can be entered in additional images, the software selects the next image with an undefined tie point pixel in the list and updates the **Secondary detail** view in order to show the tie point position.

6. Enter the tie point position with a data click in the **Secondary detail** view.

   The software computes and displays the mismatch between the tie point and the known point coordinates. It selects the next image with an undefined tie point pixel in the list and updates the **Secondary detail** view in order to show the tie point position.

7. Continue with step 6 until all tie point pixels are defined.
8. After entering the last pixel of a tie point, you can continue with step 4 if you want to place the next **Known depth** tie point.

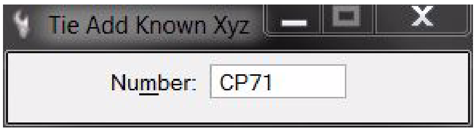
Add known xyz

Add known xyz command lets you enter a new **Known xyz** tie point. **Known xyz** tie points are entered based on points for which the x, y, and z coordinates are known, for example, control points on the ground. The coordinates of the known points can be defined by snapping to vector elements drawn into the design file or by typing a key-in command in the MicroStation key-in line.

➢ **To enter a new known xyz point:**

1. Select **Add known xyz** command from the **Point** pulldown menu.

   The **Tie Add Known Xyz** dialog opens:



2. Define a **Number** for the new point. By default, the number increments automatically.
3. Enter the position of the known xyz point with a data click in a MicroStation view. You may snap to a vector element drawn in the design file in order to get the exact coordinates of the known point.

   Alternatively, you can type a key-in command with the exact coordinates:

```
xy=212457.65,670960.11,73.45
```

   The application adds the point to the list of tie points. All tie point pixels are undefined at this stage.

   The application updates the **Active detail** view in order to show the known point location.

4. Enter the tie point position with a data click in the **Active detail** view.

   The software computes and displays the mismatch between the tie point and the known point coordinates. It selects the next image with an undefined tie point pixel in the list and updates the **Secondary detail** view in order to show the tie point position.

5. Enter the tie point position with a data click in the **Secondary detail** view.

   The software computes and displays the mismatch between the tie point and the known point coordinates. It selects the next image with an undefined tie point pixel in the list and updates the **Secondary detail** view in order to show the tie point position.

6. Continue with step 5 until all tie point pixels are defined.
7. After entering the last pixel of a tie point, you can continue with step 3 if you want to place the next **Known xyz** tie point.

✍ If the tie point position can not be defined in one of the secondary images, you should select the next undefined pixel for this tie point and continue entering the tie point pixels. Use the **Clean** command from the **Point** pulldown menu in order to remove undefined pixels from a selected tie point.

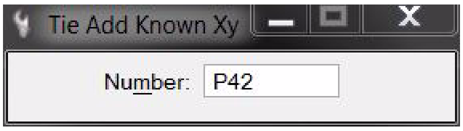
Add known xy

Add known xy command lets you enter a new **Known xy** tie point. **Known xy** tie points are entered based on points for which the x and y coordinates are known, for example, control points on the ground without (valid) elevation values. The coordinates can be defined by snapping to vector elements drawn into the design file or by typing a key-in command in the MicroStation key-in line.

➢ **To enter a new known xy point:**

1. Select **Add known xy** command from the **Point** pulldown menu.

   The **Tie Add Known Xy** dialog opens:



2. Define a **Number** for the new point. By default, the number increments automatically.
3. Enter the position of the known xy point with a data click in a MicroStation view. You may snap to a vector element drawn in the design file in order to get the exact coordinates of the known point.

   Alternatively, you can type a key-in command with the exact coordinates:

   ```
   xy=212457.65,670960.11
   ```

   The application adds the point to the list of tie points. All tie point pixels are undefined at this stage.

   The application updates the **Active detail** view in order to show the known point location.
4. Enter the tie point position with a data click in the **Active detail** view.

   The software computes and displays the mismatch between the tie point and the known point coordinates. It selects the next image with an undefined tie point pixel in the list and updates the **Secondary detail** view in order to show the tie line position.
5. Enter the tie point position with a data click in the **Secondary detail** view.

   The software computes and displays the mismatch between the tie point and the known point coordinates. It selects the next image with an undefined tie point pixel in the list and updates the **Secondary detail** view in order to show the tie point position.
6. Continue with step 5 until all tie point pixels are defined.
7. After entering the last pixel of a tie point, you can continue with step 3 if you want to place the next **Known xy** tie point.

✍ If the tie point position can not be defined in one of the secondary images, you should select the next undefined pixel for this tie point and continue entering the tie point pixels. Use the **Clean** command from the **Point** pulldown menu in order to remove undefined pixels from a selected tie point.

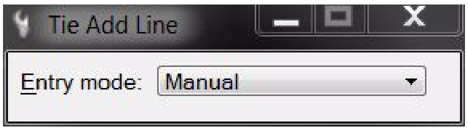
Add line

Add line command lets you enter a new tie line on the ground. **Lines** can be placed manually or in semi-automatic entry mode depending on the setting in the command's dialog.

➢ **To enter a new line:**

1. Select **Add line** command from the **Point** pulldown menu.

   The **Tie Add Line** dialog opens:



2. Select the **Entry mode**: **Manual** or **Auto image match**.
3. Identify an approximate location with a data click in the **Active full** view where you intend to enter a tie line.

   The application updates the **Active detail** view in order to show the selected location as an orthorectified image.

4. Enter the position of the line with two data clicks in the **Active detail** view. You may move or zoom the image in the view in order to find a good tie line location.

   The application adds the tie line to the list in the **Tie points** window. The tie line is manually defined in the active image. If **Entry mode** is set to **Auto image match**, the software tries to place the tie line in all other images automatically. If all tie line pixels are found correctly, you can continue with step 3 in order to place the next **Line**.

   The tie line pixels in the other images are undefined at this stage if you are using the manual entry mode. The software selects the next image with an undefined tie line pixel in the list and updates the **Secondary detail** view in order to show the tie line position.

5. Enter the tie line position with two data clicks in the **Secondary detail** view.

   The application recomputes the solution point for the tie line and displays the current mismatch for each image. It selects the next image with an undefined tie line pixel in the list and updates the **Secondary detail** view in order to show the tie line position.

6. Continue with step 5 until all tie line pixels are defined.
7. After entering the last pixel of a tie line, you can continue with step 3 if you want to place the next **Line**.

✍ If the tie line position can not be defined in one of the secondary images, you should select the next undefined pixel for this tie line and continue entering the tie line pixels. Use the **Clean** command from the **Point** pulldown menu in order to remove undefined pixels from a selected tie line.

Add known line

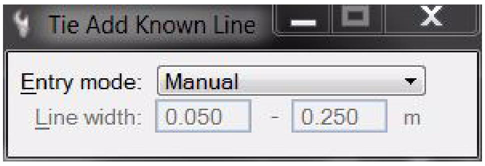
Add known line command lets you enter a new **Known line**. **Known line** tie lines are entered based on points for which the xyz coordinates of one point along a linear feature are known, for example, control points on a linear paint marking. The coordinates can be defined by snapping to vector elements drawn into the design file or by typing a key-in command in the MicroStation key-in line.

Known lines can be placed manually or in automatic entry mode depending on the setting in the command's dialog.

➢ **To enter a new known line:**

1. Select **Add known line** command from the **Point** pulldown menu.

   The **Tie Add Known Line** dialog opens:

2. Select the **Entry mode**: **Manual** or **Auto line search**. Define **Line width** values if **Entry mode** is set to **Auto line search**. The **Line width** defines the distance from the tie line within which the software tries to place tie line pixels automatically.
3. Enter the position of the known xyz point with a data click in a MicroStation view. You may snap to a vector element drawn in the design file in order to get the exact coordinates of the known point.

   Alternatively, you can type a key-in command with the exact coordinates:

   ```
   xy=212457.65,670960.11,73.45
   ```

   The application adds the tie line to the list in the **Tie points** window. If **Entry mode** is set to **Auto line search**, the software tries to place the tie line in all images automatically. If all tie line pixels are found correctly, you can continue with step 3 in order to place the next **Known line**.

   The tie line pixels are undefined at this stage if you are using the manual entry mode. The software selects the active image and updates the **Active detail** view in order to show the tie line position.

4. Enter the tie line position with two data clicks in the **Active detail** view.

   The software selects the next image with an undefined tie line pixel in the list and updates the **Secondary detail** view in order to show the tie line position.

5. Enter the tie line position with two data clicks in the **Secondary detail** view.

   The application recomputes the solution point for the tie line and displays the current mismatch for each image. It selects the next image with an undefined tie line pixel in the list and updates the **Secondary detail** view in order to show the tie line position.

6. Continue with step 5 until all tie line pixels are defined.
7. After entering the last pixel of a tie line, you can continue with step 3 if you want to place the next **Known line**.

✍ If the tie line position can not be defined in one of the secondary images, you should select the next undefined pixel for this tie line and continue entering the tie line pixels. Use the **Clean** command from the **Point** pulldown menu in order to remove undefined pixels from a selected tie line.

Add straight line

Add straight line command lets you enter a new tie line that represents a straight horizontal or vertical line in an image captured by a side-looking camera. Typically, this tie line type is used in calibration to solve **Zero radius function** lens distortion in images of mobile ground-based systems.

The best **Straight lines** are located close to image boundaries and run over a large distance within an image. An image should show an object with long straight lines, for example, a building with long edges. A few horizontal and vertical straight lines close to all four edges of images provide a good base for solving the lens distortion.

See also Section **Mobile camera calibration** on page 64 for more information about using **Straight lines** in calibration.

➢ **To enter a new straight line:**

1. Select an image in the upper list of the **Tie points window**.

   The software updates all views in order to show the active image.

2. Select **Add straight line** command from the **Point** pulldown menu.
3. Digitize the straight line as you see it in the image in the **Active detail** view. Due to the lens distortion, the line is not straight but curved in the image.

   A straight tie line is defined by at least three vertices. The longer the line can be drawn, the better for solving the lens distortion. Place the vertices of the line by data clicks and finish it with a reset click.

   The application adds the tie line to the list in the **Tie points** window. The values in the list show how much each vertex of the tie line differs from a straight line. The left column shows these differences after lens distortion correction, the right column before the correction. The values are given in pixels.

4. Continue with step 3 until there are enough **Straight lines** for solving the lens distortion.

✍ Place **Straight lines** in different images and for each camera of the mission. You can check the distribution of the tie lines by using the **Draw pixel distribution** command from the **File** pulldown menu. For each camera, there should be lines along all four edges of the grid model.

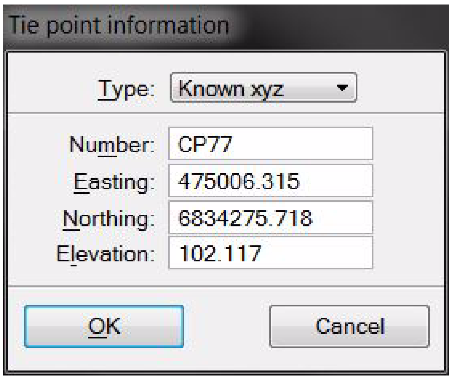
Edit information

Edit information command lets you modify the type of the selected tie point. For **Known xyz** tie points, the number and coordinate values can be modified as well.

➢ **To modify a tie point**

1. Select the tie point in the **Tie points** window.
2. Select **Edit information** command from the **Point** pulldown menu.

   The **Tie point information** dialog opens:



3. Select a new **Type** from the list.

   If **Type** is set to **Known xyz**, the **Number**, **Easting**, **Northing**, and **Elevation** fields become active.

4. Define a new number and/or coordinate values for the **Known xyz** tie point.
5. Click OK.

   This changes the tie point type and possibly the attributes of a **Known xyz** tie point.

6. Use **Save** or **Save As** commands from the **File** pulldown menu in order to save the tie points into a file.

Clean

Clean command removes all undefined pixels from a selected tie point. This is useful if not all pixels for a tie point are placed.

This command automatically restarts commands for adding tie points. Therefore, you can immediately continue with placing the next tie point of the same type.

✍ **Clean all** command from the **File** pulldown menu removes all undefined pixels from all tie points at once.

Delete

Delete commands remove tie points from the list. There are different options to define the tie points that are deleted:

- **Selected point -** the tie point selected in the list is removed.
- **Inside fence -** all tie points that are located inside a MicroStation fence or inside a selected shape are removed.
- **By criteria -** all tie points with certain attribute values are removed.

➢ **To delete a selected tie point:**

1. Select the tie point in the **Tie points** window.
2. Select **Delete / Selected point** command from the **Point** pulldown menu.

   This removes the point from the list.
3. Use **Save** or **Save As** commands from the **File** pulldown menu in order to save the tie points into a file.

➢ **To delete tie points inside a fence:**

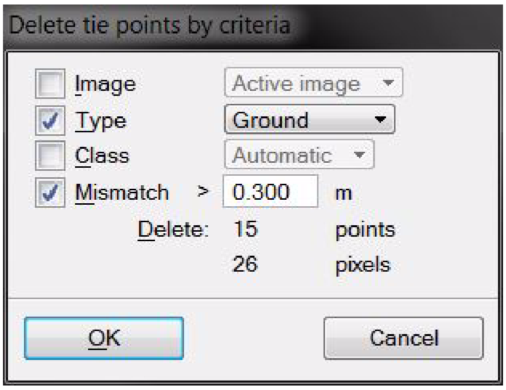
1. Draw a fence or polygon around the tie points you want to delete. Select the polygon.
2. Select **Delete / Inside fence** command from the **Point** pulldown menu.

   A dialog shows the number of tie points inside the fence and requests the confirmation of the removal process.
3. Click OK in order to remove the tie point(s) from the list.
4. Use **Save** or **Save As** commands from the **File** pulldown menu in order to save the tie points into a file.

➢ **To delete tie points with certain attributes values:**

1. Select **Delete / By criteria** command from the **Point** pulldown menu.

   The **Delete tie points by criteria** dialog opens:



2. Select attributes and values for tie point removal.

   The amount of effected tie points and pixels is displayed in the dialog.
3. Click OK.

   This removes the tie point(s) from the list.
4. Use **Save** or **Save As** commands from the **File** pulldown menu in order to save the tie points into a file.

Setting:	Effect:
Image	Tie points are removed from: • **Active image -** the active image only.

Setting:	**Effect:**
Type	Tie points of the selected type are removed.
Class	Tie points are removed according to their entry mode: • **Automatic -** automatically placed tie points. • **Manual** - manually placed tie points.
Mismatch	Tie points with a mismatch bigger than the given value are removed.

✍ Use the **Delete** command from the **Pixel** pulldown menu in order to remove only selected tie point pixels instead of complete tie points.

Pixel pulldown menu

Commands in the **Pixel** pulldown menu are used to enter tie point pixel positions, to identify a tie point in the list, to delete tie point pixels, and to find tie point pixels with large mismatch distances.

To:	**Choose menu command:**
Enter position for the selected tie point pixel	**Enter position**
Select a tie point pixel by identifying a location	**Identify in image**
Delete the selected tie point pixel	**Delete**
Find the pixel with the largest mismatch distance	**Find worst**
Find the first pixel exceeding given mismatch limit	**Find first bad**
Find the next pixel exceeding given mismatch limit	**Find next bad**
Delete tie point pixels with large mismatch distances	**Filter bad**

Enter position

Enter position command lets you enter the position of a selected tie point pixel. You can use this to enter the position of an undefined pixel or to correct the position of a pixel.

The command is also used to enter the positions of tie points that have been imported using **Import known points** or **Import known lines** commands.

➢ **To enter position for a pixel:**

1. Select the tie point pixel in the lower list of the **Tie points** window.
2. Select **Enter position** command from the **Pixel** pulldown menu.
3. Enter the new position with a data click in one of the detail views. If the selected pixel is in the active image, enter the new position in the **Active detail** view, if it is in a secondary image, enter the position in the **Secondary detail** view.

   If the position of a tie line is entered or corrected, define the new position with two data clicks.

   This sets the new position of the tie point pixel and recomputes the solution point for this tie point.

Identify in image

Identify in image command lets you identify a tie point with a data click. The corresponding tie point pixel is then selected in the list.

➢ **To select a tie point by its location:**

1. Select **Identify in image** command from the **Pixel** pulldown menu.

   If the mouse pointer is moved inside a view, the tie point closest to the mouse pointer is highlighted.

2. Identify a tie point with a data click. You can identify a point in the **Active full** view or in the detail views.

   This selects the tie point pixel closest to the data click in the **Tie points** window.

Delete

Delete command removes the selected tie point pixel from the list. It keeps all other pixels of the tie point unchanged.

➢ **To delete a tie point pixel:**

1. Select the pixel in the lower list of the **Tie points** window.
2. Select **Delete** command from the **Pixel** pulldown menu.

   This removes the pixel from the list.

✍ Use the **Delete** commands from the **Point** pulldown menu in order to delete tie points completely.

Find worst

Find worst command finds the tie point pixel with the largest mismatch distance. If you filter out bad tie points, it is recommended to first check the pixel with the largest mismatch distance.

➢ **To find the worst tie point pixel:**

1. Select **Find worst** command from the **Pixel** pulldown menu.

   The software finds the tie point pixel with the biggest mismatch, activates the first image containing this tie point, and selects the worst pixel in the **Tie points** window. All views are updated in order to show the tie point location.

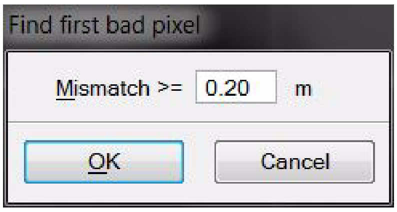
Find first bad

Find first bad command finds the first tie point pixel in the list that has a mismatch distance exceeding a given limit. This command is useful when you want to check all tie points with a mismatch distance larger than a certain value.

➢ **To find the first bad pixel:**

1. Select **Find first bad** command from the **Pixel** pulldown menu.

   This opens the **Find first bad pixel** dialog:



2. Define a limit in the **Mismatch** field. All tie points exceeding this mismatch value are considered as bad tie points.
3. Click OK.

   The application finds the first tie point pixel with a mismatch distance exceeding the limit, activates the first image containing this tie point, and selects the bad pixel in the **Tie points** window. All views are updated in order to show the tie point location.

✍ The tie point search is based on the order in which the tie points have been created. This order is not visible on the screen as the point list shows only those points which are located in the active image.

Find next bad

Find next bad command finds and selects the next tie point in the list whose mismatch distance exceeds the given limit. It utilizes the mismatch limit defined by the **Find first bad** command.

➢ **To find the next bad pixel:**

1. Define a mismatch limit using the **Find first bad** command.
2. Select **Find next bad** command from the **Pixel** pulldown menu.

The application finds the next tie point pixel with a mismatch distance exceeding the limit, activates the first image containing this tie point, and selects the bad pixel in the **Tie points** window. All views are updated in order to show the tie point location.

Filter bad

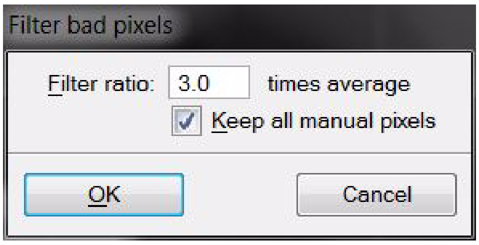
Filter bad command removes tie point pixels that do not match other tie points. It runs an iterative process where it first adjusts image rotation angles using the tie points. Then, it removes the tie point pixel with the largest mismatch distance if this pixel exceeds the given limit.

It is recommended to use this command always after running the **Search points** command for automatic tie point search. Some of the automatically placed points are likely to be bad matches and most of them can be removed automatically with this command.

➢ **To filter out bad points:**

1. Select **Filter bad** command from the **Pixel** pulldown menu.

   This opens **Filter bad pixels** dialog:



2. Define a limit for removing bad pixels and click OK.

   This starts the filtering process. An information dialog shows the amount of deleted tie points and pixels after finishing the process.

Setting:	Effect:
Filter ratio	A tie point pixel is removed if it has a mismatch distance larger than the given **Filter ratio**. The ratio is expressed as factor of the average mismatch distance.
Keep all manual pixels	If on, manually placed tie point pixels are not effected by the filtering process.

View pulldown menu

Commands in the **View** pulldown menu are used to define the view setup, to save the view layout for later use, to change the zoom ratio of detail views, and to define which attributes are displayed in the list boxes of the **Tie points** window.

To:	Choose menu command:
Setup view usage and size	**Setup**
Save the view layout as the default	**Save as default**
Change the zoom ratio of detail views	**Detail zoom**
Set the visibility of attributes in the **Tie points** window	**Fields**

Setup

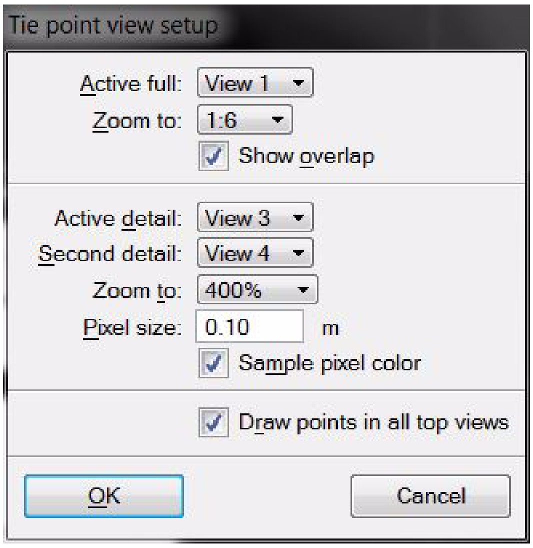
Setup command defines which views are used for tie point entry as well as display settings for the views.

The same dialog is shown if the tie point mode is started and the view setup has not been saved before.

➢ **To define the view setup for tie point entry:**

1. Select **Setup** command from the **View** pulldown menu.

   This opens the **Tie point view setup** dialog:



2. Define settings and click OK.

   This updates all views according to the settings.

Setting:	Effect:
Active full	View to use as the **Active full** view.
Zoom to	Zoom ratio for the **Active full** view. The view can use thumbnails created by the **Create thumbnails** command. The thumbnails must be stored in the /TEMP folder of the mission. The zoom ratio should be set to a ratio for which thumbnails are available in order to speed up the display.
Show overlap	If on, the application highlights areas in the active image where no tie points can be placed.
Active detail	View to use as the **Active detail** view.
Second detail	View to use as the **Secondary detail** view.
Zoom to	Zoom level for detail views. Given as a value relative to the **Pixel size**.
Pixel size	Pixel size used in detail views. The default value is about two thirds of the actual size of raw image pixels on the ground.
Sample pixel color	If on, pixel sampling is applied to the display of images in the detail views. This improves the visual quality of edges.
Draw points in all top views	If on, tie points are displayed temporarily in MicroStation top views. The display is active as long as the **Tie points** window is open.

Save as default

Save as default command saves the view layout as the default for the design file. Then, the same view arrangement is used every time when the tie point mode is started.

Detail zoom

Detail zoom commands change the zoom level of detail views. After selecting a new value, the detail views are updated. The zoom level is given as value relative to the pixel size used in the detail views.

See **Setup** for additional information.

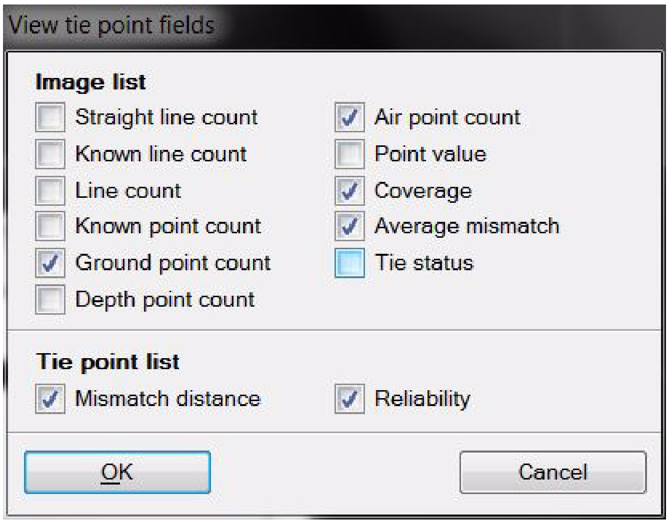
Fields

Fields command determines the attribute fields that are visible in the **Tie points** window. It lets you select the visibility of information shown in the two list boxes of the window.

➢ **To select visible fields:**

1. Select **Fields** command from the **View** pulldown menu.

   This opens the **View tie point fields** dialog:



2. Select fields and click OK.

   This updates the attribute fields display in the **Tie points** window.

Field:	Description:
Straight line count	Amount of **Straight lines** in the image.
Known line count	Amount of **Known lines** in the image.
Line count	Amount of **Lines** in the image.
Known point count	Amount of known tie points in the image. Includes **Known xyz**, **Known xy**, and **Known depth** tie points.
Ground point count	Amount of **Ground** points in the image.
Depth point count	Amount of **Depth** points in the image.
Air point count	Amount of **Air** points in the image.
Point value	Sum of **Tie point values** for the image.
Coverage	**Tie point distribution** in the image expressed as percentage value.
Average mismatch	Average mismatch distance computed from the tie points in the image.
Tie status	**Tie status** of the image. A = *Approved*, C = *Check*.
Mismatch distance	Mismatch distance for each tie point pixel. Given in subunits of the design file.
Reliability	Indicates the reliability of a tie point pixel. Given in numbers for automatically placed tie point pixels. The smaller the number, the more reliable is the pixel.

12 Improving Image Positioning

The process of improving image positioning for project data starts with fine tuning the calibration parameters for all cameras of the mission. This part is very similar to the camera calibration workflow described in Chapter **Camera Calibration** on page 46.

The second part of image positioning improvement adjusts the individual images based on a large number of tie points per image. The process is usually called aerotriangulation and effects the misalignment angle values of the images themselves. Normally, this is done for airborne imagery. Mobile ground-based images can be adjusted only with the help of TerraMatch functionality.

Finally, the absolute accuracy of the images can be verified and possibly improved with the help of ground control points (GCPs). For airborne imagery, the GCPs are utilized to determine a systematic xy shift. The calculated shift values can then be used in a linear transformation applied to the images.

For mobile system imagery, the GCPs are also useful to derive fluctuating drift values for individual drive paths. These values are used by TerraMatch in order to compute fluctuating corrections. More information can be found in the **TerraMatch User's Guide** available at www.terrasolid.com.

Adjust Camera Parameters

The camera calibration file for project data is normally created in a separate calibration step at the beginning of the TerraPhoto processing workflow. This is described in Sections **Airborne camera calibration** on page 61 and **Mobile camera calibration** on page 64. However, it is most often necessary to adjust the camera parameters to the actual project imagery. If the calibration values are good, the fine tuning should not be a big issue.

Airborne projects

The workflow of improving the camera calibration values is very close to the calibration workflows described in **Airborne camera calibration**.

1. Collect a few **Ground** tie points in several images manually or half-automatically.
2. Solve and apply misalignment angles using **Output report** command in the **Tie points** window.
3. Collect more tie points and filter out bad tie points.

   If the mismatch distances for tie points become smaller (about 2-3 * pixel size of the raw images), try to switch to half-automatic tie point entry mode. See **Tie point entry modes**.
4. Solve and apply misalignment angles using **Output report** command in the **Tie points** window.
5. Solve principal point z using **Tools / Solve parameters** command in the **TerraPhoto camera dialog**.
6. Recompute the tie points by using the **Apply** button in the **Camera** dialog.
7. Go back to step 3 until images are well-defined regarding **Tie point values** and **Tie point distribution**. Continue until the values for the misalignment angles and principle point z do not change significantly anymore.
8. Solve all other solvable parameters using **Tools / Solve parameters** command in the **TerraPhoto camera dialog** and apply the changes to the tie points.

   The application adjusts roll and pitch misalignment angles if it modifies principal point x and y values. The adjustment of the misalignment angles compensates the modification of the other parameters.

   You may still check for bad tie points using the **Find worst** command from the **Tie points** window.
9. Go back to step 8 and continue until there is no more improvement and the values are stable. The mismatch of the tie points should be around 1 * pixel size of the raw images or smaller.

Mobile ground-based projects

For mobile cameras, it usually enough to fine tune the misalignment angles. The calibration of the other camera parameters require special conditions which are seldom fulfilled in project data. See **Mobile camera calibration** for more information.

1. Enter a few **Air** tie points.

   If known points are available, they can be used as **Known xyz** tie points as well.
2. Solve and apply misalignment angles using **Output report** command in the **Tie points** window.
3. Go back to step 1 and continue until the modification of misalignment angles does not improve the average mismatch of the tie points anymore.

Adjust image positions

TerraPhoto can improve the relative positions of individual images by adjusting their misalignment angle values. The process is normally called aerotriangulation and requires a large amount of tie points for each image. This is only done for airborne project imagery. Images from a mobile ground-based camera system can be adjusted with TerraMatch functionality only.

The adjustment of image positions requires that the camera parameters are good and stable for the project data.

Airborne projects

1. Collect tie points automatically using the **Search points** command in the **Tie points** window.
2. Filter out bad tie points using commands from the **Pixel pulldown menu**.
3. If possible, add additional tie points where the automatic search did not find enough tie points.
4. Check and possibly apply misalignment angles using **Output report** command in the **Tie points** window.
5. Check and possibly apply all solvable parameters using **Tools / Solve parameters** command in the **Camera** dialog.
6. Go back to step 2 and continue until there are no more bad tie points in the tie points file.
7. Adjust the positions of the individual raw images using the **Adjust positions** command from the **Images** pulldown menu of the **TPhoto Main** window.
8. Check for bad tie points using the **Find worst** command from the **Tie points** window. Bad tie points stand out clearly after image positions have been adjusted.
9. Close the adjusted image list without saving and load the original unadjusted image list.
10. Continue with steps 7 - 9 until there are no more bad tie points in the tie point file.
11. Select **Save list As** command from the **Images** pulldown menu of the **TPhoto Main** window in order to save the final adjusted image list into a new file.

✍ Do not adjust an image list several times. Load always the original unadjusted image list before you adjust positions of the images.

Mobile ground-based projects

For mobile projects, the relative and absolute image adjustment is usually done in one step. The workflow is described in detail in Section **Mobile ground-based projects** on page 123.

Ground Control Points

The absolute accuracy of the images can be verified and possibly improved with the help of ground control points (GCPs). For airborne imagery, the GCPs are utilized to detect a systematic xy shift. The calculated shift values can then be used in a linear transformation applied to the images.

For mobile system imagery, the GCPs are also useful to derive fluctuating drift values for individual drive paths. These values are used by TerraMatch in order to compute fluctuating corrections. More information can be found in the **TerraMatch User's Guide** available at www.terrasolid.com.

GPCs are placed inTerraPhoto as **Known xyz**, **Known xy**, or **Known depth** tie points. They must be entered manually in images that see the GPCs' locations.

Airborne projects

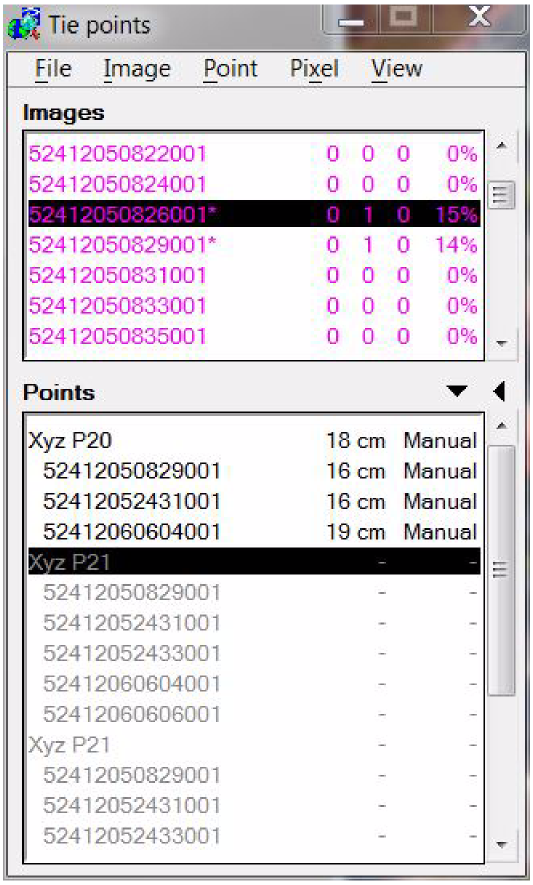
Add control points to the tie point file

For airborne projects, the GPCs' coordinates are usually imported from a text file into TerraPhoto. The text file must store the coordinates of the GCPs in one of the formats:

- Easting Northing Elevation
- Identifier Easting Northing Elevation

1. Use **Import known points** command in the **Tie points** window in order to import the text file into the **Tie points** window.

   The software adds the control points as **Known xyz** tie points. The images that see the location of a GCP are marked with the asterisk character (*) next to the image number in the upper list of the **Tie points** window. For each image, the tie points are listed in the lower list.



2. Select an image marked with an asterisk. Select the first line of a **Known xyz** tie point in the tie points list.

   The selected image is displayed in the **Active detail** view and a secondary image is displayed in the **Secondary detail** view.

3. Select **Enter position** command from the **Pixel** pulldown menu in the **Tie points** window.

   The location of the GCP coordinates is marked with a cross if the mouse pointer is moved into the **Active detail** view or the **Secondary detail** view. This can be used as indication where the point is located in the image.

4. Enter the tie point with a data click in the **Active detail** view.

   This places the tie point pixel in the active image. The distance between the tie point location in the image and GCP coordinates is shown in the tie point list.

5. Enter the tie point with a data click in the **Secondary detail** view.
6. Select the next undefined pixel of the tie point in the tie point list with a data click or the <Arrow down> key.

   Continue with step 5 until all pixels of the tie point are defined.

7. Continue with step 2 until all GPCs are defined as tie points.
8. Use **Save As** command from the **File** pulldown menu in order to save the tie points into a file.

✍ A good practice is to document an accurate description of the location of a GCPs before starting the tie points' placement. You can also use TerraScan, TerraSurvey, or MicroStation tools to read in the GCP text file and draw the points into the design file.

✍ If the elevation coordinate of a GCP is not usable, you can change the type of the tie point to **Known xy** using the **Edit information** command in the **Tie points** window.

Calculate xy shift values

The software uses the **Known xyz** or **Known xy** tie points for determining whether there is a systematic xy shift between the images and the GCPs. It suggests correction values for adjusting the positions of the images.

1. Create an **Output report** from the **File** pulldown menu in the **Tie points** window. The report must include the **Known point comparison** option.

   The **Known point comparison** part of the report contains a table that lists all GCPs, their coordinates, and the xyz shift distances at each tie point location. Then, it shows the recommended correction values that should be added to the easting and northing coordinates of the images. Finally, the average and worst shift distances are displayed. For example:

```
You should add    -0.070 to image eastings
You should add    +0.106 to image northings

Pixel mismatches
Average distance  14.22 cm
Worst distance    23.32 cm
```

Apply the xy shift to the image list

The correction values given in the tie points output report can be used to transform the image list. For this purpose, a transformation has to be defined in TerraPhoto **Settings**. Then, the transformation can be applied to the image list.

1. Open **Coordinate transformations / Transformations** in TerraPhoto **Settings**.
2. Define a new **Linear transformation**.

   The recommended corrections values for easting and northing from the output report correspond to the **Add constant X** and **Y** values in the **Settings** dialog.

3. Select **Transform positions** command from the **Images** pulldown menu in the **TPhoto Main** window.
4. Apply the transformation to the image list.
5. Use **Save list As** command from the **Images** pulldown menu in order to save the image list into a new file.

   If images and laser points need to be shifted with the same correction values, the transformation can be copied from TerraPhoto **Settings** to **TerraScan settings**. Then, the transformation can be applied to the laser points using TerraScan transformation tools. Use the **Create camera view** command in Terra Photo to check how well laser data and images match each other.

Mobile ground-based projects

In general, the absolute accuracy of mobile images can be checked and improved in a similar way as for images of **Airborne projects**. However, most often the mismatch in mobile images is not a systematic shift but a drift that changes over time. The mismatch basically depends on the accuracy of the trajectory that was used to generate the image list. The trajectory accuracy usually varies a lot during a mobile survey due to differences in GPS signal availability.

Therefore, the GCPs are rather utilized to derive fluctuating drift values for individual drive paths. These values are then used by TerraMatch in order to compute fluctuating corrections.

For mobile projects, the relative and absolute image adjustment is usually done in one step. If no GCPs are available, images can be adjusted only internally. In this case, step 5 in the workflow below is not applicable.

1. Create an image list which contains only images of a camera that is oriented downward towards the ground. For example, use **Delete / By camera** command from the **Images** pulldown menu of the **TPhoto Main** window in order to reduce a complete image list.
2. **Add known xyz** tie points from TerraMatch tie points drawn into the design file. The points represent control point locations in the (unmatched) laser data. Enter the tie points only in images ofthe closest drive path.
3. Solve and apply misalignment angles with **Output report** command for the camera in order to match the images to the laser data.
4. **Compute depth maps** for all images, if not yet available. Use laser points that are **Close in time**, which means that depth maps are created based only on points of the same drive path as the images.
5. **Add known depth** tie points for all available GCPs. Use the best image for placing a tie point. The best image sees the GCP location best and thus, it is well suited for placing the tie point accurately at the GCP location.
6. **Add depth** tie points at places where no GCPs are available. The tie points should be placed at regular distances (25 - 50 m) in order to get a good control of the trajectory drift.
7. Start TerraMatch and search tie line fluctuations based on image tie points. Apply the fluctuating corrections to the image list using TerraMatch *Apply corrections* tool. See **TerraMatch User’s Guide** available at www.terrasolid.com.

13 Color Points and Selection Shapes

Concept

The commands in the **Color points** menu provide methods for improving the quality of rectified image or colored point clouds. Besides color points, there are several types of correction shapes (called selection shapes) which can be placed using tools from the menu.

When you select **Define color points** command from the **Rectify** pulldown menu in the **TPhoto Main** window, the applications changes to color point mode. There are two modes available:

- **Ground ortho -** for rectified images or orthophotos.
- **Point cloud -** for colored point clouds, especially mobile laser scanning point clouds.

Color points for image rectification require a ground model loaded in TerraPhoto. The mode can not be selected, if there is no ground model available. If the color point mode starts, the software builds a triangulated ground model, opens the **Color points** menu for **Ground ortho** color points, and displays a preview of the ortho mosaic in a MicroStation top view.

Color points for point clouds require a TerraScan project that manages the point cloud and a point cloud format that is able to store color values, image numbers, and normal vectors/dimensions for each point. The storage of all these attributes is only possible in TerraScan **Fast binary** format. See TerraScan User's Guide for more information about projects, point cloud formats and attributes. If the color point mode starts, the software sets up the display mode for laser points, extracts on-the-fly color values for the points, and opens the **Color points** menu for **Point cloud** color points.

The color point mode is closed when the **Color points** menu is closed.

The software uses thumbnails for the preview of the orthophoto mosaic in color point mode. The thumbnails must be stored in the /TEMP folder of the mission. See **Create thumbnails** on page 279 for more information.

Color points

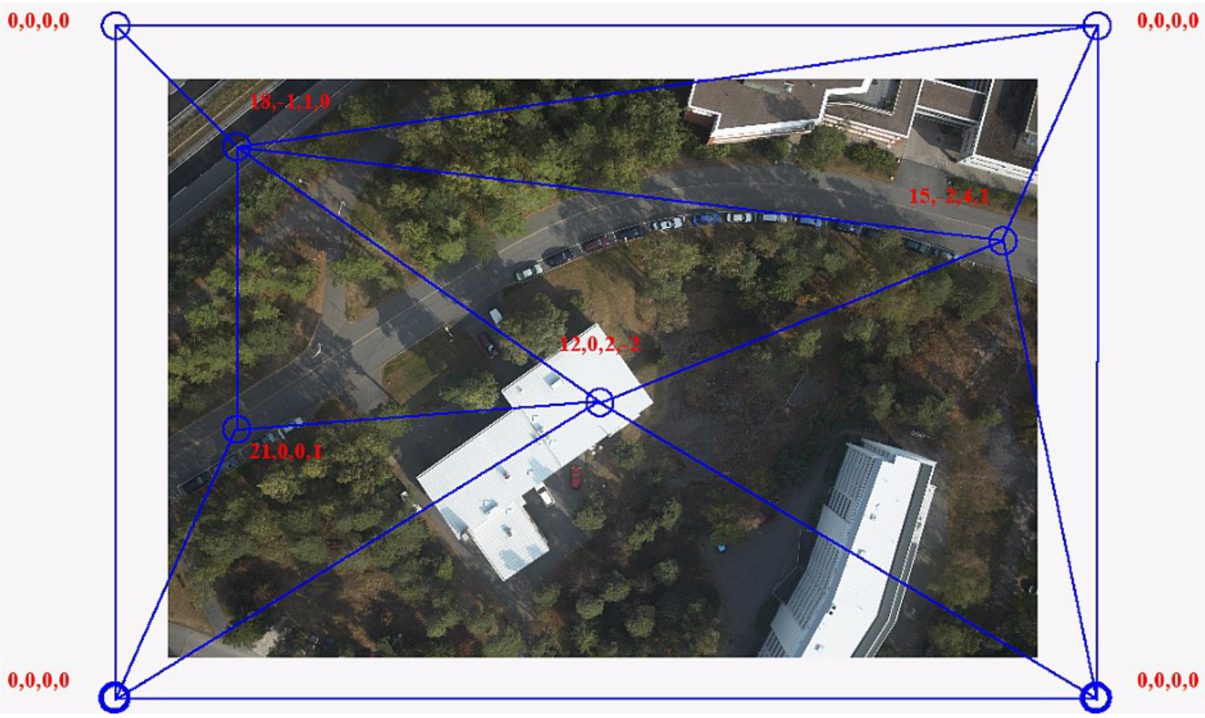
Color points form a triangulated correction model where each color point provides intensity (brightness) and RGB color balance corrections at the point's xy location. The correction model for rectified images is illustrated in the figure below.

Color points are stored in text files with the extension .CPT. The files includes the following information:

- for each color point: type, xyz coordinate values in current projection system, radius, intensity value, RGB values, for **Point cloud** color points XYZ components of the normal vector
- for each image: weight, intensity value, RGB values, color point xy coordinates in image pixels

The xyz coordinate values are recomputed whenever necessary. You do not need to apply coordinate transformations to color points.

When color points are loaded in memory, they are drawn temporarily as MicroStation circle elements on a design file level. The level and color for drawing color points are defined in **Color points** of TerraPhoto **Settings**. The drawing disappears if the **Color points** menu is closed.



Color points can be placed manually or automatically. The automatic method first searches for a large number of potential color points. Then, it rates each point by checking if the point is needed and fits into the correction model. Finally, the best points are selected. After an automatic search, the color points should be checked and possibly filtered. There are manual editing options as well as automatic methods for filtering out bad color points.

There are several types of color points according to the method of color correction computation:

- **Average -** intensity and color values are averaged from all images at the color point location. This is the method used for automatically placed **Point cloud** color points.
- **Grey average -** color values are balanced in order to get the averaged grey value.
- **Fixed -** hue, saturation, and value (HSV color model) components of the color point can be set to fixed values. This type can be placed only manually.
- **Reference -** colors from reference images are use for target color calculation. Requires an image attached as TerraPhoto reference at the location of color point. This type can be placed only manually.

If object shapes are available, they can be used for **Ground ortho** color points on roof tops. The process can also use shadow maps in order to determine locations where trees or other objects cause shadow effects. See **Compute shadow maps** on page 282 for more information.

Selection shapes

Selection shapes are correction polygons that improve the quality of the final orthophoto mosaic or colored point cloud. Basically, they manipulate the seamlines (boundaries) between adjacent raw images in the orthophoto mosaic or specify certain images for being used in areas defined by the selection shapes.

Common problems in orthophoto mosaics from airborne image data are large objects, like buildings, cut by seamlines; small objects, like trees or cars cut by seamlines; areas with differences in structure, brightness, texture, etc., such as water under changing light conditions; images from different altitudes. In image data of ground-based mobile systems, most problems are related to moving objects, for example cars on a road, that are visible in some of the raw images.

Most issues in ground-based mobile point clouds are caused by the changing light conditions for the different cameras and by moving objects.

Selection shapes are distinguished into different types:

- **Selection** shapes - specify one image to be used inside the shape. Good for larger objects, such as buildings, that are cut by raw image boundaries. For **Point clouds**, also colors from multiple images of one line can be used inside the shape.
- **Quality** shapes - specify an area within which only images with a given quality number are used for rectification. Useful, for example, if images from two altitudes and with different qualities are available. In images from mobile systems, quality shapes can be used to exclude cars or other moving objects by using images from another drive path. Available in **Ground ortho** mode only.
- **Smearing** shapes - specify an area close to raw image boundaries, where pixels are blurred. Good for water surfaces with sun reflexions or fields with low vegetation. Available in **Ground ortho** mode only.
- **Auto seamline** shapes - specify one image to use inside a small shape. Good for small objects, like trees or cars in airborne data sets. Available in **Ground ortho** mode only.
- **Shadow** shapes - specify shadow areas in point clouds. Available in **Point cloud** mode only.

Auto seamlines are created automatically, all other types of selection shapes are placed manually. All types of shapes in **Ground ortho** mode are drawn as MicroStation shape elements into the design file. They can be edited with MicroStation tools. Symbology settings of selection shapes can be defined in **Selection shapes** of TerraPhoto **Settings**.

Shapes in **Point cloud** mode are only drawn temporarily. **Selection** shapes manipulate the image assignment stored for the laser points.

File pulldown menu

Commands in the **File** pulldown menu are used to open and save color points, to recompute color points, to search for color points automatically, to filter out bad color points automatically, and to change the image numbers in a color points file.

To:	Choose menu command:
Erase currently defined color points	**New**
Open a previously saved color point file	**Open**
Save color points to an existing file	**Save**
Save color points to a new file	**Save As**
Recompute color points	**Recompute all**
Search automatically for new color points	**Search points**
Remove bad color points automatically	**Filter bad**
Modify image numbers in the color points file	**Renumber images**

New

New command erases currently defined color points and starts a new color point file. It removes active color points from the memory.

Open

Open command reads previously saved color points from one or multible files on the hard disc.

➢ **To open color points:**

1. Select **Open** command from the **File** pulldown menu.

   This opens the **Open color points** dialog, a standard dialog for opening files.
2. Select one or more files to open.
3. After all files are added to the list of files, click **Done**.

   This loads the color points into memory and displays them in MicroStation views.

Save

Save command saves the color points to the same file from which they have been opened before. The command is not available, if color points have been opened from multiple source files.

Save As

Save As command saves the color points into a new file.

Recompute all

Recompute all command recomputes color points. This is necessary if you made changes to raw image coloring using **Define color corrections** command while color points were closed.

Search points

Search points command starts the automatic color point search. The software can place color points of types **Average** (**Gound ortho** and **Point cloud** color points) and **Grey average** (**Ground ortho** color points) automatically. The search can be restricted to certain areas, images, and a color point density.

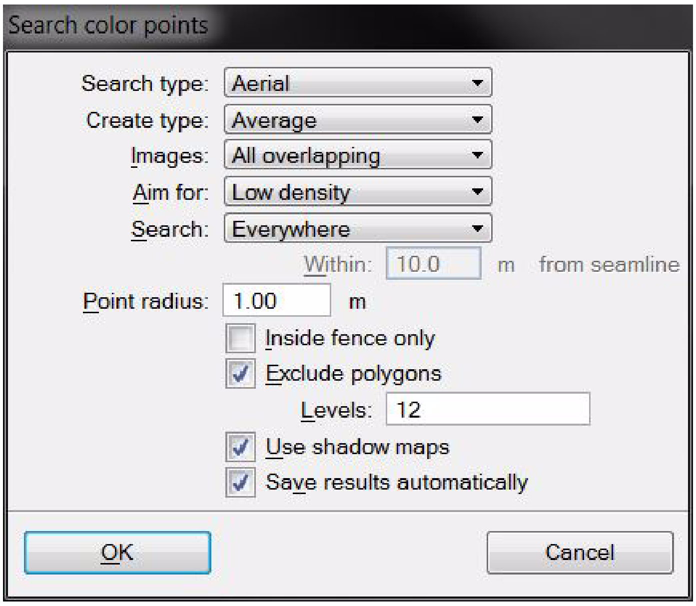
The automatic method first searches for a large number of potential color points. Then, it rates each point by checking if the point is needed and fits into the correction model. Finally, the best points are selected. After the automatic search, it might be good to check for bad color points using **Find worst**, **Find first bad**, or **Find next bad** commands and/or to filter out bad color points automatically using the **Filter bad** command.

The settings for the automatic search depend on the color point mode. The color point mode is selected when the **Define color points** command is started. See the command's description or **Concept** of color points and selection shapes for more information about color point modes.

➢ **To search color points for (ortho) rectification automatically:**

1. Select **Search points** command from the **File** pulldown menu.

   This opens the **Search color points** dialog:



2. Define settings and click OK.

   If **Save results automatically** is switch on, the **Save auto search results** dialog is opened, a standard dialog for saving files.

3. Define a location and name for the color points file and click **Save**.

   The application starts searching for color points. A progress window indicates which step is processed.

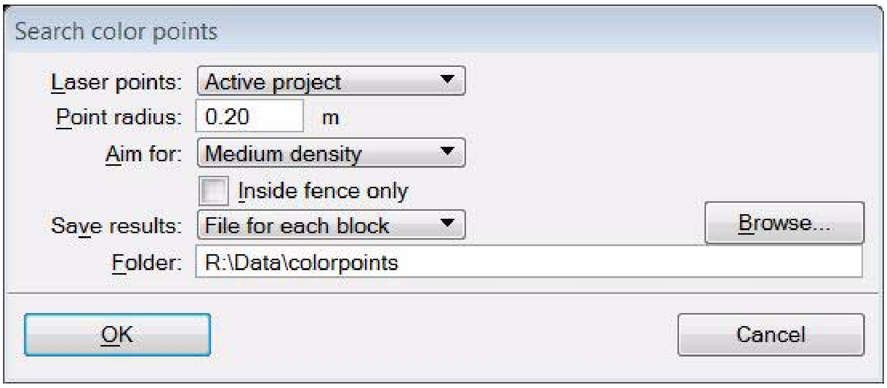
Setting:	Effect:
Search type	Defines how color points are placed related to the shape of the search area: • **Aerial -** search within an aerial project area. Color points are placed all over the area. • **Along centerline(s) -** search along selected linear elements. This requires that at least one line or shape element is selected in the design file before starting the search.

Setting:	Effect:
Create type	Type of the color points: • **Average -** intensity and color values are averaged. • **Grey average -** color values are balanced in order to get the averaged grey value.
Images	Defines what images are included in the color point computation: • **All overlapping -** all images that see the color point location. • **Assigned only -** only images which contribute to orthophoto pixel colors inside the color point radius. If the color point is placed at the seamline of two images, only those two images are used to compute the target color. This may exclude unwanted coloring effects from more distant images. • **Upto 2 ... 6 closest -** up to the given number of images closest to the color point location.
Aim for	Defines the density and thus, the overall amount of color points: • **Very low density -** generates the smalles amount of points. • **Low density -** generates fewer points. • **Medium density -** generates a medium amount of points. • **High density -** generates more points. • **Very high density -** generates the highest amount of points.
Search	Defines the area for color point search related to raw images: • **Everywhere -** searches color points within the whole image. • **Along seamlines -** searches only close to image seamlines **Within** the given distance.
Point radius	Size of color points. Defines the area that is used for computing the color point's intensity and RGB values.
Inside fence only	If on, color points are placed inside a fence only. This requires that a MicroStation fence has been drawn before the command is started.
Exclude polygons	If on, no color points are searched inside shape elements on the given design file **Levels**. Separate several levels by comma.
Use shadow maps	If on, the routine uses shadow maps stored in the /TEMP directory of the mission. See **Compute shadow maps** for more information.
Save results automatically	If on, the routine saves color points in regular intervals into the active color point file. If a new file is started, the software asks for a location and file name for storing the color points.

➢ **To search color points for point clouds automatically:**

1. Select **Search points** command from the **File** pulldown menu.

   This opens the **Search color points** dialog:



2. Define settings and click OK.

   The application starts searching for color points. Depending on the size of the point cloud, the process may take some time.

Setting:	Effect:
Laser points	Defines the source of the point cloud: • **Loaded points -** points loaded in TerraScan. • **Active project -** points referenced by a TerraScan project.
Point radius	Size of color points. Defines the area that is used for computing the color point's intensity and RGB values. Color points should be big enough to contain a few pixels in the raw images also at a longer distance in order to allow the averaging of colors.
Aim for	Defines the density and thus, the overall amount of color points: • **Very low density -** generates the smalles amount of points. • **Low density** - generates fewer points. • **Medium density -** generates a medium amount of points. • **High density** - generates more points. • **Very high density -** generates the highest amount of points.
Inside fence only	If on, color points are placed inside a fence only. This requires that a MicroStation fence has been drawn before the command is started.
Save results	Defines how color points are saved: • **No automatic save -** color points are not saved immediately into a file on a hard disk. • **One file -** all color points are stored into one file. The file is created automatically when the color point search is started. • **File for each block -** a separate color point file is stored for each block of the TerraScan project. This is recommeded for big projects in order to allow more structured manual work after the automatic search. This is only active if **Laser points** is set to **Active project**.
Folder	Storage directory for color point files. This is only active if **Save results** is set to **File for each block**.

Filter bad

Filter bad command removes color points that cause big brightness or color corrections, or that do not have other color points with approximately the same normal direction closeby.

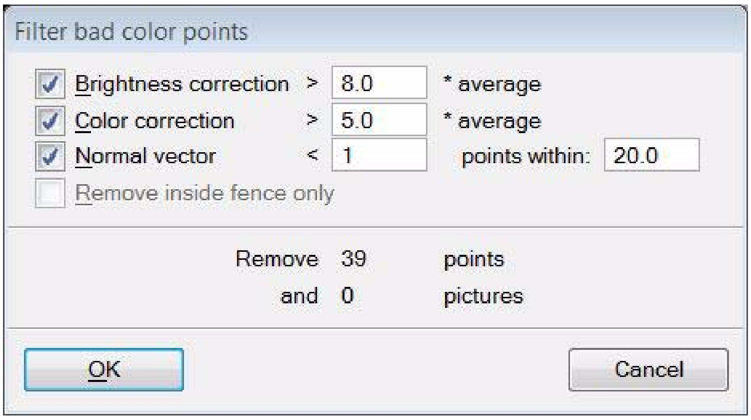
It is recommended to use this command after running the automatic color point search with the **Search points** command or the automatic placement of color point clones for mobile images using the **Add clones** command. Some of the automatically placed clones are likely to be placed at locations where there are moving objects in some of the images.

Before and after filtering bad color points automatically, it is recommended to use **Find worst** command from the **Point** pulldown menu several times in order to get an idea about the location with the biggest brightness and color corrections.

➢ **To filter out bad color points:**

1. Select **Filter bad** command from the **File** pulldown menu.

   This opens **Filter bad color points** dialog:



2. Define limits for removing bad points and click OK.

   This starts the filtering process. An information dialog shows the amount of completely and partly deleted color points after finishing the process.

3. Save the color points using **Save** or **Save As** commands from the **File** pulldown menu in order to save the color points into a file.

Setting:	Effect:
Brightness correction	If on, a color point is removed if it causes a brightness value correction larger than the given value. The limit value is expressed as factor of the average brightness correction.
Color correction	If on, a color point is removed if it causes an RGB value correction larger than the given value. The limit value is expressed as factor of the average color correction.
Normal vector	If on, a color point is removed if there is less than the given amount of points within the given distance from this color point. This is only available for **Point cloud** color points.
Remove inside fence only	If on, only color points inside a fence are effected. This requires that a MicroStation fence has been drawn before the command is started.

Renumber images

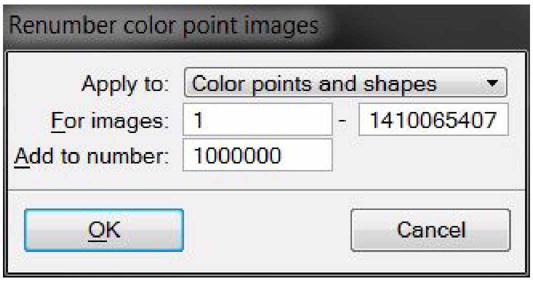
Renumber images command renumbers all or a given range of images in the color points file and/ or for selection shapes. It adds a constant number to the existing image numbers.

TerraPhoto requires a unique number for images in the active image list which is derived from the image file names. These image numbers are stored in the color points file and for selection shapes. If it is necessary to rename the image files, the numbers in the image list change. Therefore, it might be necessary to change the image numbers in the color points file and for selection shapes as well in order to ensure that they still work for the renamed images.

➢ **To renumber images:**

1. Select **Renumber images** command from the **File** pulldown menu.

   This opens the **Renumber color point images** dialog:



2. Define settings and click OK.

   The new numbering is applied for the color points and/or selection shapes. An information dialog shows the amount of images that have been renumbered.

3. Save the color points using **Save** or **Save As** commands from the **File** pulldown menu in order to save the color points with renumberd images into a file.

Setting:	Effect:
Apply to	Defines what data is effected by the renumbering process: **Color points and shapes**, **Color points only**, or **Shapes only**.
For images	Range of image numbers for which the renumbering is applied.
Add to number	Value that is added to current image numbers. Negative values can be used.

Point pulldown menu

Commands in the **Point** pulldown menu are used to add, edit, and delete color points, and to filter out bad color points manually.

To:	Choose menu command:
Add a color point manually	**Add**
Add clones of a color point	**Add clones**
Edit a color point	**Edit**
Delete color points	**Delete**
Find the color point with the biggest correction values	**Find worst**
Find the first color point with a certain correction value	**Find first bad**
Find the next color point with a certain correction value	**Find next bad**
Adjust color point corrections inside a fence	**Equalize inside fence**

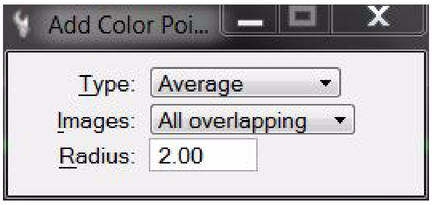
Add

Add command lets you add a new color point manually.

➢ **To add a new color point:**

1. Select **Add** command from the **Point** pulldown menu.

   This opens the **Add Color Point** dialog:



2. Select settings for the new color point.
3. Enter the position of the color point with a data click inside a view.
4. Update the view in MicroStation in order to make color changes visible.
5. Save the color points using **Save** or **Save As** commands from the **File** pulldown menu in order to save the color points into a file.

Setting:	**Effect:**
Type	Type of the color point: • **Average -** intensity and color values are averaged at the location of the color point. • **Grey average -** color values are balanced in order to get the averaged grey value. • **Fixed -** values for hue, saturation and value can be set manually. See **Edit** on page 137 for more information. • **Reference -** colors from reference images are use for target color calculation. Requires an image attached as TerraPhoto reference at the location of color point.
Images	Defines what images are included in the color point computation: • **All overlapping -** all images that see the color point location. • **Assigned only -** only images which contribute to orthophoto pixel colors inside the color point radius. If the color point is placed at the seamline of two images, only those two images are used to compute the target color. This may exclude unwanted coloring effects from more distant images. • **Upto 2 ... 6 closest -** up to the given number of images closest to the color point location. • **Select in dialog -** images can be chosen in a dialog. See **Edit** command for more information.
Radius	Size of the color point. Defines the area that is used for computing a color point's intensity and RGB values.

✍ The *Add Color Point* tool from the **Color Points** toolbar performs the same action.

Add clones

Ground ortho only

Add clones command creates clones of color points. The location of one color point clone is defined by a data click. Then, the software creates color points automatically in each image at the same location determined by the color point pixel coordinates.

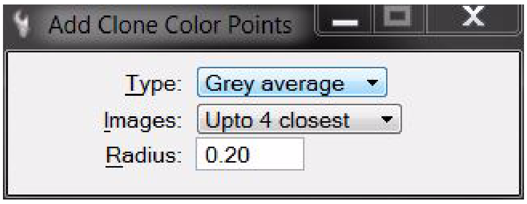
The command provides an automatic way of creating color points for mobile images captured along a road. The color point clones work well if the images were captured at a constant driving speed and if the system was driven without much left/right variation within a lane.

After the automatic placement of color points, it is recommended to check for bad color points using **Find worst**, **Find first bad**, or **Find next bad** commands. A more automatic approach of filtering out bad color points can be done using the **Filter bad** command.

➢ **To add color point clones:**

1. Select **Add clones** command from the **Point** pulldown menu.

   This opens the **Add Clone Color Points** dialog:



2. Select settings for the color point clones.
3. Enter the position of one color point with a data click inside a view.

   This starts the creation of the color point clones. A progress bar shows the progress of the process.

4. Save the color points using **Save** or **Save As** commands from the **File** pulldown menu in order to save the color points into a file.

Setting:	**Effect:**
Type	Type of the color points: • **Average -** intensity and color values are averaged at the location of the color point. • **Grey average -** color values are balanced in order to get the averaged grey value.
Images	Defines what images are included in the color point computation: • **All overlapping -** all images that see the color point location. • **Assigned only -** only images which contribute to orthophoto pixel colors inside the color point radius. If the color point is placed at the seamline of two images, only those two images are used to compute the target color. This may exclude unwanted coloring effects from more distant images. • **Upto 2 ... 6 closest -** up to the given number of images closest to the color point location. • **Select in dialog -** images for each clone must be chosen in a dialog. See **Edit** command for more information.
Radius	Size of color points. Defines the area that is used for computing a color point’s intensity and RGB values.

✍ The *Add Clone Color Points* tool from the **Color Points** toolbar performs the same action.

Edit

Edit menu command lets you modify a color point.

➢ **To edit a color point:**

1. Select **Edit** command from the **Point** pulldown menu.
2. If the mouse pointer is moved into the view, the color point closest to the mouse pointer is highlighted.
3. Select the color point for editing by a data click.

   This opens the **Color point** dialog:

   Left side: List of images involved in the color point calculation. The left point shows the coloring before color correction, the right point after correction.

   Right side: Image preview, input fields for color point attributes.

4. Make modifications to the color point and click OK.
5. Update the view in MicroStation in order to make changes visible.
6. Save the color points using **Save** or **Save As** commands from the **File** pulldown menu in order to save the color points into a file.

Setting:	Effect:
Weight	Indicates, how much a source image influences the average target color. To set the weight for an image, select it in list of images on the left side of the dialog. Images close to the color point have a big default weight value. More distant images have a smaller default weight value.
Delete image	Deletes the selected image from color point computation.

Setting:	Effect:
Radius	Modifies the size of the color point. This effects the color point in all images.
Target	Modifies the type of the color point: • **Average -** intensity and color values are averaged at the location of the color point. • **Grey average -** color values are balanced in order to get the averaged grey value. • **Fixed -** values for **Hue**, **Saturation**, and **Value** can be set manually. • **Reference -** colors from reference images are use for target color calculation. Requires an image attached as TerraPhoto reference at the location of color point.
Hue	Hue value of the color point between 0 and 359. This is only available for color points of type **Fixed**.
Saturation	Saturation value of the color point between 0 and 100. This is only available for color points of type **Fixed**.
Value	Value value of the color point between 0 and 100. This is only available for color points of type **Fixed**.

✍ The *Edit Color Point* tool from the **Color Points** toolbar performs the same action.

Delete

Delete commands remove color points from the file. There are different options to define the color points that are deleted:

- **One point -** a manually selected color point is removed.
- **Inside fence -** all color points that are located inside a MicroStation fence or inside a selected shape are removed.
- **Outside fence -** all color points that are located outside a MicroStation fence or outside a selected shape are removed.
- **Inactive images -** all color points that use inactive images are removed.

➢ **To delete one color point:**

1. Select **Delete / One point** command from the **Point** pulldown menu.

   If the mouse pointer is moved inside a view, the color point closest to the mouse pointer is highlighted. In addition, images that are used in the color point are marked with a line.

2. Identify the color point which you want to delete with a data click.

   You can continue by identifying the next color point you want to delete.

3. Update the view in MicroStation to make changes visible.
4. Save the color points using **Save** or **Save As** commands from the **File** pulldown menu in order to save the color points into a file.

✍ The *Delete Color Point* tool from the **Color Points** toolbar performs the same action.

➢ **To delete color points inside/outside a fence:**

1. Draw a fence with MicroStation **Place fence** tool around color points you want to delete.

   OR

1. Draw a shape with any MicroStation tool around the color points you want to delete. Select the shape.
2. Select **Delete / Inside fence** command from the **Point** pulldown menu.

   This opens an alert dialog that shows how many points are deleted and asks for confirmation.

3. Click **Yes** in order to delete the color points.
4. Update the view in MicroStation to make color changes visible.
5. Save the color points using **Save** or **Save As** commands from the **File** pulldown menu in order to save the color points into a file.

✍ The procedure is analog for deleting points outside a fence.

➢ **To delete color points in inactive images**

1. Select **Delete / Inactive images** command from the **Point** pulldown menu.

   This opens an alert dialog that shows how many points are deleted and asks for confirmation.

2. Click **Yes** in order to delete the color points.
3. Update the view in MicroStation to make color changes visible.
4. Save the color points using **Save** or **Save As** commands from the **File** pulldown menu in order to save the color points into a file.

✍ The process deletes color points from images with their **Rectify** status set to **No**. See **Edit** command for modifying the status of one or more images.

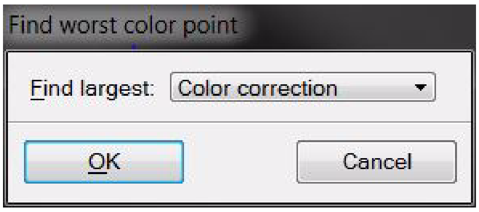
Find worst

Find worst command finds the color point with the largest brightness or color correction. If you filter out bad color points, it is recommended to first check the point with the largest corrections.

➢ **To find the worst color point:**

1. Select **Find worst** command from the **Point** pulldown menu.

   This opens the **Find worst color point** dialog:



2. Select the type of correction for which you want to see the color point with the largest correction: **Brightness correction** or **Color correction**.
3. Click OK.

   The software updates the view in order to show the color point with the biggest correction. The color point is highlighted with a cross as long as the mouse pointer is located inside the view.

✍ The dialog for **Edit**ing the color point can be opened directly by another data click as long as the color point is highlighted.

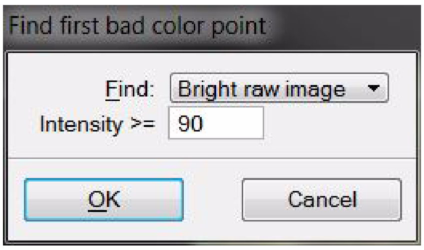
Find first bad

Find first bad command finds the first color point at a location where a raw image has an intensity value larger or smaller than a given limit. This command is useful when you want to check color points that are effected by very bright or dark images.

➢ **To find the first bad color point:**

1. Select **Find first bad** command from the **Point** pulldown menu.

   This opens the **Find first bad color point** dialog:



2. Select what kind of images you want to check: **Bright raw image** or **Dark raw image**.
3. Define a limit in the **Intensity** field.
4. Click OK.

   The software finds the first color point with a larger or smaller intensity value than the given limit. The view is updated in order to show the color point location. The color point is highlighted with a cross as long as the mouse pointer is located inside the view.

✍ The dialog for **Edit**ing the color point can be opened directly by another data click as long as the color point is highlighted.

Find next bad

Find next bad command finds and selects the next color point in the list with a larger/smaller intensity value than the given limit. It utilizes the intensity limit defined by the **Find first bad** command.

➢ **To find the next bad color point:**

1. Define an intensity limit using the **Find first bad** command.
2. Select **Find next bad** command from the **Point** pulldown menu.

   The application finds the next color point with a larger or smaller intensity value than the given limit. The view is updated in order to show the color point location. The color point is highlighted with a cross as long as the mouse pointer is located inside the view.

✍ The dialog for **Edit**ing the color point can be opened directly by another data click as long as the color point is highlighted.

Equalize inside fence

Point cloud only

Equalize inside fence command applies a color adjustment to color points inside a fence or selected polygon. As a result, the coloring of the point cloud around the effected color points looks more unique.

➢ **To equalize colors inside a fence:**

1. Draw a MicroStation fence or shape element around the area you want to adjust. Select the shape element.
2. Select **Equalize inside fence** command from the **Point** pulldown menu.

   This manipulates the color points inside the fence or selected polygon.
3. Save the color points using **Save** or **Save As** commands from the **File** pulldown menu in order to save the color points into a file.

Image pulldown menu

Commands from the **Image** pulldown menu are used to improve the quality of the final orthophotos by placing selection shapes, quality shapes, and/or smearing shapes. There are different tools for assignment or placement of the different types of shapes. Additionally, there is a tool for automatic seamline search.

The settings for selection shapes are defined in **Selection shapes** of the TerraPhoto **Settings**.

To:	Choose menu command:
Create selection shapes from polygons	**Assign selection polygons**
Create quality shapes from polygons	**Assign quality polygons**
Create smearing shapes from polygons	**Assign smearing polygons**
Create shadow shapes from polygons	**Assign shadow polygons**
Create a selection shape by mouse pointer movement	**Paint selection**
Create a selection shape by mouse clicks	**Place selection**
Search for seamline shapes automatically	**Search seamlines**
Update shapes from the design file	**Update from design**

Assign selection polygons

Ground ortho only

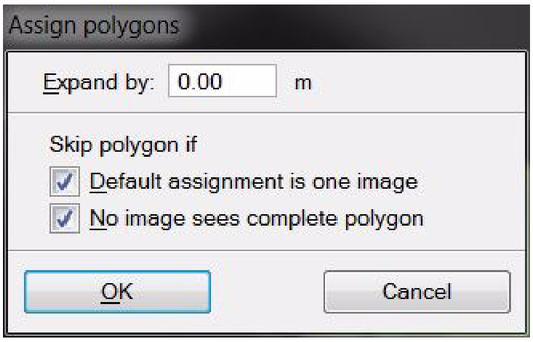
Assign selection polygons command creates **Selection** shapes from selected polygons drawn in the design file.

This is useful if you have polygons of buildings or building roofs. If they are assigned as **Selection** shapes, the area designated by one polygon is rectified from a single raw image if possible.

➢ **To assign selection polygons:**

1. Draw and select polygon(s) with MicroStation tools.
2. Select **Assign selection polygons** from the **Image** pulldown menu.

   This opens the **Assign polygons** dialog:



3. Select settings and click OK.

   This assigns the image to each selected polygon which best covers the area of the polygon.

   If **Force symbology** settings are switched on in **Selection shapes** of the TerraPhoto **Settings**, it also creates a copy of the original polygon(s) on the design file level that is defined for storing **Selection** shapes.
4. Update the view in MicroStation to make changes visible.

Setting:	Effect:
Expand by	Value by which polygons are expanded. A negative value can be used in order to shrink the polygons.
Skip polygon if	No image is assigned to a selected polygon if: • **Default assignment is one image -** the area inside the polygon is covered by only one image. • **No image sees complete polygon -** the area inside the polygon is not covered completely be a single image.

Assign quality polygons

Ground ortho only

Assign quality polygons command specifies an area to be rectified from images with a certain quality number. The tool requires the differentiation of several quality numbers for raw images. See the **Edit** command for modifying the quality numbers of one or more images.

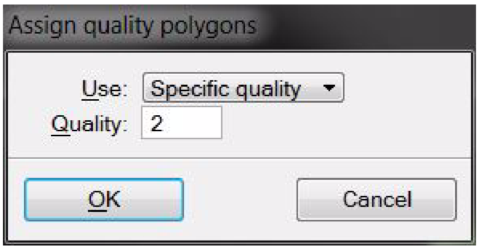
For example, if an area is covered by aerial images from two different altitudes, images from the lower altitude might have a better quality and should be used whenever possible. This can be managed by using quality shapes around the area covered by the low altitude images. Images from a higher altitude are only use outside the quality shapes.

Another usage example for mobile images of a road is to remove moving objects from orthophotos of the road surface. If the objects are seen in images of one drive path, quality shapes can define that images from another drive path are used. To achieve that, images from each drive path must have different quality numbers.

➢ **To assign quality polygons:**

1. Draw and select polygon(s) with MicroStation tools.
2. Select **Assign quality polygons** from the **Image** pulldown menu.

   This opens the **Assign quality polygons** dialog:



3. Select settings and click OK.

   This assigns images with a specified quality to the polygon(s).

   If **Force symbology** settings are switched on in **Selection shapes** of the TerraPhoto **Settings**, it also creates a copy of the original polygon(s) on the design file level that is defined for storing **Quality** shapes.
4. Update the view in MicroStation to make changes visible.

Setting:	**Effect:**
Use	Defines which images are used inside quality shapes: • **Best quality -** images with the best quality value are used. • **Specific quality -** only images with the given quality value are used. If no such images are available, the area is filled with background pixels.
Quality	Quality value of images used inside quality shapes. This is only active if **Use** is set to **Specific quality**.

Assign smearing polygons

Ground ortho only

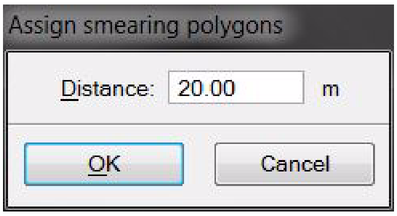
Assign smearing polygons command specifies areas where image pixels are blurred close to image seamlines.

This is useful for places where not only the color changes at image seamlines but also the texture. Examples are water areas with sun reflection or fields with small vegetation under changing light conditions.

➢ **To assign smearing polygons:**

1. Draw and select polygon(s) with MicroStation tools.
2. Select **Assign smearing polygons** from the **Image** pulldown menu.

   This opens the **Assign smearing polygons** dialog:



3. Define a **Distance** setting and click OK.

   This blurs pixels within the defined distance on both sides of image seamlines.

   If **Force symbology** settings are switched on in **Selection shapes** of theTerraPhoto **Settings**, it also creates a copy of the original polygon(s) on the design file level that is defined for storing **Smearing** shapes.

4. Update the view in MicroStation to make changes visible.

Assign shadow polygons

Point cloud only

Assign shadow polygons command specifies areas where the point cloud coloring is effected by shadows. Within such polygons, the software applies a brightness correction in order to reduce the effect of shadows.

➢ **To assign shadow polygons:**

1. Draw and select polygon(s) with MicroStation tools.
2. Select **Assign shadow polygons** from the **Image** pulldown menu.

   This applies the brightness correction to the color points and updates the view.

Paint selection

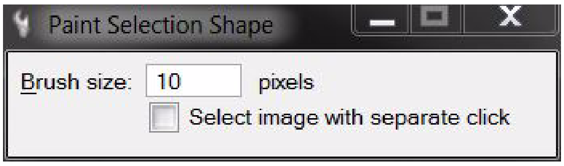
Ground ortho only

Paint selection command lets you draw a **Selection** shape by moving the mouse pointer over an area. The tool works like a brush tool. The **Selection** shape is drawn around all pixels that are touched by the brush.

➢ **To paint a selection polygon:**

1. Select **Paint selection** from the **Image** pulldown menu.

   This opens the **Paint Selection Shape** dialog:



2. Define settings for brush size and image selection.
3. Place a data click and keep the mouse button pressed. Move the mouse pointer over the area that you want to be covered by a **Selection** shape. Release the mouse button to finish the shape.

   This creates a **Selection** shape around all pixels touched by the brush.

   If **Force symbology** settings are switched on in **Selection shapes** of the TerraPhoto **Settings**, the shape is drawn on the design file level using the symbology that is defined for **Selection** shapes. Otherwise, the shape is drawn on the active level using active symbology settings of MicroStation.

Setting:	Effect:
Brush size	Pixel size of the brush for painting the shape.
Select image with separate click	If on, the image used inside the **Selection** shape is defined by a separate data click. If off, the image is defined by the first data click when the painting is started.

✍ The *Paint Selection Shape* tool from the **Color Points** toolbar performs the same action.

Place selection

Place selection command lets you draw a **Selection** shape by digitizing the shape manually.

The settings for the command depend on the color point mode. The color point mode is selected when the **Define color points** command is started. See the command's description or **Concept** of color points and selection shapes for more information about color point modes.

➢ **To place a selection shape for (ortho) rectification:**

1. Select **Place selection** from the **Image** pulldown menu.

   This opens the **Place Selection Shape** dialog:

2. Select settings.
3. Digitize a polygon around the area that you want to be covered by a **Selection** shape.

   If the mouse pointer is moved close to the first vertex, the software snaps to this vertex to close the polygon.

4. Accept the selection shape with another data click.

   This creates a **Selection** shape around all pixels inside the polygon.

   If **Force symbology** settings are switched on in **Selection shapes** of the TerraPhoto **Settings**, the shape is drawn on the design file level using the symbology that is defined for **Selection** shapes. Otherwise, the shape is drawn on the active level using active symbology settings of MicroStation.

Setting:	**Effect:**
Show coverage	If on, areas outside the image are highlighted after the image for being used for the **Selection** shape is selected. This shows whether the selected image covers the **Selection** shape area or not.
Select image with separate click	If on, the image used inside the **Selection** shape is defined by a separate data click. If off, the image is defined by the first data click when the digitization is started.

➢ **To place a selection shape for point clouds:**

1. Select **Place selection** from the **Image** pulldown menu.

   This opens the **Place Cloud Selection** dialog:

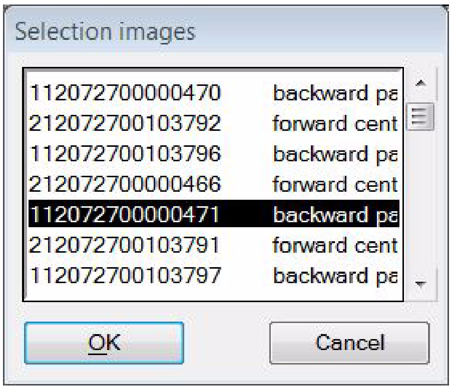
2. Select settings.

Setting:	**Effect:**
Color from	Defines from which images the color values are extracted inside the selection shape: • **Single image -** you select the best image for point cloud coloring. • **Multible images -** you select the line from which images are used for point cloud coloring.

3. Digitize a polygon around the area that you want to be covered by a **Selection** shape.

   If the mouse pointer is moved close to the first vertex, the software snaps to this vertex to close the polygon.

   This opens the **Selection images** dialog:



   If **Single image** has been selected in step 2, the dialog shows a list of all images in the active image list that see the location of the selection shape.

   If **Multiple images** has been selected in step 2, the dialog shows a list of cameras per line in the active image list that see the location of the selection shape. Use the **Deduce line numbers** command in order to get correct line numbers for images.

4. Select an image or camera from the list.

   This updates the point cloud coloring according to the selection.

5. If the best image or camera for coloring the points is selected, click OK.

   This applies the new image assignment to the laser points.

✍ The placement of a shape vertex can be undone by clicking the reset button during the digitalization process.

✍ The *Place Selection Shape* tool from the **Color Points** toolbar performs the same action.

Search seamlines

Ground ortho only

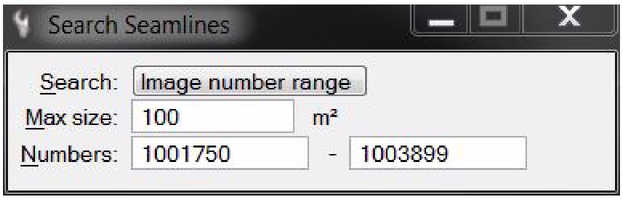
Search seamlines command creates **Auto seamline** shapes automatically along image seamlines.

This is useful for small objects in aerial images, like trees or cars, that are cut by image seamlines.

➢ **To search seamlines:**

1. Select **Search seamlines** from the **Image** pulldown menu.

   This opens the **Search Seamlines** dialog:



2. Define settings.
3. Start the search with a data click inside the view.

   If **Search** is set to **Between two images**, the search starts after the images have been defined by two data clicks.

   The application starts to search **Auto seamline** shapes. A progress bar shows the progress of the process. The search for a large data set may take a while.

Setting:	Effect:
Search	Defines the area for creating **Auto seamline** shapes: • **Between two images -** creates shapes along the seamline between two images. The two images are defined by data clicks inside the images. • **Inside fence -** creates shapes along seamlines inside a fence. • **Image number range -** creates shapes for images within a defined image number range. • **Whole dataset -** creates shapes for all images.
Max size	Maximum size of **Auto seamline** shapes.
Numbers	Numbers that define the range of images for which **Auto seamline** shapes are created. This is only active if **Search** is set to **Image number range**.

Update from design

Ground ortho only

Update from design command rebuilds selection shape information from design file elements.

Normally, this command is not needed because TerraPhoto automatically recognizes modifications of design file elements.

View pulldown menu

Commands in the **View** pulldown menu are used to set the display mode for the orthophoto preview(s), to zoom to a specific resolution ratio, and to show the area covered by one image.

To:	Choose menu command:
Change display settings for views	**Display mode**
Zoom to a defined resolution ratio	**Zoom to**
Show the area covered by a single image	**Show coverage**
Show color points that cause a color correction at a certain location	**Correction points**

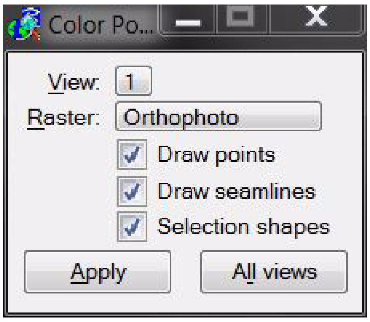
Display mode

Display mode command is used to define what elements are drawn in the orthophoto or colored point cloud previews, if the color point mode is active.

➢ **To set the display mode for (ortho) rectification:**

1. Select **Display** mode from the **View** pulldown menu.

   This opens the **Color Point Display Mode** dialog:



2. Select settings and click **Apply** or **All views**.

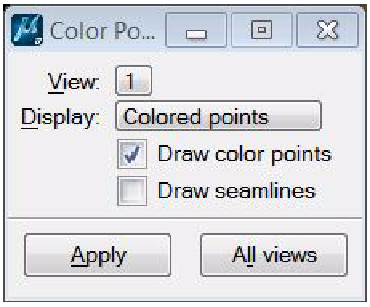
   This updates the display in the selected view or in all MicroStation views.

Setting:	Effect:
View	View for which the settings are applied.
Raster	Defines, how images are shown in the view(s): • **None -** nothing is displayed. • **Orthophotos -** the rectified raw images are displayed. If thumbnails are available, they are used for the display. • **Image assignment -** the areas covered by different raw images are displayed with different colors. • **Image quality -** the areas covered by different raw images are displayed with a color according to the image's quality number. The quality number determines the color number used from the active color table of MicroStation.
Draw points	If on, color points are shown in the view.
Draw seamlines	If on, image seamlines are shown in the view.
Selection shapes	If on, all types of selection shapes are shown in the view.

➢ **To set the display mode for point clouds:**

1. Select **Display** mode from the **View** pulldown menu.

   This opens the **Color Point Display** dialog:



2. Select settings and click **Apply** or **All views**.

   This updates the display in the selected view or in all MicroStation views.

Setting:	Effect:
View	View for which the settings are applied.
Display	Defines, how points is displayed: • **Do not display -** nothing is displayed. • **Colored points -** points colored by RGB coloring. • **Image assignment -** points colored by the image assignment attribute.
Draw color points	If on, color points are shown in the view.
Draw seamlines	If on, image seamlines are shown in the view.

Zoom to

Ground ortho only

Zoom to command zooms the view to a predefined resolution ratio.

➢ **To zoom to a predefined resolution ratio:**

1. Select one of the **Zoom to / 1:x** commands from the **View** pulldown menu.

   If the mouse pointer is moved inside the view, a rectangle with the new view extent is displayed.

2. Place a data click inside the view.

   This updates the view display in order to show the preview with the selected resolution ratio and centered to the location of the data click.

✍ The preview display is faster if the resolution is set to a ratio for which thumbnails are available. See **Create thumbnails** command for more information.

Show coverage

Ground ortho only

Show coverage displays the area cover by one single image. The image is defined by a data click. The area outside this image is masked with a temporary red transparent color filling.

➢ **To show the coverage of an image:**

1. Select **Show coverage** command from the **View** pulldown menu.
2. Move the mouse pointer inside the view.

   The footprint of an image is highlighted dynamically if the mouse pointer is inside the image.

3. Place a data click inside an image.

   The area outside the selected image is masked. You can remove the mask by clicking the reset mouse button.

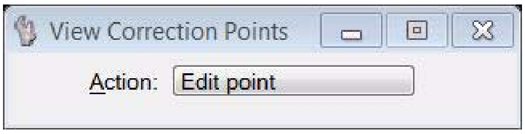
Correction points

Correction points highlights color points that effect the coloring of an image at the mouse pointer location. The highlighted color points can then be selected for editing or removal.

➢ **To highlight color points:**

1. Select **Correction points** command from the **View** pulldown menu.
2. Move the mouse pointer to a location where the coloring looks strange.

   This highlights dynamically the color points that contribute to the coloring at the mouse pointer location. It also opens the **View Correction Points** dialog:

3. Select in the **Action** field whether you want to **Edit** a **point** or **Delete**.
4. Select one of the color points with a data click.

   If **Action** is set to **Edit point**, this opens the **Color point** dialog for editing the point. See **Edit** command for more information.

   If **Action** is set to **Delete**, this deletes the selected color point.

Tool pulldown menu

Commands from the **Tool** pulldown menu are used to draw seamlines into the design file, to transform selection shapes from one projections system to another, and to derive sun hot spot corrections.

To:	Choose menu command:
Draw seamlines into the design file	**Draw seamlines into design**
Transform selection shapes	**Transform selection shapes**
Derive corrections for sun hot spots in images	**Derive image corrections**

Draw seamlines into design

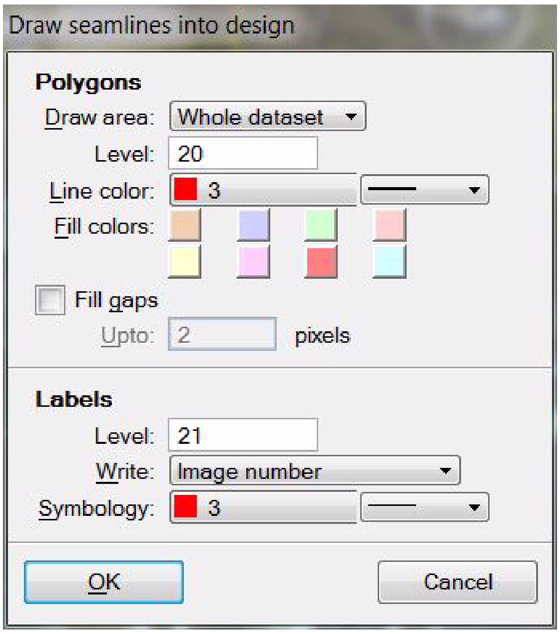
Ground ortho only

Draw seamlines into design command draws image seamlines as polygons into the design file. This illustrates where each raw image is used in the final orthophoto mosaic. In addition, a label can be created for each polygon.

➢ **To draw seamlines into design:**

1. Select **Draw seamlines into design** command from the **Tool** pulldown menu.

   This opens the **Draw seamlines into design** dialog:



2. Select settings and click OK.

   The application draws the seamline polygons into the design file. A processing window counts the number of images for which seamlines are drawn.

Setting:	Effect:
Draw area	Defines which seamlines are drawn into design file: • **Whole dataset -** seamlines of all images. • **Selected tiles -** seamlines are drawn if they are inside selected tile shapes. This requires the selection of at least one tile shape before the command is started.
Level	Design file level on which the seamline polygons are drawn.
Line color	Outline color and weight of seamline polygons. Uses the active color table of MicroStation and standard line widths.
Fill colors	Fill colors of seamline polygons. The colors are used in the given order for consecutive seamline shapes. Uses the active color table in MicroStation.
Fill gaps	If on, gaps between images **up to** the defined number of pixels are filled.
Level	Design file level on which labels of seamline polygons are drawn.

Setting:	Effect:
Write	Defines the content of the labels: • **No label -** no labels are drawn. • **Image number -** numbers of the raw images. • **File name -** file names of the raw images. • **Unique end of file name -** the part of raw image file names that is unique for each raw image.
Symbology	Label color and weight. Uses the active color table of MicroStation and standard line widths. Font type and size are defined by the active MicroStation settings for text styles.

Transform selection shapes

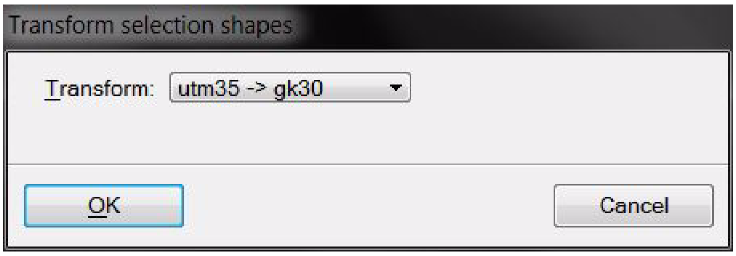
Ground ortho only

Transform selection shapes command can be used to apply a transformation to all selection shapes in a design file. The transformation must be defined in **Coordinate transformations / Transformations** of the TerraPhoto **Settings**.

➢ **To transform selection shapes:**

1. Select **Transform selection shapes** command from the **Tool** pulldown menu.

   This opens the **Transform selection shapes** dialog:



2. Select a transformation from the **Transform** pulldown list.
3. Click OK.

   This transforms the coordinates of all selection shapes into the new projection system.

Derive image corrections

Ground ortho only

Derive image corrections command derives a brightness distribution correction for images. The correction removes systematic effects from raw images caused by sun hot spots. The effect can occur in airborne images where the sun is brightening up a part of each raw image depending on the flight line direction. It shows up, for example, in the final orthophoto mosaic as a striped pattern in small-scale displays.

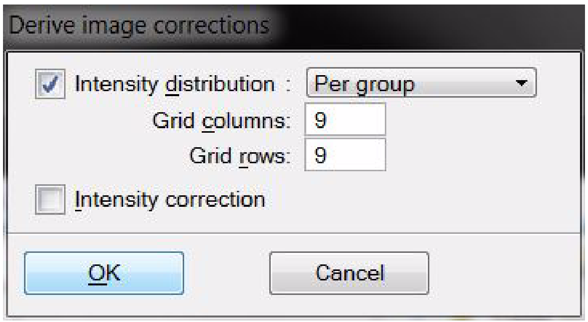
Before the software is able to derive correct brightness corrections depending on the flight line direction, the raw images must be assigned to groups. The groups are created based on the sun direction. See **Assign groups** command for detailed information about raw image groups.

Additionally, color points must be available. The brightness distribution correction is actually a grid of correction values derived from color point values. The systematic brightness distribution correction is stored as percentage values for each image in the image list file. The color points are modified and recomputed as well.

➢ **To derive image corrections:**

1. Select **Derive image corrections** command from the **Tool** pulldown menu.

   This opens the **Derive image corrections** dialog:



2. Select settings and click OK.

   This starts the derivation of the correction values. Afterwards, the color points are recomputed. A processing window shows the steps that are performed.

   When the process has finished, an information dialog is show.

3. Save the color points using **Save** or **Save As** commands from the **File** pulldown menu in order to save the recomputed color points into a file.
4. Save the image list using **Save list** or **Save list As** commands in order to save the image list into a file including the systematic brightness correction values.

Setting:	Effect:
Intensity distribution	If on, a brightness distribution correction is derived: • **For whole data set -** same distribution for all images. • **Per group -** same distribution for images of the same group (depending on the sun direction when an image was captured)
Grid columns	Number of columns in the grid of correction values.
Grid rows	Number of rows in the grid of correction values.
Intensity correction	If on, a brightness correction is derived for all images.

14 Orthophoto Production

TerraPhoto is commonly used for creating a seamless, positionally accurate orthophoto mosaic as the final product. Many steps in the TerraPhoto workflow prepare a data set for this aim. The rectification itself is an automatic process.

This chapter describes typical settings that you would use for producing orthophotos of two different quality levels. “Quick” orthophotos may be produced for internal purposes only. “Final” orthophotos are the actual end product that is delivered to the customer. These two levels of orthophotos are produced by selecting different parameters for the rectification process.

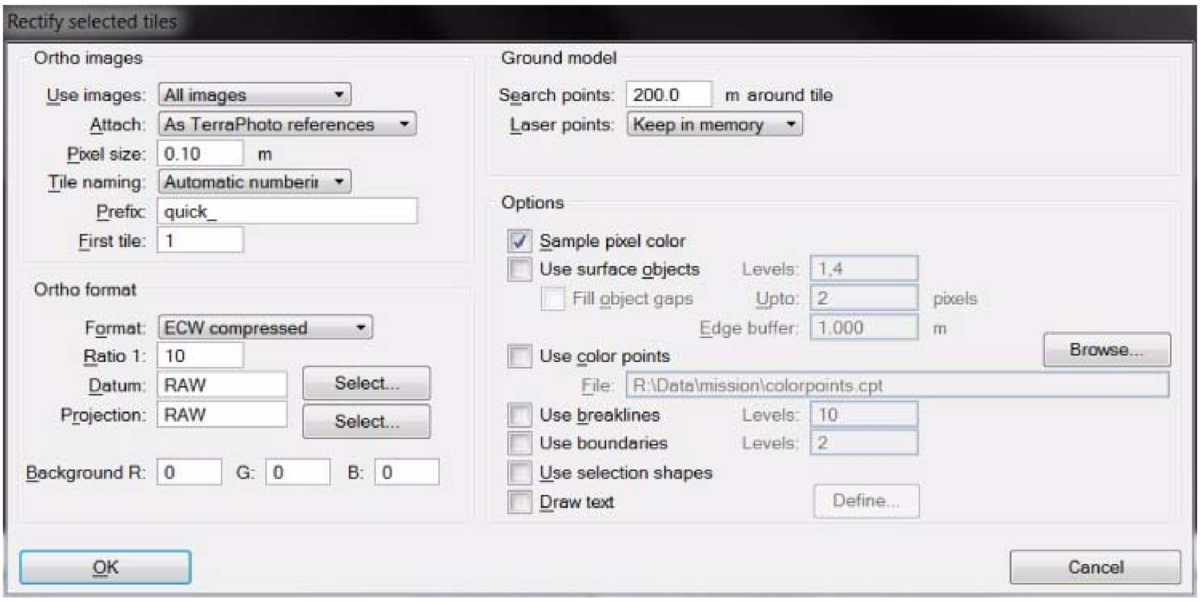
The creation of an orthophoto mosaic requires tiles which represent the orthophoto boundaries. Tiles can be produced by **Place tile array** command or *Place Tile Array* tool in TerraPhoto, or by any MicroStation tool that produces rectangular shapes. The rectification is started by the **Rectify mosaic** command from the **Rectify** pulldown menu in **TPhoto Main** window.

Settings for quick orthophotos

It is often useful to create orthophotos in a fast way for internal use before all the work for best-quality orthophotos is completed. This is done, for example, to use orthophotos in the background for the manual editing of laser data classification. Accurate orthophotos require a correct ground model but the correct classification of ground laser points is often difficult to achieve without some imagery in the background of the point cloud.

Quick orthophotos are produced based on a ground model from automatically classified laser points and roughly adjusted raw images. There is no need to take too much effort for improving the positioning of raw images or to involve color corrections and selection shapes in the production of quick orthophotos.

The recommended settings for quick orthophotos are shown below. Only **Sample pixel color** is switched on in the **Options** group of the **Rectify selected tiles** dialog. Additional settings would produce better-quality results but they would also slow down the rectification process and require more processing steps in preparation. The ECW compressed format results in handy raster files that are fast in the display as TerraPhoto raster references.



Settings for final orthophotos

Orthophotos produced as end products for delivery require more processing steps and input information. This includes a correct ground model, accurate positioning of the raw images, color corrections, selection shapes, and possibly 3D vector models of objects on the surface for producing true-orthophotos.

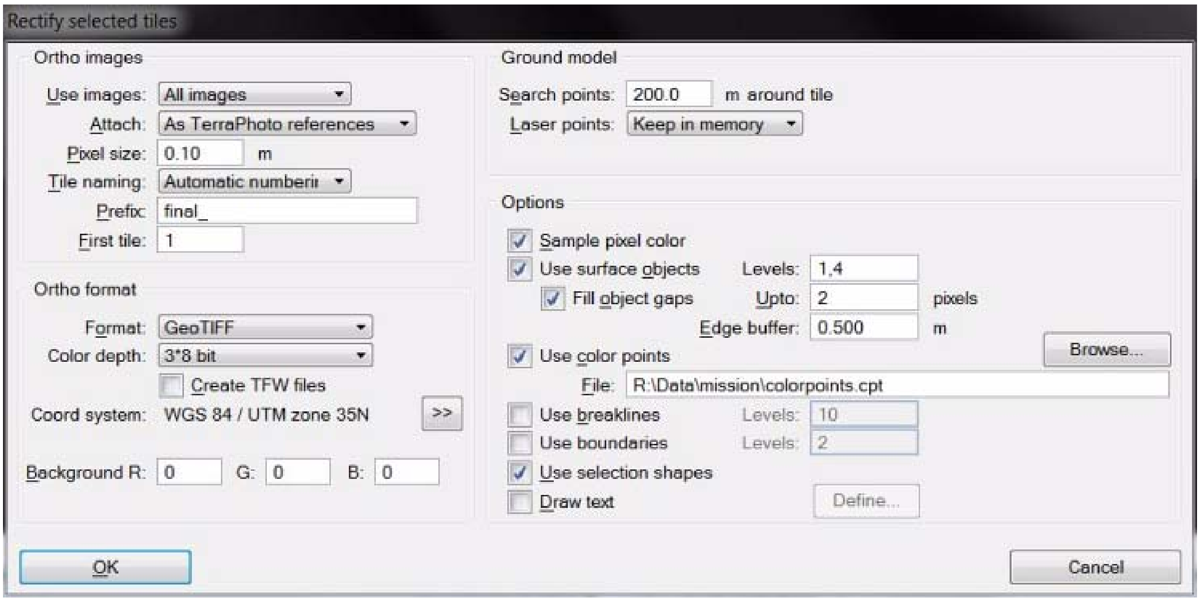
Typical settings for final orthophotos are shown below. There are now more options used in the **Options** group of the **Rectify selected tiles** dialog. They make the rectification process slower but result in better-quality orthophotos.

Format is set to GeoTIFF which results in raster files without any loss of quality caused by compression.

Use surface objects makes use of closed shapes that are drawn on the given design file levels. It produces true-orthophotos where the shapes are utilized to get the correct position of objects above the ground, such as building roofs and bridges.

Use color points defines a **Color points** file. The file contains color balancing information in order to eliminate brightness and color differences between neighbouring images.

Use selection shapes involves all types of **Selection shapes** stored in the design file. Selection shapes manipulate seamlines between images or define the usage of certain raw images in specified areas.



Tool Reference

15 Toolbox tools

TerraPhoto Settings

Settings control the way how tools and commands of TerraPhoto work. They are organized in logical categories. The **Settings** dialog is opened by the *Settings* tool.

Settings folder / category:	Settings category
Coordinate transformations / Builtin projection systems	Angle systems
Coordinate transformations / Transformations	Attitude computation
Coordinate transformations / US State Planes	Color points
Coordinate transformations / User projection systems	Define Color Corrections
Reference images / Default visibility	ECW compression
Reference images / Raster references	Exterior orientation formats
Tie points / Automation	Histogram adjustment
Tie points / Display	Laser points
Tie points / Entry	Memory usage
Video / Display	Mobile rectification
Video / Misalignment	Operation
	Selection shapes
	TFW and JGW files
	Tile naming schemes
	Trajectory formats

Coordinate transformations / Builtin projection systems

Builtin projection systems category in **Coordinate transformations** folder defines what projection systems are available for transformations. This effects lists in dialogs for transforming from WGS84 longitude and latitude coordinates to planar coordinate systems. Currently supported target systems are listed in the following table:

Setting:	Effect:
Belgium LB72/ BEREF2003	If on, transformation to LB72/BEREF2003 can be applied.
Deutsche Bahn GK	If on, transformation to Deutsche Bahn GK1 - GK5 can be applied.
Finnish KKJ	If on, transformation to KKJ using the selected **Equation** can be applied.
Finnish ETRS-TM35FIN and ETRS-GK	If on, transformation to ETRS-TM35FIN and ETRS-Gauss-Krueger zones 19 - 31 can be applied.
Northern Ireland	If on, transformation to Northern Ireland system can be applied.
Republic of Ireland	If on, transformation to Ireland Transverse Mercator system can be applied.
Japan	If on, transformation to Japanese zones 1 - 19 can be applied.
Netherlands RD/NAP 2008	If on, transformation to RD/NAP system can be applied.
South Africa	If on, transformation to South Africa LO system can be applied.
Swedish RT90	If on, transformation to Swedish RT90 system can be applied.
Swedish SWEREF99	If on, transformation to SWEREF99 system can be applied.
UK National Grid	If on, transformation to UK National Grid can be applied.
UTM WGS North	If on, transformation for given UTM **Zones** on the northern hemisphere can be applied.
UTM WGS South	If on, transformation for given UTM **Zones** on the southern hemisphere can be applied.

Coordinate transformations / Transformations

Transformations category in **Coordinate transformations** folder contains a list of coordinate transformations which can be used to transform the position of laser data, trajectories, and other data.

You can **Add**, **Edit**, and **Delete** transformation by using the corresponding buttons in the **Settings** dialog. The **Copy** button copies the selected transformation to the clipboard. With the **Paste** button you can paste a transformation from the clipboard. The **Derive** button can be used for **Deriving a transformation** from a set of control point pairs.

Seven types of coordinate transformations are supported:

- **Linear transformation**
- **Equation transformation**
- **Known points transformation**
- **Xy multiply transformation**
- **3D translate & rotate transformation**
- **3D Affine transformation**
- **Projection change transformation**

➢ **To define a new transformation:**

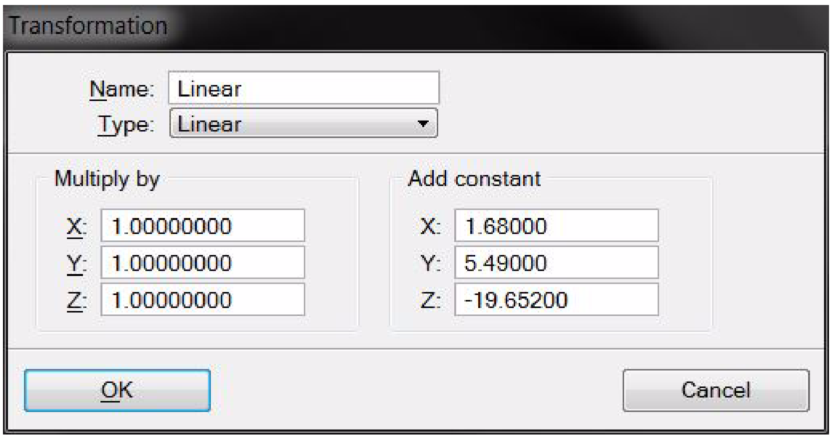
1. Open the **Transformations** category in the **Coordinate transformations** folder.
2. Click **Add** in the **Settings** dialog.

   This opens the **Transformation** dialog.

3. Type a **Name** for the transformation and select a transformation **Type**. Define the other settings depending on the transformation type.
4. Close the **Settings** dialog in order to save the modified settings for TerraPhoto.

Linear transformation

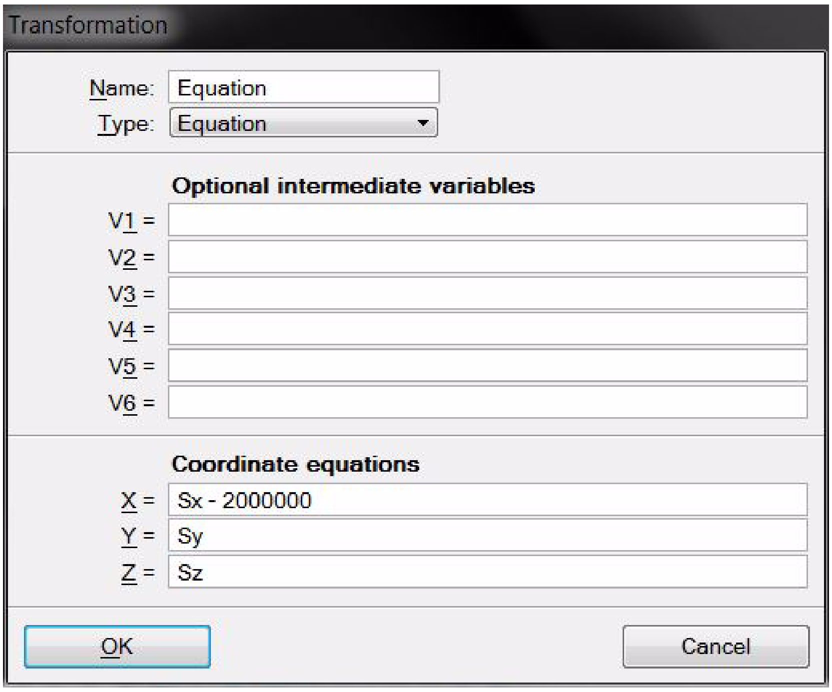
Linear transformation scales and/or translates coordinate values. You can assign a coefficient and a constant offset for each coordinate axis. The target coordinates are computed by multiplying the original coordinates with the given coefficient and by adding a given constant value.



Setting:	Effect:
Multiply by - X	Coefficient for multiplying the easting coordinate.
Multiply by - Y	Coefficient for multiplying the northing coordinate.
Multiply by - Z	Coefficient for multiplying the elevation coordinate.
Add constant - X	Value to add to the easting coordinate.
Add constant - Y	Value to add to the northing coordinate.
Add constant - Z	Value to add to the elevation coordinate.

Equation transformation

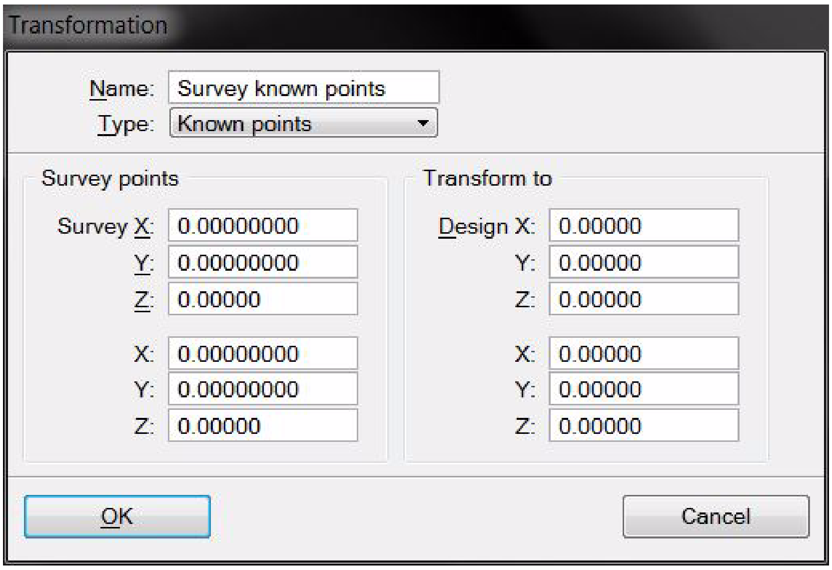
Equation transformation lets you define mathematical equations for computing new easting, northing, and elevation values from the source easting, northing, and elevation coordinates. You can also enter equations for up to six intermediate variables which are computed in order V1, V2, ..., V6 before evaluating new coordinates X, Y and Z.



Setting:	Effect:
V1, V2, ..., V6	Optional equations for calculating intermediate variables V1, V2, V3, V4, V5, and V6.
X, Y, Z	Equations for calculating the easting, northing, and elevation coordinates. The mathematical equation may contain: • Sx - survey file X coordinate. • Sy - survey file Y coordinate. • Sz - survey file Z coordinate. • Intermediate variables V1, V2, V3, V4, V5, and V6. • Mathematical functions such as sin(a), cos(a), tan(a), exp(a), log(a), log10(a), pow(a,b), sqrt(a), ceil(a), fabs(a) and floor(a) where a and b are floating point values.

Known points transformation

Known points transformation lets you specify the coordinates of two known points in the original coordinate system (survey coordinates) and their respective coordinates in the target system (design file coordinates).



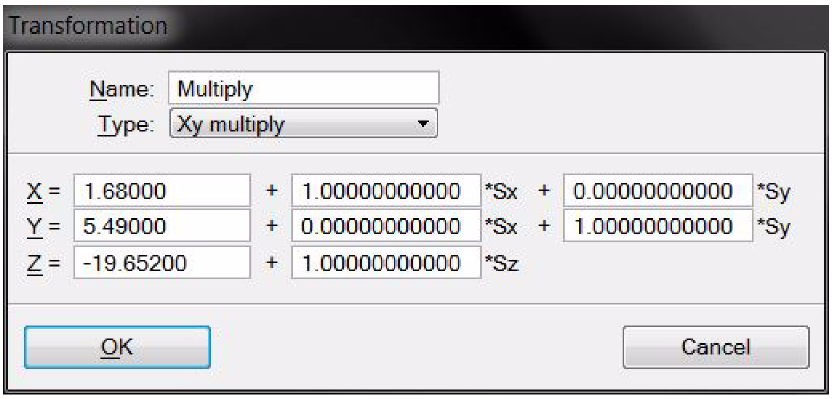
Setting:	Effect:
Survey X, Y, Z	First known point in the original coordinate system.
X, Y, Z	Second known point in the original coordinate system.
Design X, Y, Z	First known point in the target coordinate system.
X, Y, Z	Second known point in the target coordinate system.

Xy multiply transformation

Xy multiply applies a transformation using equations:

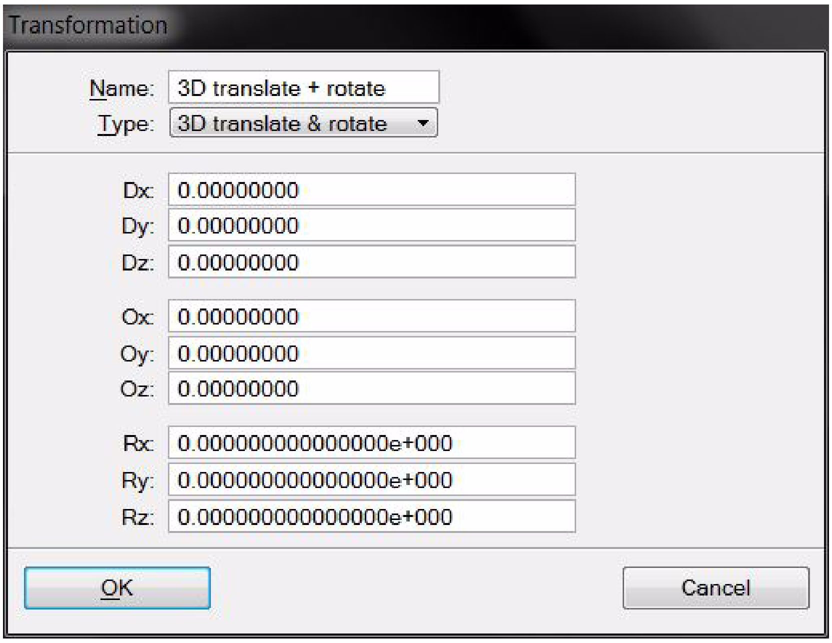
```
NewX = dx + a * Sx + b * Sy
NewY = dy + c * Sx + d * Sy
NewZ = dz + e * Sz
```

where dx, dy, dz, a, b, c, d, and e are constant parameters of the transformation and Sx, Sy, Sz are the original (survey) coordinates. This is often used as *2D Helmert* type of transformation.



3D translate & rotate transformation

3D translate & rotate applies a three dimensional translation and rotation to coordinates.



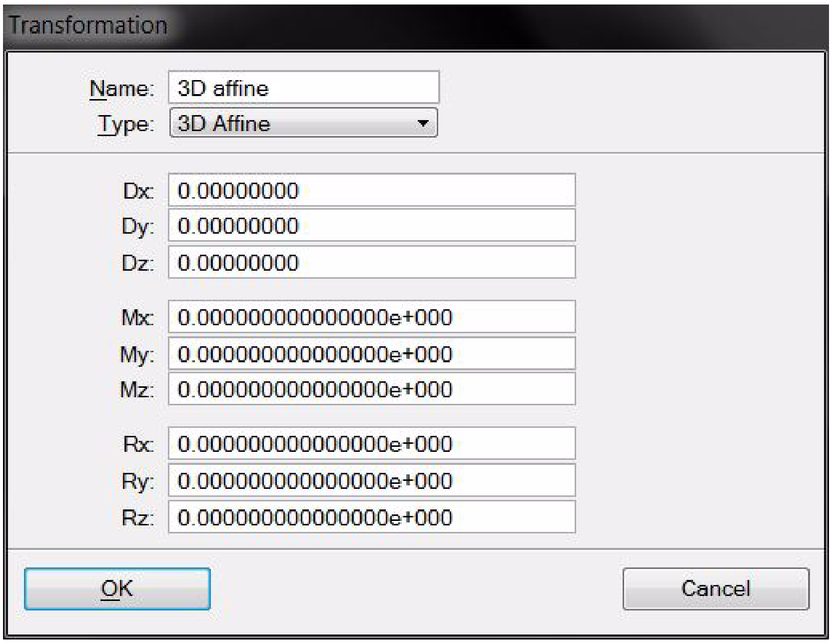
Setting:	Effect:
Dx, Dy, Dz	Values to add to X, Y, Z coordinates.
Ox, Oy, Oz	X, Y, Z coordinates of the rotation center point.
Rx, Ry, Rz	Rotation angle in radians around X, Y, Z axes.

3D Affine transformation

3D Affine applies separate translation, rotation and scaling for each coordinate axis. The transformation is defined by equations:

```
NewX = dx + (1.0 + mx) * X + rz * Y - ry * Z
NewY = dy + (1.0 + my) * Y - rz * X + rx * Z
NewZ = dz + (1.0 + mz) * Z + ry * X - rx * Y
```

where dx, dy, dz, mx, my, mz, rz, ry, and rz are constant parameters of the transformation and X, Y, Z are the original coordinates.



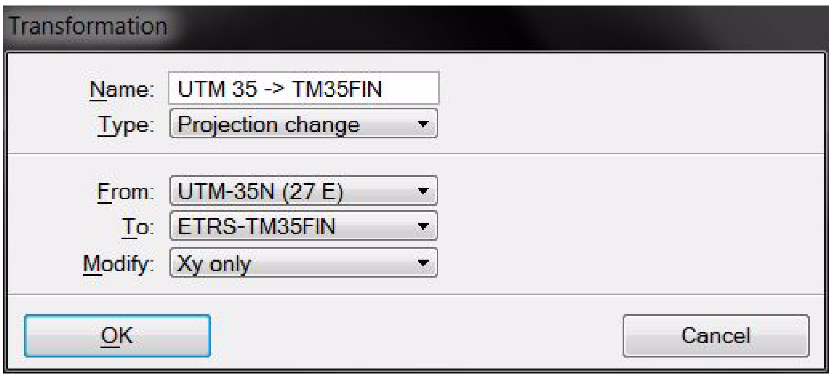
Setting:	Effect:
Dx, Dy, Dz	Values to add to X, Y, Z coordinates (translation).
Mx, My, Mz	Factors to scale the data along the X, Y, Z axes.
Rx, Ry, Rz	Rotation angle in radians around X, Y, Z axes.

Projection change transformation

Projection change transforms coordinates from one projection system to another. The software transforms the X, Y, Z coordinates from the source projection system back into WGS84 geocentric X, Y, Z and then computes the transformation into the target projection system.

All projections systems that are active in **Coordinate transformations / Builtin projection systems**, **Coordinate transformations / US State Planes**, or defined in **Coordinate transformations / User projection systems** are available for a projection change transformation.

If you already applied a geoid correction, you should run a reverse geoid correction to the data set before using a projection change transformation. This is essential in cases where the source and the target systems use different ellipsoids or datums. A geoid correction or a reverse geoid correction is only applied automatically if the UK National Grid system is used in the transformation.



Setting:	Effect:
From	Source projection system.
To	Target projection system.

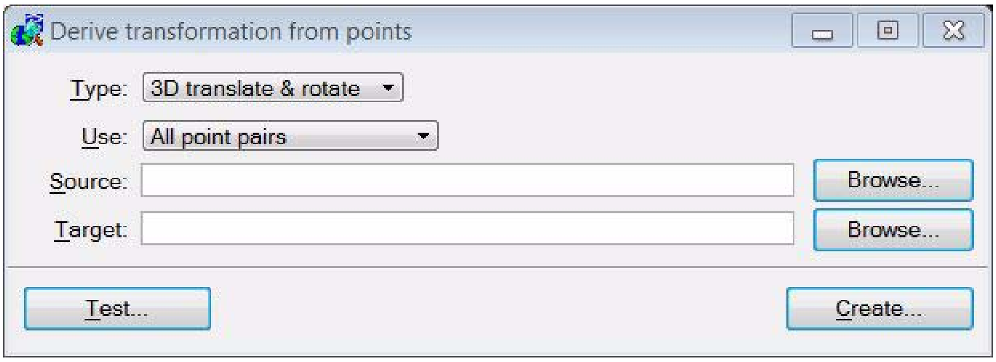
Setting:	Effect:
Modify	Coordinate values to modify: • **Xyz** - modifies all coordinates. • **Xy only** - no changes to elevation values.

✍ You can copy transformations from one Terra application to another. Select the transformation in the **Settings** dialog and click on the **Copy** button to copy the definition to the clipboard. Click on the **Paste** button in the other Terra application to paste the definition.

Deriving a transformation

You can also derive transformation parameter values from point pairs. This requires that identical control points (point pairs) are available in source and target coordinate values. The points must be stored in text files. The number of required control point pairs depends on the transformation type.

To derive a transformation, click on the **Derive** button in the **Settings** dialog. This opens the **Derive transformation from points** dialog:



Setting:	Effect:
Type	Type of the derived transformation: • **2D transformation** - parameter values for a 2D Helmert transformation are derived. • **3D translate & rotate** - parameter values for a 3D translation and rotation transformation are derived. • **7 parameter affine** - parameter values for a 3D affine transformation (7 parameters) are derived. • **9 parameter affine** - parameter values for a 3D affine transformation (9 parameters) are derived.
Use	Points used for deriving the transformation: • **All point pairs** - uses all control point pairs. • **Inside source fence only** - points inside a fence in the source coordinate system are used. • **Inside target fence only** - points inside a fence in the target coordinate system are used.
Source	Text file that contains the point pair coordinates in the source system.
Target	Text file that contains the point pair coordinates in the target system.

The transformation derivation can be tested by using the **Test** button. This computes the parameter values and displays the result in a report window. To create the transformation, click on the **Create** button. This opens the **Transformation** dialog that displays the derived parameter values. Type a **Name** for the transformation and click OK in order to add the transformation to the list in the **Settings** dialog.

Coordinate transformations / US State Planes

US State Planes category in **Coordinate transformations** folder contains a list of US State Plane projection systems using the NAD83 datum. Check the toggle box of those state plane systems you want to use.

You can view the parameters of a system by using the **View** button. In case you need to change the parameters of a built-in US State Plane definition, you can use the **Copy** button to copy/paste the system into **Coordinate transformations / User projection systems**.

Coordinate transformations / User projection systems

User projection systems category in **Coordinate transformations** folder contains a list of user defined projection systems. You can define your projection system based on **Transverse Mercator / Gauss-Krueger**, **Lambert conic conformal** or **Hotine oblique mercator** projection.

A projection system definition can be divided into three distinct parts:

- **Ellipsoid** - defined by **Semi-major axis** and **Inverse flattening**.
- **Datum** - defined by seven parameter Bursa/Wolfe transformation.
- **Projection** - defined by the projection type, true origin, false origin, scale factor at the central meridian, and distance unit.

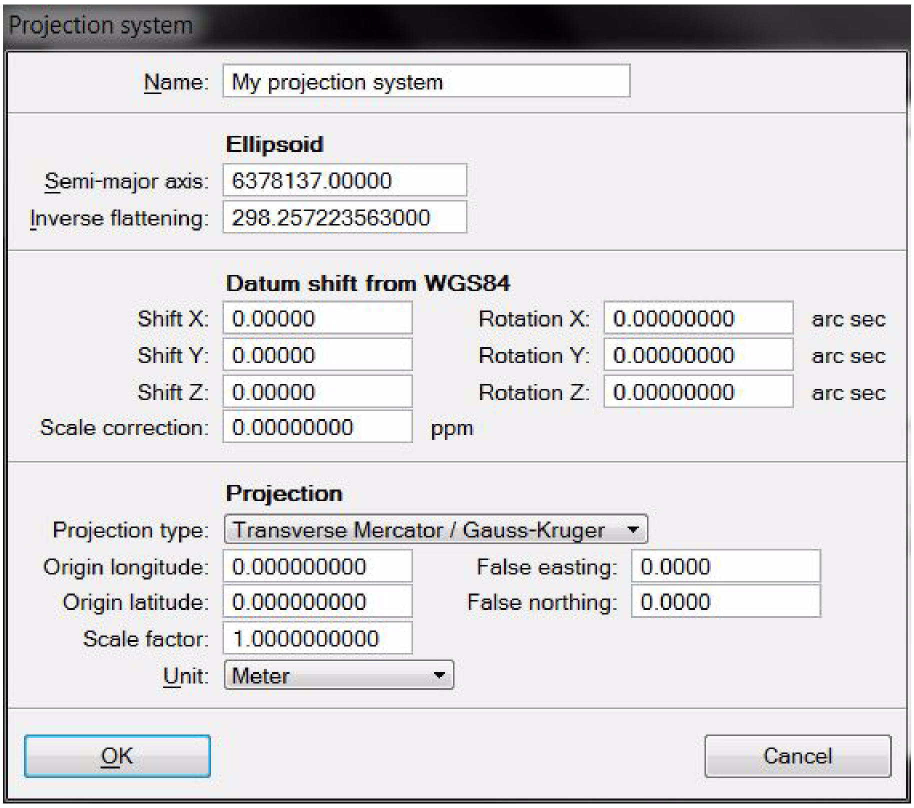
The list of user projection system displays a toggle box for each row. The toggle box indicates whether a projection system is active or not. Only active projection systems can be selected when applying a transformation. To activate or deactivate a projection system, place a data click inside its toggle box in the list.

You can **Add**, **Edit**, and **Delete** user projection systems by using the corresponding buttons in the **Settings** dialog. The **Copy** button copies the selected projections system definition to the clip-board. With the **Paste** button you can paste a projection system definition from the clipboard.

➢ **To define a new projection system:**

1. Open the **User projection systems** category in the **Coordinate transformations** folder.
2. Click **Add** in the **Settings** dialog.

   This opens the **Projection system** dialog:



3. Define settings and click OK.
4. Activate the projection system.
5. Close the **Settings** dialog in order to save the modified settings for TerraScan.

Setting:	Effect:
Name	Descriptive name for the projection system.
Semi-major axis	Semi-major axis of the target ellipsoid.

Setting:	**Effect:**
Inverse flattening	Inverse flattening of the target ellipsoid.
Shift X	Datum X shift from WGS84 to the target system in meter.
Shift Y	Datum Y shift from WGS84 to the target system in meter.
Shift Z	Datum Z shift from WGS84 to the target system in meter.
Rotation X	Datum rotation around the X axis in arc seconds.
Rotation Y	Datum rotation around the Y axis in arc seconds.
Rotation Z	Datum rotation around the Z axis in arc seconds.
Scale correction	Datum scale correction as parts per million. The actual scale factor is computed as *1.0 + (0.000001 * ScaleFactor)*.
Projection type	Type of the projection system: **Transverse Mercator/Gauss-Kruger**, **Lambert conic conformal**, or **Hotine oblique mercator**.
Origin longitude	Longitude of the true origin in decimal degrees.
Origin latitude	Latitude of the true origin in decimal degrees.
False easting	Map coordinate easting of the true origin.
False northing	Map coordinate northing of the true origin.
Scale factor	Scale factor on the central meridian.
Unit	Distance unit: **Meter**, **International foot**, **US Survey Foot**, or **International yard**.

You can copy user projection systems from one Terra application to another. Select the system in the **Settings** dialog and click on the **Copy** button to copy the definition to the clipboard. Click on the **Paste** button in the other Terra application to paste the definition. You can also paste the definition in a text editor in order to save it into a text file.

Reference images / Default visibility

Default visibility category in **Reference images** folder defines the MicroStation views for which TerraPhoto raster references are switched on for display by default. This is used by **Attach files** and **Attach directory** commands in the **Manage Raster References window**.

Reference images / Raster references

Raster references category in **Reference images** folder defines the ratios of lower resolution versions of raster references and how references are displayed when viewed from a far distance.

A full resolution version of an image is required only when the display is zoomed close to the pixel detail level. When viewing images from further away, the application can use smaller versions of the images and thus, fit more of those images in the image cache.

Lower resolution versions are not used with ECW images.

Setting:	Effect:
Medium ratio	Subsampling ratio of medium resolution versions. Default is 2.
Low ratio	Subsampling ratio of low resolution versions. Default is 4.
Thumbnail ratio	Subsampling ratio of thumbnail versions. Default is 8.
Beyond factor	Zoom factor beyond which the raster images are no longer drawn. Default is 1000 which is a reasonable setting for ECW images.
Draw rectangle	If on, the application draws a rectangle using the given line color and line width for each raster image if the zoom factor is smaller than the value given in the **Beyond factor** field.
Fill rectangle	If on, the application fills the rectangle with the given color for each raster image if the zoom factor is smaller than the value given in the **Beyond factor** field.

Tie points / Automation

Automation category in **Tie points** folder defines how semi-automatic tie point search works. See **Tie point entry modes** on page 80 for more information. Another setting relates to the usage of keyboard keys for navigating in the tie point lists.

Setting:	Effect:
Find matches automatically	If on, the application searches matching positions in secondary images automatically for **Ground** tie points.
Search width	Size of the comparison raster to find matching tie point positions.
Match limit	Limit for how good or bad matches are accepted for tie points. Good matches have a lower value, bad matches have a higher value. Default setting is 10.
Bad matches	Action to take for matches which are worse than the **Match limit**: • **Set manually -** applications leaves the tie point pixel undefined and displays the secondary image for the user to enter the pixel manually. • **Reject -** bad matches are ignored and not shown to the user.
Focus point list automatically	If on, the focus of key commands stays on the tie point list in the **Tie point** window. Thus, the <Arrow up> and <Arrow down> keys can be used immediately after a tie point has been placed to select tie point pixels in the **Tie point** window.

Tie points / Display

Display category in **Tie points** folder contains values which determine whether an image is well-defined by tie points or not. See **Tie point values** on page 78 and **Tie point distribution** on page 79 for more information. The settings effect the display color of tie point attributes in the **Tie points** window. Further, you can define a color for highlighting image areas where no tie points can be placed.

Setting:	**Effect:**
Point value	Required sum of **Tie point values** for an image to be considered well-defined.
Coverage	Required **Tie point distribution** value for an image to be considered well-defined. The better the tie points are distributed over an image, the higher is the coverage value.
Distance	Limit for displaying large mismatch distances of tie points in red.
R, G, B	RGB color values for highlighting image areas where no tie points can be placed. Values can range between -255 and +255. Negative values cause transparency of the highlight color.

Tie points / Entry

Entry category in **Tie points** folder defines settings for entering tie points.

Setting:	**Effect:**
Default	Default distance from a mobile camera for placing a new tie point.
Maximum	Maximum distance from a mobile camera for placing a new tie point.
Hilite known point location	If on, **Known xyz** and **Known xy** tie point locations are marked with a cross in the tie point entry views.
Reset when image loses point values	If on, the **Tie status** attribute of an image is reset from *Approved* to *Check* if the image’s tie point value becomes smaller then the value defined in **Tie points / Display**.

Video / Display

Display category in **Videos** folder defines display settings for the *Display Video* tool.

Setting:	Effect:
Zoom factor	Size of the video display on screen relative to the original resolution of the video.
Step size	Length of the video sequence to display when stepping forward or backward.
Fast forward	Speed factor for fast forward playing mode.
Display video location	If on, the location of the video along a trajectory line is dynamically displayed in a MicroStation view. The location is marked with a rectangle.
Level	Design file level for the dynamic display of the video location.
Symbology	Color and line width for the dynamic display of the video location. Uses the active color table of MicroStation and standard line weights.
Altitude	Height in meter above ground on which the rectanlge for the dynamic display of the video location is drawn.
Width	Width in meter of the rectangle for the dynamic display of the video location.
Height	Height in meter of the rectangle for the dynamic display of the video location.

Video / Misalignment

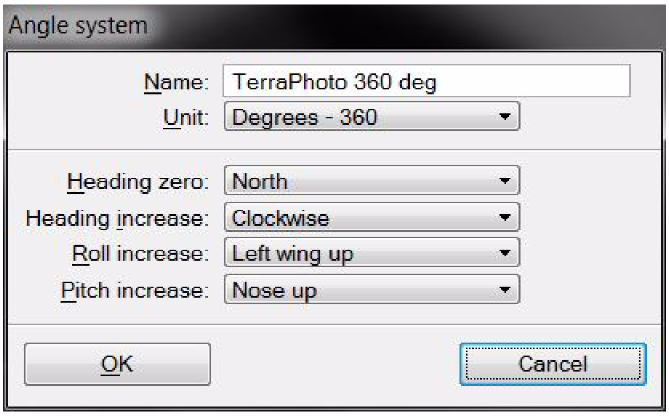
Misalignment category in **Videos** folder defines the misalignment angles of video cameras compared to the IMU. The vertical video and forward video parameters refer to the corresponding definitions for Video 1 and Video 2 in **Edit information** dialog.

Setting:	Effect:
Heading	Heading misalignment value for a vertical video (Video 1).
Roll	Roll misalignment value for a vertical video (Video 1).
Pitch	Pitch misalignment value for a vertical video (Video 1).
Heading	Heading misalignment value for a forward video (Video 2).
Roll	Roll misalignment value for a forward video (Video 2).
Pitch	Pitch misalignment value for a forward video (Video 2).

Angle systems

Angle systems category let you define angle systems. The definition includes the unit of the angles, the direction of zero for heading, and the directions of increasing heading, roll, and pitch angles.

A new angle system can be defined by using the **Add** button in the TerraPhoto **Settings** dialog. An existing system is modified by selecting the system and using the **Edit** button. A data click on the **Delete** button deletes a selected angle system.



Setting:	Effect:
Name	Descriptive name for the angle system.
Unit	Format of the input angles: • **Radians - 2*pi -** angle values are given in radians. The software normalizes the values between -pi and +pi. • **Degree - 360 -** angle values are given in degree. The software normalizes the values between -180 and +180 degree. • **Gones - 400 -** angle values are given in gones. The software normalizes the values between -200 and +200 gones.
Heading zero	Defines the direction where heading is zero: **North**, **East**, **South**, or **West**.
Heading increase	Defines the direction of increasing heading values: **Clockwise** or **Counter clockwise**.
Roll increase	Defines the direction of increasing roll values: **Left wing up** or **Right wing up**.
Pitch increase	Defines the direction of increasing pitch values: **Nose up** or **Nose down**.

Attitude computation

Attitude computation category defines how to compute camera rotation from input angles. This effects mainly the creation of image lists using the **Compute list** command.

Three angles is not enough to explicitly define a rotation. In addition, the order in which those angles are applied must be fixed as well. Most IMU systems use the order *Heading Pitch Roll*.

Setting:	Effect:
Order	Order in which to apply angles. The possible choices are: • **Heading roll pitch** • **Heading pitch roll** - this is the standard order used by common IMU systems. • **Roll pitch heading** • **Pitch roll heading** • **Roll heading pitch** • **Pitch heading roll**

Color points

Color points category defines symbology settings for drawing color points and display settings for drawing image assignment instead of ortho images.

Setting:	Effect:
Level & Color	Design file level number and color for drawing color points temporarily into the design file. The list of colors contains the active color table of MicroStation.
Beyond factor	Minimum zoom factor for displaying rectified images in color points mode. If the zoom factor is smaller, the image assignment is drawn instead.

Define Color Corrections

Define Color Corrections category determines how many image rows are skipped when using the <Page up> and <Page down> keys in the **Define color corrections dialog** dialog. The setting applies only if the image thumbnails in the **Define color corrections** dialog are displayed in a single row.

Setting:	Effect:
Move	Determines the number of image rows that are skipped when using the <Page up> or <Page down> keys to scroll through the image list in the **Define color corrections** dialog.

ECW compression

ECW compression category defines how coordinate information is written to ECW files.

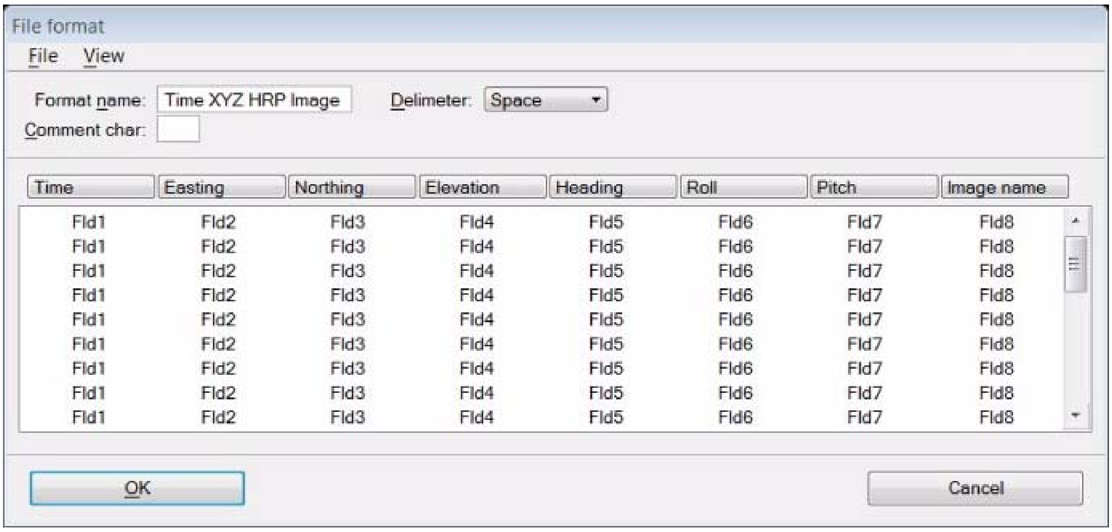
Setting:	Effect:
Write as	Sign of Y step: **Negative values** or **Positive values**.

Exterior orientation formats

Exterior orientation formats category lets you define formats for importing exterior orientation information from text files. The format definition determines the order of the attributes that are stored in the text file, the delimeter that separates attribute fields, and possibly a character which marks comment lines.

A new format can be defined by using the **Add** button in the TerraPhoto **Settings** dialog. An existing format is modified by selecting the format and using the **Edit** button. A data click on the **Delete** button deletes a selected format.

You can load an example text file by using the **Load example** command from the **File** pulldown menu. With the commands from the **View** pulldown menu the dialog can be resized to enable the import of text files with **8 fields**, **10 fields**, or **15 fields**.



Setting:	Effect:
Format name	Descriptive name for the exterior orientation format.
Delimeter	Character used to separate attribute fields in the text file: **Space**, **Tabulator**, **Comma**, or **Semicolon**.
Comment char	Character that introduces a comment in the text file. Lines beginning with this character are ignored when information is read from the text file.
No field	Selection of what attribute is stored in the field: • **No field -** no field definition. • **Ignore -** the column in the text file is ignored. • **Image name -** names of images. • **Image number -** numbers of images. • **Time -** time stamps of image positions. • **Easting**, **Northing**, **Elevation -** X, Y, Z coordinates of image positions. • **Heading**, **Roll**, **Pitch -** misalignment angles of images. • **Omega**, **Phi**, **Kappa -** orientation angles of images.

Histogram adjustment

Histogram adjustment category determines values for automatic histogram adjustment. The settings are used in the **Adjust images** command.

The adjustment routine first builds a histogram of pixel intensity values for red, green, and blue channels separately. For each color channel, it determines a boundary location at the low end and at the high end of the histogram. A percentage value defines the lowest and highest intensity pixels that are outside the boundary. Then, the intensity values are remapped so that the low end boundary and the high end boundary are moved to the specified values.

Settings:	Effect:
Boundary	Percent of pixels on the lowest and highest ends of the histogram that are outside the boundary.
Move to - low value	Value to which the low-end boundary is moved.
Move to - high value	Value to which the high-end boundary is moved.

Laser points

Laser points category defines how ground model points are displayed if they are loaded into TerraPhoto directly from a binary file. Additionally, the maximum triangle length in the ground model TIN is defined.

Setting:	Effect:
Order	Defines whether points are drawn on the screen **Before** or **After** MicroStation draws vector **elements**.
Level	Design file level on which the points are drawn. You can control the visibility of the points by switching the level on or off.
Color	Color of the points. Uses the active color table of MicroStation.
Weight	Size of the points. Uses MicroStation line weights.
Max length	Maximum triangle length of the ground model TIN. If there are no points within a distance larger than **Max length**, the ground in that area is considered to be undefined.

Memory usage

Memory usage category defines how much memory the application can use for caching images.

The combined size of reference images is often much larger than the amount of available memory. TerraPhoto keeps recently used raster images in memory and can therefore display those images very fast. The application needs to read an image from the hard disk only if it is not already in the cache when it needs to be drawn on the screen.

You should set the image cache size to be 10% to 50% of your computer's physical memory if you are viewing GeoTIFF images. A larger cache size results in a better performance for image display.

ECW images are separately cached by the ECW library routines. If you are viewing ECW images only, set the image cache size to a relatively small value (8 - 32 MB). The image cache is then used to keep copies of uncompressed raster fragments.

Setting:	Effect:
Size	Image cache size in megabytes.
Free all	Button to remove everything from the image cache and thus, empty the memory.
Maximum	Maximum number of ECW files kept open at the same time. Default value is 200.

Mobile rectification

Mobile rectification category defines the maximum distance from a camera of a mobile ground-based system within which images are used for rectification. The distance depends on the height of the camera above the ground.

Setting:	Effect:
Max distance	Distance from a camera within which images are used for rectification. The distance is expressed as factor of the camera's height above the ground.

Operation

Operation category defines what happens when TerraPhoto is started, whether it is unloaded when the **TPhoto Main** window is closed, and how many processor threads can be used by TerraPhoto.

Setting:	Effect:
Create Applications menu	If on, TerraPhoto creates an **Applications** pulldown menu in MicroStation's menu bar at startup. This menu contains commands for opening TerraPhoto tool boxes and windows.
Open Main window	If on, the application opens the **TPhoto Main** window at startup.
Open Main tool box	If on, the application opens the **Main** tool box at startup.
Main window is closed	If on, TerraPhoto is unloaded when **TPhoto Main** window is closed.
Maximum	Defines the maximum amount of processor threads used by TerraPhoto.

Selection shapes

Selection shapes category defines the level assignments and symbology settings for the different types of selection shapes. TerraPhoto distinguishes several selection shape types which are useful for different kinds of image corrections: manually placed shapes, automatically placed shapes (auto seamline shapes), quality shapes, and smearing shapes. See **Selection shapes** on page 125 for more information.

Setting:	**Effect:**
Force symbology	If on, new selection shapes are created on the specified design file level using the given symbology.
Manually placed	Level number, color, and fill type of **manually placed** shapes.
Auto seamline	Level number, color, and fill type of **automatically placed** shapes (auto seamline shapes).
Quality	Level number, color, and fill type of **Quality** shapes.
Smearing	Level number, color, and fill type of **Smearing** shapes.
Apply to file	Enforces the given level and symbology settings for all existing selection shapes in the active design file.

✍ You can use the **Apply to file** button at any stage in order to force all selection shapes in the active design file to match the given level and symbology settings.

TFW and JGW files

TFW and JGW files category defines the exact position of the origin of TIFF and JPEG files. The origin determines the referencing point of a raster file and is stored in an external georeferencing file.

Setting:	**Effect:**
Input files	Location of the origin of TIFF/JPEG files with external georeferencing files: **Pixel corner** or **Pixel center**. The setting effects image files attached as raster references in TerraPhoto.
Output files	Location of the origin of TIFF/JPEG files with external georeferencing files: **Pixel corner** or **Pixel center**. The setting effects image files that are created with TerraPhoto.

Tile naming schemes

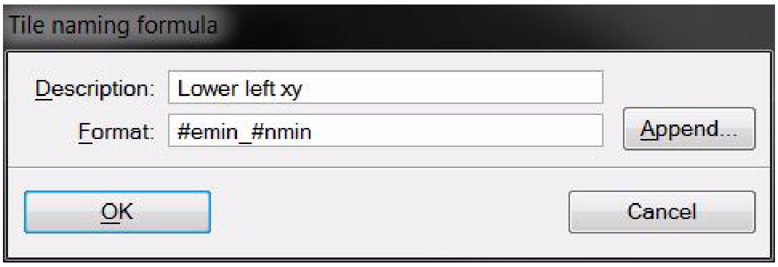
Tile naming schemes category lets you define your own tile naming formats.

This is useful, for example, to create specific names for ortho photo tiles which then can be used for naming the ortho photos. The definition allows you to insert tile corner coordinates into a name used in rectification.

The application can recognize and insert the following fields in a name text string:

- #emin - Easting coordinate of the lower left corner.
- #nmin - Northing coordinate of the lower left corner.
- #emax - Easting coordinate of the upper right corner.
- #nmax - Northing coordinate of the upper right corner.
- #number - Incremental number for tiles. The tile numbers increase by 1.
- #text - Selected text inside the tile.

A new format can be defined by using the **Add** button in the TerraPhoto **Settings** dialog. An existing format is modified by selecting the format and using the **Edit** button. A data click on the **Delete** button deletes a selected format.



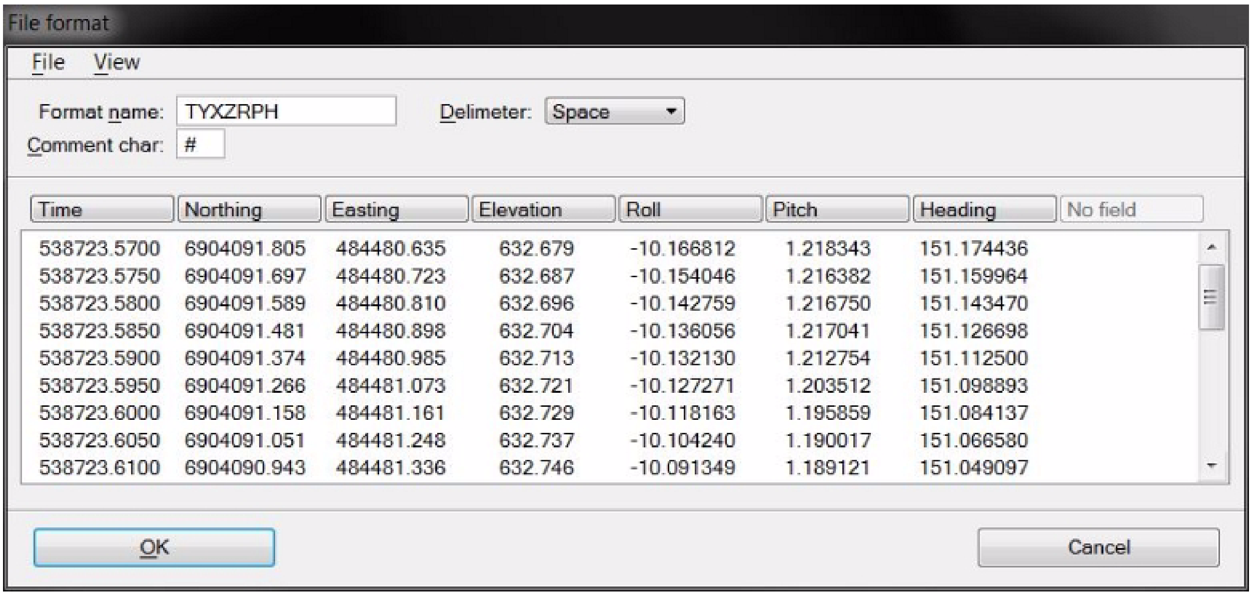
Setting:	**Effect:**
Description	Descriptive name for the tile naming format.
Format	Text string that defines the format and thus, the tile name. Use the **Append** button in order to add defined fields to the format.

Trajectory formats

Trajectory formats category defines formats for importing trajectory information from text files. The format definition determines the order of the attributes that are stored in the text file, the delimeter that separates attribute fields, and possibly a character which marks comment lines.

A new format can be defined by using the **Add** button in the TerraPhoto **Settings** dialog. An existing format is modified by selecting the format and using the **Edit** button. A data click on the **Delete** button deletes a selected format.

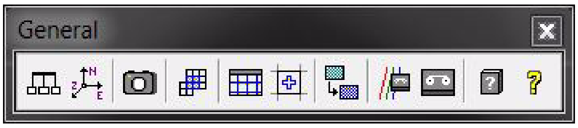
You can load an example text file by using the **Load example** command from the **File** pulldown menu. With the commands from the **View** pulldown menu the dialog can be resized to enable the import of text files with **8 fields**, **10 fields**, or **15 fields**.



Setting:	**Effect:**
Format name	Descriptive name for the trajectory format.
Delimeter	Character used to separate attribute fields in the text file: **Space**, **Tabulator**, **Comma**, or **Semicolon**.
Comment char	Character that introduces a comment in the text file. Lines beginning with this character are ignored when information is read from the text file.
No field	Selection of what attribute is stored in the field: • **No field** - no field definition. • **Ignore** - the column in the text file is ignored. • **Time** - time stamps of trajectory positions. • **Easting**, **Northing**, **Elevation** - X, Y, Z coordinates of trajectory positions. • **Heading**, **Roll**, **Pitch** - misalignment angles of trajectory positions. • **X, Y, Z accuracy** - accuracy estimates for easting, northing, elevation coordinates. • **Heading, Roll, Pitch accuracy** - accuracy estimates for heading, roll, pitch angles.

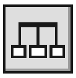
General tool box

Tools in the **General** tool box are used to define TerraPhoto **Settings**, to define camera parameters, to manage raster references, to convert files from one raster format to another, to manage camera trajectories, to view videos assigned to trajectories, and to access license information and the TerraPhoto User’s Guide.

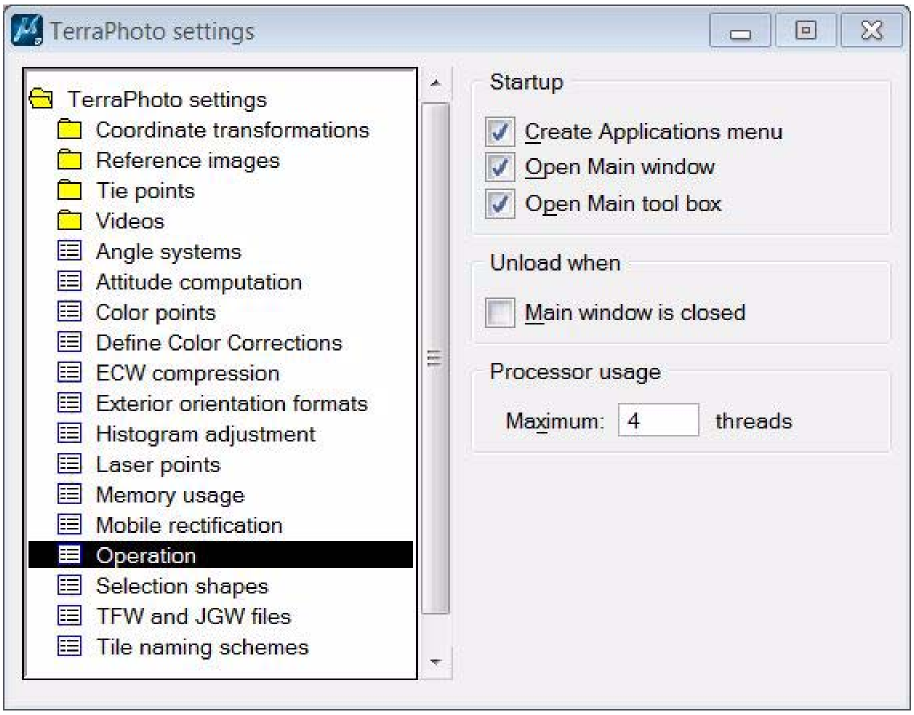


To:	Use:
Modify user settings	*Settings*
Define coordinate range and resolution	*Define Coordinate Setup*
Define camera parameters	*Define Camera*
Open a window for managing raster references	*Manage Raster References*
Set raster reference visibility by view contents	*Set References By View*
Toggle visibility of a single raster reference	*Set Reference*
Convert files from one raster format to another	*Convert Raster Files*
Manage camera trajectories	*Manage Camera Trajectories*
Display video sequence	*Display Video*
View information about TerraPhoto	*About TerraPhoto*
View on-line help	*Help On TerraPhoto*

Settings



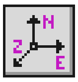
Settings tool lets you change a number of settings that control the way TerraPhoto works. Selecting the tool opens the TerraPhoto **Settings** dialog.



The settings are grouped into logical categories. Selecting a category in the list displays the appropriate controls next to the category list.

The different categories and related settings are described in detail in Section **TerraPhoto Settings**.

Define Coordinate Setup



Define Coordinate Setup tool sets up coordinate system values that a Terra Application uses for laser points and images. It determines the coordinate range inside which all data must be located and the resolution to which coordinate values are rounded. The coordinate setup is stored into the active design file and is used by all Terra Applications.

Terra Applications use signed 32 bit integer values for storing coordinates of laser points and images. This has the advantage of using only 12 bytes of memory for the coordinate information of each point. You can control how accurately coordinate values are stored by defining how big each integer step is.

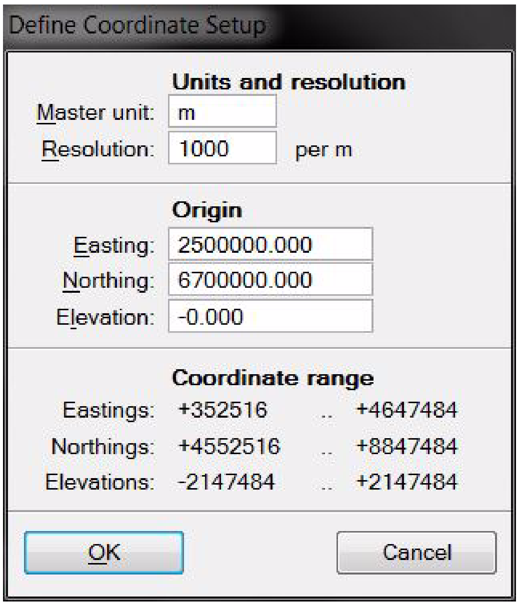
If, for example, one integer step is equal to one millimeter, all coordinate values are rounded to the closest millimeter. At the same time it would impose a limitation on how far apart points can be or how big the coordinate ranges are. Millimeter steps produce a coordinate cube which has a size of 2^{32} millimeters or 4294967.296 meters. If the origin of the coordinate system is at [0.0, 0.0, 0.0], the coordinate ranges are limited to values between -2147483 and +2147483. If necessary, you can fit the coordinate ranges to your data by modifying the Easting and Northing coordinates of the coordinate system origin.

If one integer step is equal to one centimeter, the coordinate values can range from -21 million to +21 million which is large enough for most coordinate systems.

➢ **To define the coordinate setup:**

1. Select the *Define Coordinate Setup* tool.

   This opens the **Define Coordinate Setup** dialog:



2. Define settings and click OK.

   This modifies the coordinate system values used by all Terra Applications in the active design file.

MicroStation SE and MicroStation J

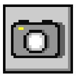
Each design file contains a definition of a 32 bit integer coordinate system which MicroStation uses internally for vector elements. All applications share the same coordinate setup with MicroStation. When you change the coordinate setup with *Define Coordinate Setup* tool, it changes the design file coordinate system.

✍ Since Terra Applications’ version 009.00x these MicroStation versions are no longer supported.

MicroStation V8 and V8i

MicroStation V8 uses 64 bit values for storing vector elements. Terra Applications use a coordinate setup which is separate from the design file coordinate system. Their default coordinate setup defines 100 integer steps for each master unit. You can use *Define Coordinate Setup* tool to change the coordinate setup which the application stores in the design file but it does not affect MicroStation itself or the vector elements.

Define Camera



Define Camera tool lets you create and modify a TerraPhoto camera file.

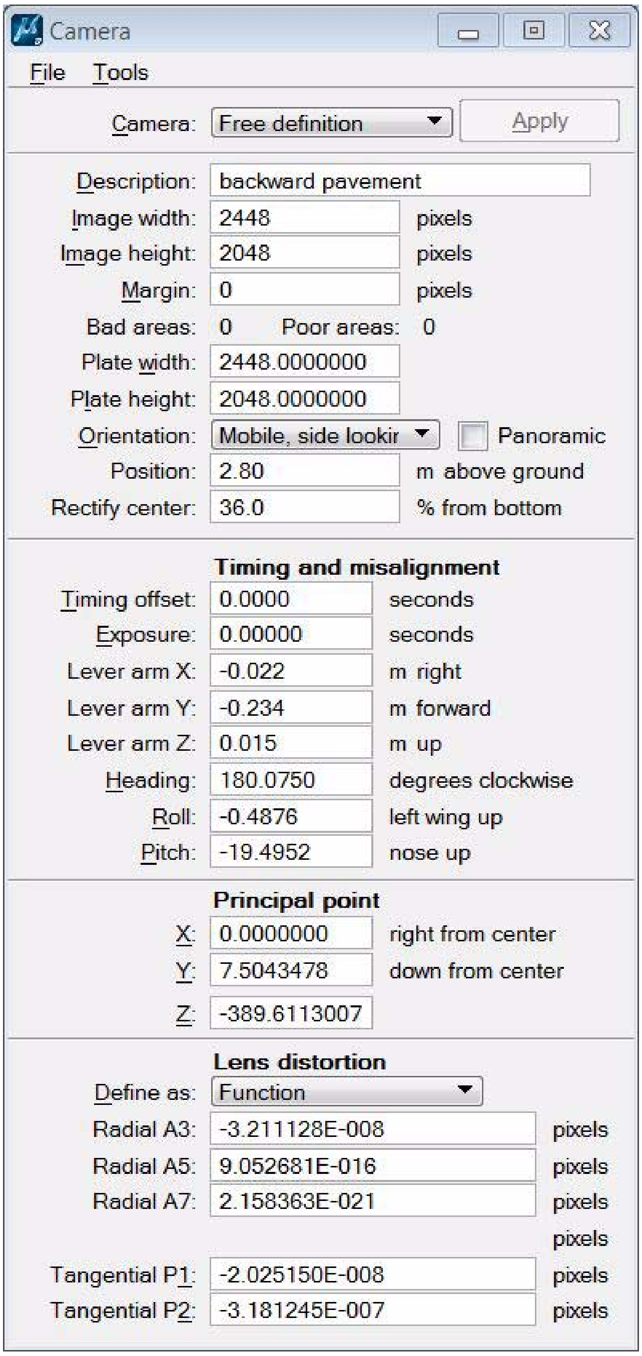
A detailed description of the parameters and menu commands in the **Camera** dialog, as well as information about camera calibration workflows can be found in Chapter **Camera Calibration** on page 46.

➢ **To define camera parameters:**

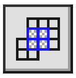
1. Select the *Define Camera* tool.

   This opens the **Camera** dialog.

2. If the mission contains one or more cameras, select the camera in the **Camera** field.
3. Define settings.
4. Click on the **Apply** button in order to apply the modified camera parameters to active tie points and image displays.
5. Select **Save** or **Save As** commands from the **File** pulldown menu in order to save changes into a camera calibration file.



Manage Raster References

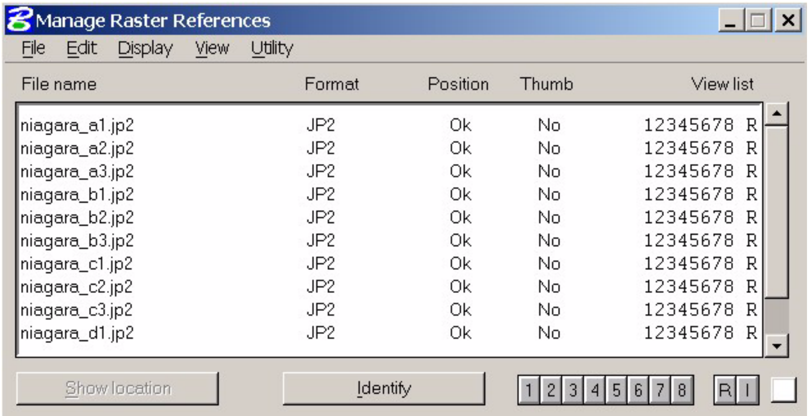


Manage Raster References tool opens a window for managing raster references. The **Manage Raster References** window contains menu commands for attaching, detaching, viewing, and manipulating raster files.

➢ **To open the window for managing raster references:**

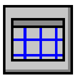
1. Select the *Manage Raster References* tool.

   This opens the **Manage Raster References** window:



See Chapter **Commands for Raster References** on page 315 for detailed descriptions of the menu commands.

Set References By View



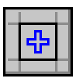
Set References By View tool switches on the visibility of all raster references that are completely or partly within a MicroStation top view and switches off all other raster references which are completely outside the view. The tool requires that images have been attached as raster references in TerraPhoto by using the *Manage Raster References* tool.

➢ **To switch on all raster references within view contents:**

1. Select the *Set References By View* tool.
2. Select a top view with a data click.

   This sets the visibility of raster references in the selected view.

Set Reference



Set Reference tool switches the visibility of a single raster reference in a view on or off. The tool requires that images have been attached as raster references in TerraPhoto by using the *Manage Raster References* tool.

➢ **To toggle the visibility of a single raster reference:**

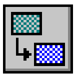
1. Select the *Set Reference* tool.

   If the mouse pointer is moved inside a top view, the boundaries of raster references are displayed dynamically.

2. Place a data click inside the rectangular area covered by a raster reference.

   This switches the visibility of the raster reference on or off.

Convert Raster Files



Convert Raster Files tool converts raster files from one image format to another. The tool can also be used to adjust the brightness of images, to transform the positions of images, to modify the background color, or to change the image orientation between landscape and portrait.

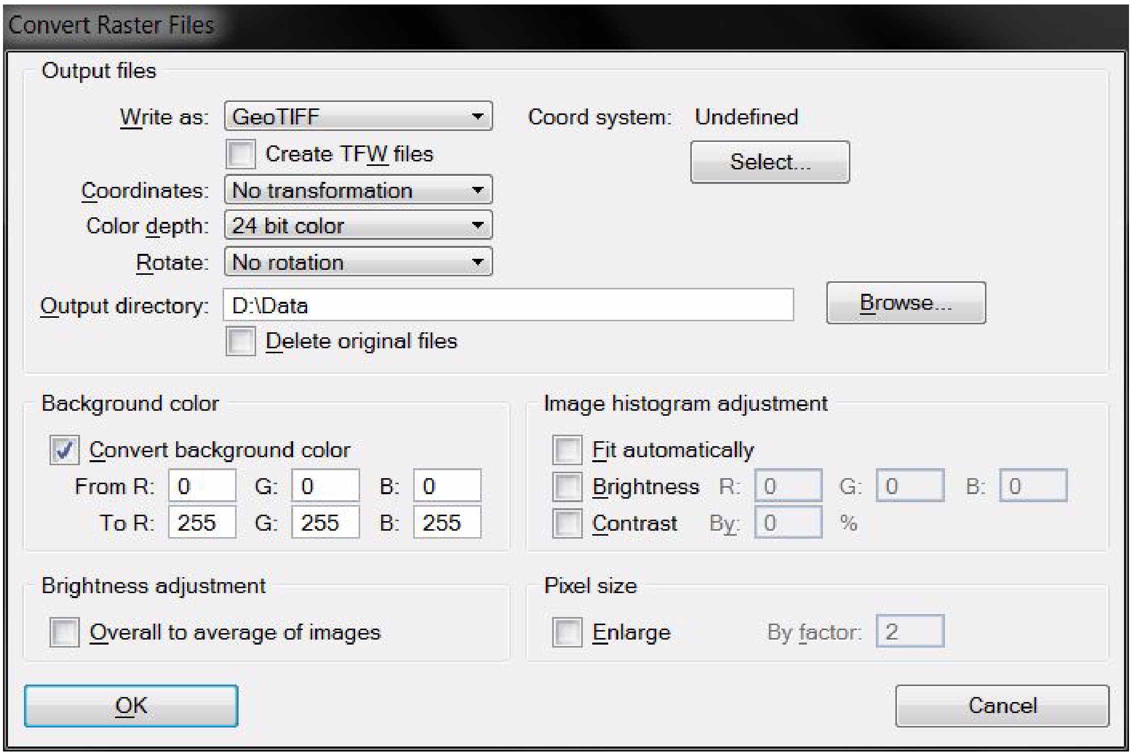
➢ **To convert raster files:**

1. Select the *Convert Raster Files* tool.

   This opens the **Source files** dialog, a standard dialog for selecting files.

2. Add the raster file(s) to the list of files to process and click **Done**.

   This opens the **Convert Raster Files** dialog:



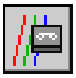
3. Define settings and click OK.

   This converts the images and creates new files in the **Output directory**. A progress bar shows the progress of the process.

Setting:	Effect:
Write as	Format of the output files. Supported file formats include: **BMP**, **ECW compressed**, **GeoTIFF**, **JPEG**, **JPEG2000**, **Raw RGB**, and **TIFF**. Some of the following settings depend on the selected format.
Target ratio	Compression ratio for **ECW** or **JPEG2000** files.
Datum	Datum information that is written in the header of **ECW** and **JPEG2000** files. Commonly used datum names can be selected by using the **Select** button.
Projection	Projection information that is written in the header of **ECW** and **JPEG2000** files. Commonly used projection names can be selected by using the **Select** button.
Create TFW|JGW file	If on, external georeference files are created for **GeoTIFF** and **JPEG** files. The files have the extension .TFW|.JGW.

Setting:	Effect:
Coord system	Coordinate system information that is written in the header of **GeoTIFF** files. Commonly used coordinate system names and numbers can be selected by using the **Select** button.
Coordinates	Coordinate transformation to apply to image positions. The transformation can result in translation of position and scaling of pixel size but no rotation is supported. The list contains transformations that are defined in **Coordinate transformations / Transformations** of TerraPhoto **Settings**.
Color depth	Defines how color values are stored in the output file: **24 bit color** or **Grey scale**.
Rotate	Rotation applied to converted raster files: • **Clockwise** - 90 degree clockwise. • **Counter clockwise** - 90 degree counter clockwise. • **180 degrees** - 180 degree. • **Clockwise to landscape** - 90 degree clockwise if the source image has portrait orientation. • **Counter clockwise to landscape** - 90 degree counter clockwise if the source image has portrait orientation.
Output directory	Directory into which the converted images are stored.
Delete original files	If on, the original raster files are deleted after conversion.
Convert background color	If on, the background color is changed **From RGB** values **To RGB** values.
Overall to average of images	If on, the application computes the average brightness of all source images and adjust each converted image to that average brightness.
Fit automatically	If on, the histogram of each image is fitted automatically.
Brightness	If on, the brightness of each image is modified by adding the given values in the **RGB** fields to the red, green, and blue color components separately.
Contrast	If on, the contrast of each image is modified by adding the given percentage value in the **By** field.
Enlarge	If on, the resolution of the converted images is reduced by merging source image pixels into larger pixels. The value given in the **By factor** field determines how many pixels are merged horizontally and vertically.

Manage Camera Trajectories



Manage Camera Trajectories tool opens the TerraPhoto **Trajectories** window. The windwo displayes the active trajectories and contains menu commands for handling trajectory information in TerraPhoto.

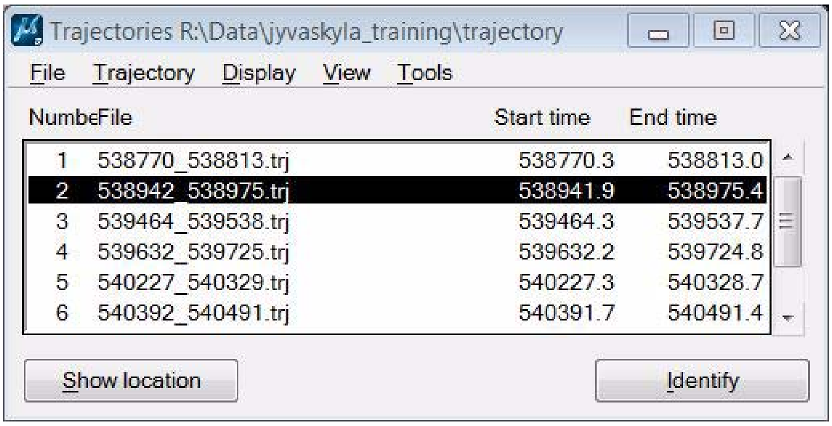
Trajectory information is required by the following processing steps:

- creating an image list by using the **Compute list** command.
- placing tie points of type **Depth** and **Known depth**.
- setting up and displaying a video by using the *Display Video* tool.

➢ **To view information about active trajectories:**

1. Select the *Manage Camera Trajectories* tool.

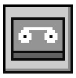
   This opens the **Trajectories** window:



If there are active trajectories in TerraScan, the title bar of the window displays the active trajectory folder. Further, the window shows the list of trajectory files that are stored in the active trajectory folder.

The menu commands of the **Trajectory** window are described in detail in Chapter **Manage Trajectories** on page 292.

Display Video



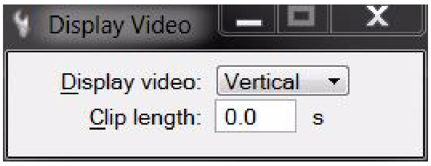
Display Video tool searches and displays a video sequence from a given geographical location. You can identify the geographical position with a data click. The application projects the given xyz location to the closest trajectory which has a video file linked to it and displays the corresponding sequence.

Before you can use this tool, you must link a digital video file to a trajectory using the **Edit information** command in the **Trajectories** window.

➢ **To display a video sequence:**

1. Select the *Display Video* tool.

   The **Display Video** dialog opens:

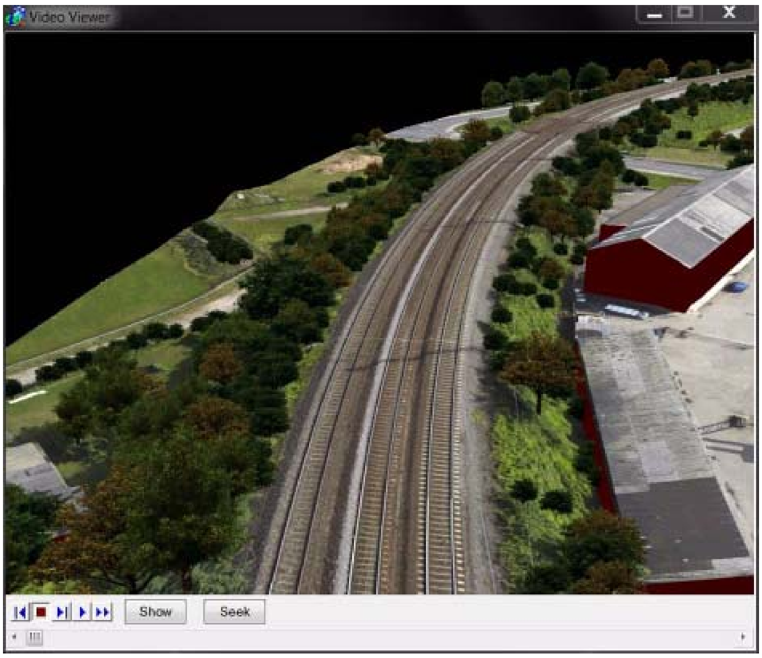


2. Define settings.

Setting:	Effect:
Display video	Video file that is displayed: • **Vertical -** file that is defined as **Video 1** in the **Trajectory information** dialog. • **Forward -** file that is defined as **Video 2** in the **Trajectory information** dialog.
Clip length	Determines the length of the video sequence that is displayed. The video display stops after the given amount of seconds.

3. Identify a geographical position from which you want to see a video sequence.

   This opens the **Video Viewer** window and starts the display of the video:



✍ If the display of the video does not run automatically, start the video with the controls in the **Video Viewer** window. The display depends a bit on the format and the size of the video. See also **Verticle video** and **Forward video** commands in the **Trajectories** window for viewing videos.

Video Viewer

The **Video Viewer** window provides some controls for displaying a video or for seeking a new position from which to start the video display.

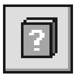
To:	Use:
Play a short sequence backward	
Stop playing	
Play a short sequence forward	
Play the video forward continuously	
Play the video in fast forward mode	
Show the geographical location of the current video position in a MicroStation view	**Show**
Display the video from a given geographical position	**Seek**

The length of the sequence for playing stepwise backward or forward as well as the speed of the video display in fast mode are defined in **Video / Display** of TerraPhoto **Settings**.

To show the geographical location of a video position, click on the **Show** button and move the mouse pointer inside a view. The current position of the video is highlighted by a cross.

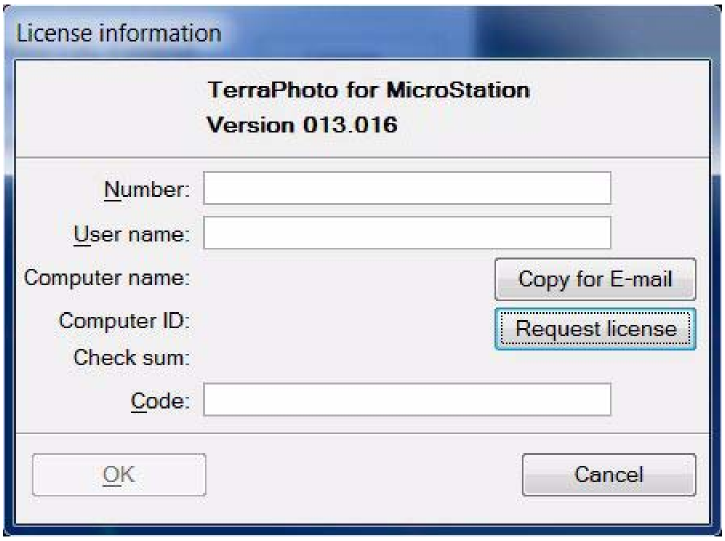
To display a video from a geographical location, click on the **Seek** button and define the location with a data click inside a MicroStation view. Click on a **Play** button in order the start the video display from the given location. Depending on the video format and size it may take a few seconds until the display starts.

About TerraPhoto



About TerraPhoto tool opens a dialog which shows information about TerraPhoto and about the license.

From this dialog you can open the **License information** dialog:



Use the **Request license** button to start the online registration for node-locked licenses.

More information about license registration is available on the Terrasolid web pages: www.terrasolid.com/registration.php.

Help On TerraPhoto

Help On TerraPhoto tool launches Acrobat Reader for accessing this User's Guide in PDF format. The PDF must be stored in the */docs* folder of your Terra Software installation directory.

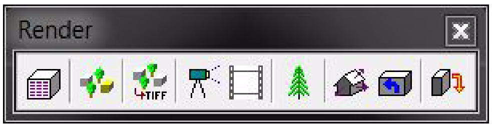
If you installed TerraPhoto in the default directory C:\TERRA, the User's Guide must be stored in C:\TERRA\DOCS\TPHOTO.PDF.

The PDF has hypertext links built in, so you can jump between topics by clicking on the topic names highlighted in green color.

Accessing the PDF also requires that you have the Acrobat Reader installed on your computer. The software looks for a file named ACRORD32.EXE. If the file can not be found, you are asked to locate the file on the hard disk manually.

Render tool box

Tools in the **Render** tool box are used to create rendered views, to save rendered views as image files, to create flythru movies, to place single RPC trees, to change normal directions for surface shapes, and to export building models.



To:	Use:
Define level settings for rendering	*Define Rendering Settings*
Display a rendered view	*Display Rendered View*
Save a rendered view as image file	*Save Rendered View*
Create a flythru movie	*Create Flythru Movie*
Build a movie from previously saved frames	*Build Movie From Frames*
Place RPC trees manually	*Place Rpc Tree*
Fix building normal vectors	*Fix Building Normals*
Select another raw image for wall texture	*Change Texture Image*
Export a city model file	*Export City Model*

See also Chapter **Creating Rendered Views and Movies** on page 25 for a detailed description of rendered images and flythru movie creation.

Define Rendering Settings

Define Rendering Settings tool defines settings for rendering views with TerraPhoto tools.

This concerns levels in the active design file or in a reference design file that are used to drape the raster references on when a view is rendered. These levels have to contain vector models of objects, e.g. building roofs, which are used for draping.

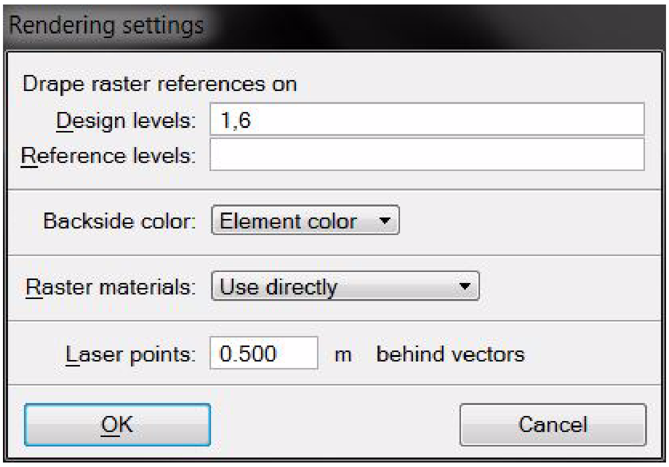
The backside color refers to the display of backsides of 3D planes. When 3D planes are rendered, the normal direction of the plane determines the frontside and backside of the plane. Textures and lightning are usually applied to the frontside of planes, while backsides are displayed using a constant color and in shadow.

Further, the settings define how raster materials are used as textures and how laser points are drawn in relation to vector elements.

➢ **To define rendering settings:**

1. Select *Define Rendering Settings* tool.

   This opens the **Rendering settings** dialog:

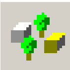


2. Define settings and click OK.

   The settings are used by the TerraPhoto tools *Display Rendered View* and *Save Rendered View*, as well as in frame and movie creation with *Create Flythru Movie* tool.

Setting:	Effect:
Design levels	Levels in the active design file used for draping raster references on vector elements. Separate several levels by comma.
Reference levels	Levels in attached reference design file used for draping raster references on vector elements. Separate several levels by comma.
Backside color	Display color for the backside of 3D planes: • **Element color -** the color of the element is used. • **Red -** backsides are displayed in red color. • **Green -** backsides are displayed in green color. • **Blue -** backsides are displayed in blue color.
Raster materials	Defines how raster files are used as textures: • **Do not use -** no textures are displayed. • **Use thru MicroStation -** texture files are used in MicroStation rendering. This requires that the material files are available in MicroStation. • **Use directly -** texture files are used in TerraPhoto rendering.
Laser points	Determines the distance of laser points behind vector elements in rendered views. This effects only the display of the points in views created with TerraPhoto rendering tools.

Display Rendered View



Display Rendered View tool applies TerraPhoto rendering to a MicroStation view.

For more information about rendering in TerraPhoto, see Section **Rendered Views** on page 25. Some settings for rendered views can be defined by the *Define Rendering Settings* tool.

➢ **To render a view:**

1. Select *Display Rendered View* tool.
2. Click inside a view.

   This displays the rendered view.

Save Rendered View

Save Rendered View tool saves a rendered view into an image file. The view must be open in order to save it.

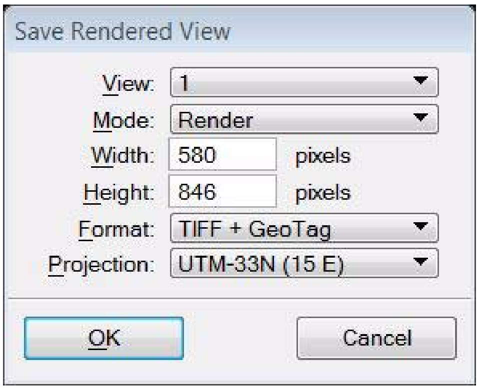
The tool can be used to create geotagged TIFF files. The geotag contains the latitude and longitude coordinates of the view that is saved. If the view is a orthographic view, the coordinates of the view's center point are stored. If the view is a perspective view, the coordinates of the camera location are stored. The geotagged TIFF files can then be combined in another software into a .KMZ package for being displayed in Google Earth, for example.

For more information about rendering in TerraPhoto, see Section **Rendered Views** on page 25. Some settings for rendered views can be defined by the *Define Rendering Settings* tool.

➢ **To save a rendered view:**

1. Select *Save Rendered View* tool.

   This opens the **Save Rendered View** dialog:



2. Define settings and click OK.

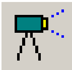
   This opens the **Rendered view raster file** dialog, a standard dialog for saving files.

3. Define a directory and a file name for storing the image.
4. Click **Save** to save the image.

Setting:	Effect:
View	Defines the MicroStation view which is saved into an image.
Mode	Defines the mode for capturing an image of the view: • **Render -** TerraPhoto rendering is applied to the view. This excludes text elements from the captured image. • **Capture -** a screen capture is created of the view. This includes text elements.
Width	Width of the image in pixels. The default value is the view width when the tool is started.
Height	Height of the image in pixels. The default value is the view height when the tool is started.
Format	Format of the stored image. Supported formats are **BMP**, **ECW**, **JPEG**, and **TIFF + GeoTag**.
Ratio	Compression ratio for ECW images. This is only active if **Format** is set to **ECW**.

Setting:	Effect:
Projection	Projection system that is used to write the GeoTag information for a TIFF image. The list contains all projection systems that are active in **Coordinate transformations / Builtin projection systems**, **Coordinate transformations / US State Planes**, or **Coordinate transformations / User projection systems** of TerraPhoto **Settings**. This is only active if **Format** is set to **TIFF + GeoTag**.

Create Flythru Movie



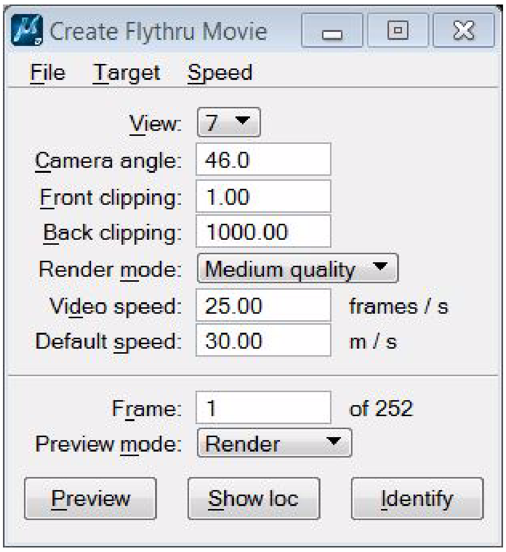
Create Flythru Movie tool defines settings for the creation of flythru movies. It requires a selected linear element as camera path. The tool provides commands for the definition of target vectors, view and speed settings, some preview options, as well as the opportunity to save frames as .TIF files or a movie as .AVI file.

For a detailed description of the creation of flythru movies and menu commands, see Section **Flythru Movies** on page 31.

➢ **To create a flythru movie:**

1. Digitize and select a path element.
2. Select *Create Flythru Movie* tool.

   This opens the **Create Flythru Movie** dialog:

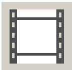


3. Create target vectors using **Create vectors** from the **Target** pulldown menu.
4. Define values for display and speed settings.
5. Set up the display of data in the view selected for rendering. Preview frames in order to check the setup at different locations along the camera path.
6. Modify the camera path and target vectors, if necessary. Use **Update from design** command from the **Target** pulldown menu in order to apply modifications to the flythu.
7. Save frames or a movie using **Save frames** or **Save movie** commands from the **File** pulldown menu.

Setting:	Effect:
View	MicroStation view that is used for rendering the frames.
Camera angle	Field-of-view angle of the camera.
Front clipping	Distance up to which the content of the frame is clipped in the foreground. Data is rendered in the range between **Front** and **Back clipping**.
Back clipping	Distance after which the content of the frame is clipped in the background. Data is rendered in the range between **Front** and **Back clipping**.

Setting:	Effect:
Render mode	Rendering method for frames: • **Low quality -** TerraPhoto rendering with low image quality. • **Medium quality -** TerraPhoto rendering with medium image quality. • **High quality** - TerraPhoto rendering with high image quality. • **Capture -** elements are rendered as they are displayed on the screen (like a screen capture). This method may include text elements.
Video speed	Speed of the resulting movie in frames per second.
Default speed	Traveling speed of the viewer in meter per second.
Frame	Frame number for being displayed in a preview.
Preview mode	Display mode for previews: • **Wireframe -** elements are drawn as wireframe graphics. • **Render -** elements are rendered.
Preview	Displays the frame with the given **Frame** number in the given **View**.
Show loc	Shows the location of the given **Frame** number as dashed line in a MicroStation view if the mouse pointer is moved inside the view.
Identify	Sets the **Frame** number based on a data click close to a location along the camera path.

Build Movie From Frames



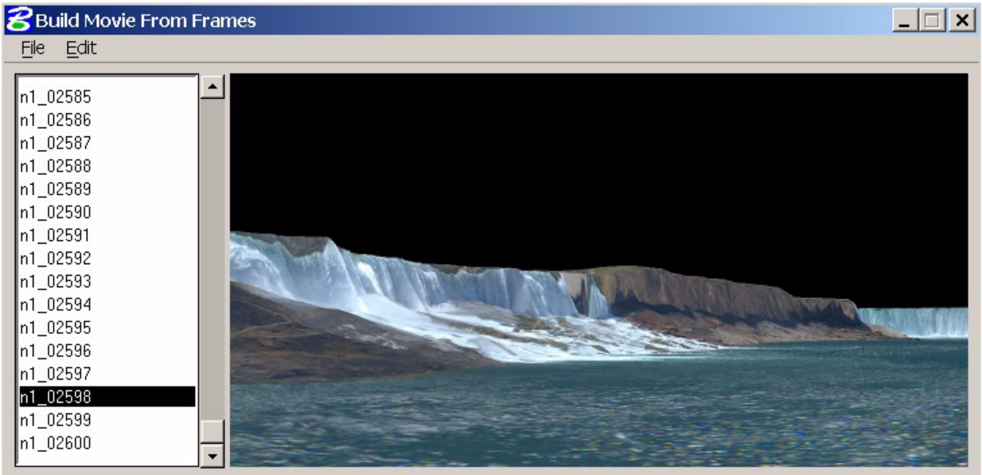
Build Movie From Frames tool creates a movie from previously saved frames. It lets you load frame image files, cut, copy, and paste frames, and record the frames into an .AVI file.

For a more detailed description of menu commands provided by the tool, see Section **Creation of movies from frames** on page 36.

➢ **To build a movie from frames:**

1. Select *Build Movie From Frames* tool.

   This opens the **Build Movie From Frames** dialog:



2. Load frame images with **Import files** or **Import directory** commands from the **File** pulldown menu.
3. Check the frames. Apply changes, if necessary.
4. Select **Save as** command from the **File** pulldown menu to save the movie.

   Depending on the amount of frames, the import of files and the saving process may take some time.

Place Rpc Tree

Place Rpc Tree tool enables the manual placement of RPC trees. The tree’s location, height and width can be set based on images and laser data.

The tool creates RPC cells which are linked with RPC files on the hard disk. The default directory set in TerraPhoto for storing RPC files is C:/TERRA/RPC. If such a folder does not exist, the application asks for browsing to another directory when the tool is selected. If a view is rendered, the cells are replaced by the RPC files. The tool requires that RPC files are available.

For more information about RPC trees and rendering, see Section **TerraPhoto Rendering** on page 28.

➢ **To place RPC trees:**

1. Select *Place Rpc Tree* tool.

   This opens the **Place Rpc Tree** dialog:

2. Select a **Tree cell** and the placement method.
3. Define the base center point of the cell by a data click.
4. If the placement method is set to **Mouse**, define the tree height and/or width.

Setting:	Effect:
Tree cell	Name of the RPC tree cell that is placed.
Height	Placement method for the tree cell height: • **Automatic -** defined by the original cell height. • **Keyin -** defined by a keyin value. • **Mouse -** defined by a mouse click.
Width	Placement method for the tree cell width: • **Automatic -** defined by the original cell width. • **Keyin -** defined by a keyin value. • **Mouse -** defined by a mouse click.

✍ RPC tree cells can be placed automatically based on laser data by using the tree detection tool of TerraScan.

Fix Building Normals

Fix Building Normals tool enforces the normal direction of 3D planes to point to the outside of, for example, building models. This is useful to fix errors in the normal direction of wall polygons in order to ensure the correct textureing of the walls.

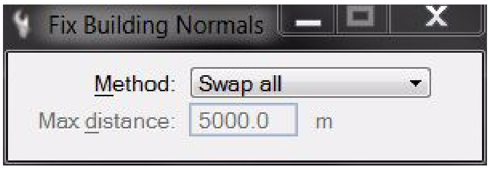
To check the normal direction of a 3D polygon, the **Backside coloring** setting in *Define Rendering Settings* dialog should be set to a constant color. Then, the *Display Rendered View* tool can be used to display a rendered view. Wall polygons displayed with the backside color at the outside of the building model do not have a correct normal direction for wall texturing.

The software can determine the inside and outside of polygons based on different methods. It can analyze how adjacent polygons touch each other, what side of the polygon is seen by raw images of an active image list, or what side is displayed in a view towards the viewer. The usage of raw images requires that a mission, a ground model, and an images list are loaded into TerraPhoto.

➢ **To fix normals of 3D planes:**

1. Select the building model(s) for which the normals need to be fixed.
2. Select *Fix Building Normals* tool.

   The **Fix Building Normals** dialog opens:



3. Select a **Method** for normal correction.
4. Accept the selection with another data click inside the view.

   This fixes normals for all selected polygons to point to the outside of a building model.

Setting:	Effect:
Method	Defines how the software determines the inside and outside of polygons: • **Swap all -** the normal direction is reversed for each selected polygon. • **Fix using geometry -** touching polygons are compared and determine what is inside/outside. • **Fix using images -** images of an active image list are used to determine inside/outside. The software assumes that the images see the outside of a polygon better than the inside. • **Fix using view -** the view orientation determines the inside/outside. The software assumes that the viewer sees the outside of a polygon in a selected view.
Max distance	Maximum distance between an image position and the polygon for which to determine the normal direction. This is only active if **Method** is set to **Fix using images**.

Change Texture Image

Change Texture Image tool lets you interactively change the raw image used for creating a wall texture. The tool opens a list of raw images which cover a selected building wall. From this list, you can select a raw image from which you want to create a texture.

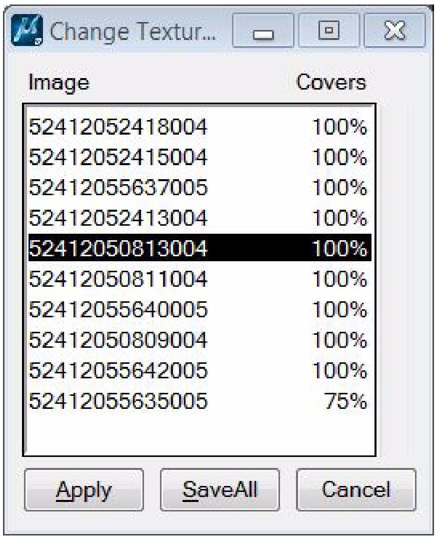
The tool requires that textures files are already available. A new texture file overwrites the existing texture file for this wall.

The tool's dialog contains a **Save All** button which can be used to save texture files from all available images for a wall into a folder. The folder is created as subdirectory of the folder in which the original texture files are stored. It is named with the prefix IMAGES_ and the name of the original wall texture, for example IMAGES_WALL0005681 for all possible texture files of WALL0005681.TIF. This may be useful, if you need to merge different parts of a wall from several images in order to get one texture file that covers the wall completely. In this case, you can use any image processing software for merging the different parts of the wall and then, replace the original texture file.

➢ **To change a texture image interactively:**

1. Select *Change Texture Image* tool.
2. Identify the wall for which to change the texture with a data click.
3. Accept the selection with another data click.

   This opens the **Change Texture Image** dialog:



4. Select an image from the list of raw images in the dialog.

   This displays the wall texture created from the selected image. In addition, all building models are rendered using existing textures.

5. Choose the raw image from which you want to create the wall texture.
6. Click **Apply**.

   This creates the new texture file. You can continue with step 2.

Export City Model

Note Lite

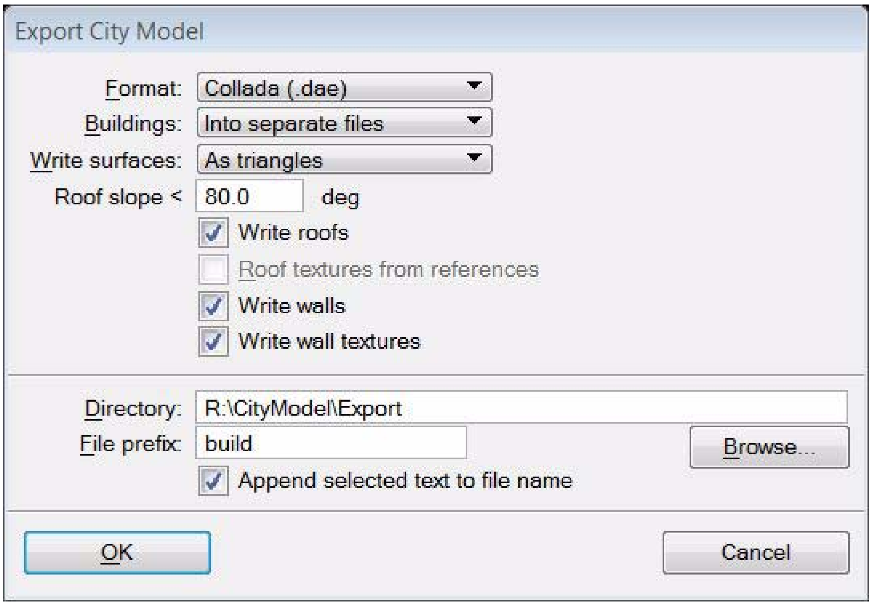
Export City Model tool exports selected building models into a standardized text file. The supported file format is Collada (.DAE).

The selected building models are either exported into one Collada file of into separate files for each building model. Wall texture files are copied into a separate folder. In addition, textures for roofs can be created from images that are attached as raster references in TerraPhoto's **Manage Raster References window**.

➢ **To export a city model into Collada file(s):**

1. Select the building model(s) to be included in the export file.
2. Select *Export City Model* tool.

   The **Export City Model** dialog opens:



3. Define settings and click OK.

   This exports the selected building model(s) into Collada file(s). The .DAE file(s) are stored in the given **Directory** in a folder "*models*". The wall and possibly roof texture files are stored in the given **Directory** in a folder "*images*".

Setting:	Effect:
Format	Format of the export file: **Collada**.
Buildings	Defines how building models are stored: • **All into one file -** all selected building models are written into one Collada file. • **Into separate files -** a separate Collada file is written for each selected building model.
Write surfaces	Method of surface storage in the Collada file format: • **As polygons -** surfaces are defined as polygons. • **As triangles -** surfaces are defined as triangles.
Roof slope	Determines what polygons are exported as walls and roofs. Any polygon with a slope smaller than the given value is considered a roof polygon.
Write roofs	If on, roof polygons are included in the export file.

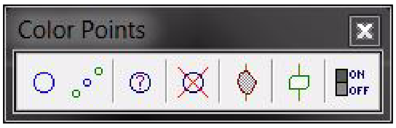
Setting:	Effect:
Roof textures from references	If on, texture files for roof polygons are created from raster references. This is only active if raster files are attached in TerraPhoto's **Manage Raster References window**.
Write walls	If on, wall polygons are included in the export file.
Write wall textures	If on, wall texture files are included in the export file and stored in the export folder.
Directory	Directory on the hard disk where the export files are stored. Inside this directory the software creates the *models* and *images* folders for storing the Collada and texture files, respectively.
File name	Name of the Collada file. The default extension of collada files is .DAE and added to the file name automatically. This is only active if **Buildings** is set to **All into one file**.
File prefix	Text added at the beginning of each Collada file name. The name is completed by an increasing number for each building model and the extension .DAE. This is only active if **Buildings** is set to **Into separate files**.
Append selected text to file name	If on, selected text elements are added to the Collada file names. This is only active if text elements are selected and if **Buildings** is set to **Into separate files**.

Color Points tool box

Tools from the **Color Points** tool box are used to add, edit, or delete color points, to paint or place selection shapes, and to set images active or inactive. The same actions can be performed by using commands from the **Color points** menu.

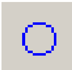
It is required to start the color points mode in TerraPhoto in order to use the tools. The mode is started by using **Define color points** command from the **Rectify** pulldown menu in the **TPhoto Main** window. This creates a preview of rectified images on the ground model and opens the **Color points** menu.

See Chapter **Color Points and Selection Shapes** on page 124 for more detailed information about color points and selection shapes.



To:	Use:
Add a single color point	*Add Color Point*
Add color points and produce clones	*Add Clone Color Points*
Edit a single color point	*Edit Color Point*
Delete a single color point	*Delete Color Point*
Paint a selection shape	*Paint Selection Shape*
Place a selection shape	*Place Selection Shape*
Set an image active or inactive for rectification	*Change Image Rectify Setting*

Add Color Point

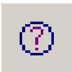


Add Color Point tool performs the same action as the **Add** command in the **Point** pulldown menu from the **Color points** menu.

Add Clone Color Points

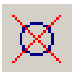
Add Clone Color Point tool performs the same action as the **Add clones** command in the **Point** pulldown menu from the **Color points** menu.

Edit Color Point



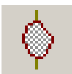
Edit Color Point tool performs the same action as the **Edit** command in the **Point** pulldown menu from the **Color points** menu.

Delete Color Point



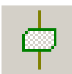
Delete Color Point tool performs the same action as the **Delete / One point** command in the **Point** pulldown menu from the **Color points** menu.

Paint Selection Shape



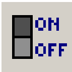
Paint Selection Shape tool performs the same action as the **Paint selection** command in the **Image** pulldown menu from the **Color points** menu.

Place Selection Shape



Place Selection Shape tool performs the same action as the **Place selection** command in the **Image** pulldown menu from the **Color points** menu.

Change Image Rectify Setting



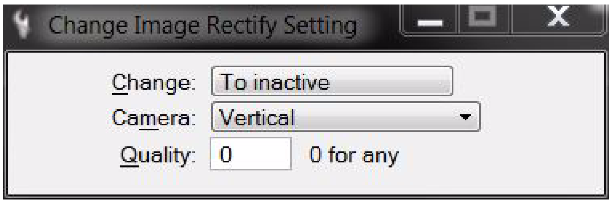
Change Image Rectify Setting tool changes the status of an image between active and inactive. An inactive image is still present in the image list but is excluded from the orthorectification process. The image status is saved in the image list.

The tool is useful, for example, for testing which images can be deleted from the image list without causing a gap or to exclude images from the ortho mosaic while keeping them as part of the tie point solution.

➢ **To change image active setting:**

1. Select the *Change Image Rectify Setting* tool.

   This opens the **Change Image Rectify Setting** dialog:



2. Select settings.
3. Move the mouse pointer inside a MicroStation view.

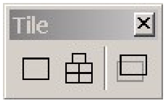
   The image footprint closest to the mouse pointer location is shown. An active image footprint is displayed with continuous lines while an inactive image footprint is displayed with dashed lines.

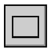
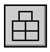
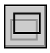
4. Switch the image status between active and inactive with data clicks inside the image footprint.
5. Save the image list using **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Setting:	**Effect:**
Change	Defines what status changes are possible: • **To inactive** – only active to inactive. • **To active** – only inactive to active. • **Toggle** – changes from active to inactive and vice versa.
Camera	Name of the camera for which image status changes are applied. Alternatively, the status of images from any camera can be modified.
Quality	Quality number. Status changes effect only images with the given quality. Quality 0 enables changes to all images.

Tile tool box

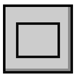
Tools in the **Tile** tool box are used to place tile rectangles for orthophoto mosaics.



To:	Use:
Place a tile rectangle for orthorectification	 *Place Tile*
Place an array of tile rectangles	 *Place Tile Array*
Move location of tile rectangles	 *Move Tile*

Place Tile

Not Lite



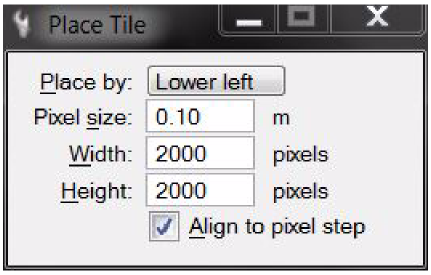
Place Tile tool places a single tile rectangle. When used in orthorectification, the application creates one orthorectified raster file covering the area of each tile rectangle.

This tool is very similar to MicroStation's *Place Block* tool. The only difference is that the rectangle size is specified by a pixel size and the number of pixels for width and height. In addition, the corner points of the rectangles can be fixed to be at coordinate values which are multiples of the given pixel size.

➢ **To place a tile rectangle:**

1. Select the *Place Tile* tool.

   This opens the **Place Tile** dialog:



2. Define settings.

   If the mouse pointer is moved inside a top view, the rectangle is displayed dynamically at the mouse pointer location.

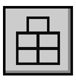
3. Place the tile rectangle with a data click inside a top view.

   This draws the rectangle into the design file using the active level and symbology settings.

Setting:	Effect:
Place by	Corner point used to define the tile position with a data click: **Lower left**, **Lower right**, **Upper left**, or **Upper right**.
Pixel size	Pixel size to use for computing the tile width and height.
Width	Tile width in pixels.
Height	Tile height in pixels.
Align to pixel step	If on, the corner position of the tile is fixed to coordinates that are a multiple of the given pixel size.

Place Tile Array

Not Lite

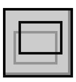


Place Tile Array tool performs exactly the same action as the **Place tile array** command from the **Utility** pulldown menu of the **TPhoto Main** window.

Placing a tile array works only if a mission, a ground model, and an image list are loaded into TerraPhoto.

Move Tile

Not Lite



This tool is not implemented yet.

16 Main Window Menu Commands

Mission pulldown menu

Commands from the **Mission** pulldown menu are used to define mission parameters, to open a previously saved mission, to save the active mission, and to close TerraPhoto.

To:	Choose menu command:
Setup a new mission definition	**New mission**
Open a previously saved mission from a file	**Open mission**
Modify settings of the active mission	**Edit mission**
Save a mission definition	**Save mission**
Save a mission definition to a new file	**Save mission As**
Setup a mission from a Lynx survey index file	**Import Lynx Survey**
Setup a mission from a Pictometry index file	**Import Pictometry Survey**
Close TerraPhoto	**Exit**

New mission

New mission command opens the dialog for defining a new mission. A mission definition contains descriptive information, a scale factor, ouput directories for storing specific types of files during the TerraPhoto workflow, and camera definitions. A mission definition is stored into a file with the extension .MIS.

The output directories are used by TerraPhoto to store specific file types:

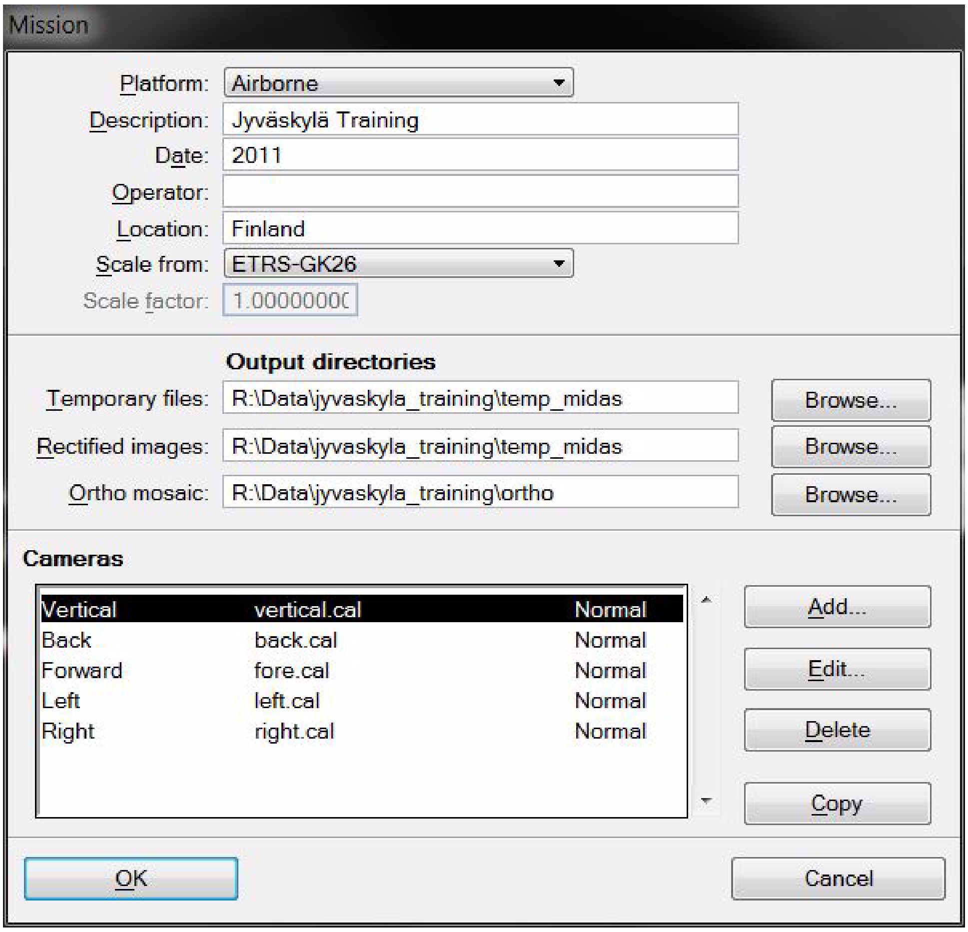
- **Temporary files** - files for internal use in TerraPhoto processing. This includes thumbnails, shadow maps, and depth maps.
- **Rectified images** - image files produced by the **Rectify images** command.
- **Ortho mosaic** - image files produced by the **Rectify mosaic** command.

A mission may include several cameras. For each camera, a camera calibration file is required. See *Define Camera* tool for more information. Further, the camera definition determines the format and storage folder(s) of the raw images, the method of deducing unique image numbers from the raw image file names, and a positional accuracy attribute for images of this camera.

➢ **To create a mission definition:**

1. Select **New mission** command from the **Mission** pulldown menu.

   This opens the **Mission** dialog:

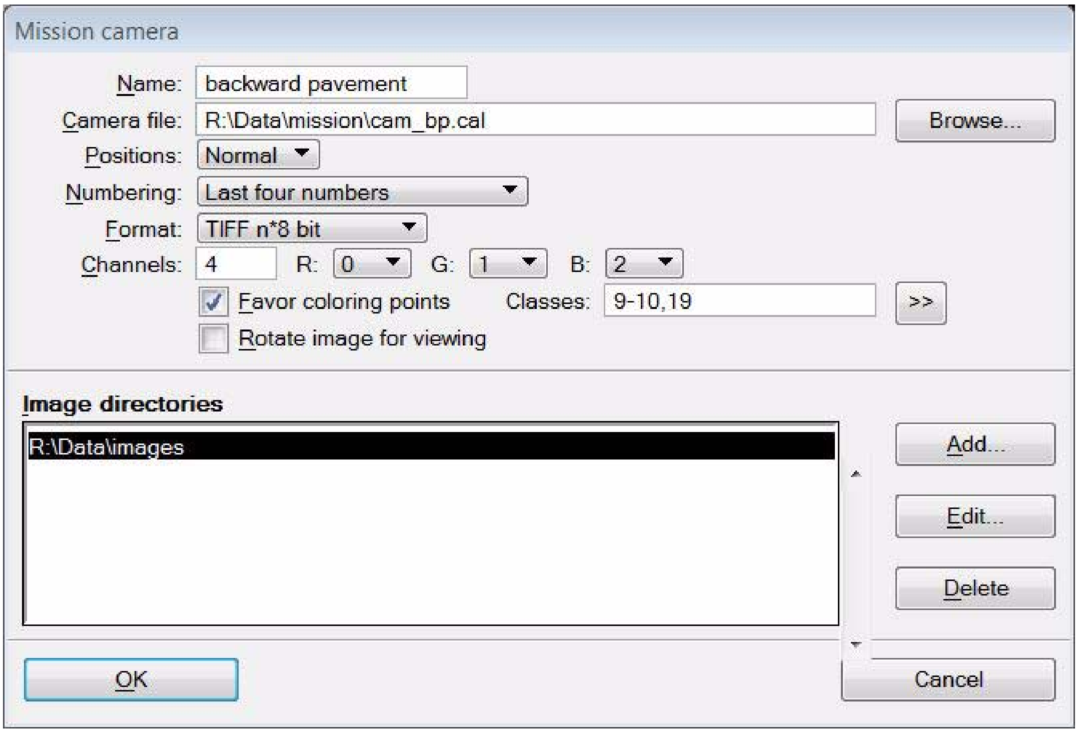


2. Select the **Platform** of your system: **Airborne** or **Mobile**.
3. (Optional) Fill in descriptive information into the fields in the **Description** group.
4. Select a coordinate system in the **Scale from** list from which to use the **Scale factor**. Alternatively, define a **Scale factor** value manually.
5. Define a directory for storing **Temporary** files. Use the **Browse** button to select a folder from the hard disk.
6. Define a directory for storing **Rectified images**. Use the **Browse** button to select a folder

from the hard disk.

7. Define a directory for storing **Ortho mosaic** files. Use the **Browse** button to select a folder from the hard disk.
8. Click **Add** to specify camera(s) used in the mission.

   This opens the **Mission camera** dialog:



9. Define settings for the camera.

   Repeat steps 8 and 9 if multiple cameras are used in the mission. Use the **Copy** and **Edit** buttons in order to speed up the definition of multiple cameras.
10. Click OK to close the **Mission camera** dialog.
11. Click OK to close the **Mission** dialog.
12. Select **Save mission As** command from the **Mission** pulldown menu to save the mission definition into a file.

Setting:	Effect:
Name	Descriptive name for the camera.
Camera file	Location and name of the camera calibration file.
Positions	Relative positional accuracy of images from this camera. This setting has an effect if multiple cameras are used. The application tries to modify less accurate image positions more in adjustment routines.

Setting:	Effect:
Numbering	Rule for how to extract a unique image number from the raw image file name: • **Last number in file name** – last sequence of digits. • **Last two numbers** – last two sequences of digits. • **Last three numbers** – last three sequences of digits. • **Last four numbers** – last four sequences of digits. • **Line + image number** – strip and a number. • **Last letter + number** – last letter and a number. • **Last number + letter + number** – the last number and letter in file name and a number. • **Eagle Eye numbering -** system-specific numbering method. • **Mitsubishi numbering -** system-specific numbering method. • **First number -** first sequence of digits. • **First two numbers** – first two sequences of digits. • **First three numbers** – first three sequences of digits. • **First four numbers** – first four sequences of digits.
Format	Raster format of the raw images. The image list does not have to specify the default extension as part of the image names.
Channels	Number of channels in the raw images. If the number is bigger than 3, the **RGB** fields become available. Select a channel number that is displayed in place of TerraPhoto’s red, green, and blue channel. This is only active if **Format** is set to **TIFF n*8 bit** or **TIFF n*16 bit**.
Favor coloring points	If on, the **Classes** field defines point classes that are colored perferably from images of this camera. This has an effect for extracting color from images to laser points in TerraScan.
>>	Opens the **Select classes** dialog which contains the list of active classes in TerraScan. You can select multiple source classes from the list that are then used in the **Classes** field.
Rotate image for viewing	
Image directories	Directories that store the raw images.

Open mission

Open mission command reads information from a previously saved mission file.

Edit mission

Edit mission command lets you modify the definition of the active mission.

➢ **To modify a mission definition:**

1. Select **Edit mission** command from the **Mission** pulldown menu.

   This opens the **Mission** dialog.

2. Edit the settings in the dialog.

   They are described in detail in Section **New mission** on page 218.

3. Click OK.
4. Select **Save mission** command in order to save the changes to the mission file on the hard disk.

Save mission

Save mission command saves the mission definition into the same file from which it has been opened before.

Save mission As

Save mission As command saves the mission definition into a new file.

Import Lynx Survey

Import Lynx Survey command reads information from a Lynx index file and creates a mission file, an image list, and (optional) camera files.

The index file is a text file that contains information about the survey, camera parameters, and images. The file is created by Optech software delivered with the Lynx system. The camera parameters for each camera of the system are converted into a TerraPhoto camera calibration file. The time and positional information for the images are converted into a TerraPhoto image list.

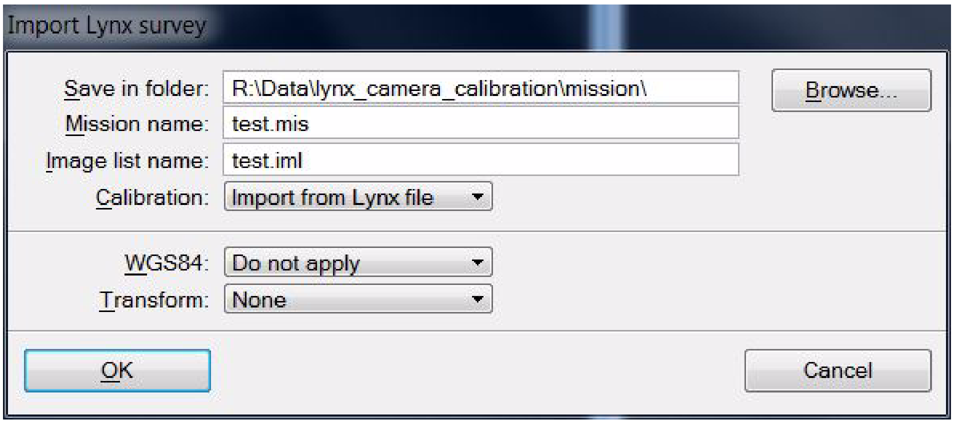
➢ **To import a Lynx survey index file:**

1. Select **Import Lynx Survey** command from the **Mission** pulldown menu.

   This opens the **Import Lynx survey** dialog, a standard dialog for opening files.

2. Select the index file and click **Open**.

   The **Import Lynx survey** dialog opens:



3. Define settings and click OK.

   The mission file, an image list file, and possibly camera calibration files are created in the given directory. The camera files are named *CAMERA1.CAL* and *CAMERA2.CAL*.

Setting:	Effect:
Save in folder	Directory that stores the mission file, the image list file, and the camera files.
Mission name	Name of the mission file. The extension must be *.mis*.
Image list name	Name of the image list file. The extension must be *.iml*.
Calibration	Method of handling camera calibration files: • **Import from Lynx file -** the camera calibration information is read from the index file and new TerraPhoto camera files are created. • **Use existing cal files -** existing TerraPhoto camera files are used and the software does not create new files. The files must be named *camera1.cal* and *camera2.cal*.
WGS84	Transformation from WGS84 coordinates to a projection system that is applied to the image list. You can choose from any of the builtin or user-defined projections systems which are set as active in **TerraPhoto** *Settings*.
Transform	User-defined transformation that is applied to the image list. The list contains transformations defined in **Coordinate transformations / Transformations** of TerraPhoto **Settings**.

Import Pictometry Survey

Import Pictometry Survey command reads information from a text file and creates a mission file, an image list, and camera files. The text file can be created, for example, from the .DBF file delivered by the Pictometry system software.

The text file must include a specific set of columns which are delimited by tabulator. The two options for columns and their labels are:

- NAME, OMEGA, PHI, KAPPA, X COORD, Y COORD, ALTITUDE, X PP OFFSET, Y PP OFFSET, FOCAL LENGTH, FOCAL WIDTH, FOCAL HEIGHT, K1, K2, K3, GPS TIME
- IMAGENAME, IMAGEEXT, OMEGA, PHI, KAPPA, CAMERAX, CAMERAY, ALT, PPX, PPY, FOCALLEN, IMAGECOLS, IMAGEROWS, K1, K2, K3

The text file must have the extension .CSV. The camera parameters for each camera of the system are converted into a TerraPhoto camera calibration file. The time and positional information for the images are converted into a TerraPhoto image list.

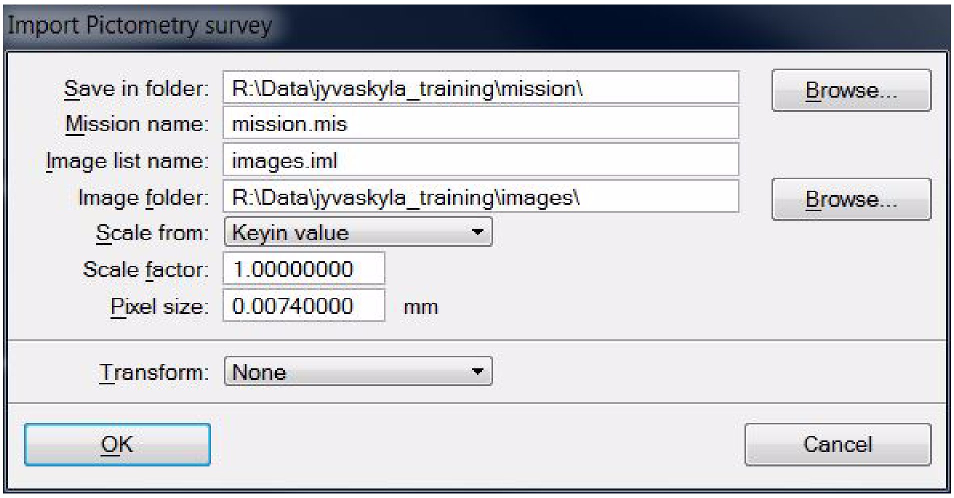
➢ **To import a Pictometry survey index file:**

1. Select **Import Pictometry survey** command from the **Mission** pulldown menu.

   This opens the **Import Pictometry survey** dialog, a standard dialog for opening files.

2. Select the text file and click **Open**.

   The **Import Pictometry survey** dialog opens:



3. Define settings and click OK.

   The mission file, an image list file, and camera calibration files are created in the given directory.

Setting:	Effect:
Save in folder	Directory that stores the mission file, the image list file, and the camera files.
Mission name	File name of the mission file. The extension must be *.mis*.
Image list name	File name of the image list file. The extension must be *.iml*.
Image folder	Directory that stores the image files.
Scale from	Method of deriving the scale factor: • **Keyin value** - the scale factor is defined by the given value in the **Scale factor** field. • **<projection system>** - the scale factor is defined by the selected projection system. You can choose from any of the builtin or user-defined projections systems which are set as active in **TerraPhoto** *Settings*.

Setting:	Effect:
Pixel size	Pixel size of the raw images in millimeter.
Transform	User-defined transformation that is applied to the image list. The list contains transformations defined in **Coordinate transformations / Transformations** of TerraPhoto **Settings**.

Exit

Exit command closes TerraPhoto and unloads the application.

Points pulldown menu

Commands from the **Points** pulldown menu are used to load points into TerraPhoto which are then used to create a ground surface model. The software can reference points loaded into TerraScan. Alternatively, it can load points directly from files.

To:	**Choose menu command:**
Reference points loaded into TerraScan	**Load from TerraScan**
Load ground points from file(s) into TerraPhoto	**Load from file**

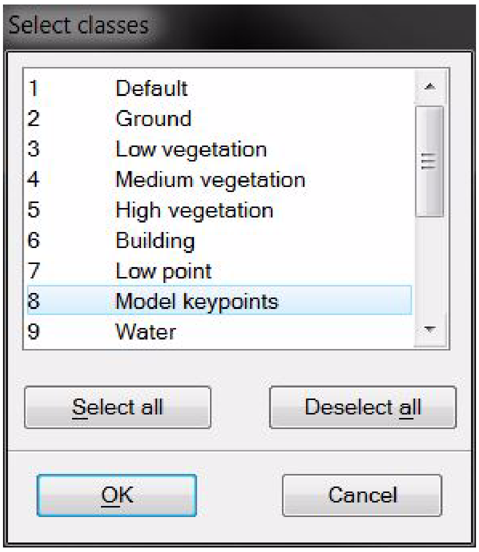
Load from TerraScan

Load from TerraScan command references points loaded into TerraScan and uses them as a ground model for rectifying the images.

➢ **To reference points from TerraScan:**

1. Select **Load from TerraScan** command from the **Points** pulldown menu.

   This opens the **Select classes** dialog displaying active point classes in TerraScan:



2. Select the class(es) which form the rectification surface.
3. Click OK.

   The application reports how many points it references in TerraScan tables.

Load from file

Load from file menu command reads ground model points from a file into TerraPhoto's memory. All points in the input file(s) are used to create the ground model for rectifying the images.

Supported file formats include:

- Space-delimited X Y Z text file.
- Space-delimited Code X Y Z text file.
- Space-delimited Pulse X Y Z Intensity text file.
- TerraScan binary 8 bit format.
- TerraScan binary 16 bit format.

Images pulldown menu

Commands from the **Images** pulldown menu are used to create and manage the active list, to start the tie point mode, and to manipulate attributes of the images of the active image list. The commands do always effect the entries of the active image list and not the raw image files.

To:	Choose menu command:
Load an image list from file(s) on the hard disk	**Load list**
Compute an image list from trajectory and image timing information	**Compute list**
Close the current image list	**Close list**
Save the active image list	**Save list**
Save the active image list into a new file	**Save list As**
Define color adjustments for raw images	**Define color corrections**
Apply a coordinate transformation to image positions	**Transform positions**
Adjust elevations of images using a geoid model	**Adjust to geoid**
Compute new orientation angles	**Convert angles**
Start the tie point mode	**Define tie points**
Adjust image positions using tie points	**Adjust positions**
Manually add a new image to the image list	**Add**
Modify information of selected image(s)	**Edit**
Delete selected images from the list	**Delete / Selected images**
Delete images of a certain camera from the list	**Delete / By camera**
Delete inactive images from the list	**Delete / Inactive images**
Delete closeby images from the list	**Delete / Closeby images**
Delete redundant overlapping images from the list	**Delete / Overlapping images**
Delete images inside a fence from the list	**Delete / Inside fence**
Delete images outside a fence from the list	**Delete / Outside fence**
Delete image outside the ground model from the list	**Delete / Outside ground**
Delete images outside powerline towers from the list	**Delete / Non-tower images**
Delete image entries without a raster file from the list	**Delete / Missing file images**

Load list

Load list command reads an image list file and adds it to the active list of images in TerraPhoto.

The command is also used to load an exterior orientation file into TerraPhoto and convert it into an image list. This requires the definition of the exterior orientation file format in TerraPhoto **Settings**. See **Exterior orientation formats** for more information.

Typically, the command is used if the exterior orientation of the images is defined using angles omega, phi, and kappa. These angles have to be converted into heading, pitch, and roll in order to process the image data in TerraPhoto.

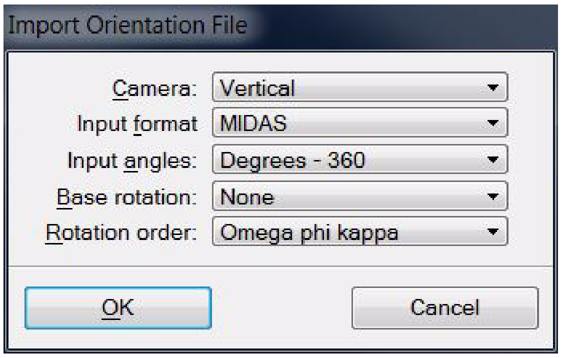
➢ **To load exterior orientation files:**

1. Select **Load list** command from the **Images** pulldown menu.

   This opens the **Image list files** dialog, a standard dialog for opening files.

2. Define the text files that contain the exterior orientation information for the images and click **Done**.

   This opens the **Import Orientation File** dialog:



3. Define settings and click OK.

   The software reads the content of the text file and converts the information into a TerraPhoto image list.

4. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the image list file.

Setting:	**Effect:**
Camera	Name of the camera for which image orientation values are loaded.
Input format	Name of the exterior orientation format defined in **TerraPhoto** *Settings*.
Input angles	Format of the input angles: • **Radians - 2*pi -** angle values are given in radians. The software normalizes the values between -pi and +pi. • **Degree - 360 -** angle values are given in degree. The software normalizes the values between -180 and +180 degree. • **Gones - 400 -** angle values are given in gones. The software normalizes the values between -200 and +200 gones.
Base rotation	Rotation of the camera within the system relative to the flight direction.
Rotation order	Order of the input angles. Usually, the order is omega phi kappa. This is used to derive the correct rotation matrix for heading, roll, and pitch angles.

Compute list

Not Lite

Compute list command creates an image list from time-stamped trajectory information and system-specific image list files. The application derives the corresponding xyz position and orientation angles for each image from the trajectory. If there is already an active image list in TerraPhoto, the new entries are added to the active list.

This command requires that trajectories are imported first by using the *Manage Camera Trajectories* tool. In most cases, the image list is computed for one camera at a time. Therefore, the steps have to be repeated several times in order to add images from multiple cameras to the image list.

The image information can be provided in different ways:

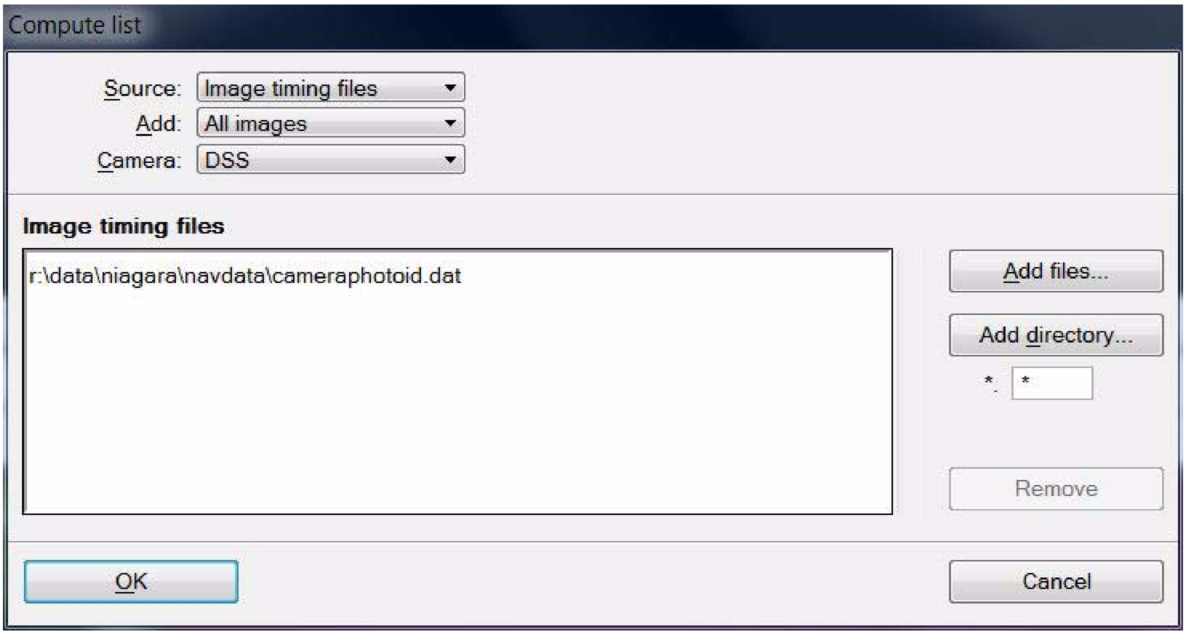
- **Image timing files -** time of image capture and name of each image are stored space- or tab-separated columns in a text file.
- **Event + naming file -** time of image capture and an event number are stored in one text file, event number and image name are stored in another text file.
- **Lynx survey file -** specific text file from the Optech Lynx system.
- **Riegl csv files -** specific text files from the Riegl system.
- **Trimble MX8 dbf files -** specific dbf files from the Trimble MX8 system.

The command can utilize a selected shape for bounding an area. Only images, for which the xyz position is located inside the boundary are added to the image list.

➢ **To compute an image list from image timing files:**

1. (Optional) Draw and select a shape around the area for which to add images to the image list.
2. Select **Compute list** command from **Images** pulldown menu.

   This opens the **Compute list** dialog:



3. Select the source file format in the **Source** list.
4. Select whether to add all images from the selected source file or only image inside a selected shape.

   The following settings depend on the selected source file format.

Image timing files, Riegl csv files

5. Select the camera in **Camera** field for which the input files apply.
6. Click on the **Add** botton to add image timing files to the list.

   OR

   Click on the **Add directory** botton to add all text files from a directory to the list.

   This opens the **Image timing files/directory** dialog, a standard dialog for opening files/folders.
7. Define the text file(s)/folder and add them to the list in the **Compute list** dialog.
8. Click OK.

   The software links each image timing file with the trajectory information using the time stamps. For each image, the positional and orientation information is derived and added to the image list.
9. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the image list file.

Event + naming files

5. Select the camera in **Camera** field for which the input files apply.
6. Click on the **Add files** botton to add event files to the list.

   This opens the **Event files** dialog, a standard dialog for opening files.
7. Define the text file(s) and add them to the list in the **Compute list** dialog.
8. Click on the **Add files** botton to add image name files to the list.

   This opens the **Image naming files** dialog, a standard dialog for opening files.
9. Define the text file(s) and add them to the list in the **Compute list** dialog.
10. Click OK.

    The software links each image naming file to the corresponding event file using the event number. Then, the event file is linked with the trajectory information using the time stamps. For each image, the positional and orientation information is derived and added to the image list.
11. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the image list file.

Lynx survey files

5. Click on the **Add** button to add the survey-specific text files to the list.

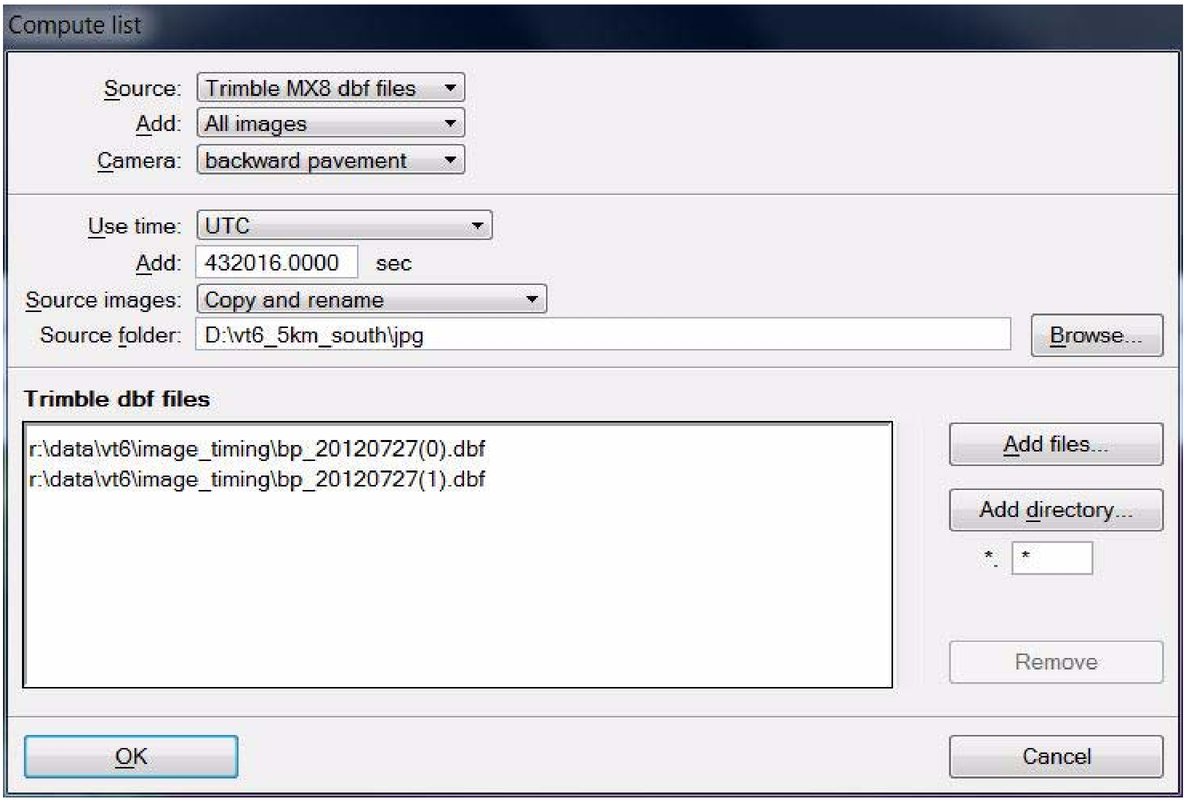
   OR

   Click on the **Add directory** botton to add all text files from a directory to the list.

   This opens the **Image timing files/directory** dialog, a standard dialog for opening files/folders.
6. Define the text file(s)/folder and add them to the list in the **Compute list** dialog.
7. Click OK.

   The software reads the positional and orientation information for each image from the survey file and adds it to the image list.
8. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the image list file.

Trimble MX8 dbf files



5. Select a camera in **Camera** field for which the input files apply.
6. Select the time stamp format that is used in the source files.
7. Define a number of seconds to be added to the time stamps.
8. Define a method of handling the **Source images**.

   Source images are renamed during the image list computation in order to make their naming unique over all cameras.
9. Define the **Source folder**, where images are stored. The images can be stored in several subfolders within the source folder.
10. Click on the **Add** botton to add .dbf files to the list.

    OR

    Click on the **Add directory** botton to add all .dbf files from a directory to the list.

    This opens the **Image timing files/directory** dialog, a standard dialog for opening files/ folders.
11. Define the .dbf file(s)/folder and add them to the list in the **Compute list** dialog.

    The file names of the dbf files also define the name of subfolders the software checks for source images.
12. Click OK.

    The software links each image timing file with the trajectory information using the time stamps. For each image, the positional and orientation information is derived and added to the image list.
13. Repeat steps 5 to 12 for all cameras for which to add images to the image list.
14. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the image list file.

Close list

Close list command closes the active list of images. This results in an empty image list.

➢ **To close an image list:**

1. Select **Close list** command from the **Images** pulldown menu.

   If the image list has been changed and not yet saved, a dialog opens and asks for confirmation of the closing action.

2. Click **Yes** in order to close the image list without saving the changes to the image list file.

Save list

Save list command saves the active image list to the same file from which it was opened before. This is only possible as long as no additional images have been added to the original image list.

Save list As

Save list As command saves the active image list into a new file.

Define color corrections

Define color corrections command applies color corrections for all or selected images in the image list. Corrections can be applied for red, green, and blue color channels, as well as for intensity, saturation, and contrast values.

The command can be used, for example, to correct systematic color or brightness issues in the raw images, such as color casts in all images of a camera or within a certain time interval. Furthermore, are grid-based brightness correction can be applied to the images. This improves images that are darker towards the image edges/corners and brighter in the center.

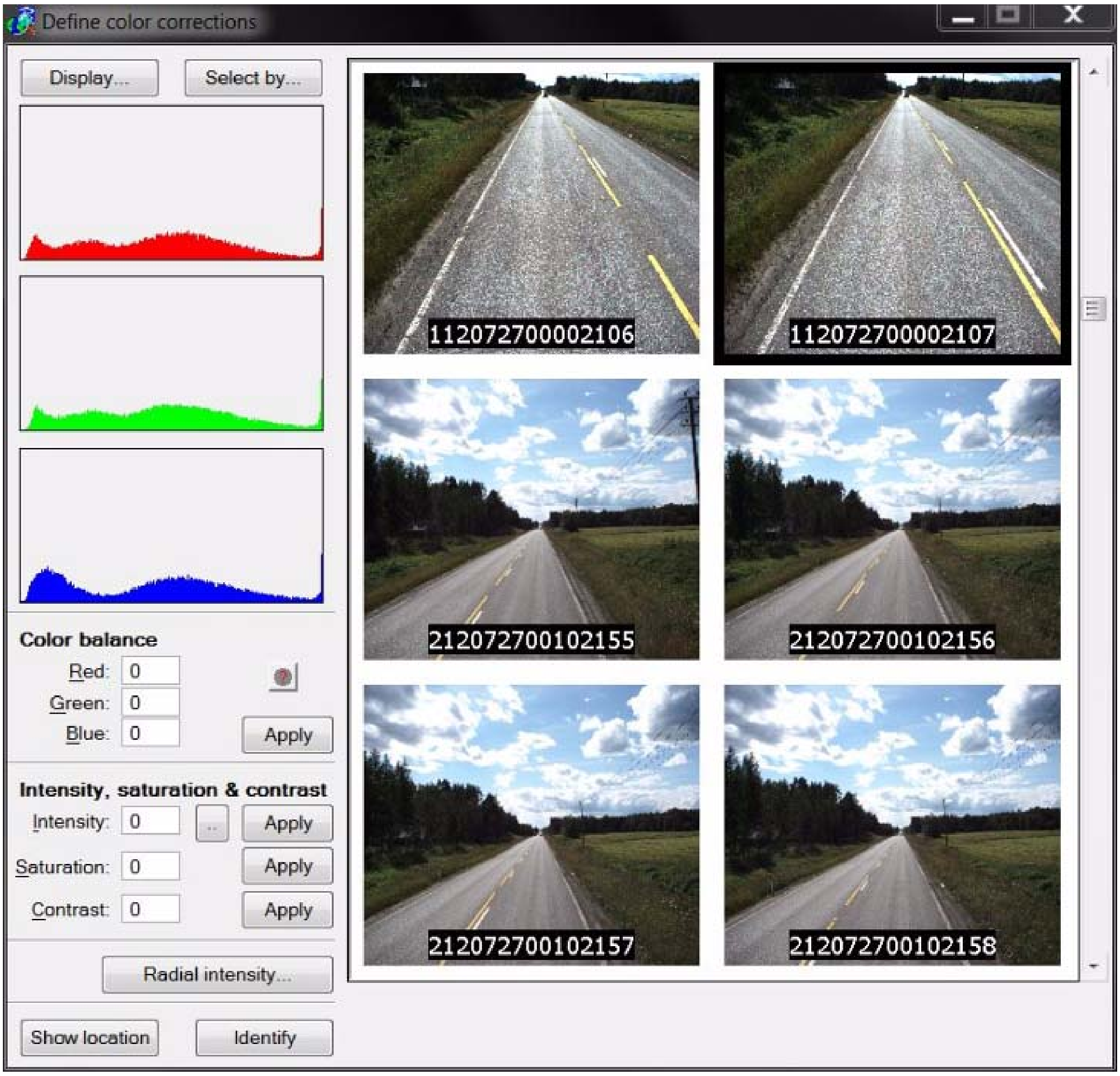
See Chapter **Color corrections** on page 67 for a detailed description of settings and commands for defining color corrections.

➢ **To define color corrections:**

1. (Optional) Select **Analyze images** command from the **Utility** pulldown menu in order to check a report about average color values, intensity, saturation, and contrast for each image as well as an average value for all or selected images.
2. Select **Define color corrections** command from the **Image** pulldown menu.

   If thumbnails do not yet exist in the temporary files folder of the mission, the **Create thumbnails** dialog opens. See **Create thumbnails** command for more information.

   The **Define color corrections** dialog opens:



3. Scroll through the thumbnail list on the right side to get an overview of the image coloring.

4. Select images in the thumbnail list for which you want to apply color corrections. Set correction values and click **Apply** for each setting.

   This updates the display of the thumbnails and writes the correction values into the image list. Continue with step 4 for all images that need color corrections.

5. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the color corrections into an image list file.

✍ You can check the result of color corrections by choosing **Define color points** command from the **Rectify** pulldown menu in the **TPhoto Main** window. This creates a preview of the ortho mosaic using the color corrections on-the-fly.

Transform positions

Not Lite

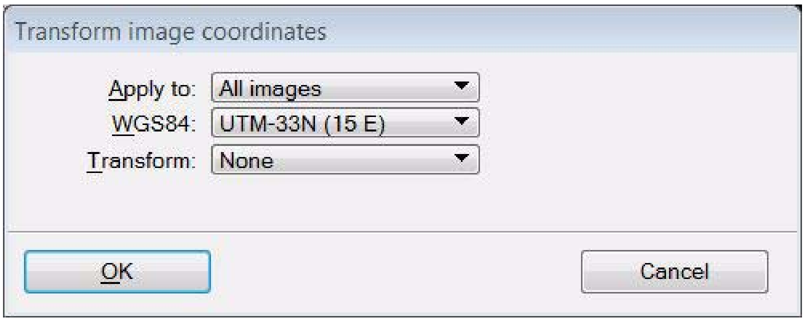
Transform positions command changes the positions of images in the image list by applying a transformation. You can apply a transformation from WGS84 coordinates to a projection system and/or a user-defined transformation.

The projection systems and transformations must be defined in the **Coordinate transformations** categories of **TerraPhoto** *Settings*.

➢ **To transform image list positions:**

1. Select **Transform positions** command from the **Images** pulldown menu.

   This opens the **Transform image coordinates** dialog:



2. Select settings and click OK.

   This transforms the image positions for the active image list.

3. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Setting:	Effect:
Apply to	Images to transform: • **All images** - all images in the image list. • **Selected images** - selected images only. This requires the selection of images in the image list before the command is started.
WGS84	Target projection system for applying a transformation from WGS84 coordinates to the given projection system. You can choose from any of the builtin or user-defined projections systems which are set as active in **Coordinate transformations / Builtin projection systems**, **Coordinate transformations / US State Planes**, and **Coordinate transformations / User projection systems** of TerraPhoto **Settings**.
Transform	User-defined transformation to apply. You can choose from any transformation that is defined in **Coordinate transformations / Transformations** of TerraPhoto **Settings**.
Dz	Value by which images are transformed in elevation. This is only active if **Transform** is set to **Dz**.
Dxyz	Location and name of a file that contains transformation values. This is only active if **Transform** is set to **Dxyz**.

Adjust to geoid

Not Lite

Adjust to geoid command applies an elevation correction to images of the active image list. This command is often used to transform the WGS84-based ellipsoidal elevation values to a geoid-based height model.

The input model for elevation adjustment can be provided in different ways:

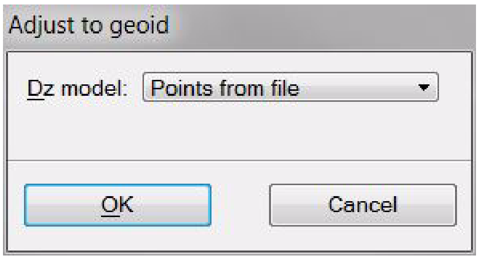
- **Points from file -** text file containing space-delimited X Y dZ points.
- **TerraModeler surface -** triangulated surface created from X Y dZ points. The model must be loaded in TerraModeler. This has the advantage that you can visualize the adjustment model.
- **Selected linear chain -** linear element which has vertices derived from X Y dZ points.

The first two input models utilize aerial interpolation while the last input model uses linear interpolation along the linear element’s segments in order to derive adjustment values.

➢ **To adjust image elevations to a geoid model:**

1. (Optional) Load a geoid model into TerraModeler.
2. Select **Adjust to geoid** command from the **Images** pulldown menu.

   This opens the **Adjust to geoid** dialog:



3. Select the input model type in the **Dz model** field and click OK.

   If **Points from file** is selected as the **Dz model**, the **Geoid dz file** dialog opens, a standard dialog for opening files.
4. Define the text file that contains the geoid coordinates and elevation differences and click **Open**.

   This applies the elevation adjustment to all images of the active image list. An information dialog shows the minimum and maximum values of the adjustment.
5. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Convert angles

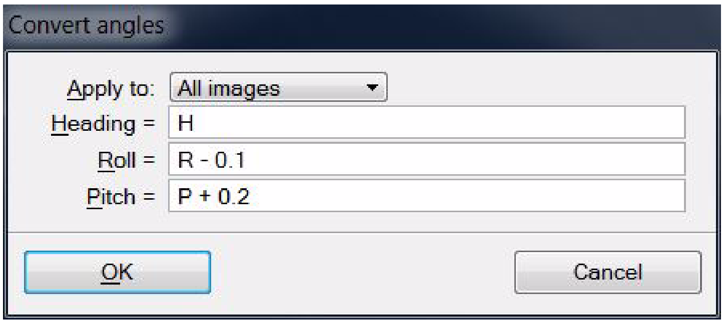
Not Lite

Convert angles command lets you apply a mathematical equation to the image orientation angles heading, pitch, and roll. The modification effects the anlges of all or selected images in the active image list.

➢ **To convert angles of images:**

1. Select **Convert angles** command from the **Images** pulldown menu.

   This opens the **Convert angles** dialog:



2. Define equations for the angles.
3. Click OK.

   This computes the new values for the image orientation angles.

4. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Setting:	**Effect:**
Apply to	Images for which the computation of new angles is applied: • **All images -** all images in the image list. • **Selected images -** selected images only. This requires the selection of images in the image list before the command is started.
Heading	Equation for modifying the heading angle.
Roll	Equation for modifying the roll angle.
Pitch	Equation for modifying the pitch angle.

Convert time stamps

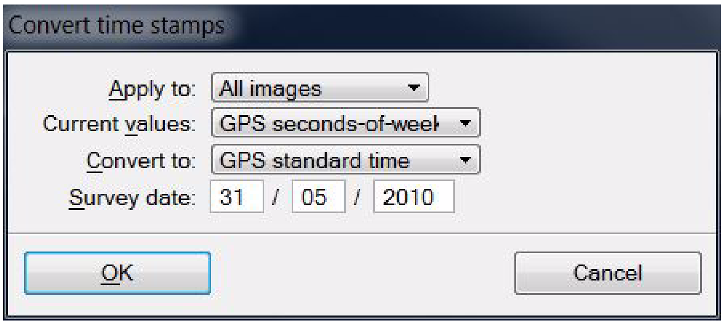
Not Lite

Convert time stamps command can be used to convert the format of time stamps. Supported conversions are GPS seconds-of-week to GPS standard time, Unix time to GPS standard time, GPS standard time to GPS seconds-of-week, and Unix time to GPS seconds-of-week. The modification effects the time stamps of all or selected images in the active image list.

➢ **To convert time stamps:**

1. Select **Convert time stamps** command from the **Images** pulldown menu.

   This opens the **Convert time stamps** dialog:



2. Define settings for the conversion.
3. Click OK.

   This converts the image time stamps to the new format.

4. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Setting:	Effect:
Apply to	Images for which the computation of new angles is applied: • **All images -** all images in the image list. • **Selected images** - selected images only. This requires the selection of images in the image list before the command is started.
Current values	Original time stamp format of the images.
Convert to	Target time stamp format.
Survey date	Date when the images were captured. The format is day / month / year. The date should be given within 2-3 days of the actual surveying day. This is only active for the conversion from **GPS seconds-of-week** to **GPS standard time**.

Define tie points

Not Lite

Define tie points command switches the application into tie point mode. This involves building a triangulated model of the ground (if available) and re-arranging the views for the work with tie points.

For airborne missions, the tie point mode is only available if a ground model is loaded into TerraPhoto. For mobile missions, a ground model is not required for working with tie points.

The processing workflow and all commands related to tie points are described in detail in Chapter **Working with Tie Points** on page 76.

➢ **To start the tie points mode:**

1. Select **Define tie points** command from the **Images** pulldown menu.

   This might open the **Tie point view setup** dialog, unless the view setup has been saved for the design file before.

2. Define view setup settings and click OK. See **Setup** command for more information about the view setup.

   The software reorganizes the MicroStation views according to the setup settings. It also opens the **Tie points** window which contains the active image list.

✍ If the **Tie points** window is closed, the MicroStation windows used for tie point processing are closed as well. The view setup switches back to the same arrangement that had been active before the tie point mode was started. However, the tie points are still active and loaded in the memory.

Adjust positions

Not Lite

Adjust positions command adjusts the positions of the images in the active image list. The software tries to improve the match of the tie point rays from different images. This process is also called aerial triangulation. The adjustment can use tie points from a file or active tie points. The latter alternative requires that the **Tie points** window is open and tie points are active.

The adjustment can be applied to image orientation angles, image elevation, and/or image xyz positions. If the raw positioning of the images is good and based on GPS measurements, it is recommended to modify the orientation angles only. There is a high correlation between xy and roll/pitch adjustments. The adjustment of both is reliable only if there is a very good number of tie points for each image.

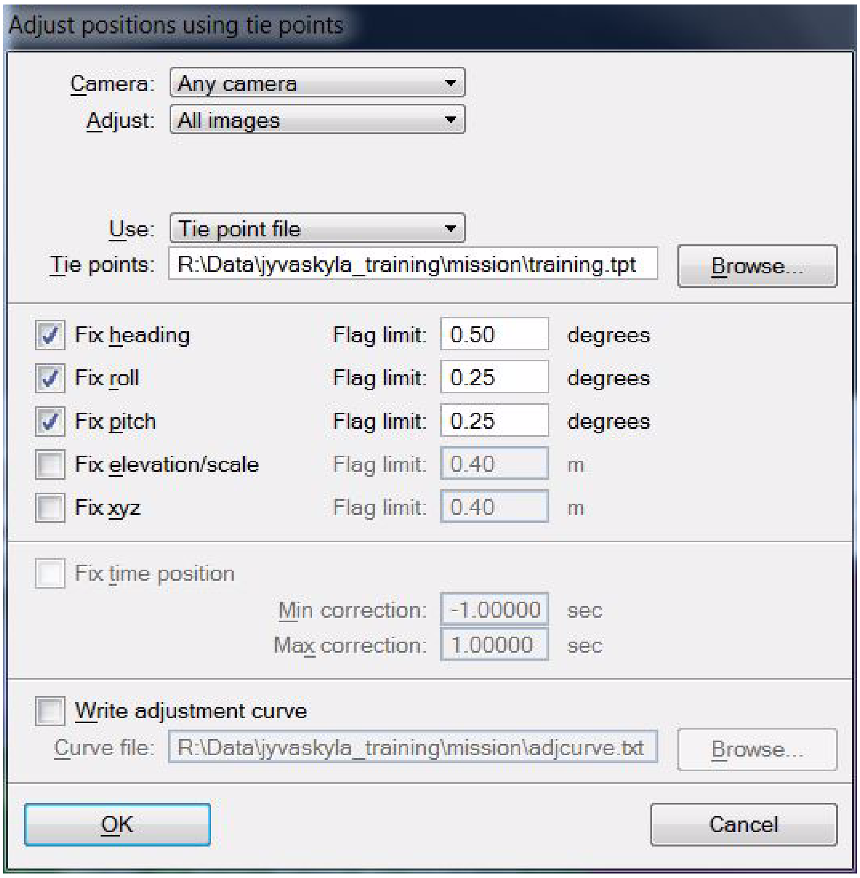
Positional adjustment of the images can be performed with the following goals in mind:

- Improve camera calibration parameters. You can make changes to camera misalignment angles or principal point z based on the adjustment report.
- Find bad tie points. Bad tie points cause bigger changes to raw positioning which are highlighted in the report if you specify suitable flagging limits. Furthermore, when you have adjusted image positioning, bad tie points stand out by having larger mismatch values.
- Produce an adjusted image list which provides more accurate image positioning. This image list should be saved as its own file and can be used for orthorectification or for vectorization tasks.

➢ **To adjust image positioning using tie points:**

1. Select **Adjust positions** command from the **Images** pulldown menu.

   This opens the **Adjust position using tie points** dialog:



2. Define settings and click OK.

   This starts the adjustment process. After the process has finished, the **Tie point adjustment**

report is displayed.

3. Select **Save list As** commands from the **Images** pulldown menu in order to save the image list into a new file.

Setting:	Effect:
Camera	Name of the camera for which to apply the adjustment. Alternatively, images from **Any camera** can be adjusted.
Adjust	Images that are effected by the adjustment: • **All images -** all images in the active image list that have tie points. • **Well defined images -** images that have enough tie points to meet the given **Point value** and **Coverage** limits. • **Selected -** selected images only. This requires the selection of images in the image list before the command is started.
Point value	Required **Tie point values** for images to be adjusted. This is only active if **Adjust** is set to **Well defined images**.
Coverage	Required **Tie point distribution** for an image to be adjusted. This is only active if **Adjust** is set to **Well defined images**.
Use	Source of tie points: **Active tie points** or **Tie point file**.
Tie points	File from which to read tie points. This is only active if **Use** is set to **Tie point file**.
Fix heading	If on, the process modifies the heading angles of images.
Fix roll	If on, the process modifies the roll angles of images.
Fix pitch	If on, the process modifies the pitch angles of images.
Fix elevation/scale	If on, the process modifies the camera z coordinates of images.
Fix xyz	If on, the process modifies the camera xyz coordinates of images.
Fix time position	Not yet implemented.
Write adjustment curve	If on, the changes are written to a text file that contains time stamps and adjustment values. This may be useful, for example, to find out whether there has been drift in the IMU measurement.

Tie point adjustment report

Adjust positions produces a report which plays a central role for optimizing camera parameters and for fine tuning tie points.

The start of the report may look like:

```
Start average          4.9789 cm
Final average          1.3724 cm
```

Start average indicates how well tie point rays match each other before the adjustment. This value is a measure of how good the raw positioning of images is, how good the camera calibration works, and how good the tie points are. Whenever you try to improve any of these factors, you aim to minimize the average mismatch.

Final average indicates how well tie point rays match each other after the adjustment. This value is primarily a measure of how good the camera calibration is and how good the tie points are.

The end of the report may look like:

```
Avg magnitude   0.0     0.0     0.0   0.039   0.010   0.009
Average        +0.0    +0.0    +0.0  -0.000  -0.001  -0.000
Median         +0.0    +0.0    +0.0  +0.000  -0.001  -0.000
```

Avg magnitude indicates how big the average changes to parameters are. These changes give an indication of the quality of the raw GPS/IMU trajectory information.

Average and **Median** give an indication if heading, roll, and pitch misalignment values for the camera are good. Average heading, roll and pitch changes should be practically zero if the misalignment values in the camera file are correct and if you have good tie points.

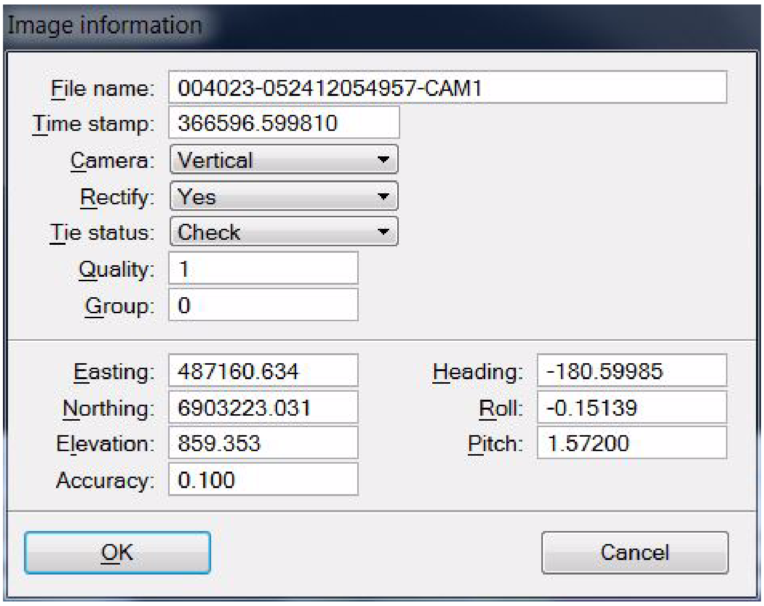
Add

Add command lets you add an image to the active image list. You define manually the image file name, xyz position, heading, roll, pitch angles, and (optional) other image parameters.

➢ **To add an image to the list:**

1. Select **Add** command from the **Images** pulldown menu.

   This opens the **Image information** dialog:



2. Define settings and click OK.

   This adds a new image to the image list.

3. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Setting:	**Effect:**
File name	Name of the raw image file.
Time stamp	(Optional) Time stamp of the image.
Camera	Name of the camera which captured the image.
Rectify	Defines whether the image is used in orthorectification processes or not. An image with rectification status **Yes** is considered an active image, otherwise images are considered as inactive.
Tie status	Defines the status of the image for tie point work: • **Check -** the image is included in the list of images for placing tie points. • **Approved -** the image is excluded from the list of images for placing tie points.
Quality	(Optional) Quality value of the image.
Group	(Optional) Group number of the image.
Easting	Easting coordinate of the image position (focal point).
Northing	Northing coordinate of the image position (focal point).
Elevation	Elevation coordinate of the image position (focal point).
Heading	Heading angle of the image orientation. Given in degree.
Roll	Roll angle of the image orientation. Given in degree.
Pitch	Pitch angle of the image orientation. Given in degree.
Accuracy	(Optional) Accuracy estimate of the image xyz positioning.

Edit

Edit command lets you modify the information of one or several images in the active image list.

If information is changed for several images, the values for image position coordinates, orientation angles, and time are no longer absolute values but difference values. These difference values are then added to the original values of the selected images.

➢ **To modify information of a single image:**

1. Select one image in the image list.
2. Select **Edit** command from the **Images** pulldown menu.

   This opens the **Image information** dialog.

3. Modify settings and click OK. See **Add** command above for more information.

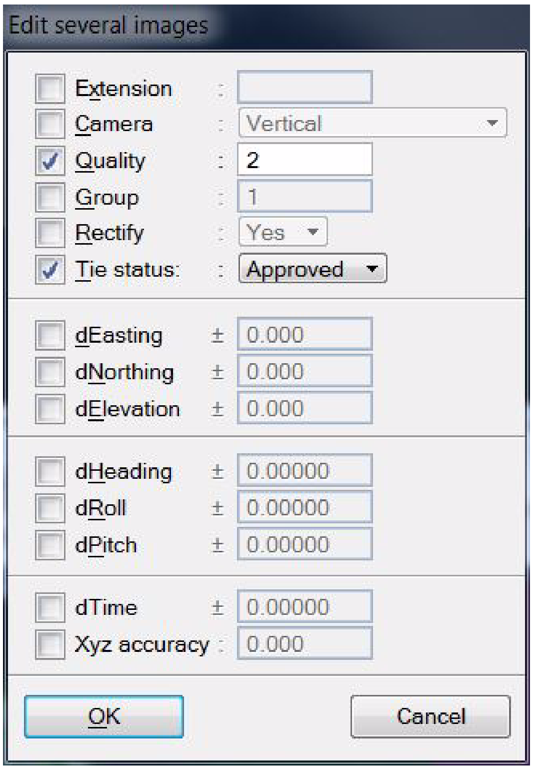
   This modifies the values for the selected image.

4. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

➢ **To modify information of multiple images:**

1. Select multiple images in the image list.
2. Select **Edit** command from the **Images** pulldown menu.

   This opens the **Edit several images** dialog:



3. Check the toggle buttons for the parameters to modify.
4. Define values and click OK.

   This applies the modified values to the selected images.

5. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Delete / Selected images

Delete / Selected images command removes selected images from the active image list.

➢ **To delete selected images:**

1. Select the images to be deleted in the image list.
2. Select **Delete / Selected images** command from the **Images** pulldown menu.

   An alert dialog is displayed that asks for a confirmation of the delete action.
3. Click **Yes** to the **Alert** dialog in order to remove the images from the image list.
4. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

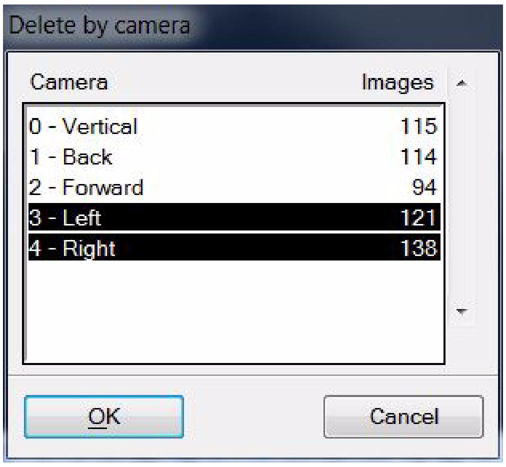
Delete / By camera

Delete / By camera command removes images captured by a given camera from the active image list.

➢ **To delete images of certain camera(s):**

1. Select **Delete / By camera** command from the **Images** pulldown menu.

   This opens the **Delete by camera** dialog:



2. Select the camera(s) from which to delete the images.

   The images captured by the selected camera(s) are removed from the image list. An information dialog displays the number of removed images.
3. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Delete / Inactive images

Delete / Inactive images command removes images from the active image list for which the rectification status attribute is set to **No**. See **Add** and **Edit** commands for selected images for more information about the attributes of images.

➢ **To delete selected images:**

1. Select **Delete / Inactive images** command from the **Images** pulldown menu.

   An alert dialog is displayed that asks for a confirmation of the delete action.

2. Click **Yes** to the dialog in order to remove the images from the image list.
3. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

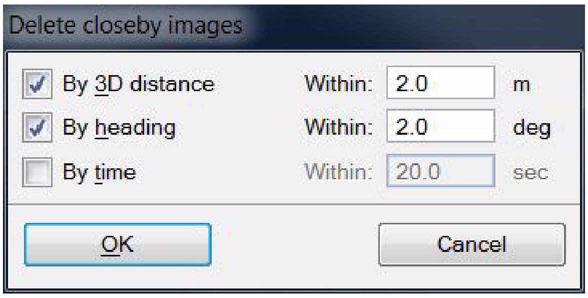
Delete / Closeby images

Delete / Closeby images command removes images from the image list that are captured within a defined time interval, distance, or turn angle. This can be used, for example, to delete multiple images that see almost the same location, such as images captured by a mobile ground-based camera system during a stop, slow drive, or sharp turn.

➢ **To delete closeby images:**

1. Select **Delete / Closeby images** command from the **Images** pulldown menu.

   This opens the **Delete closeby images** dialog:



2. Define settings and click OK.

   The software detects closeby images and removes them from the image list. An information dialog displays the number of deleted images.

3. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Setting:	Effect:
By 3D distance	Images captured within the given distance from each other are deleted.
By heading	Images for which the change in heading angle is within the given value are deleted.
By time	Images captured within the given time interval are deleted.

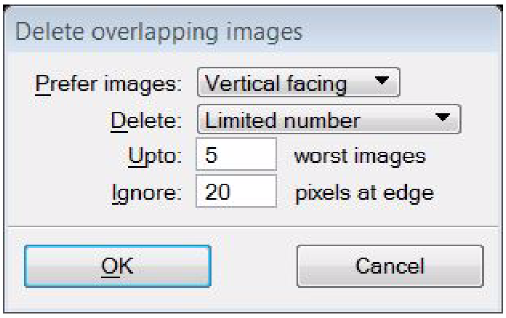
Delete / Overlapping images

Delete / Overlapping images command removes unnecessary overlapping images from the active image list. It computes accurate coverage areas of images on the ground and makes sure that the removal of images does not result in gaps.

➢ **To delete overlapping images:**

1. Select **Delete / Overlapping images** command from the **Images** pulldown menu.

   This opens the **Delete overlapping images** dialog:

2. Define settings and click OK.

   The application detects the image overlap and removes the unnecessary images according to the given settings.

3. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Setting:	**Effect:**
Prefer images	Determines which images to keep and which to remove: • **Vertical facing -** keeps images with smaller roll or pitch angles. • **Small pixel size -** keeps images from a lower altitude and deletes images from a higher altitude. • **First in list -** keeps images which appear first in the image list. • **Last in list -** keeps images which appear last in the image list.
Delete	Defines, how many images are deleted: • **All redundant images -** deletes all images which can be removed without causing gaps. • **Limited number -** deletes only up to a given number of images.
Upto	Maximum number of images that are removed. This is only active if **Delete** is set to **Limited number**.
Ignore	Number of pixels on the edge of an image to ignore when detecting the overlap between images.

Delete / Inside fence

Delete / Inside fence command removes images from the active image list whose camera xy position is inside the fence. You can also use a selected shape instead of a fence to specify the area.

➢ **To delete images inside a fence:**

1. Use MicroStation tools to draw a fence or digitize and select a shape around the area from which to remove the images.
2. Select **Delete / Inside fence** command from the **Images** pulldown menu.

   An alert dialog is displayed that asks for a confirmation of the delete action.
3. Click **Yes** to the dialog in order to remove the images inside the fence from the image list.
4. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Delete / Outside fence

Delete / Outside fence command removes images from the active image list whose camera xy position is outside the fence. You can use a selected shape instead of a fence to specify the area.

➢ **To delete images outside a fence:**

1. Use MicroStation tools to draw a fence or digitize and select a shape around the area for which to keep the images in the image list.
2. Select **Delete / Outside fence** command from the **Images** pulldown menu.

   An alert dialog is displayed that asks for a confirmation of the delete action.
3. Click **Yes** to the dialog in order to remove the images outside the fence from the image list.
4. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

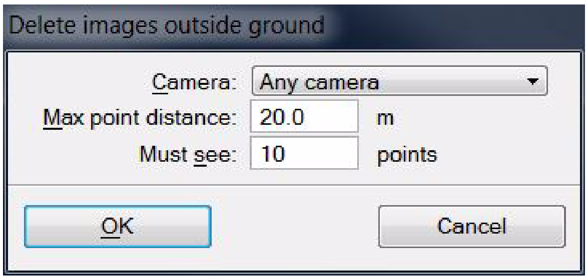
Delete / Outside ground

Delete / Outside ground command removes images from the active image list that are not located inside the area defined by the ground model in TerraPhoto. It computes accurate coverage areas of images on the ground and makes sure that only those images are removed that do not see enough ground area.

➢ **To delete overlapping images:**

1. Select **Delete / Outside ground** command from the **Images** pulldown menu.

   This opens the **Delete images outside ground** dialog:



2. Define settings and click OK.

   The application detects the images outside the ground model area and removes them from the image list.

3. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Setting:	Effect:
Camera	Name of the camera for which to apply the image removal. Alternatively, images from **Any camera** can be removed.
Max point distance	Distance between the camera position of an image and points in the ground model within which the ground model points are considered for the process. The usage of points that are far away from a camera position slows down the computation process. This is especially relevant for images seeing the ground from a direction that is much off from vertical.
Must see	Minimum amount of points of the ground model that an image must see in order to being kept in the image list.

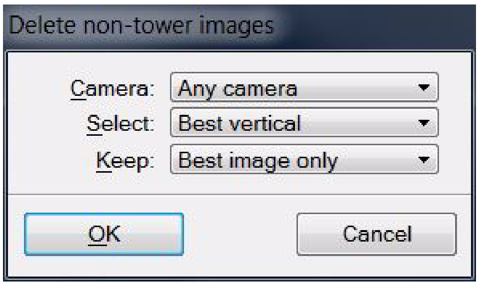
Delete / Non-tower images

Delete / Non-tower images command removes images from the active image list that are not captured from a tower locations along a power line. The tower locations are defined by a tower string element in TerraScan. The process keeps only those images which provide the vertical or the best oblique view of tower structures.

➢ **To delete images outside tower locations:**

1. Select the tower string element.
1. Select **Delete / Non-tower images** command from the **Images** pulldown menu.

   This opens the **Delete non-tower images** dialog:



2. Define settings and click OK.

   The application detects the images at tower locations and removes all other images from the image list.

3. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Setting:	**Effect:**
Camera	Name of the camera for which to apply the image removal. Alternatively, images from **Any camera** can be removed.
Select	Method for selecting images that remain in the image list: • **Best vertical -** the most vertical image for each tower location. • **Best oblique -** the most oblique image for each tower location. • **Dual sided oblique -** two oblique images facing each tower from different directions.
Keep	Defines the images that are kept in the image list: • **Best image only -** only the best image for each tower location. • **Sequence of three -** the best three consecutive images for each tower location.
Tower sizes	Method of determining the tower size in order to decide which oblique image(s) see the tower best: • **From tower cells -** the size of a tower is determined by a cell element. • **From wires -** the size of a tower is determined by wire elements. This is only active if **Select** is set to **Best oblique** or **Dual sided oblique**.
Levels	Numbers of levels in the design file that contain the tower cells or wire elements for determining the tower sizes. This is only active if **Select** is set to **Best oblique** or **Dual sided oblique**.

Delete / Missing file images

Delete / Missing file images command removes images from the active image list for which there are no raster files in the image directory of the camera that captured the images.

The image directory for a camera is stored in the mission definition. If an image file is not stored in the given directory, the **File status** attribute for the image in the image list is set to '**-**'. See **New mission** command for a description of how to define a mission and image directories for specific cameras.

➢ **To delete missing file images:**

1. Select **Delete / Missing file images** command from the **Images** pulldown menu.

   An alert dialog is displayed that asks for a confirmation of the delete action.

2. Click **Yes** to the dialog in order to remove the images from the image list.
3. Select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Rectify pulldown menu

Commands from the **Rectify** pulldown menu are used to define color points and selection shapes, to lay out an array of tiles, to produce an orthophoto mosaic, and to create wall textures.

To:	Choose menu command:
Define color points and selection shapes to improve the quality of orthos	**Define color points**
Draw an array of tiles for rectification	**Place tile array**
Produce orthorectified images for selected tiles	**Rectify mosaic**
Produce wall textures	**Rectify wall rasters**

Define color points

Define color points command starts the color point mode. This includes opening of the **Color points** menu and additional processing steps depending on the specified color point mode:

- **Ground ortho -** creation of a ground model, preview of rectified images.
- **Point cloud -** on-the-fly extraction of color values for each point, display of the point cloud.

The **Color points** menu allows you to create color points and to define different types of correction polygons that improve the quality of the final ortho mosaic or a colored point cloud.

Color points for the rectification of images or orthophoto production require a ground model. Therefore, the corresponding color point mode is only available, if ground points are loaded into TerraPhoto.

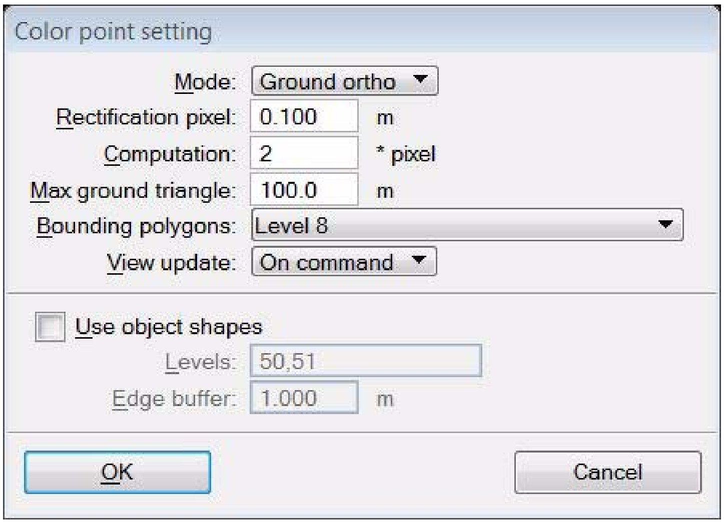
Color points for point clouds require a TerraScan project that manages the point cloud and a point cloud format that is able to store color values, image numbers, and normal vectors/dimensions for each point. The storage of all these attributes is only possible in TerraScan **Fast binary** format. See TerraScan User’s Guide for more information about projects, point cloud formats and attributes.

The concept of color points and commands of the **Color points** menu are described in detail in Chapter **Color Points and Selection Shapes** on page 124.

➢ **To start the color point mode for (ortho) rectification:**

1. Select **Define color points** from the **Rectify** pulldown menu.

   This opens the **Color point setting** dialog:



2. Select **Ground ortho** in the **Mode** list.
3. Define settings and click OK.

   This starts the color point mode.

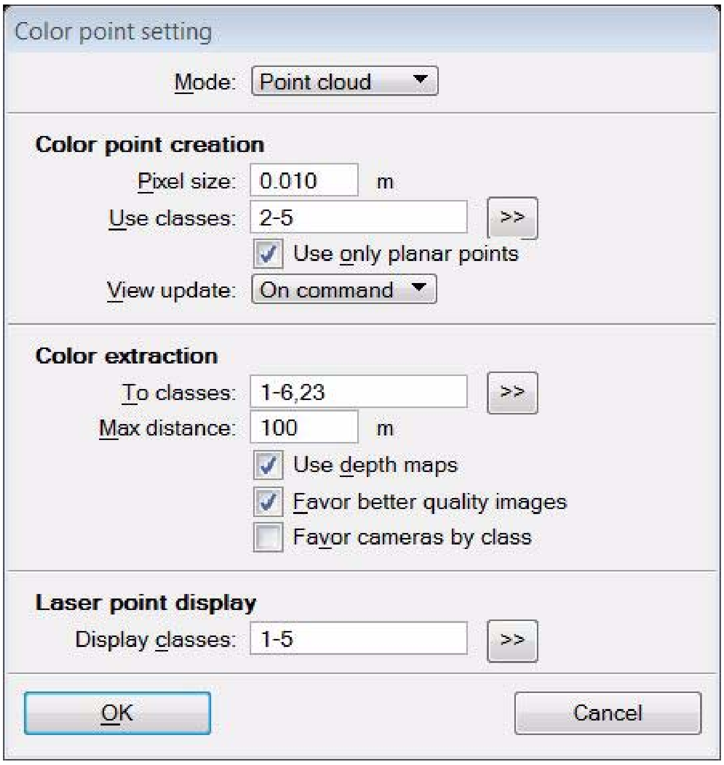
Setting:	Effect:
Rectification pixel	Intended pixel size of the final orthophoto mosaic.
Computation	Pixel size scale factor for color point computation. Color points and selection shapes do not need to be computed at the full resolution of the final orthophoto. It is recommended to use a factor of 2 or 3 in order to make computation processes faster.
Max ground triangle	Maximum triangle length in the ground model.
Bounding polygons	If on, the area available for color points is limited by the polygon(s) drawn on the given MicroStation level. The list contains all levels with elements in the design file.

Setting:	Effect:
View update	Method of updating the view display after modifications to color points and selection shapes: • **On command** - the display must be updated manually. • **Automatic** - the display is updated automatically after each modification.
Use object shapes	If on, object shapes on the given levels are used to create a true orthophoto preview.
Levels	Number(s) of MicroStation design file levels that contain 3D objects for true orthophotos. Separate several levels by comma. This is only active if **Use object shapes** is switched on.
Edge buffer	Distance from the edge of a 3D object within which object pixels are not rectified on the ground. The prevents, for example, roof pixels to be rectified on the ground next to buildings. This is only active if **Use object shapes** is switched on.

➢ **To start the color point mode for point clouds:**

1. Select **Define color points** from the **Rectify** pulldown menu.

   This opens the **Color point setting** dialog:



2. Select **Point cloud** in the **Mode** list.
3. Define settings and click OK.

   This starts the color point mode.

Setting:	Effect:
Pixel size	Approximate pixel size of raw images. Determines the size of a color point.
Use classes	Point classes used for color point creation. Exclude classes with non-planar objects, such as poles, wires, etc.
>>	Opens the **Select classes** dialog which contains the list of active classes in TerraScan. You can select multiple source classes from the list that are then used in the **Use classes** field.

Setting:	Effect:
Use only planar points	If on, only points with dimension attribute *Planar* are used for color point creation.
View update	Method of updating the view display after modifications to color points and selection shapes: • **On command -** the display must be updated manually. • **Automatic -** the display is updated automatically after each modification.
To classes	Point classes for which color values are extracted on-the-fly for displaying points in the color point mode.
>>	Opens the **Select classes** dialog which contains the list of active classes in TerraScan. You can select multiple source classes from the list that are then used in the **To classes** field.
Max distance	Maximum distance between a raw image and a laser point. Images outside that distance are not considered for color extraction.
Use depth maps	If on, depth maps files are included in the color extraction process.
Favor better quality images	If on, the quality attribute stored for raw images in an image list is considered in the color extraction process.
Favor cameras by class	If on, the settings in the TerraPhoto mission file related to favouring cameras for coloring points are considered in the color extraction process.
Display classes	Point classes that are displayed in color point mode.
>>	Opens the **Select classes** dialog which contains the list of active classes in TerraScan. You can select multiple source classes from the list that are then used in the **Display classes** field.

Place tile array

Not Lite

Place tile array command places an array of tile rectangles which can be used as orthophoto boundaries. The area covered by the tiles can be defined by laser points loaded in TerraScan, the footprints of the active image list, or selected shapes.

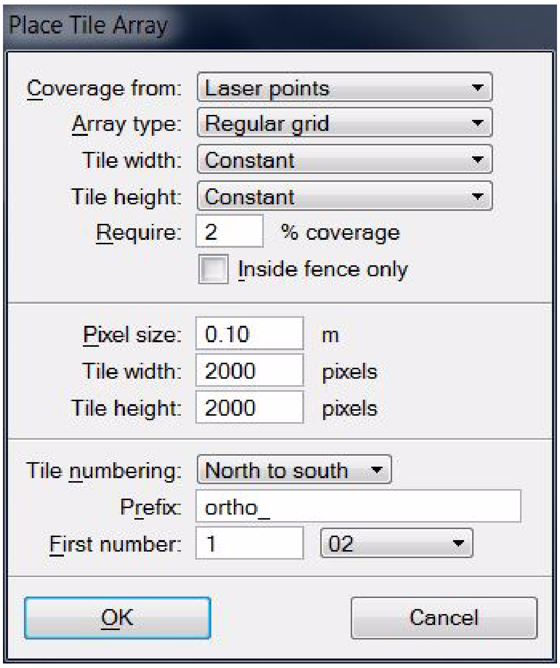
Placing a tile array only works if a mission, a ground model, and an image list are loaded into TerraPhoto.

The size of the tiles is defined in pixels. Width and height of a tile can be constant (all tiles have the same size) or variable (tiles are minimized at coverage area boundaries). The figures below the command description illustrate different settings for array type, tile width and height.

➢ **To place an array of tile rectangles:**

1. Select **Place tile array** command from the **Rectify** pulldown menu.

   This opens the **Place Tile Array** dialog:



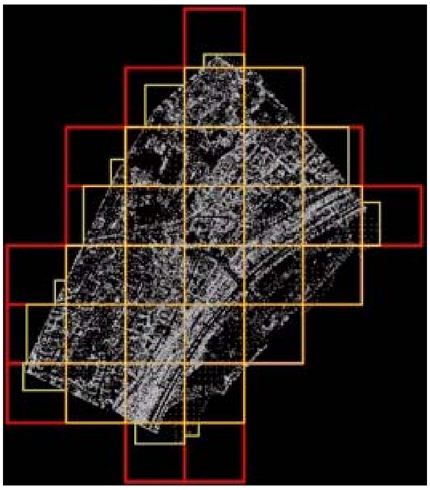
2. Define settings and click OK.

   This places an array of tile rectangles on the active level using the active symbology settings in MicroStation.

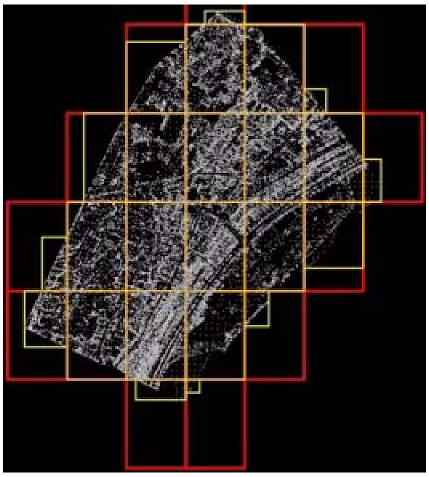
Setting:	Effect:
Coverage from	Source from which to determine the covered area: **Image footprints**, **Laser points**, or **Selected shapes**.
Array type	Tile pattern to construct: • **Regular grid** - regular tile pattern. The positioning is organized as multiple of the nominal tile size. • **X axis filling** - tiles are extended horizontally. • **Y axis filling** - tiles are extended vertically.
Tile width	Determines the tile width: • **Constant** - all tiles have a constant width. • **Minimized by coverage** - the width is minimized to the coverage area.

Setting:	Effect:
Tile height	Determines the tile height: • **Constant** - all tiles have a constant height. • **Minimized by coverage** - the height is minimized to the coverage area.
Require	Percentage of tile size that image footprints, laser data, or selected shapes must cover for the tile to be placed.
Inside fence only	If on, tiles are placed to cover fence contents only. This requires the placement of a MicroStation fence before the command is started.
Pixel size	Intended pixel size of the orthophotos.
Tile width	Width of a nominal tile in pixels.
Tile height	Height of a nominal tile in pixels.
Tile numbering	Order for placing text elements inside tiles: • **None** - no text elements are created. • **North to south** - increasing numbering from north to south and east to west. • **South to north** - increasing numbering from south to north and east to west. • **Along element** - incresing numbering in the direction of a selected linear element.
Prefix	Text that is included in the text elements before the numbering. This is only active if **Tile numbering** is not set to **None**.
First number	Number of the first tile and amount of digits used in the text elements. This is only active if **Tile numbering** is not set to **None**.

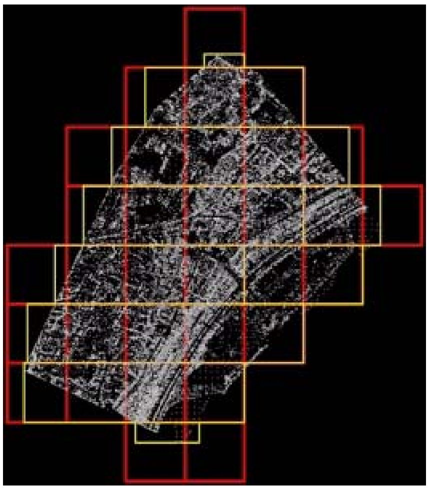
✍ The **Place Tile Array** dialog can also be opened by using the *Place Tile Array* tool.



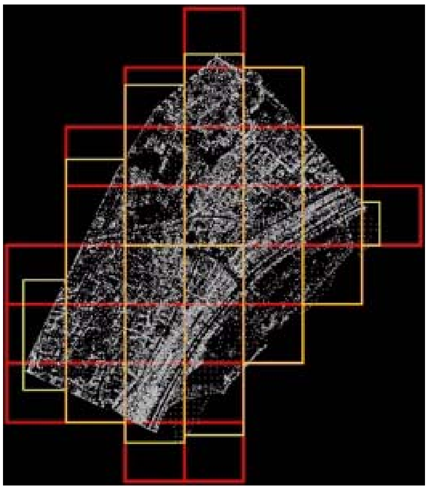
Regular grid 2000 x 2000 pixels with constant (red) and minimized (yellow) width and height.



Regular grid 2000 x 3000 pixels with constant (red) and minimized (yellow) width and height.



X axis filling with tile height 2000 pixels (yellow)



Y axis filling with tile width 2000 pixels (yellow)

Rectify mosaic

Not Lite

Rectify mosaic command starts the production of an orthophoto mosaic.

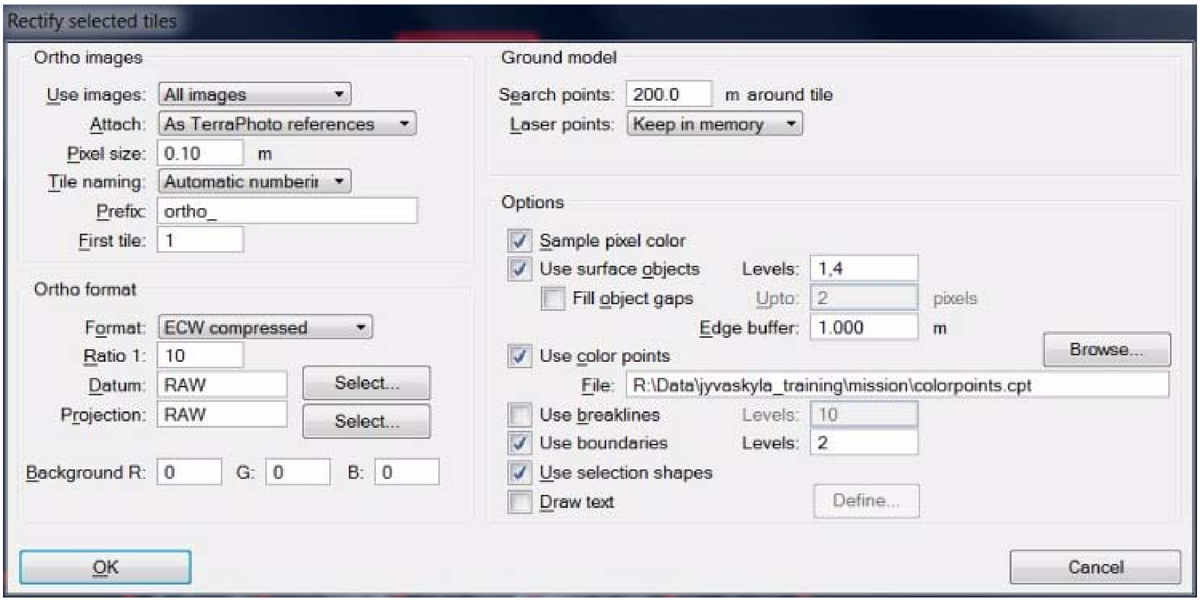
Various rectification settings control the quality and the speed of the rectification process. TerraPhoto can produce lower quality ortho photos very fast. In contrast, if you select the highest quality options, the application uses a more complex process which takes a longer time. The different settings are illustrated in Chapter **Orthophoto Production** on page 162.

The process requires the selection of rectangular shape elements prior to starting the command. The rectangular shapes specify the tiles of the resulting orthophoto mosaic. They are preferably created with **Place tile array** command or *Place Tile Array* tool in TerraPhoto, but any MicroStation tool the produces rectangular shapes can be used as well.

➢ **To create an ortho photo mosaic:**

1. Use MicroStation *Selection* tool in order to select tile shapes and (optional) text elements for naming the tiles.
2. Select **Rectify mosaic** command from the **Rectify** pulldown menu.

   This opens the **Rectify selected tiles** dialog:



3. Define settings and click OK.

   This starts the rectification process. The software produces one orthophoto for each selected tile.

Setting:	Effect:
Use images	Raw images to use: **All images** or **Selected**.
Attach	Defines how to display the produced ortho images: • **Do not attach -** no display. • **As TerraPhoto references -** attach and display as reference files in TerraPhoto. • **As MicroStation references -** attach and display as MicroStation raster references *(not MicroStation V8i)*.
Pixel size	Pixel size of the orthophotos. This should be the same or a multiple of the pixel size used when creating the tiles.

Setting:	Effect:
Tile naming	Tile naming method. In addition to user-defined tile naming schemes, you can select from: • **Automatic numbering -** application assigns increasing numbers to tiles in selection order. • **Selected names -** a selected text element inside each tile is used. • **Selected numbers -** a selected numerical text element inside each tile is used. User-defined tile naming schemes are defined in **Tile naming schemes** of TerraPhoto **Settings**.
Prefix	Text that is included in the tile names before the numbering or the selected text elements.
First tile	Number of the first selected tile. This is only active if **Tile naming** is set to **Automatic numbering**.
Ratio	Compression ratio for **ECW** or **JPEG2000** files.
Datum	Datum information that is written in the header of **ECW** and **JPEG2000** files. Commonly used datum names can be selected by using the **Select** button.
Projection	Projection information that is written in the header of **ECW** and **JPEG2000** files. Commonly used projection names can be selected by using the **Select** button.
Color depth	Defines how color values are stored in **GeoTIFF** files: **8 bit**, **3*8 bit**, **3*16 bit**, **n*8 bit**, **n*16 bit** where **n** is the number of channels in the created orthophoto.
Create TFW file	If on, external georeference files are created for **GeoTIFF** files. The files have the extension .TFW.
Coord system	Coordinate system information that is written in the header of GeoTIFF files. Commonly used coordinate system names and numbers can be selected by using the >> button.
Format	Raster file format to produce: **ECW compressed**, **GeoTIFF**, or **JPEG2000**.
Background R, G, B	RGB color values for locations outside the image area.
Search points	Margin around each tile for searching ground model points.
Laser points	Memory handling of ground model points: • **Keep in memory** - keep all ground model points in memory. • **Save temporarily -** save laser points temporarily, load only needed points for each tile and reload all points at the end of the process. • **Abandon -** free laser point memory, load only needed points for each tile but do not reload points at the end of the process.
Cache	Image cache increase in megabytes for the rectification task. This is only active if **Laser points** is not set to **Keep in memory**.
Sample pixel color	If on, the pixel color for the orthophoto is computed by sampling a circular area of the raw image.
Use surface objects	If on, true orthophotos are produced using shapes from given **Levels** in addition to the rectification surface.
Fill object gaps	If on, small gaps **Up to** the given amount of pixels next to surface objects in true orthophotos are filled. This is only active if **Use surface objects** is switched on.
Edge buffer	Distance from the edge of a 3D object within which object pixels are not rectified on the ground. The prevents, for example, roof pixels to be rectified on the ground next to buildings. This is only active if **Use surface objects** is switched on.

Setting:	Effect:
Use color points	If on, color points from the selected file are used to balance brightness and color differences between images.
Use breaklines	If on, breaklines from the given **Levels** are add to the ground model and thus, included in the rectification process.
Use boundaries	If on, polygons from the given **Levels** are used to limit the area that is filled with raw image information. Pixels outside the polygons are filled with the given **Background RGB** color.
Use selection shapes	If on, selection shapes stored in the active design file are used in the rectification process.
Draw text	If on, a text is burned into each ortho photo. This can be used, for example, to at a watermark to all orthophotos. The text as well as size, color, transparency, and position of the text can be set by using the **Define** button.

Rectify wall rasters

Not Lite

Rectify wall rasters command starts the production of wall texture files. Wall textures can be created from oblique images from an airborne system or from side-looking images from a ground-based mobile system. The textures are created as raster files which are used when a view is rendered with *Display Rendered View* tool in TerraPhoto. In addition, MicroStation material table and palette files can be created in order to use the wall textures for MicroStation rendering.

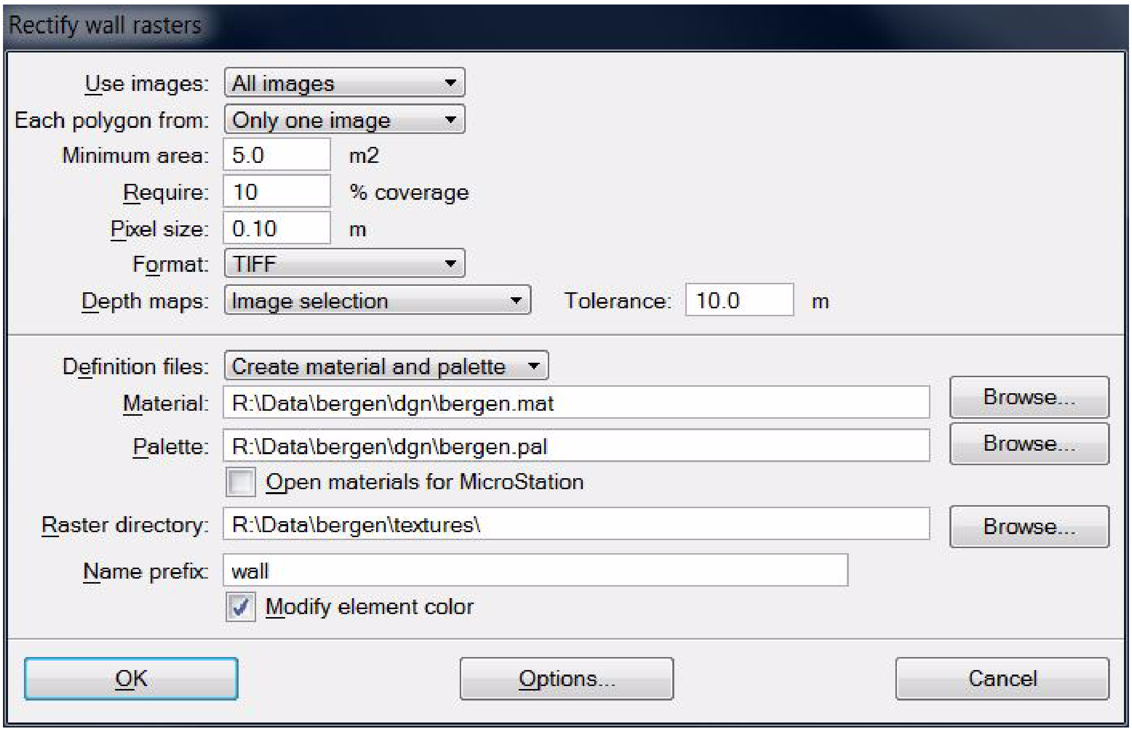
The process requires the selection of 3D building vector models prior to starting the command. The vector models can been created, for example, with TerraScan tools for building vectorization.

The software decides what image to use for a wall polygon based on the viewing direction and percentage of wall area seen by the image. Depth maps created in TerraPhoto can support the creation of wall textures. See **Compute depth maps** for more information about depth maps.

➢ **To create wall textures:**

1. Use MicroStation *Selection* tool in order to select 3D vector models of buildings.
2. Select **Rectify wall rasters** command from the **Rectify** pulldown menu.

   This opens the **Rectify wall rasters** dialog:



3. Define settings and click OK.

   This starts the rectification process. The software produces raster file(s) for each selected wall polygon.
4. Save the design file and the design file settings in order to save the references to the wall raster files.

Setting:	Effect:
Use images	Raw images to use: **All images** or **Selected**. Alternatively, the name of one camera can be selected from which to use the images.

Setting:	Effect:
Each polygon from	Defines the amount of images that are used for creating a texture for a wall polygon: • **Only one image -** the best image is used. • **Upto two|three|four best -** up to two|three|four best images are used. • **Any number of images -** any amount of images can be used.
Minimum area	Smallest wall area for which the software creates a texture file.
Require	Minimum percentage of a wall polygon that an image must cover in order to be considered for texture creation.
Pixel size	Pixel size of the wall textures.
Format	Raster file format to produce: **BMP**, **JPG**, or **TIFF**.
Depth maps	Method of using depth maps in the rectification process: • **Do not use -** depth maps are not used. • **Image selection -** the best image(s) are used even if there are obstructing objects in the image(s). • **Selection and obstruction -** an image is not used if there are obstructing objects in the image. This may result in blank areas for walls.
Tolerance	Distance from a wall in depth maps, within which objects in front of the wall are ignored. This is only active if **Depth maps** are used.
Definition file	Defines how the software creates material table and palette files: • **Create material and palette -** both file types are created. • **Add to existing palette -** the new textures are added to an existing palette file.
Material	Directory and name of the material table file.
Palette	Directory and name of the palette table file.
Open materials for MicroStation	If on, the material table and palette files are opened in MicroStation and thus, are available for MicroStation rendering.
Raster directory	Directory for storing the wall texture files on a hard disk.
Name prefix	Text to add before an increasing number for naming the wall texture file.
Modify element color	If on, the color of the wall shape in the 3D model is changed to the average color of the texture pixels.

View pulldown menu

Commands from the **View** pulldown menu are used to control the appearance of the **TPhoto Main** window, to sort images in the image list, to create or remove camera views, and to fit a view to show the entire area covered by images.

To:	Choose menu command:
Switch main window to minimal size	**Minimal dialog**
Switch main window to small size	**Small dialog**
Switch main window to large size	**Large dialog**
Set columns which are visible in the main window	**Fields**
Sort the images in the image list	**Sort images**
Setup a perspective view using an image from the list	**Create camera view**
Stop displaying a perspective image in a view	**Remove camera view**
Fit a view to show area covered by all images	**Fit view**

Minimal dialog

Minimal dialog command changes the **TPhoto Main** window to a minimal size which consists of a title bar and pulldown menus only.

Small dialog

Small dialog command changes the **TPhoto Main** window to a small size which consists of a title bar, the pulldown menus, and a small size list displaying the active image list.

Large dialog

Large dialog command changes the **TPhoto Main** window to a large size which consist of a title bar, the pulldown menus, and a large size list displaying the active image list.

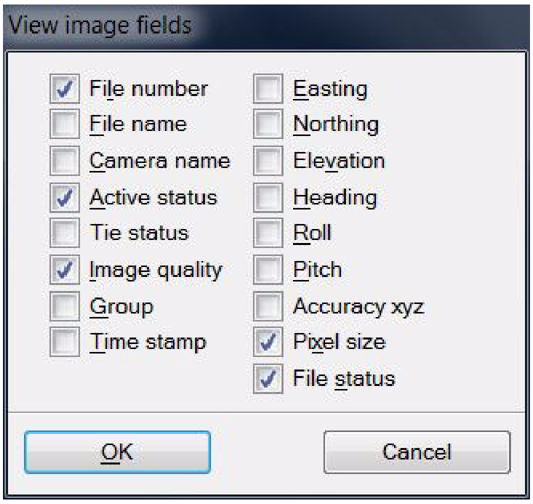
Fields

Fields command lets you select which attributes are displayed for each image in the image list. The command is only active if the **TPhoto Main** window size is set to a **Small dialog** or **Large dialog**.

➢ **To select visible fields:**

1. Select **Fields** command from the **View** pulldown menu.

   This opens the **View image fields** dialog:



2. Select fields and click OK.

Field:	Description:
File number	Internal image number.
File name	Name of the image file.
Camera name	Name of the camera that captured the image.
Active status	Image status for ortho rectification.
Tie status	Image status for placing tie points.
Image quality	Number that indicates the quality of the image.
Group	Group number of the image.
Time stamp	Time stamp of the camera position when the image was captured.
Easting	Easting coordinate of the image position (focal point).
Northing	Northing coordinate of the image position (focal point).
Elevation	Elevation coordinate of the image position (focal point).
Heading	Heading angle of the image orientation. Given in degree.
Roll	Roll angle of the image orientation. Given in degree.
Pitch	Pitch angle of the image orientation. Given in degree.
Accuracy xyz	Accuracy estimate of the image xyz positioning.
Pixel size	Size of a raw image pixel on a rectification surface.
File status	Indicates whether the image file is available in the image directory on the hard disk or not.

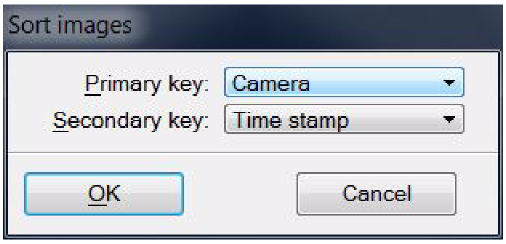
Sort images

Sort images command can be used to sort the images of the active image list according to two attributes.

➢ **To sort the images of the image list:**

1. Select **Sort images** command from the **View** pulldown menu.

   The **Sort images** dialog opens:



2. Select a **Primary key** and **Secondary key** for sorting the images.
3. Click OK.

   The images are sorted according to the selected attributes.

4. Save the image list using **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Setting:	Effect:
Primary key	Attribute used first for sorting the images: • **Camera -** camera name. The order is defined by the order of cameras in the mission definition. • **Time stamp -** increasing time stamps. • **Number -** increasing internal image numbers. • **Angle from vertical -** increasing angle off from vertical. • **Pixel size -** increasing pixel size of the images. • **Tie point value*** - increasing amount of tie points in the image. • **Tie point coverage*** - increasing coverage of the image by tie points. • **Tie point mismatch*** - increasing average mismatch of the image calculated from tie points. • **Tie status -** image status for tie point placement. Approved images are at the end of the image list. • **Quality -** increasing quality number. * Attributes are only available for sorting if tie points are loaded into TerraPhoto.
Secondary key	Attribute used second for sorting the images: • See **Primary key** attributes. • **None -** no secondary key is used for sorting.

Create camera view

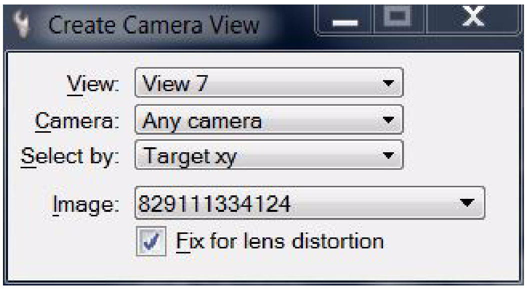
Create camera view command sets up a window as a perspective view displaying the world as seen by a camera when recording one of the raw images. In addition to displaying the image file, a camera view can display laser points and vector elements projected into the same perspective view.

MicroStation views can act as orthographic or as perspective views. An orthographic view is like a map. There is no specific viewer location and equal size objects are drawn with the same size on the screen. A perspective view has a specific viewer or camera location. Objects close to the viewer occupy a larger space on the screen than distant objects. Perspective views correspond to the way we see the world.

➢ **To create a camera view:**

1. Select **Create camera view** command from the **View** pulldown menu.

   The **Create Camera View** dialog opens:

2. Select the target view in the **View** field.

   If the mouse pointer is moved inside a view, the application displays the footprint of the closest image.

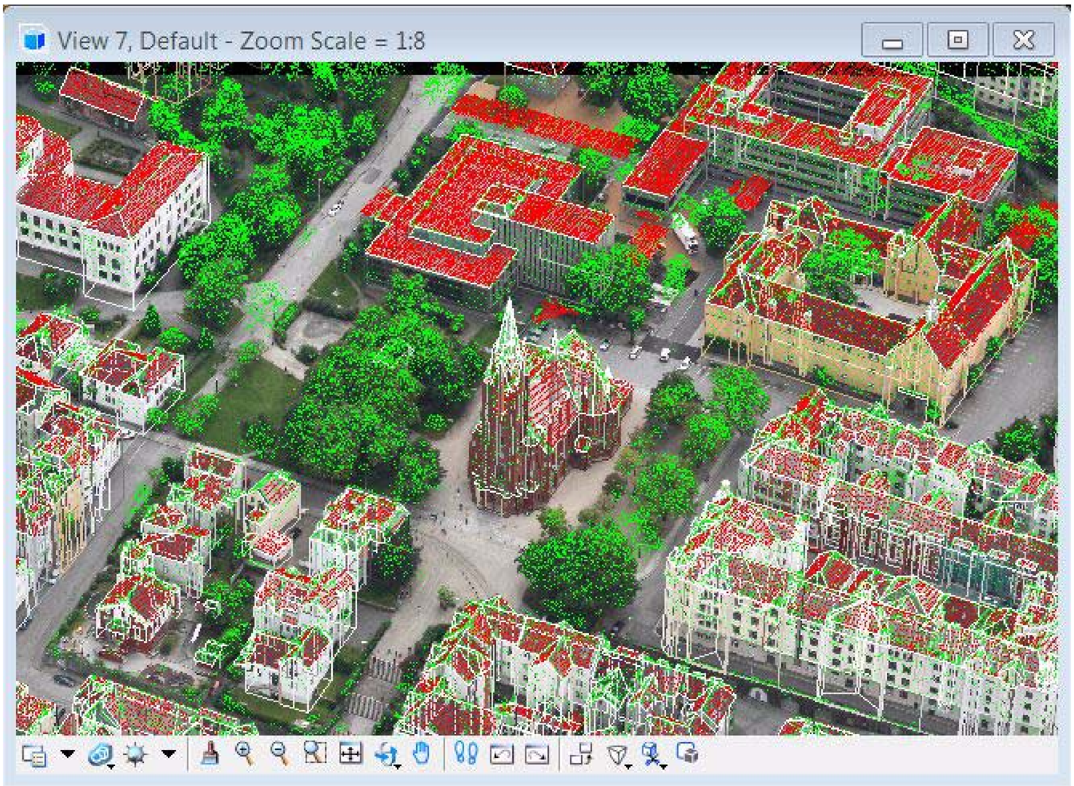
3. Identify a location with a data click to select which image to use.

   This sets the **Camera** attribute on in the view. The camera location is set to the xyz position of the camera when the selected image was captured. The selected image is displayed in the view as well as laser data and vector elements, if available.

   The display of laser data can be managed using the **Display** dialog of TerraScan. The display of vector elements is organized in the **Level Display** dialog of MicroStation.

Setting:	**Effect:**
View	MicroStation view for displaying the camera view.
Camera	Name of the camera from which to display the images. Alternatively, images from **Any camera** can be selected for display.
Select by	Defines the selection method of images for display: • **Camera xy** - the image with the camera xy position closest to the mouse pointer is selected. • **Target xy** - the image with the target xy position closest to the mouse pointer is selected. • **Target xyz** - the image with the target xyz position closest to the mouse pointer is selected.
Image	Number of the image selected for display. The selection list contains all images of the active image list.
Fix for lens distortion	If on, the image is displayed with applied lens distortion correction. The lens distortion is defined in the **TerraPhoto camera dialog** dialog.

✍ Camera views are excellent for comparing laser data and/or vector elements to images. You can compare any objects regardless of the elevation - you are not limited to ground objects as with rectified images. The figure below illustrates a camera view of an oblique image overlayed with laser data (points on roofs and high vegetation) and 3D vector models of buildings.



Remove camera view

Remove camera view command deactivates a camera view that has been set up earlier.

➢ **To deactivate a camera view:**

1. Select **Remove camera view** command from the **View** pulldown menu.
2. Place a data click inside the view.

   This deactivates the camera view display by switching the **Camera** attribute off for that view. You can continue with step 2 for other views.

Fit view

Fit view command rotates a view to top rotation and fits it to display the area covered by all images of the active image list.

➢ **To fit a view to display all raw images:**

1. Select **Fit view** command from the **View** pulldown menu.
2. Place a data click inside the view.

   This rotates the view to top rotation, fits the view to all images, and redraws the view. You can continue with step 2 for other views.

Utility pulldown menu

Commands from the **Utility** pulldown menu are used to start various processing steps for images of the active image list.

To:	Choose menu command:
Draw image footprints as shape elements	**Draw footprints**
Draw image coverage as pyramids extending to camera	**Draw projections**
Analyze brightness distribution of images	**Analyze images**
Adjust image colors	**Adjust images**
Assign a group number to images	**Assign groups**
Assign trajectory numbers to images	**Deduce line numbers**
Create thumbnail images for different resolution ratios	**Create thumbnails**
Create depth maps	**Compute depth maps**
Create shadow maps	**Compute shadow maps**
Create text files that store orientation values for images	**Export orientation**
Copy needed images from central storage	**Transfer images**
Rectify raw images	**Rectify images**
Adjust image angles and focal length visually	**Adjust image angles**
View raw images	**View images**
Open TerraPhoto **Settings** dialog	**Settings**

Draw footprints

Draw footprints command draws the footprints of images as shape elements into the design file. A footprint shape shows the area covered by the image on the rectification surface, i.e. usually the ground.

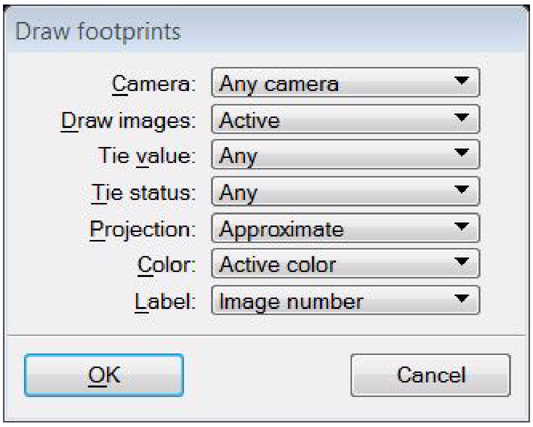
The tool may be useful for the following tasks:

- To locate places where there is redundant imagery caused by multiple overlapping flightlines.
- To locate gaps between images. This can be easily seen if you change the created footprint shapes to be filled with a color.
- To identify images that do not have enough tie points. The tie point value that is required for a well-defined image is set in **Tie points / Display** of the TerraPhoto **Settings**.
- To locate images that belong to the same group.

➢ **To draw image footprints:**

1. Select **Draw footprints** command from the **Utility** pulldown menu.

   This opens the **Draw footprints** dialog:



2. Select settings and click OK.

   This draws the footprint shapes into the design file using active level and symbology settings.

Setting:	Effect:
Camera	Name of the camera of which images are drawn. Alternatively, image footprints from **Any camera** can be drawn.
Draw images	Defines which image footprints are drawn: • **All** - all images. • **Selected** - images selected in the active image list. • **Active** - images with rectification status *Rectify*. • **Inactive** - images with rectification status *No Rect.*
Tie value	Defines which image footprints are drawn related to the tie point value of the images: • **Any** - all images. • **Well defined** - draws images with a tie point value equal or larger than the value defined in TerraPhoto **Settings**. • **Under defined** - draws images with a tie point value smaller than the value defined in TerraPhoto **Settings**. The options **Well defined** and **Under defined** are only active if tie points are loaded in TerraPhoto.

Setting:	Effect:
Tie status	Defines which image footprints are drawn related to the tie point status of the images: • **Any** - all images. • **Check -** draws images with tie point status 'Check'. • **Approve -** draws images with tie point status 'Approved'. The options **Check** and **Approve** are only active if tie points are loaded in TerraPhoto.
Projection	Accuracy of footprint shape to draw: • **Approximate -** uses ground elevation only at camera xy location. The shape is drawn assuming that the ground is flat. • **Accurate -** computes ground elevation at several locations along image edges and produces a more accurate shape.
Color	Color of the footprint shapes: • **Active color -** images inside the rectification surface are drawn with the active color set in MicroStation, images outside the rectification surface are drawn with red (or blue) color. • **Group color -** images are drawn using different colors according to assigned group numbers. The group number determines the color by using the same color number from the active color table in MicroStation. • **Mismatch distance -** images are drawn according to the mismatch computed from tie points. This is only active if tie points are loaded in TerraPhoto.
Label	Text element that is drawn for each footprint shape: • **None -** no label is drawn. • **Image number -** the unique image number. • **Full file name -** the full name of the image.

Draw projections

Draw projections command draws the footprints of all images as well as line elements connecting the image corners on the ground with the camera position. This produces three-dimensional pyramids that illustrate the image projections.

Analyze images

Not Lite

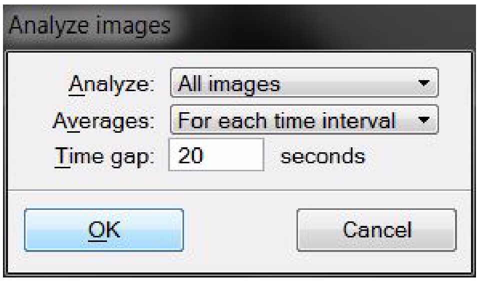
Analyze images command produces a report of color distribution of the images in the active image list. The report contains information about the average red, green, blue, intensity, saturation, and contrast values. The values are computed for each image and averaged for images of one camera or time intervals.

The values from the report may give some idea for color corrections described in Chapter **Color corrections** on page 67.

➢ **To analyze images:**

1. (Optional) Select images in the image list or draw a fence to identify images which you want to analyze.
2. Select **Analyze images** command from the **Utility** pulldown menu.

   This opens the **Analyze images** dialog:



3. Define settings and click OK.

   The application opens a report window which shows the values of the analysis. You can save the report as text file or print it directly from the **File** pulldown menu of the report window. The size of the report window can be adjusted using commands from the **View** pulldown menu.

Setting:	**Effect:**
Analyze	Images that are analyzed: • **All images -** all images from the active image list. • **Selected images -** images selected in the active image list. • **Inside fence -** images inside a fence. • **Outside fence -** images outside a fence.
Averages	Calculation of average values: • **For each camera -** averages values of images per camera. • **For each time interval -** averages values of images per time intervals. This is normally used to get averages for different flight paths.
Time gap	Defines the start of a new time interval for averaging analysis values. If the time difference between consecutive images is larger than the given value, a new time interval starts. This is only active if **Averages** is set to **For each time interval**.

Adjust images

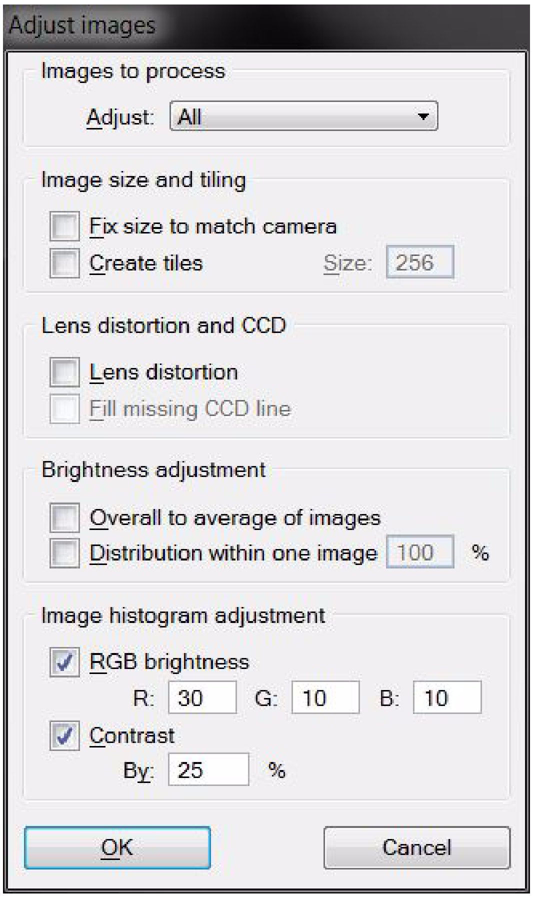
Not Lite

Adjust images command modifies images of the active image list by fixing the size, the lens distortion, or by adjusting brightness or coloring. The modifications effect the original image files.

➢ **To adjust images:**

1. Select **Adjust images** command from the **Utility** pulldown menu.

   This opens the **Adjust images** dialog:



2. Define settings and click OK.

   This processes the images and overwrites the raw image files with the modified versions.

Setting:	Effect:
Adjust	Images effected by adjustments: • **All** - all images of the active image list. • **Selected** - images selected in the active image list. • **<camera name>** - images captured by the selected camera.
Fix size to match camera	If on, the size of raw images is fixed to the image width and height values defined for the selected camera.
Create tiles	If on, the images are converted into tiled TIFFs. The tile size is defined by the **Size** value.
Lens distortion	If on, pixels are moved according to lens distortion values.
Fill missing CCD line	Not yet implemented.
Overall to average of images	If on, the average brightness of images is computed and each individual image is adjusted towards the average.

Setting:	Effect:
Distribution within one image	If on, the brightness of different parts of each raw image is computed and adjusted towards the average brightness. The percentage value determines how much of an individual image is used for computing the brightness.
RGB brightness	If on, red, green, and blue color components are adjusted separately using the given values.
Contrast	If on, the contrast is adjusted by the given percentage value.

✍ It is recommended to avoid modifications of the original raw image whenever possible. Therefore, the command should be used only in exceptional cases. The lens distortion is normally computed on-the-fly by the application based on the camera values. Brightness and color corrections should be applied by using the **Define color corrections** command.

Assign groups

Not Lite

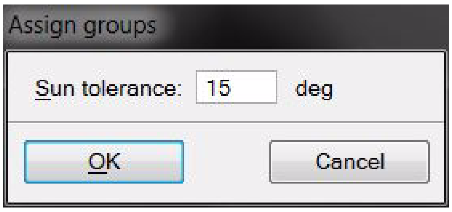
Assign groups command assigns a group number to images based on the sun direction. The group number is stored as attribute for each image in the image list.

The computation of the sun angle requires that the image time stamps are provided in GPS standard time in order to enable the software to derive the date and time of image capture. In addition, the correct projection system must be defined in the mission definition in order to provide the geographical location.

➢ **To assign a group number to images:**

1. Select **Assign groups** command from the **Utility** pulldown menu.

   This opens the **Assign groups** dialog:



2. Define a **Sun tolerance** value and click OK.

   The software assigns group numbers to all images of the active image list. The group number increases if the sun angle in two consecutive images changes more than the given tolerance value.

3. Save the image list using **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the changes into an image list file.

Deduce line numbers

Not Lite

Deduce line numbers command assigns line numbers from trajectories to images. The assignment is based on the time stamp stored for each image and the time stamps stored for trajectory positions.

The command requires that a trajectory are splitted into separate lines. This is the normal case for scanner trajectories in TerraScan. Therefore, it is recommended to use TerraScan trajectories for this command in TerraPhoto.

Line numbers for images are required for placing selection shapes in point clouds. They allow to select the image to use inside a selection shape by line number. See **Place selection** command for point clouds for more information.

➢ **To deduce line numbers for images:**

1. Use **Manage Camera Trajectories** command in order to set a TerraScan trajectory directory as active directory.
2. Select **Deduce line numbers** command from the **Utility** pulldown menu.

   This assigns the trajectory number as line number attribute to the images. An information dialog shows the number of effected images.

Create thumbnails

Not Lite

Create thumbnails command starts the creation of thumbnails for defined resolution ratios. The tool creates GeoTiffs which are stored in the /TEMP directory of the mission. The default file name is ‘thumb<ratio>_<image name>.tif’.

Thumbnails can speed up the image display for different TerraPhoto processes:

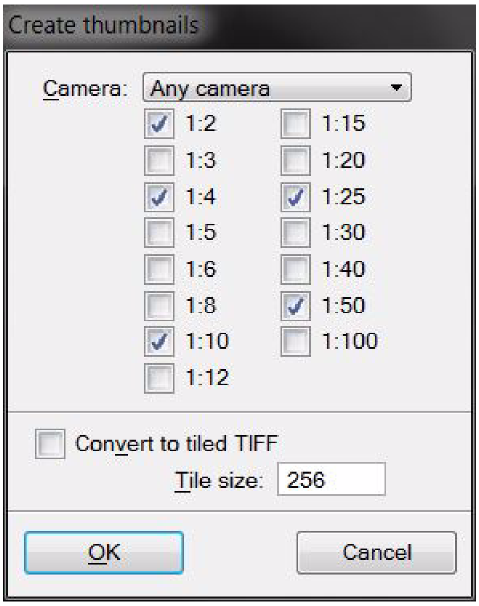
- **Define color corrections** display
- Active full view in tie point mode
- **Define color points** display

If the size of the raw images exceeds 100 MB, tiled TIFFs can be used for many operations. TerraPhoto caches tiles to reduce memory requirements and speed up tasks because only parts of images need to be read. Raw images can be converted into tiled TIFFs in the same process that creates thumbnails.

➢ **To create thumbnails and/or tiled TIFFs:**

1. Select **Create thumbnails** command from the **Utility** pulldown menu.

   This opens the **Create thumbnails** dialog:



2. Define settings and click OK.

   This starts the thumbnail creation. Depending on the amount of images and chosen ratios, this may take a while. A progress bar shows the progress of the process.

Setting:	Effect:
Camera	Name of the camera of which thumbnails are created. Alternatively, thumbnails are created for images of **Any camera**.
Thumbnail ratios	Selection of resolution ratios for which thumbnails are created: • **1:2** - 50% pixel size of a raw image. • **1:3** - 33% pixel size of a raw image. • **1:4** - 25% pixel size of a raw image. • ... • **1:50** - 2% pixel size of a raw image.
Convert to tiled TIFF	If on, raw images are converted into tiled TIFFs. This overwrites the original images in the mission’s image directories.
Tile size	Size of the tiles for converted images in pixels.

Compute depth maps

Not Lite

Compute depth maps command creates depth raster files for each image of the active image list. The pixels in the depth maps encode the distance between the camera position and the closest object represented by laser points or 3D vector elements.

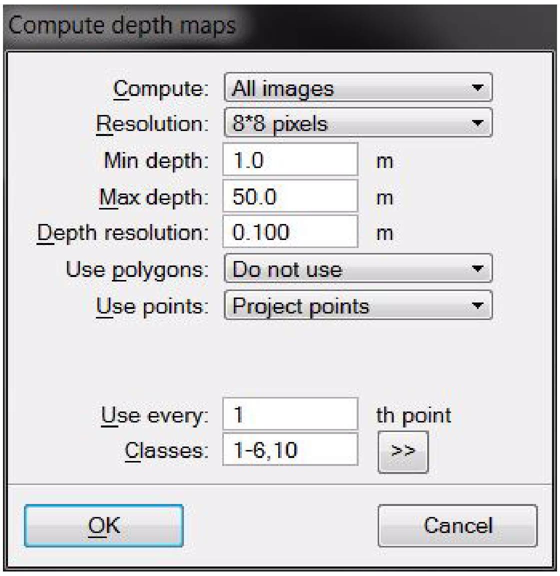
Depth maps are stored in the /TEMP directory of the mission. The files have the extension .DPM. They can be used by several processes:

- deriving the approximate location of tie points if a tie point is entered in one image
- extraction of colors from images to laser points
- production of wall textures

➢ **To compute depth maps:**

1. Select **Compute depth maps** command from the **Utility** pulldown menu.

   The **Compute depth maps** dialog opens:



2. Define settings and click OK.

   This starts the computation process. Depending on the amount of images and selected settings, the process may take some time. A progress bar shows the progress of the process.

Setting:	**Effect:**
Compute	Images for which depth maps are created: • **All -** all images of the active image list. • **Selected -** images selected in the active image list. • **<camera name>** - images captured by the selected camera.
Resolution	Pixel size of the depth maps related to the resolution of the raw images: • **1x1** - one pixel in a depth map equals one pixel in a raw image. • **2x2** - one pixel in a depth map equals the area of two times two pixels in the raw image. • ... • **20x20 -** one pixel in a depth map equals the area of 20x20 pixels in the raw image.
Min depth	Minimum distance between the camera position and an object that is included in the depth maps.
Max depth	Maximum distance between the camera position and an object that is included in the depth maps.

Setting:	Effect:
Depth resolution	Accuracy of the depth value computation. Small values (about 1 mm for mobile data, 1 cm for airborne data) are required for collecting tie points for positional improvement. Bigger values (about 0.1 m to 1 m can be used for the creation of wall textures and extraction of color values.
Use polygons	Determines whether selected 3D polygons are included in the depth maps computation of not. **Selected** is only active if the polygons are selected in MicroStation design file.
Use points	Determines the laser data source for computing depth maps: • **Do not use -** no laser points are used. • **Loaded points -** points that are loaded into TerraScan are used. This is only active if points are loaded in TerraScan. • **Project points -** points of the active project in TerraScan are used. This is only active if a project is loaded in TerraScan.
Use	Defines how to use the laser points related to time stamps: • **All points -** all points are used. • **Close in time only -** only points which are collected within the given time difference from an image are used. This is only active if the time stamps of the laser data match the time stamps of the images.
Within	Time difference between a laser point and an image that determines whether the point is used for depth map computation or not. This is only active if **Use** is set to **Close in time only**.
User every	Defines whether all laser points are used or only every **x**th point. This is only active if **Use points** is not set to **Do not use**.
Classes	Defines which points are used related to classes. Use the >> button in order to open the **Select classes** dialog which lets you select the classes. This is only active if **Use points** is not set to **Do not use**.

✍ Depth maps can be displayed using the **View image** window in TerraPhoto. The window is opened by the **View images** button from the **TPhoto Main** window or the **View images** command from the **Utility** pulldown menu.

Compute shadow maps

Not Lite

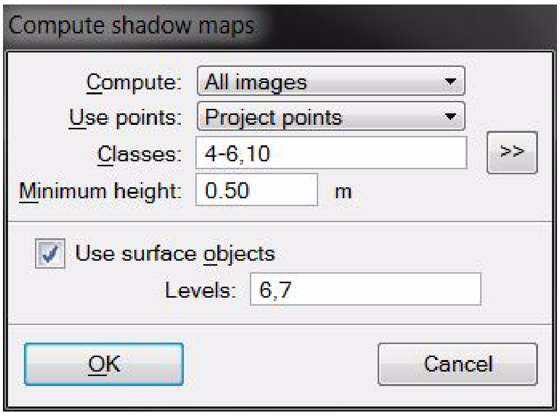
Compute shadow maps command creates raster files for each image of the active image list. The pixels in the shadow map files encode shadow areas close to high objects, such as high vegetation or buildings. The objects are represented by laser points and (optional) 3D vector elements.

Shadow maps are stored as TIFF files in the /TEMP directory of the mission. They are used for automatic tie point and color point placement.

➢ **To compute shadow maps:**

1. Select **Compute shadow maps** command from the **Utility** pulldown menu.

   The **Compute shadow maps** dialog opens:



2. Define settings and click OK.

   This starts the computation process. Depending on the amount of images and selected settings, the process may take some time. A progress bar shows the progress of the process.

Setting:	Effect:
Compute	Images for which shadow maps are created: • **All -** all images of the active image list. • **Selected -** images selected in the active image list. • **<camera name> -** images captured by the selected camera.
Use points	Determines the laser data source for computing shadow maps: • **Loaded points -** points that are loaded into TerraScan are used. This is only active if points are loaded in TerraScan. • **Project points -** points of the active project in TerraScan are used. This is only active if a project is loaded in TerraScan.
Classes	Defines which points are used related to classes. Use the >> button in order to open the **Select classes** dialog which lets you select the classes.
Minimum height	Minimum height of objects that are considered in shadow maps.
Use surface objects	If on, 3D vector elements on the given design file **Levels** are included in the shadow map computation.

Export orientation

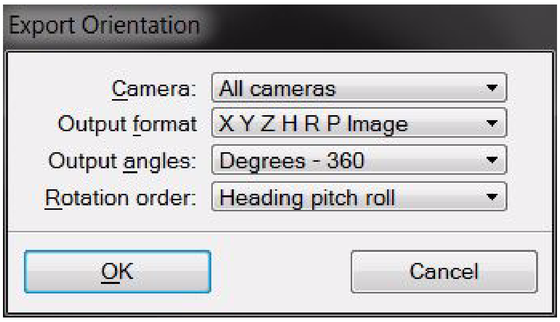
Not Lite

Export orientation command writes the exterior orientation for images of the active image list into a text file. The format of the text file can be defined in **Exterior orientation formats** of the TerraPhoto **Settings**. The output file may contain, for example, the image name, xyz position, as well as orientation angles defined as Heading Roll Pitch or Omega Phi Kappa values.

➢ **To export an orientation text file from the image list:**

1. Select **Export orientation** command from the **Utility** pulldown menu.

   The **Export Orientation** dialog opens:



2. Define settings and click OK.

   This opens the **Exterior orientation file** dialog, a standard dialog for saving files.

3. Define a location and name for saving the text file and click OK.

   This creates the text file.

Setting:	Effect:
Camera	Name of a camera. The output file contains only images captured by the selected camera. Alternatively, images from **All cameras** can be included.
Output format	Name of the exterior orientation format as defined in the TerraPhoto **Settings**. The format is used for the output file.
Output angles	Format of the orientation angles: • **Radians - 2*pi -** radian values normalized between -pi and +pi. • **Degrees - 360 -** degree values normalized between -180 and +180. • **Gons - 400 -** gon values normalized between -200 and +200.
Rotation order	Order of orientation angles required for computing the correct rotation matrix.The most common order is **Heading pitch roll**.

Transfer images

Not Lite

Transfer images command copies missing images from specified source directories into the image directory that is defined in the mission file. Only images that are contained in the active image list are effected by the process. The images of one camera can be transfered in one process.

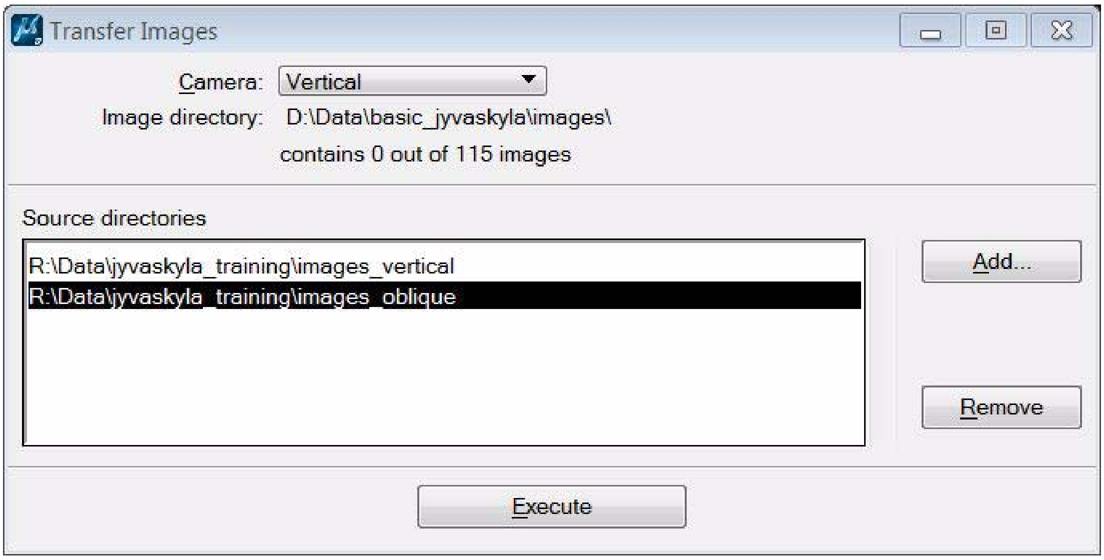
The command is useful, for example, if raw images for an entire project are stored on a central server and you want to copy the needed images to your own hard disk for processing a smaller part of the project. You may use the following workflow:

- Store all raw images on a server.
- Create an image list which contains all images.
- Draw a fence around a smaller part you are working on, delete images outside fence, and save the image list into a new file.
- Use **Transfer images** command to copy needed images from the server to your own hard disk for faster access.

➢ **To transfer images:**

1. Select **Transfer images** command from the **Utility** pulldown menu.

   This opens the **Transfer Images** dialog:



2. Select a camera in the **Camera** list. Only images captured by this camera are transfered.

   Image directory line displays the directory which is specified as the image directory for the selected camera in the mission definition. This is the target directory into which the images are copied.

   The text below the directory line shows how many raw images are already in the target directory.

3. Click **Add** to browse for a source directory from where to copy images.

   This opens a standard dialog for selecting a folder.

   You may continue to step 3 if there are multiple source directories.

4. Click **Execute** to copy the images.

   The image files are copied to the target directory. After the process has finished, you should check the text below the **Image directory** line to make sure that all needed images are copied.

Rectify images

Not Lite

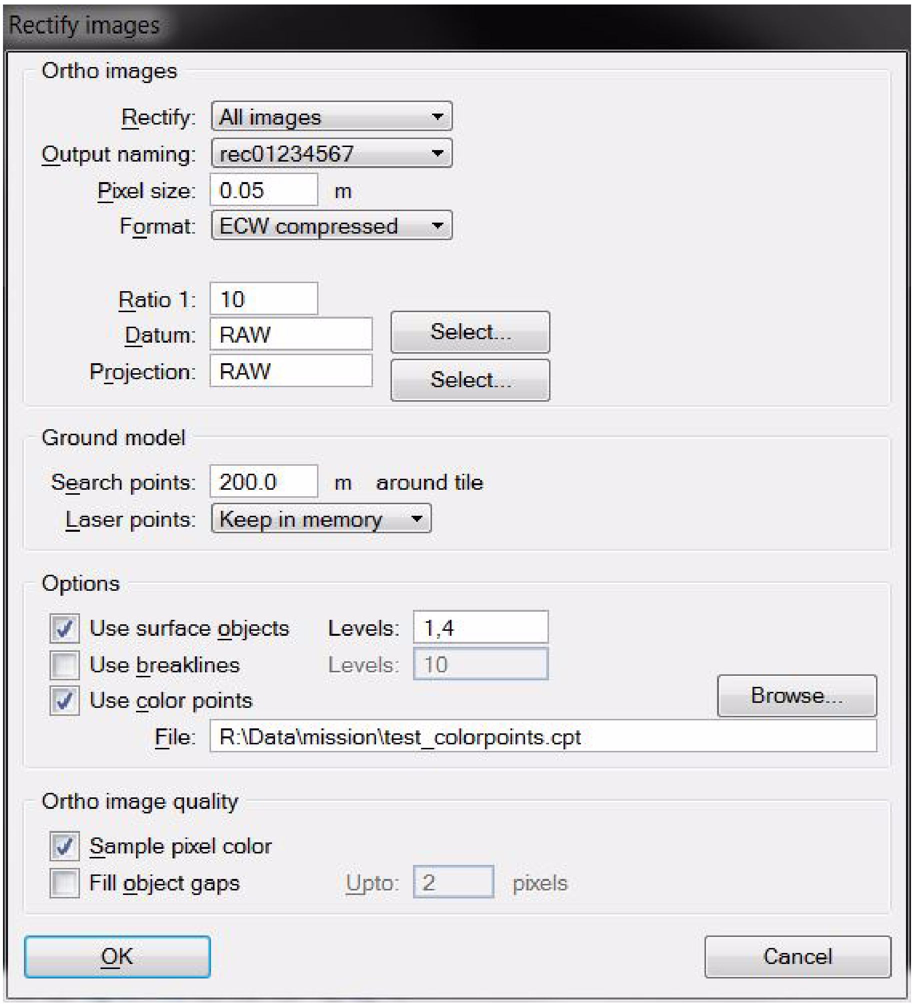
Rectify images command creates rectified images from raw images in the image list. There is no mosaic step which means that for each raw image a new georeferenced image is produced.

The process requires a rectification surface which is usually provided by a ground model. 3D surface objects and breaklines stored in the design file can be included in the rectification process.

➢ **To rectify images:**

1. Select **Rectify images** command from the **Utility** pulldown menu.

   This opens the **Rectify images** dialog:



2. Define settings and click OK.

   This starts the image rectification process. An information window shows the number of rectified images out of the number of all images. The rectified images are stored in the **Rectified images** directory that is defined in the mission definition.

Setting:	Effect:
Rectify	Raw images to use: **All images**, **Selected** or images captured by a given **<camera>**.
Output naming	Naming method of the output files: **Raw file name** or **rec<image number>**.
Pixel size	Pixel size of the ouput images.
Format	Raster file format to produce: **ECW compressed**, **GeoTIFF**, or **JPEG2000**. The following settings depend on the selected format.

Setting:	Effect:
Ratio	Compression ratio for **ECW** or **JPEG2000** files.
Datum	Datum information that is written in the header of **ECW** and **JPEG2000** files. Commonly used datum names can be selected by using the **Select** button.
Projection	Projection information that is written in the header of **ECW** and **JPEG2000** files. Commonly used projection names can be selected by using the **Select** button.
Color depth	Defines how color values are stored in **GeoTIFF** files: **8 bit**, **3*8 bit**, or **16*8 bit**.
Create TFW file	If on, external georeference files are created for **GeoTIFF** files. The files have the extension .TFW.
Coord system	Coordinate system information that is written in the header of GeoTIFF files. Commonly used coordinate system names and numbers can be selected by using the >> button.
Search points	Margin around each image for searching ground model points.
Laser points	Memory handling of ground model points: • **Keep in memory** - keep all ground model points in memory. • **Save temporarily -** save laser points temporarily, load only needed points for each image and reload all points in the end of the process. • **Abandon -** free laser point memory, load only needed points for each image but do not reload points in the end.
Use surface objects	If on, 3D shapes from the given design file **Levels** are used in addition to the ground model. This may result, for example, in roofs of high buildings being at the correct xy location in the rectified images.
Use breaklines	If on, linear elements from the given design file **Levels** are added as breaklines to the ground model.
Use color points	If on, color points from the given **File** are included in the rectification process.
Sample pixel color	If on, the pixel color for a rectified image is computed by sampling a circular area from the raw image.
Fill object gaps	If on, small gaps **Upto** the given size next to surface objects are filled.

Adjust image angles

Not Lite

Adjust image angles command can be used to test and modify the rotation angles and the focal length. The modifications are done on a step-by-step basis and can be checked in **Camera Views**.

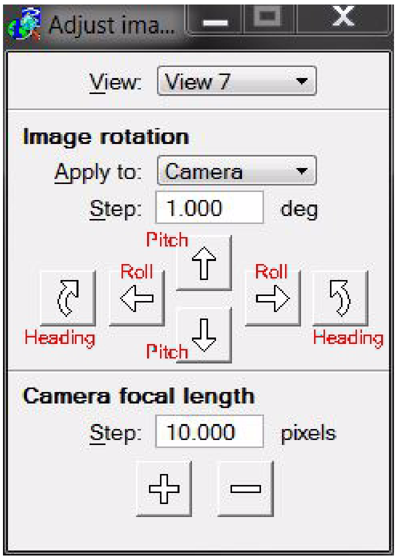
The rotation is adjusted either related to the image or related to the camera. If the modification is applied to the image, the changes in heading, roll, and pitch effect the image list. Angle adjustments applied to the camera and focal length modifications effect the camera file.

The tool is useful, for example, for adjusting individual images more accurately to laser data or for finding approximate camera values for the orientation anlges and the focal length.

➢ **To adjust image angles and focal length:**

1. Create a camera view using the **Create camera view** command. Set up the view display, for example, by loading laser points that can be used for comparing image positioning with laser data.
2. Select **Adjust image angles** command from the **Utility** pulldown menu.

   The **Adjust image angles** dialog opens:



3. Select the **View** that is used as camera view.
4. Select whether to **Apply** the rotation adjustment **to** the **Image** are to the **Camera**.
5. Define a **Step** size for adjusting angles and/or the focal length.
6. Use the arrow buttons in the dialog in order to adjust heading, roll, and pitch.

   AND/OR

7. Use the plus/minus buttons in the dialog in order to adjust the focal lenght.
8. Check the effect of the changes in the camera view.
9. If the rotation angles for an image have been adjusted, select **Save list** or **Save list As** commands from the **Images** pulldown menu in order to save the modifications to an image list file.

   AND/OR

10. If the focal length and/or the rotation of the camera have been changed, save the camera file using the commands of **Camera** dialog which is opened by the *Define Camera* tool.

View images

View images command opens a window for viewing raster images. The window has menu commands for opening raster files, for viewing an image at certain resolution levels, and for testing color, intensity, brightness, and contrast adjustments.

To:	Select menu command:
Open an image file or a depth map file	File / Open
Open the previous image in the active image list	File / Previous image
Open the next image in the active image list	File / Next image
Test histogram, brightness, or contrast adjustments	File / **View histogram**
Display an image at certain resolution levels: • full resolution • half of full resolution • third of full resolution ...	 Zoom / 1:1 Zoom / 1:2 Zoom / 1:3 ...

The **View image** button in the **TPhoto Main** window opens this same window and displays the image selected in the image list.

You can move to the previous image by selecting **File / Previous image** command or by using the <PageUp> key. You can move to the next image by selecting **File / Next image** command or by using the <PageDn> key.

View histogram

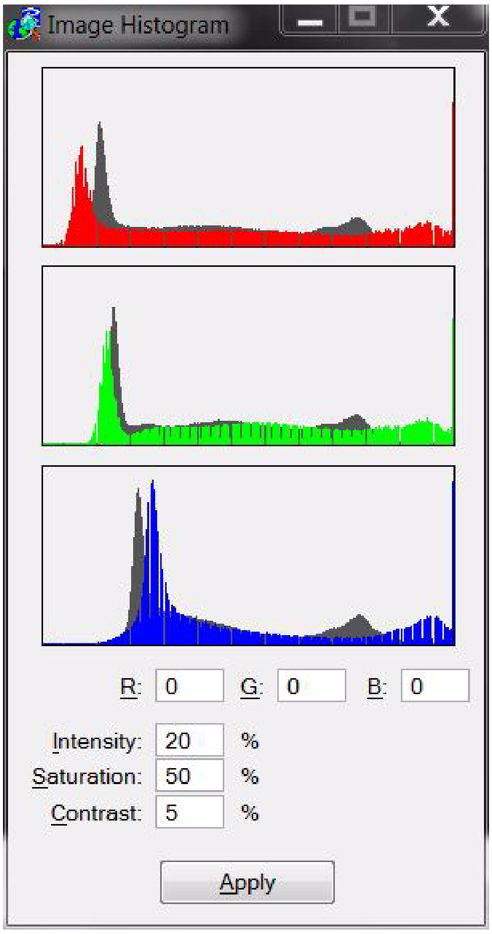
View histogram command can be used to test color, intensity, saturation, and contrast adjustments for the displayed image.

The values tested in the **Image Histogram** dialog are neither stored in the image list not do they modify the original image file. See **Define color corrections** command for correcting color values of images effectively.

➢ **To test histogram adjustments:**

1. Select **View histogram** command from the **File** pulldown menu.

   This opens the **Image Histogram** dialog:



2. Type correction values for **RGB** and/or **Intensity**, **Saturation**, **Contrast**. The values are added to the current pixel values in the image.
3. Click **Apply** in order to see the effect of the changes in the image.

Settings

Settings command opens the TerraPhoto **Settings** dialog for managing user settings. It performs the same action as the *Settings* tool.

Help pulldown menu

Commands from the **Help** pulldown menu are used to open this Users' Guide and to display license information for TerraPhoto.

To:	Choose menu command:
Open the TerraModeler Users' Guide	**Help / Contents**
Display the license information dialog	**Help / About TerraPhoto**

Help / Contents

Contents command launches Acrobat Reader for accessing this Users' Guide in PDF format. It performs the same action as the *Help On TerraPhoto* tool.

17 Manage Trajectories

Trajectories are required for some processing steps in TerraPhoto. They provide positional and, usually, attitude information of the camera system for each point of time during the data collection.

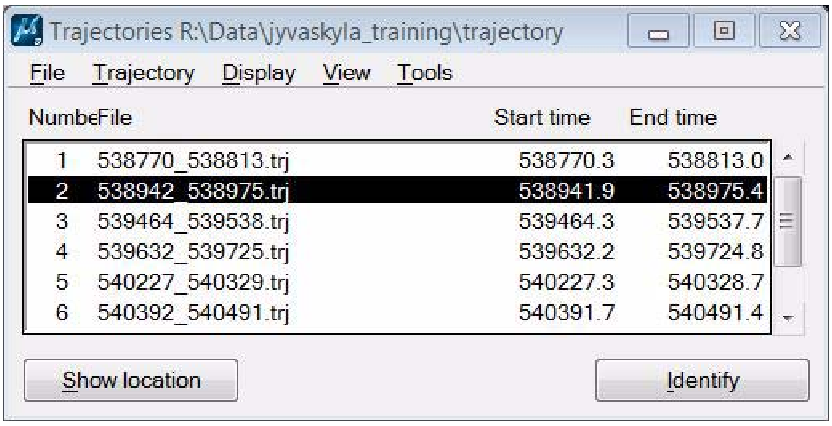
Normally, the raw trajectory is produced by so-called post-processing software that combines the input of GPS and IMU sensors. The raw trajectory may be provided in a binary or ascii file format. TerraPhoto is able to import common binary formats of post-processing software as well as a number of ASCII formats. Additional text file input formats for trajectories can be defined in **Trajectory formats** of TerraPhoto **Settings**. All imported trajectories are converted into the TerraPhoto trajectory binary format (*.TRJ).

TerraPhoto trajectory files are fully compatible with TerraScan and vice versa. Therefore, trajectories that are imported and/or processed in one of the applications, can be used in the other application without any problems.

All commands related to trajectories is combined in the TerraPhoto **Trajectories** window which is opened by the *Manage Camera Trajectories* tool.

TerraPhoto Trajectories window

The **Trajectories** window contains pulldown menu commands for importing, modifying, and managing trajectory information.



The list in the window shows all trajectory files that are stored in the active trajectory folder. The active directory is shown in the title bar of the window.

To select a trajectory, click on the line in the list. Press the **<Ctrl-key>** to select several trajectories.

To show the location of a trajectory, select a line in the list. Click on the **Show location** button and move the mouse pointer into a view. This displays the selected trajectory. With a data click inside the view you can center the selected trajectory in the view.

To identify a trajectory, click on the **Identify** button and place a data click close to a trajectory in a view. This selects the corresponding line in the **Trajectories** window.

File pulldown menu

Commands from the **File** pulldown menu are used to import trajectory information into TerraPhoto.

To:	Use:
Set active trajectory folder	**Set directory**
Import trajectory files	**Import files**
Import trajectory files from a folder and its subfolders	**Import directory**
Import separate text files from GPS and INS sensors	**Merge from GPS and INS**
Import accuracy files for trajectories	**Import accuracy files**

Set directory

Set directory command is used to define the active trajectory directory. The software writes trajectory files into this folder during the import process. It loads TerraPhoto trajectory files from a folder if it is set as active directory and files do already exist. Usually, this is the first command you use when you start working with trajectories.

It is good practice to reserve a folder in your project directory structure for storing trajectories imported into TerraPhoto. In some cases, it might be advisable to save a new copy of TerraPhoto trajectories. Then, you would have multiple trajectory directories in a project and change the active directory whenever needed in order to access the correct set of trajectory files.

➢ **To set the active trajectory directory:**

1. Select **Set directory** command from the **File** pulldown menu.

   This opens the standard dialog for selecting a folder.

2. Select a folder and click OK.

   This sets the active directory to the given folder. TerraPhoto scans the directory. If there are trajectory files in the folder, it reads the header information from each file into memory and displays them in the list.

Import files

Import files command is used to import raw trajectories into TerraScan. During the import, trajectory information is converted into TerraPhoto binary files (*.TRJ).

The input files must contain at least time-stamped position and, for most processing tasks, attitude information. The input files can be:

- text files in one of the implemented ASCII formats.
- binary files from Applanix or Riegl software.
- text files in a user-defined file format, see **Trajectory formats**.

During the import, the software assigns some attributes to the trajectories and can apply coordinate transformations and/or a time stamp format conversion. Most of the settings defined in the import process can be changed later for the converted trajectory files by using the **Edit information** command or commands from the **Tools pulldown menu**.

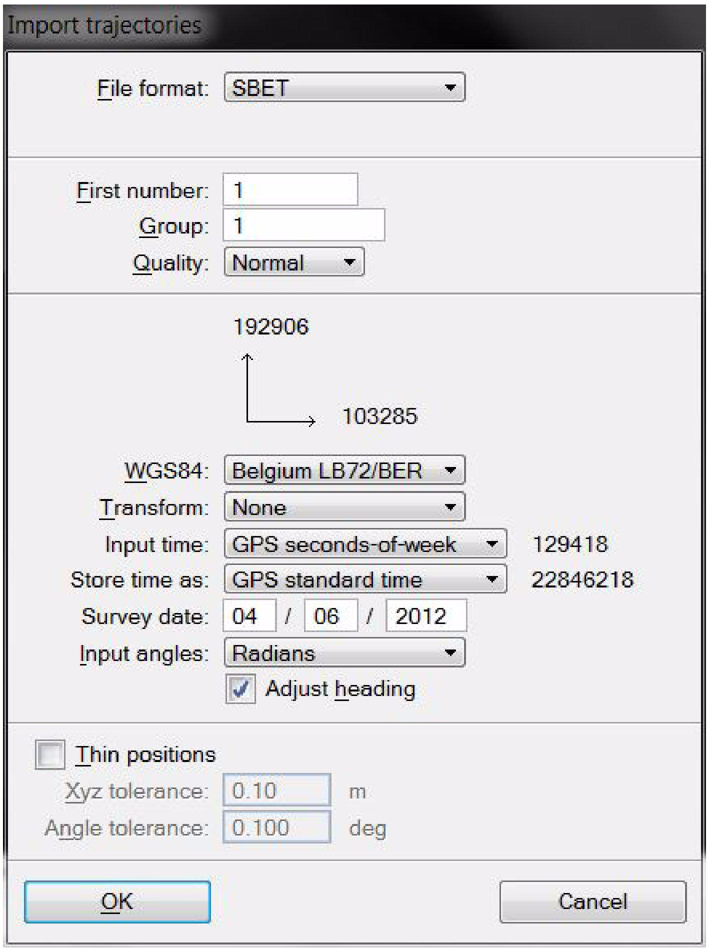
➢ **To import trajectories:**

1. Select **Import files** command from the **File** pulldown menu.

   This opens the **Import trajectory files** dialog, a standard dialog for opening files.

2. Select raw trajectory file(s) and click **Done**.

   The **Import trajectories** dialog opens:



3. Define settings and click OK.

   This imports the trajectory file(s) and stores them as TerraPhoto trajectory binary file(s) into the active trajectory directory. The name of a file is determined by the seconds values of the first and last position in a trajectory file separated by an underline character..

Setting:	**Effect:**
File format	Format of the raw trajectory file. The software tries to detect it automatically. If a text file is imported, the list of formats contains implemented formats as well as formats defined in **Trajectory formats** of TerraPhoto **Settings**.
Attitude format	Format of the INS file. This is only active if **Merge from GPS and INS** command is used to import trajectory information.
First number	Number assigned to the first trajectory file. If more than one file is imported, the files are numbered incrementally.
Group	Group number assigned to the trajectory file(s).
Quality	Quality attribute assigned to the trajectory file(s).
WGS84	Transformation from latitude/longitude coordinates to another projection system. The list contains projection systems that are active in **Coordinate transformations / Builtin projection systems**, **Coordinate transformations / US State Planes** or defined in **Coordinate transformations / User projection systems** of TerraPhoto **Settings**.
Transform	Coordinate system transformation applied to the trajectories. The list contains transformations that are defined in **Coordinate transformations / Transformations** of TerraPhoto **Settings**.
Input time	Format of the time stamps in the raw trajectory file(s): **GPS seconds-of-week**, **GPS standard time**, or **Unix time**.
Store time as	Format of the time stamps in the converted trajectory file(s): **GPS seconds-of-week** or **GPS standard time**. If the format is different from the **Input time** format, time stamps are converted.
Survey date	Date when the trajectory data was captured. The format is day/month/year (dd/mm/yyyy). This is required for the conversion of time stamps from **GPS seconds-of-week** to **GPS standard time** and is only active if **Input time** and **Store time as** are set accordingly.
Input angles	Format of angle values in the raw trajectory file(s): **Degrees**, **Radians**, or **TopEye radians**. This is usually set automatically for implemented input formats.
Adjust heading	If on, the software applies a meridian convergence correction to heading values. The correction is based on the projection system set for **WGS84** or the coordinate transformation set for **Transform**.
Thin positions	If on, intermediate trajectory positions are skipped as long as the trajectory accuracy stays within the given tolerances.
Xyz tolerance	Maximum allowed xyz difference caused by thinning. This is only active if **Thin positions** is switched on.
Angle tolerance	Maximum allowed angular difference caused by thinning. This is only active if **Thin positions** is switched on.

✍ Computing an image list based on trajectory information requires all trajectory positions. Therefore, **Thin positions** setting should be switched off if camera trajectories are imported.

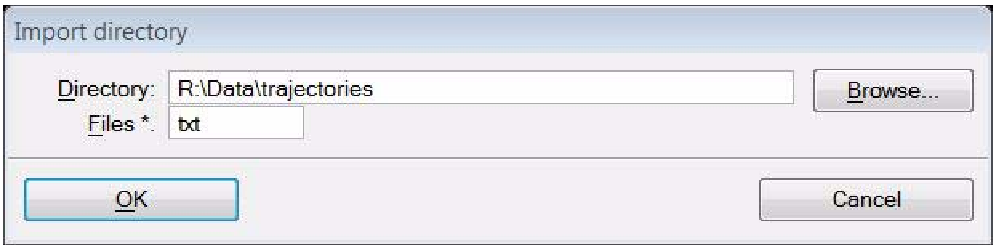
Import directory

Import directory command imports trajectory files into TerraPhoto. All files of the same format in a directory are imported. The import process itself works in the same way as described for the **Import files** command above.

➢ **To import all trajectory files in a directory:**

1. Select **Import directory** command from the **File** pulldown menu.

   This opens the **Import directory** dialog:



2. Define settings and click OK.

   This opens the **Import trajectories** dialog. Follow the steps of **Import files** procedure in order to import the files.

Setting:	Effect:
Directory	Folder from which to import files. Click on the **Browse** button in order to select a folder in the **Browse for Folder** dialog.
Files	Defines the extension of files that are imported. You can use the * character as placeholder for any file extension or type a specific extension.

Merge from GPS and INS

Merge from GPS and INS command creates a trajectory binary file for TerraPhoto from separate GPS and INS files. The GPS file contains time stamps and coordinates for the trajectory positions, while the INS file includes time stamps and orientation angle values for the same trajectory positions. The software combines the two input files using the time stamp.

The GPS and INS files are usually text files. The format of the files can be defined in **Trajectory formats** of TerraPhoto **Settings**.

➢ **To create a trajectory from GPS and INS files:**

1. Select **Merge from GPS and INS** command from the **File** pulldown menu.

   This opens the **GPS positions files** dialog, a standard dialog for opening files.

2. Open the file that contains the positional information.

   This opens the **INS attitude files** dialog, a standard dialog for opening files.

3. Open the file that contains the attitude information.

   The **Import trajectories** dialog opens. See **Import files** for a description of the settings in the dialog.

4. Define settings and click OK.

   The software combines the two input files and creates the binary trajectory file in the active trajectory directory.

Import accuracy files

Import accuracy files command imports an output file from post-processing software that contains accuracy estimates for each trajectory position. The file includes the RMS values for xyz positions as well as for heading, roll, and pitch angles. It is connected to the trajectory file by the time stamp.

TerraPhoto can import the accuracy files from Applanix and IPAS SOL software. The RMS values are stored in the binary trajectory files. TerraPhoto stores only four RMS values for each trajectory position: x/y, z, heading, roll/pitch.

The information from the accuracy files is used for computations based on certain tie point types or for drawing trajectories into the design file.

➢ **To import an accuracy file:**

1. Import the trajectory file(s) as described in **Import files** or **Import directory**.
2. Select **Import accuracy files** command from the **File** pulldown menu.

   This opens the **Import accuracy files** dialog, a standard dialog for opening files.
3. Open the accuracy file delivered by the post-processing software.

   This reads the file and connects the RMS values to the trajectory. The values are saved automatically to the binary trajectory files in the active trajectory directory. A dialog informs about the number of positions for which RMS values are available.

Trajectory pulldown menu

Commands of the **Trajectory** pulldown menu are used to modify information of a trajectory, to set the accuracy of trajectory positions, to delete trajectory files, and to view the positions of a trajectory.

To:	Use:
Modify trajectory information	**Edit information**
Set trajectory accuracy values	**Set accuracy**
Delete selected trajectories	**Delete**
Display trajectory positions information	**View positions**

The commands of the pulldown menu are only available if at least one trajectory is selected in the **Trajectories** window.

Edit information

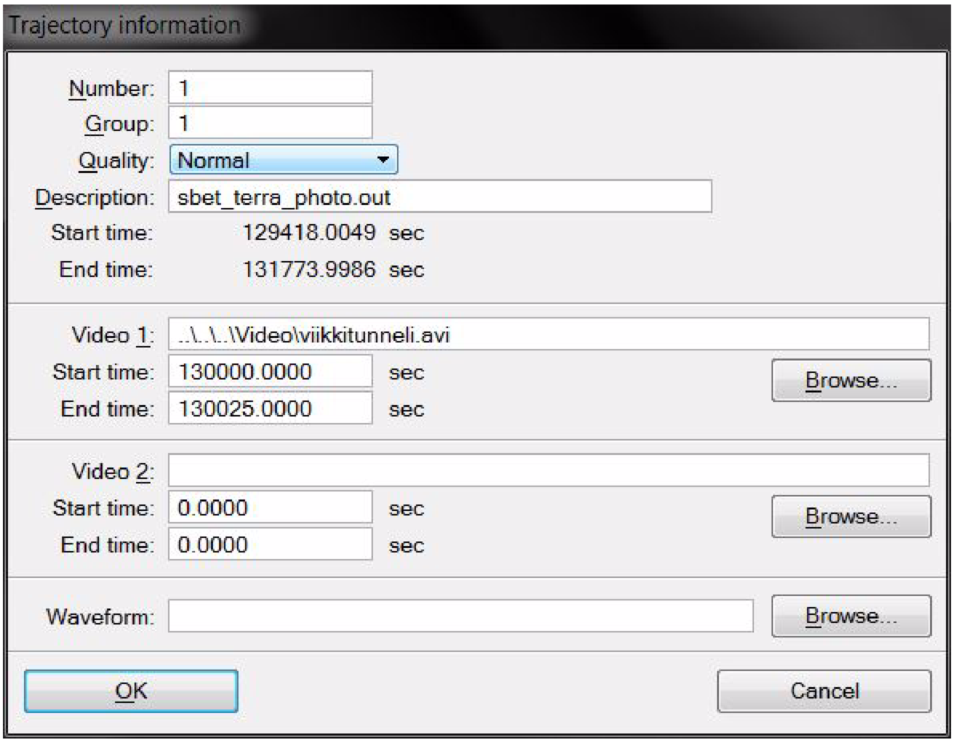
Edit information command opens a dialog that contains basic information and attributes stored for a selected trajectory. The attributes can be modified. Modifications are immediately stored in the binary trajectory file.

In addition, up to two video files can be linked to a trajectory and a waveform file can be linked to a trajectory. The waveform file settings are not actively used by TerraPhoto but required for the compatibility of trajectories with TerraScan.

➢ **To modify trajectory information:**

1. Select a trajectory in the list of the **Trajectories** window.
2. Select **Edit information** command from the **Trajectory** pulldown menu.

   This opens the **Trajectory information** dialog:



3. Define settings and click OK.

   This modifies the information in the header of the corresponding .TRJ file.

Setting:	Effect:
Number	Number of the trajectory (= flightline number).
Group	Group number of the trajectory. Different groups may be used, for example, to distinguish flight sessions.
Quality	Quality attribute of the trajectory.
Description	Text that describes the trajectory. By default, the name of the raw trajectory file is used as descriptive text.
Video 1	Primary video file linked to the trajectory. This video is referred to as **Vertical video**, for example, by **Verticle video** command.
Start time	GPS time stamp of the start position of **Video 1**.
End time	GPS time stamp of the end position of **Video 1**.
Video 2	Secondary video file linked to the trajectory. This video is referred to as **Forward video**, for example, by **Forward video** command.
Start time	GPS time stamp of the start position of **Video 2**.
End time	GPS time stamp of the end position of **Video 2**.

Setting:	Effect:
Waveform	Waveform data file linked to the trajectory. This is not actively used by TerraPhoto but required for the compatibility of trajectories with TerraScan.

✍ TerraPhoto requires that you specify both, the start time and the end time of a video file in GPS time stamp format. Normally the end time should be equal to the length of the video file added to the start time. The ability to specify the end time explicitly allows you to compensate for possible inaccuracy of the video clock. The application scales the display speed of the video file in order to cover the given time interval.

✍ If you select several trajectories in the **Trajectories** window, the **Edit information** command opens the **Edit several trajectories** dialog. This dialog allows you to modify only settings which may apply for several trajectories, such as **Group** and **Quality** settings.

Set accuracy

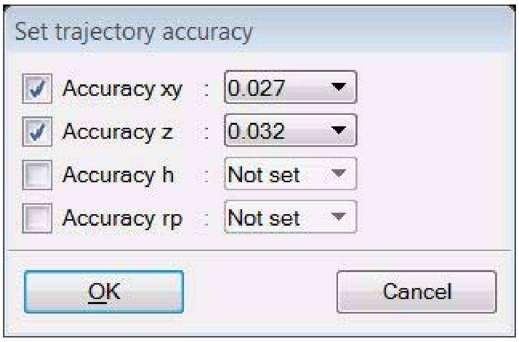
Set accuracy command defines accuracy estimates for all positions of one or more selected trajectories. Accuracy estimates are mainly used in TerraMatch for computing weighted corrections for strip matching. They also effect tie points that are collected in TerraPhoto for matching purposes. See Chapter **Working with Tie Points** on page 76 for more information about tie points.

Accuracy estimates may be computed for each trajectory position by the post-processing software together with the other attributes, such as coordinates and attitude angles. However, if the values are not provided, the command offers a way to assign accuracy estimates to trajectories manually.

➢ **To set the accuracy for trajectory files:**

1. Select one or several trajectories in the list.
2. Select **Set accuracy** command from the **Trajectory** pulldown menu.

   This opens the **Set trajectory accuracy** dialog:



3. Switch on the accuracy type that you want to set
4. Select an accuracy estimate value from the list.
5. Click OK.

   The sets the accuracy for all positions of all selected trajectories.

Setting:	Effect:
Accuracy xy	Horizontal accuracy estimate.
Accuracy z	Vertical accuracy estimate.
Accuracy h	Heading accuracy estimate.
Accuracy rp	Roll and pitch accuracy estimate.

Delete

Delete command deletes one or more selected trajectory files. The entries for the files are removed from the list and the binary files are deleted from the hard disc.

➢ **To delete trajectories:**

1. Select the trajectory file(s) in the list.
2. Select **Delete** command from the **Trajectory** pulldown menu.

   A dialog asks to confirm the removal of the file(s).

3. Click **Yes** in order to delete the selected file(s).

   A dialog informs about the deletion process.

View positions

View positions command can be used to display the single positions of a trajectory file. The command opens a window that shows the list of positions and for each position the attributes stored in the trajectory file. This may include the time stamp, coordinate values, heading, roll, and pitch values, as well as RMS values.

➢ **To view trajectory positions:**

1. Select a trajectory file in the list.
2. Select **View positions** command from the **Trajectory** pulldown menu.

   This opens the **View trajectory positions** dialog which contains the list of trajectory positions.

To show the location of a trajectory position, select a line in the list of positions. Click on the **Show location** button and move the mouse pointer into a view. This highlights the selected position with a cross. Place a data click inside a view in order to center the display at the selected position.

To identify a position, click on the **Identify** button and place a data click close to a trajectory in a view. This selects the line of the position closest to the data click in the **View trajectory positions** dialog.

Display pulldown menu

Commands from the **Display** pulldown menu in the **Trajectories** window are used display video files.

To:	Use:
Display the vertical or forward video file in TerraPhoto Video Viewer	**Verticle video** **Forward video**

Verticle video

Verticle video command opens the TerraPhoto **Video Viewer** with the video file that is linked to a trajectory as **Video 1** in the **Trajectory information** dialog. See **Edit information** command for information about linking a video file to a trajectory.

General settings for the display of videos in TerraPhoto are defined in **Video / Display** and **Video / Misalignment** of TerraPhoto **Settings**.

➢ **To start the Video 1 file of a trajectory:**

1. Select the trajectory in the list.
2. Select **Vertical video** command from the **Display** pulldown menu.

   The **Video Viewer** opens.

3. Display the video by using the control buttons of the viewer.

✍ The command performs a similar action as the *Display Video* tool. However, the command does not start the video display automatically.

Forward video

Forward video command opens the TerraPhoto **Video Viewer** with the video file that is linked to a trajectory as **Video 2** on the **Trajectory information** dialog. See **Edit information** command for information about linking a video file to a trajectory.

General settings for the display of videos in TerraPhoto are defined in **Video / Display** and **Video / Misalignment** of TerraPhoto **Settings**.

➢ **To start the Video 2 file of a trajectory:**

1. Select the trajectory in the list.
2. Select **Forward video** command from the **Display** pulldown menu.

   The **Video Viewer** opens.

3. Display the video by using the control buttons of the viewer.

✍ The command performs a similar action as the *Display Video* tool. However, the command does not start the video display automatically.

View pulldown menu

Commands of the **View** pulldown menu are used to change the size of the **Trajectories** window, to sort trajectory files in the list, and to select attribute fields for being displayed in the window.

To:	Use:
Change the size of the **Trajectories** window to a small or large window	**Small dialog** **Large dialog**
Sort trajectories according to two attributes	**Sort**
Select attribute fields for display	**Fields**

Small dialog

Small dialog command changes the size of the **Trajectories** window to be a small window.

Large dialog

Large dialog command changes the size of the **Trajectories** window to be a large window.

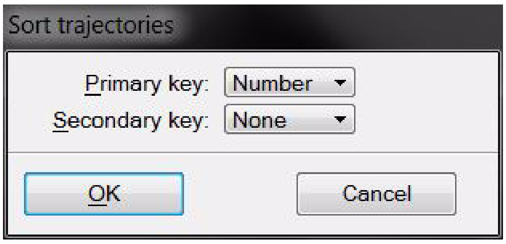
Sort

Sort command defines the display order of trajectory files in the list. The trajectories can be sorted by up to two attributes.

➢ **To sort trajectory files:**

1. Select **Sort** command from the **View** pulldown menu.

   This opens the **Sort trajectories** dialog:



2. Select a **Primary key** and **Secondary key** for sorting.
3. Click OK.

   The display order of the trajectory files in the list is changed according to the settings.

Setting:	Effect:
Primary key	Attribute used first for sorting the trajectories: • **Number -** increasing flightline numbers. • **Group -** increasing group numbers. • **Time -** increasing time stamps.
Secondary key	Attribute used second for sorting the images: • See **Primary key** attributes. • **None -** no secondary key is used for sorting.

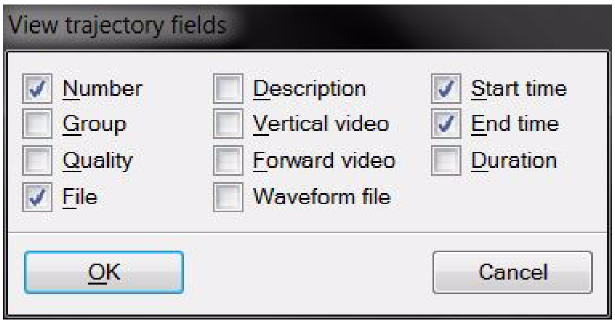
Fields

Fields command lets you select which attributes are displayed for each trajectory in the **Trajectories** window.

➢ **To select visible fields:**

1. Select **Fields** command from the **View** pulldown menu.

   This opens the **View trajectory fields** dialog:



2. Select fields and click OK.

Field:	Description:
Number	Trajectory number.
Group	Group number of the trajectory.
Quality	Attribute that indicates the quality of the trajectory.
File	Name of the trajectory file on the hard disk.
Description	Description of the trajectory given in the **Trajectory information** dialog.
Vertical video	Name of the video file defined as **Video 1** in the **Trajectory information** dialog.
Forward video	Name of the video file defined as **Video 2** in the **Trajectory information** dialog.
Waveform file	Path and name of a waveform file linked to the trajectory.
Start time	Time stamp at the start of the trajectory.
End time	Time stamp at the end of the trajectory.
Duration	Length of the trajectory in seconds.

Tools pulldown menu

Commands from the **Tools** pulldown menu are used to manipulate trajectories.

To:	Use:
Split a trajectory into smaller parts	**Split**
Transform trajectory coordinates	**Transform**
Adjust trajectory elevations to a geoid model	**Adjust to geoid**
Apply a mathematical equation to trajectory angles	**Convert angles**
Convert time stamps into another time format	**Convert time stamps**
Draw trajectories into the design file	**Draw into design**

Split

Split command can be used to split a trajectory into smaller parts. This is useful for some tools that require that one trajectory does not contain turnarounds and overlaps itself.

➢ **To split a trajectory:**

1. Select **Split** command from the **Tools** pulldown menu.

   If the mouse pointer is moved inside a MicroStation view, the closest trajectory is highlighted.

2. Identify the trajectory to split with a data click.

   A red cross shows dynamically the split location.

3. Define the position at which to split the trajectory with a data click.

   This cuts the trajectory at the given position. The application deletes the old trajectory file and creates two new files in the active trajectory directory.

✍ There are automatic ways to split a trajectory in TerraScan. See the TerraScan User's Guide for more information.

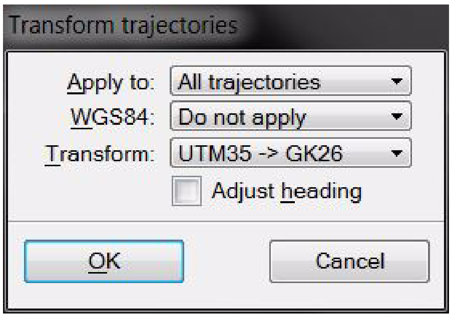
Transform

Transform command applies a transformation to the coordinates of a trajectory. The transformation can be, for example, a change of the projections system or any other transformation defined in **Coordinate transformations / Transformations** of TerraPhoto **Settings**.

➢ **To transform a trajectory:**

1. Select **Transform** command from the **Tools** pulldown menu.

   This opens the **Transform trajectories** dialog:



2. Define settings and click OK.

   The coordinates of the trajectory are changed. The modification is saved to the trajectory binary files in the active trajectory directory.

Setting:	Effect:
Apply to	Trajectories to transform: • **All trajectories** - all trajectories in the list. • **Selected only** - selected trajectories only. This requires the selection of one or more trajectory files in the list before the command is started.
WGS84	Target projection system for applying a transformation from WGS84 to the given projection system. You can choose from any of the builtin or user-defined projections systems which are set as active in **Coordinate transformations / Builtin projection systems**, **Coordinate transformations / US State Planes**, and **Coordinate transformations / User projection systems** of TerraPhoto **Settings**.
Transform	User-defined transformation to apply. You can choose from any transformation that is defined in **Coordinate transformations / Transformations** of TerraPhoto **Settings**.
Adjust heading	If on, the software applies a meridian convergence correction to heading values. The correction is based on the projection system set for **WGS84** or the coordinate transformation set for **Transform**.

Adjust to geoid

Adjust to geoid command applies an elevation correction to trajectory files. The command is used, for example, to transform the WGS84-based ellipsoidal elevation values of a raw trajectory file to a local height model. The input model for geoid adjustment must be provided in one of the following formats:

- **Points from file -** text file containing space-delimited X Y dZ points.
- **TerraModeler surface -** triangulated surface created from X Y dZ points. The model must be loaded in TerraModeler. This has the advantage that you can visualize the adjustment model.
- **Selected linear chain -** linear element which has vertices derived from X Y dZ points.

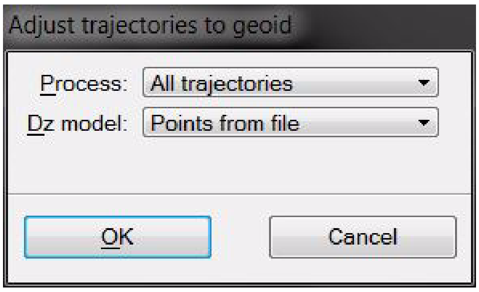
XY are the easting and northing coordinates of the geoid model points, dZ is the elevation difference between ellipsoidal and local heights at the location of each geoid model point. Intermediate adjustment values of the model are derived by aerial (text file or surface model as input) or linear (linear element as input) interpolation between the known geoid model points.

The first two input models utilize aerial interpolation while the last input model uses linear interpolation along the linear element's segments in order to derive adjustment values.

➤ **To adjust trajectories to a geoid model:**

1. (Optional) Load a geoid model into TerraModeler.
2. (Optional) Select trajectory file(s) to adjust.
3. Select **Adjust to geoid** command from the **Tools** pulldown menu.

   This opens the **Adjust trajectories to geoid** dialog:



4. Define settings and click OK.

   If **Points from file** is selected as the **Dz model**, the **Geoid dz file** dialog opens, a standard dialog for opening files.
5. Define the text file that contains the geoid coordinates and elevation differences and click **Open**.

   This applies the elevation adjustment to all or selected trajectories. The modification is saved to the trajectory binary files in the active trajectory directory. An information dialog shows the minimum and maximum values of the adjustment.

Setting:	Effect:
Process	Trajectories to adjust: • **All trajectories -** all trajectories in the list. • **Selected only -** selected trajectories only.
Dz model	Source file that provides the geoid correction model: • **Points from file -** text file. • **Selected linear chain -** linear element selected in the design file. • *<name>* **-** name of the geoid model surface loaded in TerraModeler.
Extend	Distance of a linear extension. This is only active if **Dz model** is set to **Selected linear chain**.

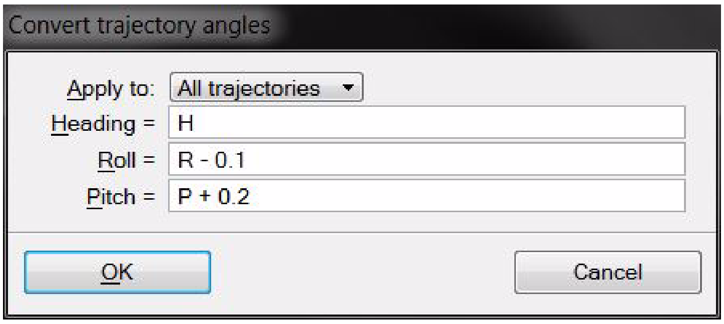
Convert angles

Convert angles command lets you apply a mathematical equation to the orientation angles heading, pitch, and roll of each trajectory position. The current angle value can be accessed by using constants H (heading), R (roll), and P (pitch). Thus, the command can also be used to exchange angle values.

➢ **To convert angles of trajectory positions:**

1. (Optional) Select trajectory file(s) for which to manipulate angles.
2. Select **Convert angles** command from the **Tools** pulldown menu.

   This opens the **Convert trajectory angles** dialog:

3. Define equations an click OK.

   This computes the new values for the orientation angles. The modification is saved to the trajectory binary files in the active trajectory directory. An information dialog shows the number of effected trajectories.

Setting:	Effect:
Apply to	Trajectories for which the computation of new angles is applied: • **All trajectories -** all trajectories in the list. • **Selected only -** selected trajectories only.
Heading	Equation for modifying the heading angle.
Roll	Equation for modifying the roll angle.
Pitch	Equation for modifying the pitch angle.

Convert time stamps

Convert time stamps command can be used to convert the format of time stamps. Supported conversions are GPS seconds-of-week to GPS standard time, Unix time to GPS standard time, GPS standard time to GPS seconds-of-week, and Unix time to GPS seconds-of-week.

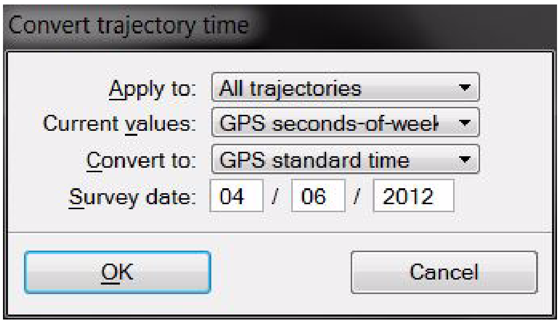
The conversion is necessary, for example, if data collected in several weeks is processed together in one project. Then, GPS seconds-of-week time stamps result in repeated values and GPS standard time must be used in order to provide unique time stamps for each trajectory position. This is a requirement for many processes that rely on trajectory information. Some post-processing software generates data with Unix seconds-of-day time stamps. They must be converted into another GPS time format as well.

It is essential that time stamps of trajectories and images are stored in the same GPS time format.

➢ **To convert time stamps:**

1. (Optional) Select trajectory file(s) for which to manipulate angles.
2. Select **Convert time stamps** command from the **Tools** pulldown menu.

   This opens the **Convert trajectory time** dialog:



3. Define settings and click OK.

   This converts the trajectory time stamps to the new format. The modification is saved to the trajectory binary files in the active trajectory directory. An information dialog shows the number of effected trajectories.

Setting:	Effect:
Apply to	Trajectories for which the conversion of time stamps is applied: • **All trajectories -** all trajectories in the list. • **Selected only -** selected trajectories only.
Current values	Original time stamp format of the trajectory positions.
Convert to	Target time stamp format.
Survey date	Date when the trajectory data was captured. The format is day/month/year (dd/mm/yyyy). This is only active for the conversion from **GPS seconds-of-week** to **GPS standard time**.

Draw into design

Draw into design command draws the trajectories as line elements into the design file. The line elements are drawn on the active level using the active line width and style settings of MicroStation. The color(s) of the line elements are defined by the command's settings.

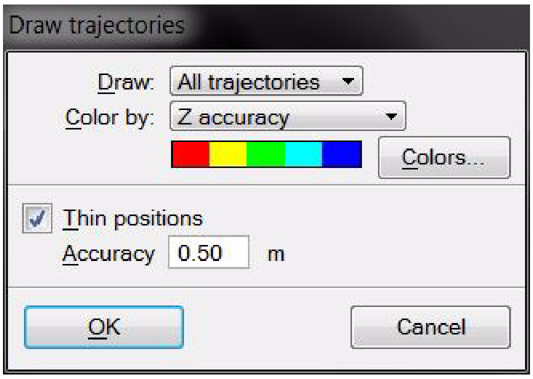
The command can use accuracy values that are assigned to trajectory positions. See **Import accuracy files** for more information.

The line elements are drawn by placing a vertex for each trajectory position. The lines can by simplified by removing positions within a given tolerance.

➢ **To draw trajectory lines into the design file:**

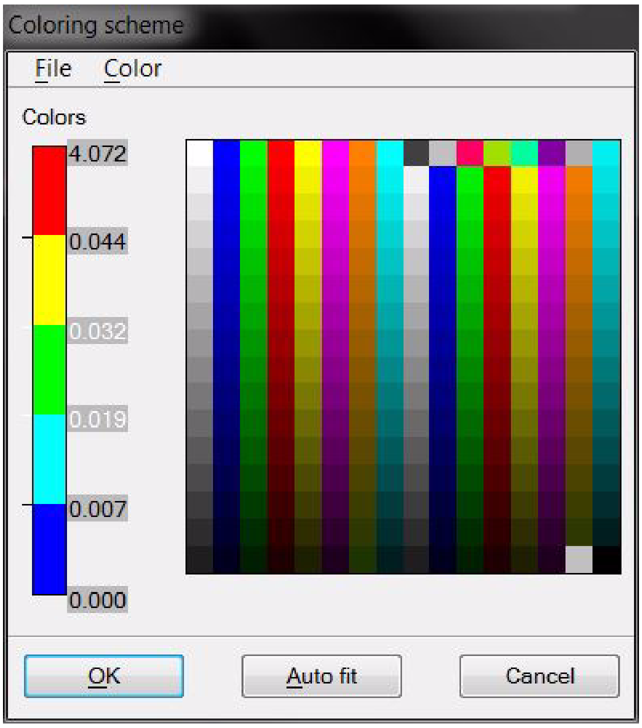
1. (Optional) Select trajectory file(s) to draw.
2. Select **Draw into design** command from the **Tools** pulldown menu.

   This opens the **Draw trajectories** dialog:



3. Define settings.
4. If the trajectory is drawn with an accuracy-based coloring option, click on the **Colors** button.

   This opens the **Coloring scheme** dialog:



5. (Optional) Define your own coloring scheme for drawing trajectories.
6. Click on the **Auto fit** button in order to fit the colors to RMS value ranges.

7. Click OK to the **Coloring scheme** dialog.
8. Click OK to the **Draw trajectories** dialog.

   This draws the line element(s) into the design file.

Setting:	Effect:
Draw	Trajectories that are drawn: • **All trajectories -** all trajectories in the list. • **Selected only -** selected trajectories only.
Color by	Determines how the color is chosen for drawing a trajectory line: • **Active color -** the active color of MicroStation is used. • **Trajectory number -** the color whose number in the active color table of MicroStation corresponds to the trajectory number is used. • **Xy accuracy -** x/y accuracy values are applied to a color scheme. • **Z accuracy -** z accuracy values are applied to a color scheme. • **H accuracy -** heading accuracy values are applied to a color scheme. • **Rp accuracy -** roll/pitch accuracy values are applied to a color scheme.
Colors	Button to open the coloring scheme for accuracy-based coloring methods.
Thin positions	If on, intermediate trajectory positions are skipped when the line is drawn as long as the line accuracy stays within the given positional **Accuracy** tolerance.

✍ You can undo the drawing of trajectories by using the **Undo** command from the **Edit** pulldown menu of MicroStation.

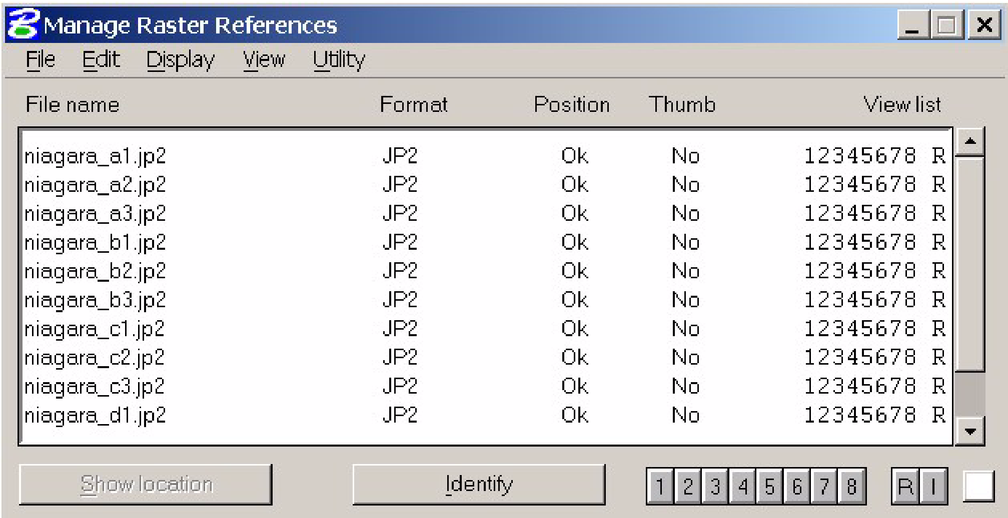
18 Commands for Raster References

Raster references are usually orthophotos which are attached in TerraPhoto's **Manage Raster References** window. However, every image in one of the supported formats can be attached, visualized, and modified by TerraPhoto raster reference tools. Supported formats include BMP, ECW compressed, GeoTIFF, JPEG, JPEG2000, RawRGB, and TIFF. A brief description of how to visualize reference images in TerraPhoto is given in Chapter **Viewing Images** on page 21.

General settings for reference images are defined in **Reference images / Default visibility** and **Reference images / Raster references** of the TerraPhoto **Settings**.

Manage Raster References window

The **Manage Raster References** window can be opened by using the *Manage Raster References* tool. The window provides menu commands for handling and modifying raster references as well as buttons for manipulating the display of the reference files.



Button:	**Effect:**
Show location	Shows the location of a selected image if the mouse pointer is moved into a MicroStation top view.
Identify	Identifies an image in the list, if it is selected in a MicroStation top view by a data click.
1 ... 8	Switches the display for selected images on/off in the corresponding MicroStation views.
R	(=Render) If on, image(s) are used by TerraPhoto rendering tools. The raster files are draped on shape elements, such as building roofs, and on a surface model displayed as **Raster triangles** in TerraModeler.
I	(=Invert) If on, images are displayed with inverted colors.
Color field	Display color of monochrome images.

Overlapping reference images are displayed in MicroStation views in the order given in the reference list. This means, that images on top of the list are displayed behind images further down in the list. The order of images in the list can be changed by using commands from the **Display pulldown menu**.

File pulldown menu

Commands from the **File** pulldown menu are used to attach and detach raster files, to save a list of attached reference files, or to create thumbnails of attached reference images.

To:	Choose menu command:
Attach individual image files	**Attach files**
Attach all image files in a directory	**Attach directory**
Attach a previously saved list of images	**Attach list**
Save a list of attached images	**Save list As**
Save a list of attached images to the design file	**Save list to design**
Create thumbnails for attached raster files	**Create thumbnails**
Detach reference images	**Detach / Selected** **Detach / Inside fence** **Detach / Outside fence** **Detach / All**

Attach files

Attach files command attaches individual files as raster references.

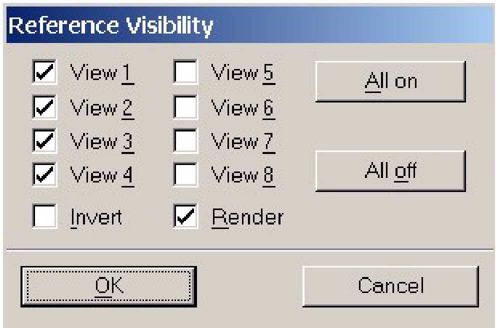
➢ **To attach individual raster files:**

1. Select **Attach files** command from the **File** pulldown menu.

   This opens the **Attach raster files** dialog, a standard dialog for opening files.

2. Select the images you want to attach.

   TerraPhoto checks the selected files and opens the **Reference Visibility** dialog:



3. Select views for reference visibility and click OK.

   This attaches the selected images as raster references. The images are displayed if the selected views are top views and cover the location of the images.

Setting:	Effect:
View 1 ... 8	If on, images are displayed in the selected MicroStation views, provided that they are top views.
Render	If on, images are displayed in views that are rendered by TerraPhoto rendering tools.
Invert	If on, images are displayed with inverted colors.

Attach directory

Attach directory command attaches all image files from a directory as raster references.

➢ **To attach all raster files from a directory:**

1. Select **Attach directory** command from the **File** pulldown menu.

   This opens the **Browse For Folder** dialog, a standard dialog for selecting a directory.

2. Select the folder which contains the images you want to attach and click OK.

   TerraPhoto checks the selected files and opens the **Reference Visibility** dialog.

3. Select views for reference visibility as described for **Attach files** command above.

   This attaches all images in the selected folder as raster references.

Attach list

Attach list command attaches a previously stored TerraPhoto reference list. For information about creating a reference list, see **Save list As** command below.

➢ **To attach a reference list:**

1. Select **Attach list** command from the **File** pulldown menu.

   This opens the **Attach reference list**, a standard dialog for opening files.

2. Select the reference list you want to attach and click **Open**.

   This attaches all images included in the list as raster references.

Save list As

Save list As command creates a TerraPhoto reference list. A reference list is a text file which includes information for each raster reference, such as coordinates of image corners, image height and width in pixels, color depth, background color, view display settings, and the path to the referenced image.

➢ **To save a reference list:**

1. Attach images.
2. Select **Save list as** command from the **File** pulldown menu.

   This opens the **Save reference list** dialog, a standard dialog for saving a file.

3. Select a location for storing the list, define a name for the list file, and click **Save**.

   This creates a reference list file with the extension .LST.

Save list to design

Save list into design command saves the attached references with their current settings to the design file. As a result, the references are automatically loaded, when TerraPhoto is started in this design file.

➢ **To save a list to design:**

1. Attach images.
2. Select **Save list to design** command from the **File** pulldown menu.

   This saves the reference list into the design file. An Information dialog is displayed.

✍ To remove a saved reference list from a design file, detach all references and save the empty list to the design file.

Create thumbnails

Create thumbnails command creates thumbnails for all attached reference images. The ratio for the thumbnails is defined in **Reference images / Raster references** of the TerraPhoto **Settings**.

Thumbnails speed up the display of reference images at lower resolution ratios. The resolution ratio of a display can be defined by using **Zoom to** commands from the **Display** pulldown menu.

➢ **To create thumbnails for reference images:**

1. Attach images for which you want to create thumbnails.
2. Select **Create thumbnails** command from the **File** pulldown menu.
3. Click OK in the alert dialog in order to start the process.

   The thumbnail files are saved as .tif files with the file name ‘thumb<imagename>.tif’ into the same directory where the attached images are stored. If thumbnail files already exist, they are overwritten without warning.

Detach / Selected

Detach / Selected command detaches selected reference images.

➢ **To detach selected reference images:**

1. Select images in **Manage Raster References** window which you want to detach.
2. Select **Detach / Selected** command from the **File** pulldown menu.
3. Click **Yes** in the alert dialog in order to detach the selected images.

Detach / Inside fence

Detach / Inside fence command detaches reference images that are located completely inside a fence. The fence can be defined by a MicroStation fence element or by a selected shape.

➢ **To detach reference images inside a fence:**

1. Draw a fence around the images which you want to detach.
2. Select **Detach / Inside fence** command from the **File** pulldown menu.
3. Click **Yes** in the alert dialog in order to detach the images. The dialog shows how many images are effected.

Detach / Outside fence

Detach / Outside fence command detaches reference images that are located completely outside a fence. The fence can be defined by a MicroStation fence element or by a selected shape.

➢ **To detach reference images outside a fence:**

1. Draw a fence that excludes the images which you want to detach.
2. Select **Detach / Outside fence** command from the **File** pulldown menu.
3. Click **Yes** in the alert dialog in order to detach the images. The dialog shows how many images are effected.

Detach / All

Detach / All command detaches all reference images.

➢ **To detach all reference images:**

1. Select **Detach / All** command from the **File** pulldown menu.
2. Click **Yes** in the alert dialog in order to detach the images.

Edit pulldown menu

Commands from the **Edit** pulldown menu are used to modify attached reference images. This includes the modification of image parameters like image corner coordinates and pixel size as well as interactive changes or transformation of image positions.

Modifications made with these tools effect only the display of attached references. The changes get lost, if the references are detached. However, they can be stored in TerraPhoto reference lists using **Save list As** command from the **File** pulldown menu.

To:	Choose menu command:
Modify parameters of an attached image	**Modify attachment**
Enter an image position interactively	**Enter position**
Transform positions of reference images	**Transform positions**

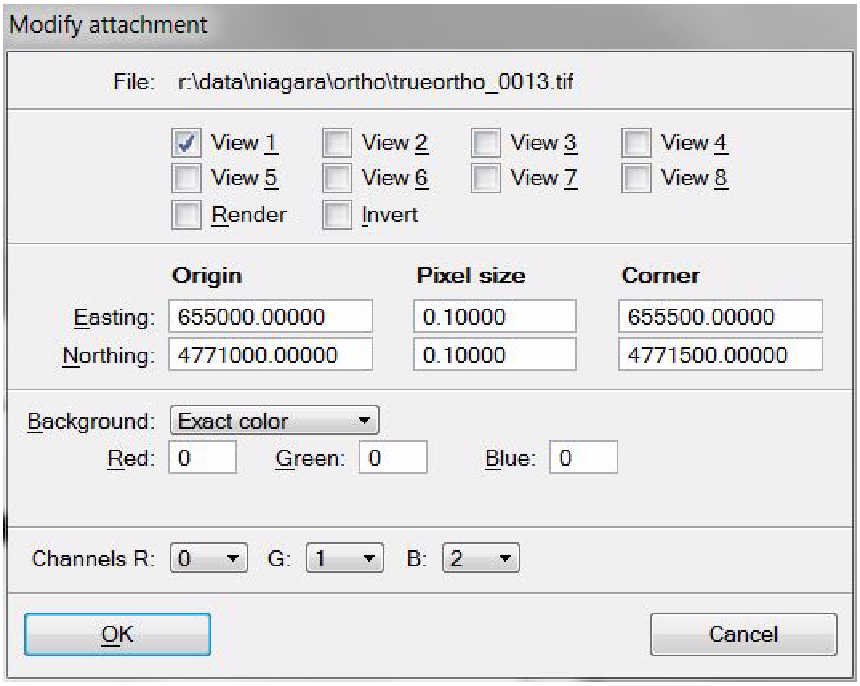
Modify attachment

Modify attachment command lets you change parameters for single or several reference images. This includes visibility parameters, image coordinates and size, and background information. If several images are selected for modification, the options are limited.

➢ **To modify a single attached reference image:**

1. Select the reference image which you want to modify.
2. Select **Modify attachment** command from the **Edit** pulldown menu.

   This opens the **Modify attachment** dialog:



3. Enter new values for parameters which you want to change.
4. Click OK.

➢ This applies the new parameters to the selected image.

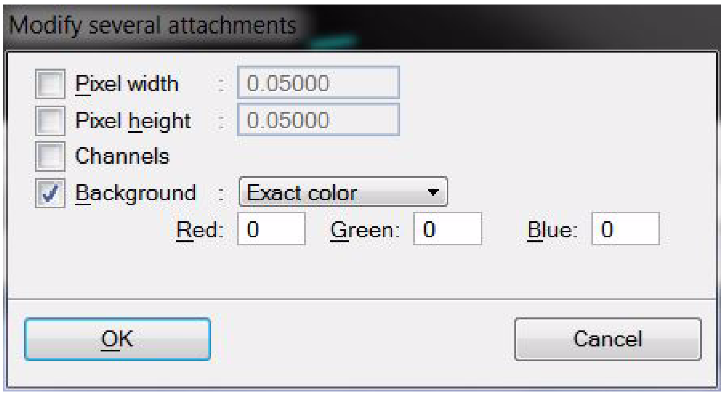
Setting:	Effect:
View 1 ... 8	Defines the visibility of the reference image in MicroStation views.
Render	Defines the visibility of the reference image in views that are rendered with TerraPhoto rendering tools.
Invert	Defines the reference image to be displayed with inverted colors.
Easting	Values for image positioning along the x axis: • **Origin** - X coordinate of the image origin. • **Pixel size** - pixel width. • **Corner** - X coordinate of the image corner opposite to the origin.
Northing	Values for image positioning along the y axis: • **Origin** - Y coordinate of the image origin. • **Pixel size** - pixel height. • **Corner** - Y coordinate of image corner opposite to the origin.
Background	Pixels to display as transparent: • **Not transparent** - no image pixels are transparent. • **Extract color** - pixels with exact given RGB color value. • **Close to color** - pixels close to a given RGB color value.

Setting:	Effect:
Red Green Blue	Color values for transparent pixels expressed in RGB color space values. This is only active if **Background** is set to **Exact color** or **Close to color**.
Tolerance	Tolerance value added to the RGB values for defining transparent pixels. This is only active if **Background** is set to **Close to color**.
Channels	Channel numbers of the reference images which are displayed in place of TerraPhoto's **RGB** channels. You may replace, for example, the red channel with a near-infrared channel stored in the reference image.

➢ **To modify multiple attached reference images:**

1. Select several reference images which you want to modify.
2. Select **Modify attachment** command from the **Edit** pulldown menu.

   This opens the **Modify several attachments** dialog:



3. Enter new values for parameters which you want to change.
4. Click OK.

   This applies the new parameters to the selected images.

Setting:	Effect:
Pixel width	Width of the image pixels.
Pixel height	Height of the image pixels.
Channels	Number of original image channels applied to **RGB** channels in TerraPhoto.
Background	Pixels to display as transparent: • **Not transparent -** no image pixels are transparent. • **Extract color -** pixels with exact given RGB color value. • **Close to color -** pixels close to a given RGB color value.
Red Green Blue	Color values for transparent pixels expressed in RGB color space values. This is only active if **Background** is set to **Exact color** or **Close to color**.
Tolerance	Tolerance value added to the RGB values for defining transparent pixels. This is only active if **Background** is set to **Close to color**.

Enter position

Enter position command allows to define the position of a reference image interactively. This can be used, for example, to change the positioning of images that do not have georeferencing information. MicroStation elements can be used for placing an image position accurately.

➢ **To place a reference image interactively:**

1. Select the reference image which you want to place interactively.
2. Select **Enter position** command from the **Edit** pulldown menu.
3. Define the image origin (south-west corner) of the image by a data click.
4. Define the opposite image corner (north-east corner) of the image by another data click.

   This moves the image to the new position. If the defined rectangle is smaller/larger than the original image size, the pixel size of the image is changed.

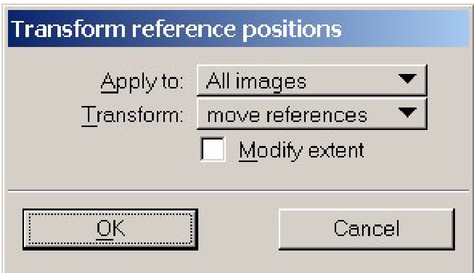
Transform positions

Transform positions command applies an user-defined transformation to the display of attached raster references. The transformation must be defined in **Coordinate transformations / Transformations** of the TerraPhoto **Settings**.

➢ **To transform the display of reference images:**

1. Select **Transform positions** command from the **Edit** pulldown menu.

   This opens the **Transform reference positions** dialog:



2. Select settings and click OK.

   This transforms the reference images to the new position.

Setting:	Effect:
Apply to	Apply transformation to **All images** or **Selected images**.
Transform	Transformation to be applied. The transformation must be defined in **Coordinate transformations / Transformations** of the TerraPhoto **Settings**.
Modify extent	If on, a transformation can modify the pixel size of the images. Otherwise only the position is changed.

✍ To apply a transformation permanently for reference images, use **Convert references** command from the **Utility** pulldown menu.

Display pulldown menu

Commands in the **Display** pulldown menu are used to fit views to images, zoom to defined resolution ratios, and change the display order for overlapping images.

To:	Choose menu command:
Fit a view to show the area covered by all or selected reference images	**Fit**
Zoom to defined resolution ratios	**Zoom to**
Send a reference image to the back of the display	**Send to back**
Bring a reference image to the front of the display	**Bring to front**
Send a reference image stepwise backward	**Send backward**
Bring a reference image stepwise forward	**Bring forward**

Fit

Fit command fits a view to show the area that is covered by all or selected reference images. The view has to be a top view in order to display the reference images.

➢ **To fit a view to image locations:**

1. (Optional) Select images in the **Manage Raster References** window.
2. Select **Fit / All** or **Fit / Selected** command from the **Display** pulldown menu.
3. Select a view with a data click inside the view.

   This fits the selected view to display all or the selected reference images.

Zoom to

The resolution options in the **Zoom to** command apply the respective resolution ratio to a view. The predefined ratios are **1:1** (full resolution), **1:2** (50% of full resolution), **1:4** (25% of full resolution), and **1:8** (12.5% of full resolution).

For viewing many reference images at a small resolution ratio, the display is faster if thumbnails are used instead of the full resolution images. See **Create thumbnails** command for more information about thumbnails for raster references.

➢ **To zoom to a defined ratio:**

1. Select a ratio from **Zoom to** command from the **Display** pulldown menu.
2. Move the mouse pointer inside a view.

   The mouse pointer shows a rectangle indicating the size of an image at the selected resolution ratio.

3. Click inside the view.

   This fits the view to display the images with the selected ratio.

Send to back

Send to back command moves an image to the back of the reference image display order.

➢ **To send an image to the back:**

1. Select one or more images in the **Manage Raster References** window.
2. Select **Send to back** command from the **Display** pulldown menu.

   The image is moved to the top of the reference list. It is displayed behind all other images in MicroStation top views.

Bring to front

Bring to front command moves an image to the front of the reference image display order.

➢ **To bring an image to the front:**

1. Select one or more images in the **Manage Raster References** window.
2. Select **Bring to front** command from the **Display** pulldown menu.

The image is moved to the end of the reference list. It is displayed in front of all other images in MicroStation top views.

Send backward

Send backward command moves an image stepwise backward in the reference image display order.

➢ **To send an image backward:**

1. Select one or more images in the **Manage Raster References** window.
2. Select **Send backward** command from the **Display** pulldown menu.

The image is moved up in the reference list. It is displayed behind the next image in display order in MicroStation top views.

Bring forward

Bring forward command moves an image stepwise forward in the reference image display order.

➢ **To bring an image forward:**

1. Select one or more images in the **Manage Raster References** window.
2. Select **Bring forward** command from the **Display** pulldown menu.

The image is moved down in the reference list. It is displayed in front of the next image in display order in MicroStation top views.

View pulldown menu

Commands in the **View** pulldown menu are used to control the appearance of the **Manage Raster References** window.

To:	Choose menu command:
Change the size of the raster references window	**Small dialog** **Medium dialog** **Large dialog**
Set the visibility of columns in the window	**Fields**

Small dialog

Small dialog command changes the **Manage Raster References** window to small size which consists of a title bar, a menu bar, and a small size list displaying the attached reference images.

Medium dialog

Medium dialog command changes the **Manage Raster References** window to medium size which consists of a title bar, a menu bar, and a medium size list displaying the attached reference images.

Large dialog

Large dialog command changes the **Manage Raster References** window to large size which consists of a title bar, a menu bar, and a large size list displaying the attached reference images.

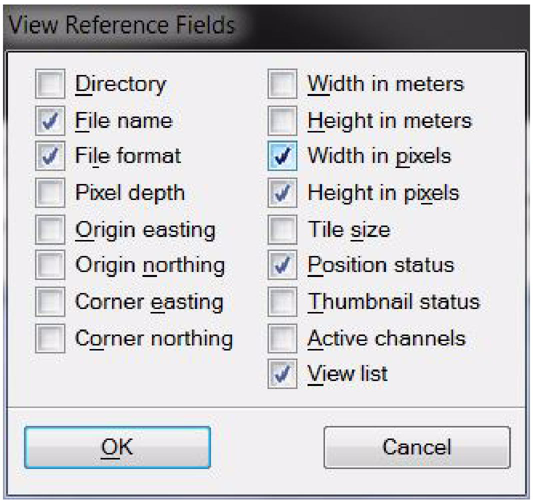
Fields

Fields command lets you select which attribute columns are displayed for each attached image in the **Manage Raster References** window.

➢ **To select visible fields:**

1. Select **Fields** command from the **View** pulldown menu.

   This opens the **View Reference Fields** dialog:



2. Select the fields you want to display and click OK.

Setting:	Effect:
Directory	Directory where the reference image is stored.
File name	File name of the reference image.
File format	File format of the reference image.
Pixel depth	Pixel depth of the reference image.
Origin easting/northing	Coordinate values of the image origin.
Corner easting/northing	Coordinate values of image corner opposite to the origin.
Width/Height in meters	Image width and height in meters.
Width/Height in pixels	Image width and height in pixels.
Tile size	Shows the size of tiles, if the image is a tiled image file.
Position status	Indicates, if the position of the image is defined: • **OK -** positional information for the image is available. • **Undefined -** no positional information is available for the image. • **Outside -** the position is outside the coordinate range defined for the design file.
Thumbnail status	Indicates, if thumbnails are available: • **OK -** thumbnails are available. • **No -** thumbnails are not available.
Active channels	Numbers of active channels of the reference image.
View list	View numbers for which the display of the image is switched on.

Utility pulldown menu

Commands in the **Utility** pulldown menu are used to retile attached reference images, convert reference images into another image format, and to create roof materials.

To:	Choose menu command:
Retile images into new tiles	**Retile images**
Create roof materials for MicroStation rendering	**Create roof materials**
Convert images into another format	**Convert references**

Retile images

Retile images command creates new images from reference files using a new tile array. This requires the definition of tiles using for example **Place tile array** command in TerraPhoto or any other tool for digitizing rectangles. The new images can be named automatically or by utilizing text elements placed inside each tile.

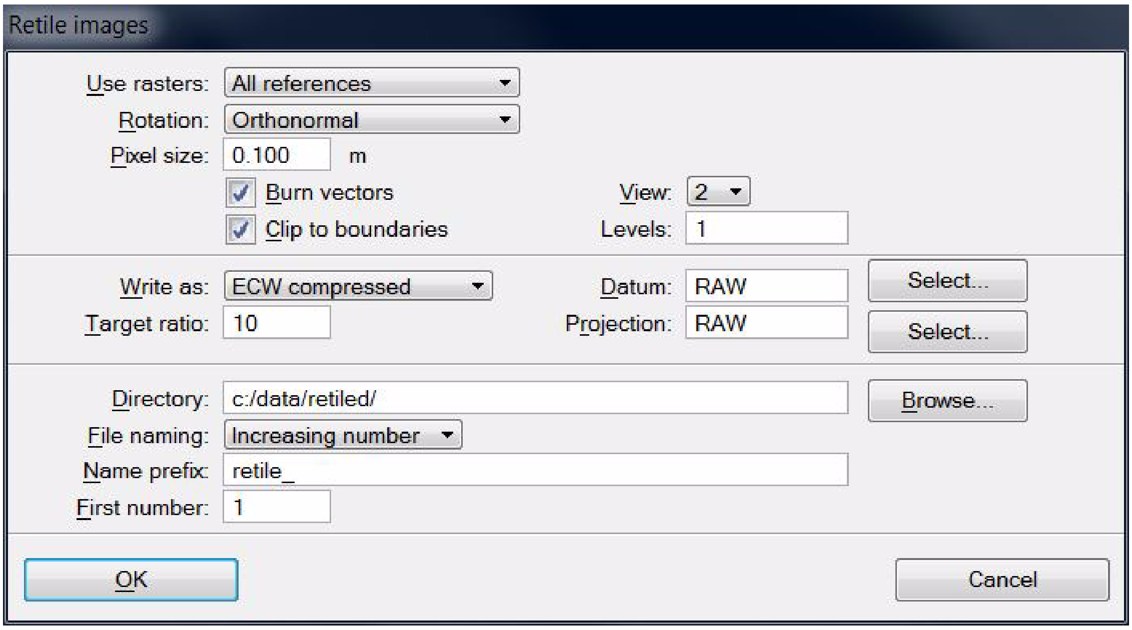
During the retile process, another image format, pixel size, or clip boundaries can be applied to the new images. In addition, the process can use vector elements on a specific design file level and “burn” these elements into the new image.

The rotation of the images can be orthonormal or defined by a line element. The line element represents the left-right axis for the new images and must be drawn into the design file before starting the retiling process. Rotated images can not be saved with internal georeferencing information.

➢ **To retile images:**

1. Select tiles and (optional) text elements inside each tile using MicroStation *Selection* tool.
2. (Optional) Select a line element that defines the rotation for the new images.
3. (Optional) Select reference images to be used for retiling images.
4. Select **Retile images** command from the **Utility** pulldown menu.

   This opens the **Retile images** dialog:



5. Select settings and click OK.

   This starts the retiling process. A window shows the progress of the process.

Setting:	**Effect:**
Use rasters	Reference images used for retiling: **All references** or **Selected only**.
Rotation	Rotation of the new images: • **Orthonormal** - the north direction points up in the new images. • **From selected vectors** - a selected line element defines the direction of the left-right axis in the new images.
Pixel size	Pixel size of the new images.
Burn vectors	If on, all vector elements that are visible in the selected **View** are drawn into the new images.
Clip to boundary	If on, new images are clipped to boundaries drawn on the given **Levels**.

Setting:	Effect:
Write as	Image format of the new images. If the rotation of the images is defined by a selected vector element, only formats **JPEG**, **TIFF**, and **RawRGB** are available.
Create TFW/JGW files	If on, separate georeferencing files are created for the image formats **GeoTIFF**, **TIFF**, and **JPEG**.
Target Ratio	Compression ratio for the new images. This is only active for the formats **ECW** and **JPEG2000**.
Datum/Projection	Datum and projection information that is written into the image file header. This is only active for formats **ECW** and **JPEG2000**.
Coord system	Coordinate system information that is written into the image file header. This is only active for format **GeoTIFF**.
Directory	Directory where the new image files are stored.
File naming	Defines the naming method for the new image files: • **Increasing numbers -** files are named by increasing numbers. • **Selected names -** selected text elements are used to name the files. Requires that a text element is placed inside each tile and selected before the command is started.
Name prefix	Text that is added at the beginning of an image name.
First number	Number of the first image. This is only active if **File naming** is set to **Increasing numbers**.

Create roof materials

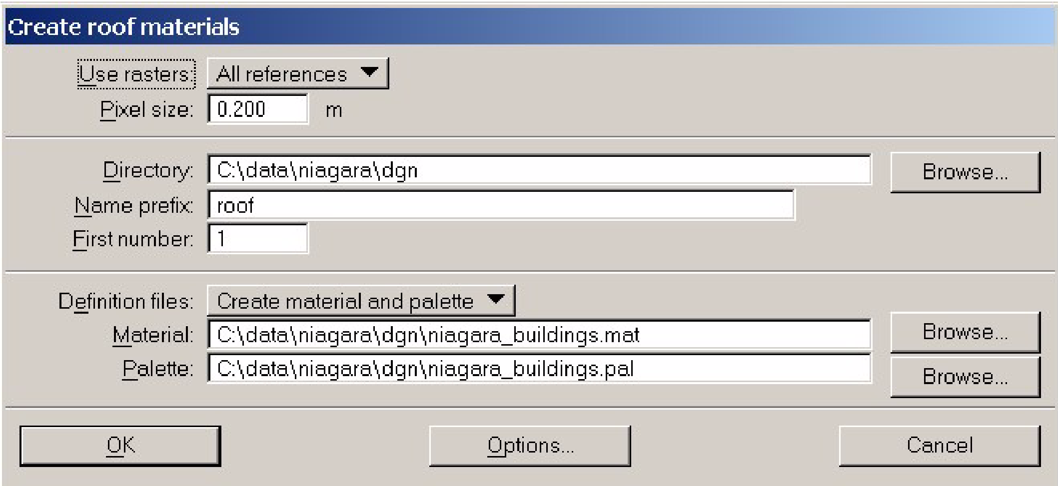
Create roof materials command creates a MicroStation material definition based on reference images. This can be used for rendering design file elements with MicroStation rendering. The tool creates the following files which form a MicroStation material definition:

- **Material table file (.mat)** – defines material assignments to MicroStation elements.
- **Palette file (.pal)** – defines the appearance of material.
- **Image files (.tif)** – material images.

➢ **To create roof materials:**

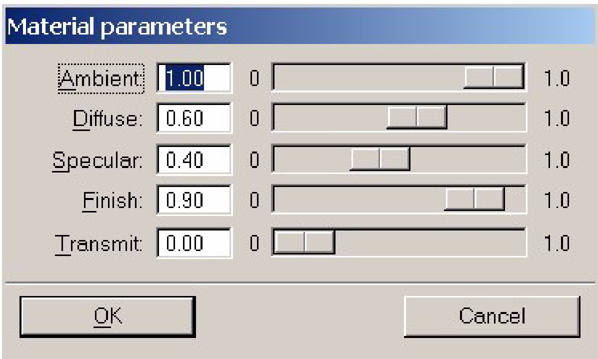
1. Digitize one or more shapes around the area(s) for which to define roof materials.
2. Select the shape(s).
3. (Optional) Select reference images to be used for material creation.
4. Select **Create roof material** command from the **Utility** pulldown menu.

   This opens the **Create roof materials** dialog:



5. Define settings and locations for file creation and storage.
6. (Optional) Click the **Options** button.

   This opens the **Material parameters** dialog:



7. (Optional) Adjust settings and click OK.
8. Click OK to the **Create roof materials** dialog.

   A .mat, .pal, and one or more .tif files are created in the given directories. Material images are named with the given **Name prefix** and an increasing number.

Setting:	Effect:
Use rasters	Reference images used for roof material creation: **All references** or **Selected only**.

Setting:	Effect:
Pixel size	Pixel size of the material images.
Directory	Location on a hard disk where the material images are stored.
Name prefix	Text added at the beginning of material image names.
First number	Number of the first material image.
Definition files	Files for material definition in MicroStation: • **Create material and palette -** new files are created. Existing files with the same name are overwritten. • **Add to existing palette -** if the files already exist, the new material images are added to the existing palatte file.
Material	Path and file name of the material table file.
Palette	Path and file name of the palette file.

✍ The created material definition can be used and edited in MicroStation tools *Assign materials* and *Define Materials* and thus, be applied for MicroStation rendering.

Convert references

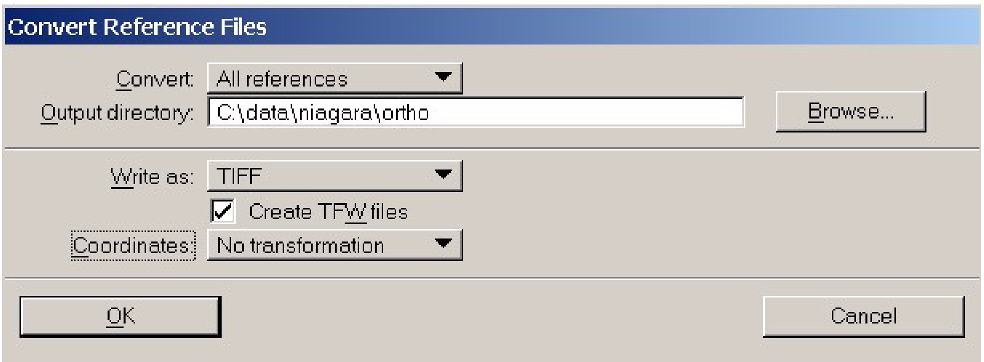
Convert references command converts attached reference images into another image format. During the conversion process, a user-defined transformation can be applied to the images. The transformation must be defined in **Coordinate transformations / Transformations** of the TerraPhoto **Settings**.

If the transformation is a projection system change, the original rectangular tiles of the images do not remain the same rectangles. The software computes new rectangular tiles by using multiple reference images for each tile.

➤ **To convert reference images:**

1. (Optional) Select reference images to be converted.
2. Select **Convert references** command from the **Utility** pulldown menu.

   This opens the **Convert Reference Files** dialog:



3. Select settings and click OK.

   This starts the conversion process. A window shows the progress of the process.

   Existing image files in the output directory of the conversion that have the same name and format are overwritten without warning.

Setting:	Effect:
Convert	Reference images that are converted: **All references** or **Selected only**.
Output directory	Directory for storing the new image files.
Write as	File format of the converted images.
Create TFW/JGW files	If on, separate georeference files are created for the image formats **GeoTIFF**, **TIFF**, and **JPEG**.
Target Ratio	Compression ratio for the new images. This is only active for the formats **ECW** and **JPEG2000**.
Datum/Projection	Datum and projection information that is written into the image file header. This is only active for formats **ECW** and **JPEG2000**.
Coord system	Coordinate system information that is written into the image file header. This is only active for format **GeoTIFF**.
Coordinates	Transformation applied to the converted images. The transformation must be defined in the TerraPhoto **Settings**. This is only active if an output format is seleced that stores georeferencing information, either internally in the file header (ECW, GeoTIFF, JPEG2000) or externally in an additional file (TIFF + TFW, JPEG + JGW).

✍ **Convert references** command can be used to save temporary modifications for reference images permanently into new image files. See command descriptions in Section **Edit pulldown menu** on page 320 for information about temporary changes of reference images.

Programming Interface

19 MDL Public Functions

TerraPhoto has a number of public functions which can be called by other MDL applications.

Public functions make it possible for another MDL application to interact with TerraPhoto. These same routines are used internally by Terrasolid for interaction between TerraScan, TerraModeler and TerraPhoto.

The public functions can be used to:

- retrieve information about attached raster references
- attach, detach or control raster references
- open a mission file or an image list
- retrieve information about active mission or active image list
- create a camera view
- derive an average color inside a polygon from raw images

Calling Method

The functions can be called with mdlCExpression_ getValue(). The code example below illustrates the method:

```
void    Example( void)
{
    int     Ret ;

    if (TphotoCall( &Ret, "FnPhotoCount()") > 0)
        mdlOutput_printf( MSG_PROMPT, “%d references attached”, Ret) ;
}

/*-------------------------------------------------------------------
    Call a function in TerraPhoto.
    Set *Ret to be the return value.

    Return 1 if successful.
    Return 0 if could not load TPHOTO.
    Return -1 if failed.
*/

int     TphotoCall( int *Ret, const char *Expr)
{
    CExprValue    Val ;
    CExprResult   Res ;
    int           Ok ;

    if (!LoadApp( “TPHOTO”))
        return (0) ;
    Ok = mdlCExpression_getValue( &Val, &Res, Expr, VISIBILITY_CALCULATOR);
    if (Ok != SUCCESS)
        return (-1) ;
    if (Ret)
        *Ret = (int) Val.val.valLong ;
    return (1) ;
}

/*-------------------------------------------------------------------
    Load MDL application with Name (such as “TPHOTO”).

    Return 1 if successful.
    Return 0 if application not found.
*/

int    LoadApp( char *Name)
{
    void    *Ptr ;
    int     Ok ;

    // Is application already loaded?

    Ptr = mdlSystem_findMdlDesc( Name) ;
    if (Ptr)                                return (1) ;

    // Not loaded, attempt loading

    Ok = mdlSystem_loadMdlProgram( Name, NULL, "") ;
    if (Ok == SUCCESS)                      return (1) ;

    return (0) ;
}
```

Structure definitions

```
//    FnPhotoRefGet() info about raster reference

typedef struct {
      char    Name[400] ; // Full path to file
      double  OrgX ;      // Lower left corner X
      double  OrgY ;      // Lower left corner Y
      double  SizeX ;     // X size of covered area
      double  SizeY ;     // Y size of covered area
      int     CntX ;      // X number of pixels
      int     CntY ;      // Y number of pixels
      int     Fmt ;       // 1051=geotiff, 1052=ecw, 1053=tiff or IMAGEFILE_xxx
      int     Views ;     // visibility view bits
      BYTE    Bck[4] ;    // Background transparency color RGBT
                          // where T: 0=exact RGB, 1-254=tolerance, 255=not transparent
      BYTE    Clr[4] ;    // Foreground color for monochrome images RGB + unused
} PhoRef ;

//    FnPhotoCamImages() info about possible camera images

typedef struct {
      int     CamInd ;   // Camera index
      int     Nbr ;      // Image number
      int     Outside ;  // Number of vertices outside image
      int     HasGrd ;   // Ground exists
      double  Dst ;      // Squared distance from camera to furthest vertex
      Dp3d    Xyz ;      // Camera position
      Dp3d    Vrt[4] ;   // Projection vertices on ground
      double  Par1 ;     // Free for caller to use
      int     Par2 ;     // Free for caller to use
      int     Par3 ;     // Free for caller to use
} PhoCim ;

//    FnPhotoCameraList() info about mission cameras

typedef struct {
      char    Name[40] ;        // Descriptive name
      char    RawDir[400] ;     // Directory for input images
      char    CameraFile[400] ; // Camera calibration file
      int     RawFormat ;       // Raw image file format
      int     Accuracy ;        // Positional accuracy 0=low, 1=normal, 2=good
} PhoCam ;
```

Function prototypes

```
//    ================================================================
//    Return number of currently attached raster references.
//    ================================================================

int   FnPhotoCount( void)

//    ================================================================
//    Return information about reference raster with index Ind.
//    Valid indexes are 0,1,2,...FnPhotoRefCnt()-1.
//
//      P      Pointer to structure to fill.
//      Ind    Index of raster reference to query.
//
//    Return 1 on success.
//    Return 0 if invalid index.
//    ================================================================

int   FnPhotoGet( PhoRef *P, int Ind) ;

//    ================================================================
//    Find reference raster which has file name Name.
//
//      Name    Full path of raster file to search.
//
//    Return index (0,1,2,...) on success.
//    Return -1 if not found.
//    ================================================================

int   FnPhotoFindName( char *Name) ;

//    ================================================================
//    Find first reference raster which covers point X,Y.
//    If (View >= 0) and (View <= 7), search only rasters which
//    are on for that view. If View is outside those limits,
//    search all attached raster references.
//
//      X     X position
//      Y     Y position
//      View  Search view or -1 for any view.
//
//    Return index (0,1,2,...) on success.
//    Return -1 if not found.
//    ================================================================

int   FnPhotoFindPos( double X, double Y, int View) ;

//    ================================================================
//    Attach raster file Name as reference. Raster file must be
//    contain georeferencing (ECW, GeoTIFF, TIFF+TFW, ...).
//
//      Name    Full path of raster file to attach.
//      Update  If non zero, update affected views.
//
//    Return index (0,1,2,...) of attached file on success.
//    Return -1 if failed.
//    ================================================================

int   FnPhotoAttach( char *Name, int Update) ;
```

```
//    ================================================================
//    Attach raster file Name as reference setting position explicitly.
//    Any georeferencing in raster file is ignored.
//
//      Name    Full path of raster file to attach.
//      OrgX    Lower left corner X coordinate.
//      OrgY    Lower left corner Y coordinate.
//      PixW    Width of each pixel.
//      PixH    Height of each pixel.
//      Update  If non zero, update affected views.
//
//    Return index (0,1,2,...) of attached file on success.
//    Return -1 if failed.
//    ================================================================

int   FnPhotoAttachPos( char *Name, double OrgX, double OrgY,
                        double PixW, double PixH, int Update) ;

//    ================================================================
//    Detach raster reference with index Ind.
//
//      Ind     Index of raster. If Ind == -1, detach all.
//      Update  If non zero, update affected views.
//
//    Return 1 on success.
//    Return 0 if Ind is invalid or nothing to detach.
//    ================================================================

int   FnPhotoDetach( int Ind, int Update) ;

//    ================================================================
//    Set view visibility of raster reference with index Ind.
//
//      Ind     Index of raster.
//      View    View (0-7, -1=all views) to switch on or off.
//      On      If non zero, set on. If zero, set off.
//      Update  If non zero, update affected views.
//
//    Return 1 on success.
//    Return 0 if invalid parameters.
//    ================================================================

int   FnPhotoSetView( int Ind, int View, int On, int Update) ;
```

```
//    ================================================================
//    Open mission file Name.
//
//    If Action is true, read mission always.
//    If Action == 0, read mission if it is not active already.
//
//    Return 2 if mission was opened.
//    Return 1 if mission was already active (Action == 0).
//    Return 0 if could not read mission.
//    ================================================================

int   FnPhotoOpenMission( char *Name, int Action) ;

//    ================================================================
//    Reference points of class Class from TerraScan as ground model.
//
//    Return number of points referenced.
//    ================================================================

int   FnPhotoReferClass( int Class) ;

//    ================================================================
//    Open image list file Name.
//
//    If Action is true, read list always.
//    If Action == 0, read list if it is not active already.
//
//    Return 2 if list was opened.
//    Return 1 if list was already active (Action == 0).
//    Return 0 if could not read list.
//    ================================================================

int   FnPhotoOpenList( char *Name, int Action) ;

//    ================================================================
//    How many images are in the image list?
//
//    Return number of images.
//    Return 0 if no images or no mission.
//    ================================================================

int   FnPhotoListSize( void) ;

//    ================================================================
//    Fill table Tbl[] of camera definitions for active mission.
//    MaxCnt is the number of definitions calling application has
//    allocated Tbl to hold.
//
//    Return number of cameras in mission.
//    Return 0 if no mission or no cameras.
//    ================================================================

int   FnPhotoCameraList( PhoCam *Tbl, int MaxCnt) ;

//    ================================================================
//    Find image which best sees points Vrt[].
//
//      Cam       camera index 0,1,2,... (-1 for any)
//
//    Return image number on success.
//    Return 0 if no image sees the location.
//    ================================================================

int   FnPhotoCamBest( Dp3d *Vrt, int Vct, int Cam) ;
```

```
//    ================================================================
//    Create camera view View using image which best sees points Vrt[].
//    Open view if it is not open already.
//    Zoom window to show area Vrt[].
//
//    Return image number on success.
//    Return 0 if no image sees the location.
//    ================================================================

int   FnPhotoCamView( int View, Dp3d *Vrt, int Vct) ;

//    ================================================================
//    Create camera view View using image number Nbr.
//    Open view if it is not open already.
//    Zoom window to show area Vrt[].
//
//    Return 1 on success.
//    Return 0 if no image with number Nbr or failed.
//    ================================================================

int   FnPhotoCamViewNbr( int View, int Nbr, Dp3d *Vrt, int Vct) ;

//    ================================================================
//    Create camera view View using image number Nbr using rotation
//    so that Dir vector is y axis on screen.
//
//    Open view if it is not open already.
//    Zoom window to show area Vrt[].
//
//    Return 1 on success.
//    Return 0 if no image with number Nbr or failed.
//    ================================================================

int   FnPhotoCamViewDir( int View, int Nbr, Dp3d *Vrt, int Vct, Dp3d *Dir) ;

//    ================================================================
//    Create a sorted list of images which see vertices Vrt[].
//
//    If CamInd < 0, use any camera.
//    If CamInd >= 0, use only images from that camera.
//
//    Return number of images in Tbl[].
//    ================================================================

int   FnPhotoCamImages( PhoCim *Tbl, int Max, Dp3d *Vrt, int Vct, int CamInd) ;

//    ================================================================
//    Create camera view View using image which gives the best
//    oblique view to points Vrt[].
//
//    Dir specifies an xy direction vector.
//    If Side < 0, find image looking in direction of vector.
//    If Side > 0, find image looking opposite to vector direction.
//
//    If CamInd < 0, use any camera.
//    If CamInd >= 0, use only images from that camera.
//
//    Return image number.
//    Return 0 if no image found.
//    ================================================================

int   FnPhotoObliqueView( int View, Dp3d *Vrt, int Vct, Dp3d *Dir, int Side, int Cam) ;
```

```
//    =================================================================
//    Compute average color for planar shape Vrt[]. Use image which
//    sees the shape best.
//
//    Return number of pixels used on success.
//    Return 0 if no image sees the location.
//    =================================================================

int   FnPhotoShapeClr( RgbClr *Clr, Dp3d *Vrt, int Vct) ;

//    =================================================================
//    Retrieve color values for marked laser points Tbl[] from open
//    ortho images.
//
//    Note that this routine changes Flag values of laser points.
//
//    Return number of colors retrieved.
//    =================================================================

int   FnPhotoColorOrtho( RgbClr *Clr, BYTE *Flg, Point3d *Pnt, BYTE *Mrk, int Cnt,
                         int Mark, double Foot) ;

//    =================================================================
//    Retrieve color values for marked laser points Tbl[] from raw
//    images of the active image list.
//
//    Return number of colors retrieved.
//    Return -1 if failed (out of memory).
//    Return -2 if no mission.
//    Return -3 if no image list.
//    =================================================================

int   FnPhotoColorRaw( RgbClr *Clr, Point3d *Pnt, BYTE *Mrk, double *Dbl, int Cnt,
                       int Mark, int Use, double Foot) ;
```

20 File formats

Mission file format

A mission file stores the basic information about a mission definition. The default extension for a mission file is .MIS.

The mission file is written as a text file where the first row is a constant header which is used for recognizing the file. Each of the following rows contains one parameter name followed by an equal sign and the value(s) for that parameter. The order of the parameter rows is free. This file structure is very flexible as the basic file structure does not need to be changed if new parameters are added or old ones are removed.

The possible parameters are:

- Description - descriptive name for the mission.
- Date - date of the survey.
- Operator - operator during the survey.
- Location - location of the survey.
- Platform - system platform used for the survey (0=Airborne, 1=Mobile).
- ProjectionSystem - projections system of the data used for defining the scale factor.
- ProjectionScale - scale factor.
- OrthoDirectory - directory for storing rectified images of a ortho mosaic.
- TempDirectory - directory for storing temporary files.
- RectifyDirectory - directory for storing rectified images.
- CameraCount - number of camera systems or camera setups in the mission.

- Name0 - descriptive name of the first camera.
- Accuracy0 - 0=bad, 1=normal, 2=good accuracy.
- DirectoryCount0 - number of raw image directories.
- Directory0_n - directory from where to read raw images (n = number of the directory).
- CalFile0 - camera calibration file ofthe first camera.
- RawFormat0 - raw image format (9=BMP, 18=JPG, 1001=RAW, 1052=ECW, 1053=TIFF).
- Numbering0 - method of deriving unique image numbers from the file name.

- Name1 – descriptive name for the second camera.
- ...

```
[TerraPhoto mission v2]
Description=Training
Date=
Operator=
Location=Finland
Platform=0
ProjectionSystem=9026
ProjectionScale=1.00000000
OrthoDirectory=..\ortho
TempDirectory=..\temp
RectifyDirectory=..\rect
CameraCount=3
Name0=Vertical
Accuracy0=1
DirectoryCount0=1
Directory0_0=..\images_vert\
CalFile0=.\vertical.cal
RawFormat0=1052
Numbering0=5
Name1=Back
Accuracy1=1
DirectoryCount1=1
Directory1_0=..\images_obl\
CalFile1=.\back.cal
RawFormat1=18
Numbering1=5
Name2=Forward
Accuracy2=1
DirectoryCount2=1
Directory2_0=..\images_obl\
CalFile2=.\fore.cal
RawFormat2=18
Numbering2=5
```

Image list file format

An image list stores the positions and the orientations of raw images. The default extension for an image list file is .IML.

TerraPhoto stores an image list as a text file where the first row is a header row which is used to recognize the file format. Each of the following rows contains one parameter name followed by an equal sign and the value(s) for that parameter. Several rows contain the complete information for one image.

The possible attributes stored for each image are:

- Image - image file name.
- Time - image time stamp.
- Xyz - camera easting, northing, and elevation (focal point of the image), values separated by space.
- Hrp - heading angle (degrees, zero north, increase clockwise), roll angle (degrees, zero wings level, increase left wing up), and pitch angle (degrees, zero nose level, increase nose up), values separated by space.
- Camera - camera index from the mission definition.
- Quality - quality value.
- Color - color correction values, start with letter C followed by semicolon-separated values for red, green, blue, intensity, saturation, contrast.
- Contrast
- Rectify - status related to ortho rectification (0=inactive)
- TieStatus - status related to tie points (1=approved)
- Group - group value.
- AccuracyXyz - accuracy value of the image.
- BrightDistr - comma-separated grid values for radial intensity corrections.
- Histogram information field

```
[TerraPhoto image list v5]
Image=003151-052412050144-CAM1
Time=363703.858196
Xyz=487929.914 6904407.122 858.887
Hrp=-180.22586 1.47839 2.76466
Camera=0
Quality=1
Color=C0;-1;2;4;40;20
Contrast=55
Rectify=0
TieStatus=1
Group=1
AccuracyXyz=0.100
BrightDistr=9,7,20,12,6,3,2,3,6,12,20,14,6,0,-3,-4,-3,0,6,14,11,3,-3,-6,-8,-6,-3,3,11,10,2,-4,-8,-9,-8,-4,2,10,11,3,-3,-6,-8,-6,-3,3,11,14,6,0,-3,-4,-3,0,6,14,20,12,6,3,2,3,6,12,20
```

Camera calibration file format

A camera calibration file stores the geometrical parameters of a camera system. The default extension for a camera calibration file is CAL.

The camera calibration file is written as a text file where the first row is a constant header which is used for recognizing the file. Each of the following rows contains one parameter name followed by an equal sign and the value(s) for that parameter. The order of the parameter rows is free. This file structure is very flexible as the basic file structure does not need to be changed if new parameters are added or old ones are removed.

The possible parameters are:

- Version - camera calibration file format version.
- Description - descriptive name of the camera.
- TimeOffset - time offset (seconds) to add to time stamps.
- Exposure - additional time offset (seconds) for xy position vs. attitude offset.
- LeverArm - vector from trajectory positions to the camera, space-separated values for lever arm XYZ components.
- AntennaToCameraOffset - not used by the software.
- AttitudeCorrections (HRP) - heading, roll, and pitch misalignment angles separated by space.
- PlateSize - size of the CCD plate (pixels recommended), space-separated width and height values.
- ImageSize - image size in pixels, space-separated width and height values.
- Margin - number of pixels ignored along image edges.
- FiducialRadius
- FiducialMarks
- Orientation - overall camera orientation.
- PrincipalPoint(XoYoZo) – principal point XYZ position (pixels recommended), separated by space.
- LensModel - lens distortion model.
- LensA3, A5 - radial lens distortion parameter.
- LensA7 - radial lens distortion parameter (if modeled as **Function** or **Homogenous**).
- LensA9 - lens distortion parameter (if modeled as **Homogenous**).
- LensR0 - zero radius for lens distortion (if modeled as **Zero radius functions**).
- LensK0, K1, K2 - lens distortion parameter (if modeled as **Balanced**)
- LensP1, P2 - tangential lens distortion parameters.
- LensColumns - number of lens distortion grid columns (if modeled as **Grid**)
- LensRows - number of lens distortion grid row (if modeled as **Grid**)
- LensRow01 ... AA - values for each lens distortion grid row, colums separated by space (AA=number of rows in the grid)

```
[TerraPhoto calibration]
Version=20050513
Description= Vertical
TimeOffset= 0.0000
Exposure= 0.00000
LeverArm= 0.0000 0.0000 0.0000
AntennaToCameraOffset= 0.0000 0.0000 0.0000
AttitudeCorrections(HRP)= 0.0094 -0.0450 -0.0635
PlateSize= 5616.00000000 3744.00000000
ImageSize= 5616 3744
Margin= 0
Orientation= TOP
PrincipalPoint(XoYoZo)= -14.24375000 -6.49375000 -8059.35469829
LensModel=Function
LensA3=-9.646484E-010
LensA5=2.248258E-017
LensA7=-1.177917E-025
LensP1=-3.806478E-008
LensP2=-5.885584E-008
```

Additional Information

21 Technical Details

Rotation Computation

TerraPhoto uses three angles to define the rotation of airborne images: heading, roll, and pitch. The angles are stored in the image list and displayed to the user as degree values where:

- heading zero is aircraft nose pointing north, increases clockwise
- roll zero is wings horizontal, increases left wing up
- pitch zero is nose horizontal, increase nose up

Three angles alone is not enough to fully define the rotation of an image. The order of rotation needs to be specified as well. TerraPhoto supports six different rotation orders. **Attitude computation** in the TerraPhoto **Settings** contains a list for selecting which order to use. This order must match the order in which input data was generated (normally the input trajectory). The standard order of IMU systems is TerraPhoto's **Heading pitch roll** order setting.

Angle values heading 30.0, roll 8.0 and pitch 3.0 degrees would result in the following rotation matrices going from camera image to world coordinate system:

Heading roll pitch

```
 0.85759730   0.50562269   0.09419428
-0.49513403   0.86119667  -0.11481545
-0.13917310   0.05182663   0.98891094
```

Heading pitch roll

```
 0.86123918  0.49931477    0.09461413
-0.48882612  0.86483855   -0.11446973
-0.13898237  0.05233596    0.98891094
```

Roll pitch heading

```
 0.85395543   0.50144195   0.13898237
-0.49931477   0.86483855  -0.05233596
-0.14644075  -0.02470338   0.98891094
```

Pitch roll heading

```
 0.85759730   0.49513403   0.13917310
-0.49300685   0.86848042  -0.05182663
-0.14653024  -0.02416692   0.98891094
```

Roll heading pitch

```
 0.85759730   0.50173923   0.11306906
-0.50000000   0.86483855  -0.04532427
-0.12052744  -0.01766456   0.99255282
```

Pitch heading roll

```
 0.85759730   0.50000000   0.12052744
-0.48717171   0.86483855  -0.12131781
-0.16489568   0.04532427   0.98526906
```

22 Installation Directories

TerraPhoto shares the same directory structure with all Terra Applications. It is recommended that you install all Terra Applications in the same directory.

The list below shows a typical directory structure when TerraPhoto has been installed in path C:\TERRA.

c:\terra	directory where TerraPhoto was installed
config	for configuration files
tphoto.cfg	defines environment variables
coordsys	for coordinate system data
ostn02.txt	OSTN02 transformation grid data
docs	for documentation
tphoto.pdf	documentation in Acrobat Reader format
license	for user license files
tphoto.lic	user license
ma	for application files
tphoto.ma	application
tphoto.dll	routine library
ncscnet.dll	ECW library
ncsecw.dll	ECW library
ncsecwc.dll	ECW library
ncsutil.dll	ECW library
seed	for seed files
seed3dcm.v8	example 3D seed file for V8
tphoto	for user settings

23 Configuration Variables

MicroStation is able to locate TerraPhoto with the help of configuration variables. When you install TerraPhoto, the installation program will create a configuration file TERRA.CFG which defines the required environment variables. This file is placed in MicroStation's CONFIG\APPL subdirectory.

For example, C:\USTATION\CONFIG\APPL\TERRA.CFG may contain:

```
#-------------------------------------------------------
#
#  TERRA.CFG - Configuration for Terra Applications
#
#-------------------------------------------------------

TERRADIR=c:/terra/
TERRACFG=$(TERRADIR)config/
TERRADOCS=$(TERRADIR)docs/

MS_MDLAPPS < $(TERRADIR)ma/

%if exists ($(TERRACFG)*.cfg)
%   include $(TERRACFG)*.cfg
%endif
```

This configuration file will include all the configuration files in C:\TERRA\CONFIG directory. TerraPhoto's configuration file TPHOTO.CFG contains:

```
#--------------------------------------------------------------
#
#  TPHOTO.CFG - TerraPhoto Configuration File
#
#--------------------------------------------------------------

TPHOTO_DATA=$(TERRADIR)data/
TPHOTO_LICENSE=$(TERRADIR)license/

#   Directory for user preferences (user has write access)

TPHOTO_PREF=$(TERRADIR)tphoto/

#   Directory for settings (may point to read-only directory)

TPHOTO_SET=$(TERRADIR)tphoto/

#   Files for settings (may be shared by organization)

TPHOTO_TILENAMING = $(TPHOTO_SET)tilename.inf
TPHOTO_TRANSFORM  = $(TPHOTO_SET)trans.inf

#   WGS84 to Ordnance Survey National Grid data files

TPHOTO_UK_OSTN   = $(TERRADIR)coordsys/ostn02.txt
```

In a default configuration, MicroStation will automatically include these settings as configuration variables. You can use MicroStation's **Configuration** command from **Workspace** menu to check the values for these variables. In case these variables have not been defined correctly, you should define them manually.

MS_MDLAPPS should include the directory where TPHOTO.MA is located.

TPHOTO_DATA defines a default directory for incoming laser points.

TPHOTO_LICENSE should point to the directory where user license TPHOTO.LIC is located.

TPHOTO_SET should point to a directory where user settings and user preferences can be stored.

TPHOTO_TILENAMING specifies a file in which tile naming schemes are stored.

TPHOTO_TRANSFORM specifies a file in which coordinate transformations are stored.

TPHOTO_UK_OSTN specifies a file from which to read UK National Grid data.