ProjectionTools Documentation

Release 6.1.1

domeprojection.com GmbH

Mar 17, 2025

GETTING STARTED

CHAPTER

ONE

INTRODUCTION

This documentation describes ProjectionTools, a suite of software tools specifically designed for multi-projection systems. It supports camera based automatic calibration, alignment, and content adaptation for multi-channel projection setups.

Creator
Captures calibration data with digital camera(s) and generates the base data for exporting correction data in *Mapper2d*, *Mapper3d* and *MapperPM*

Align
Automatic realignment of projection systems using fixed installed camera(s).

Mapper2d
Prepare, preview and export correction data for 2D Mediaservers.

Mapper3d
Prepare, preview and export correction data for 3D engines and Simulators.

MapperPM
Prepare, preview and export correction data for 3D projection mapping software.

PatternGenerator
Software running on display computers to show testpatterns for data capture and previews.

CHAPTER

TWO

PREPARATION

2.1 System Requirements

Operating System:
Windows 7/8/10/11

CPU:
Intel Core i5 or equivalent (Intel Core i7 recommended)

RAM:
4 GB

Graphic Card:
OpenGL capable

Copy Protection:
CodeMeter Runtime 5.20

LAN Connection:
The Creator/Mapper2d rely on network communication with the PatternGenerator. After starting the program for the first time, windows firewall (or other 3rd party products) may ask for permission to use certain network ports in conjunction with the program. It's crucial to allow those connections.

2.2 Supported Cameras

ProjectionTools rely on calibrated cameras and lenses. Due to the calibration need, usually prime lens optics are used.

Creator
Normal and fisheye lenses are supported.

Calibrated and uncalibrated cameras are supported.

Creator Demo
The demo version supports only uncalibrated cameras. The list of supported cameras is not limited.

Normal and fisheye lenses are supported.

Align
Align relies on calibrated cameras and lenses. Due to the calibration need, usually prime lens optics are used.

Normal and fisheye lenses are supported.

Here is the list of supported camera types:

Webcam:
Windows supported webcams can be used. Then default resolution is 1080p if supported. The following models are recommended:

- Logitech BRIO
- Logitech C920

Canon EOS series:
No drivers required

- EOS 6D/7D
- EOS 1300D

AVT Firewire:
Vimba 5.0 required

- Guppy 046B, 046C, 146B, 146C
- Oscar 810C
- Marlin 145C2

AVT Gigabit Ethernet:
Vimba 5.0 required. In order to use AVT camreas, make sure camera backend is set to Vimba using `Help/Camera Backend...`.

- Manta G-145B, G-146B, G-223B, G-504B
- Mako G-223B, G-503B, G507B
- Alvium G1-500m, G1-507m

IDS:
uEye 4.95.00 required

- UI524xCP
- UI528xCP
- UI536xCP
- UI537xCP
- UI546xSE
- UI548xCP, UI548xSE
- UI558xCP
- UI588xCP

Daheng Imaging:
Galaxy 1.6.2001 required. In order to use Daheng Imaging camreas, switch camera backend to Daheng using `Help/Camera Backend...`.

- MER-500-14GM-P
- MER-531-20GM-P
- MER-630-16GM-P
- MER2-503-23GM-P
- MER2-507-23GM-P
- MER2-630-18GM-P

- ME2P-1230-9GM-P
- ME2P-1840-6GM-P

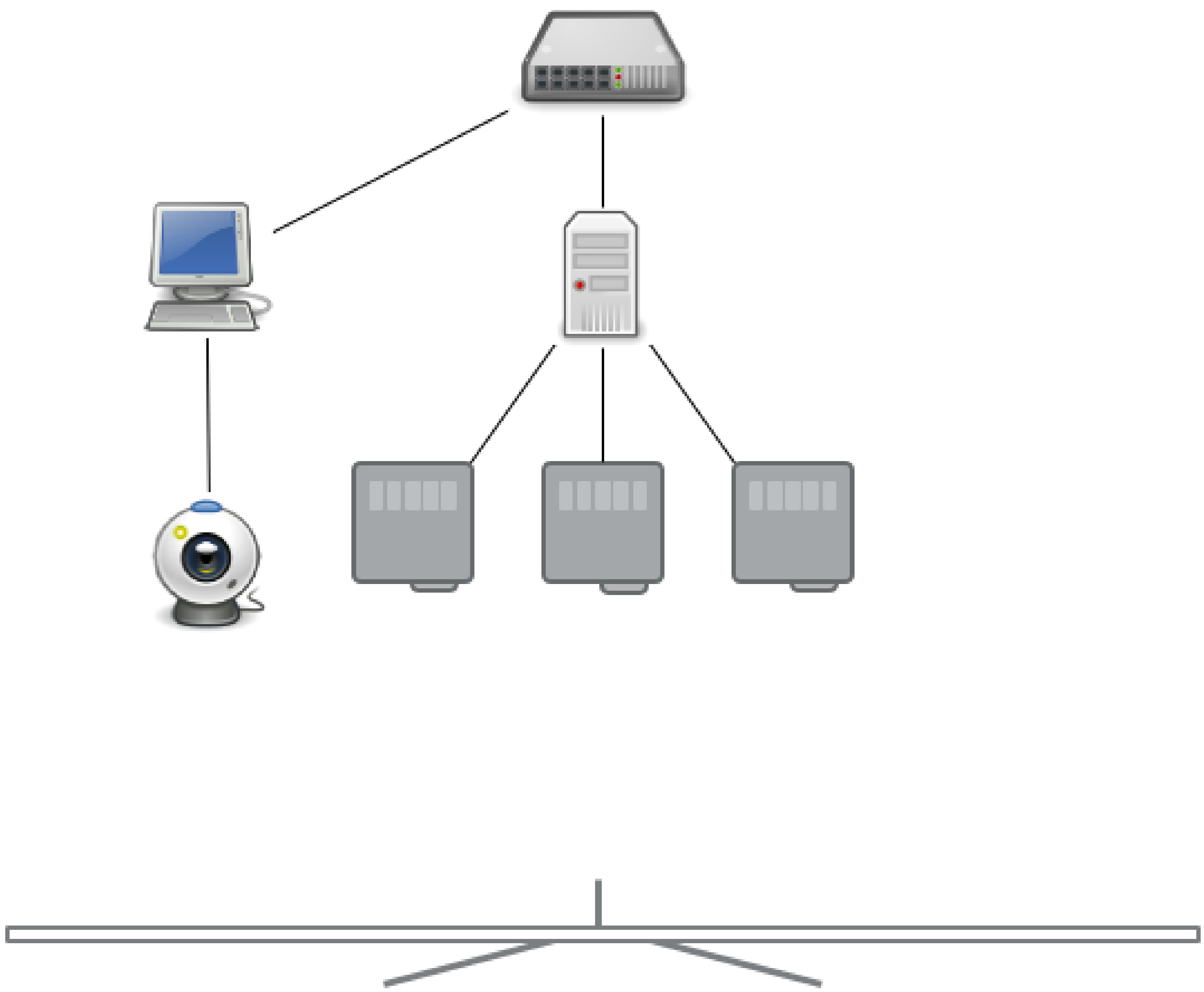
Basler:

Pylon Runtime 7.3 required

- acA1920-51gc
- acA2440-20gm
- acA2500-14gc
- acA2500-14gm
- acA4024-8gc

2.3 Setup and Installation

Several devices need to be wired up and running for calibrating a projection system.



Projectors

- They should cover the screen.
- Neighboring projection channels should have an overlap of roughly 10%.
- Image optimizations like dynamic brightness/contrast should be disabled, since they might negatively interfere with camera-based calibration process.
- A clean gamma curve should be set (as a default, gamma 2.2 is expected).

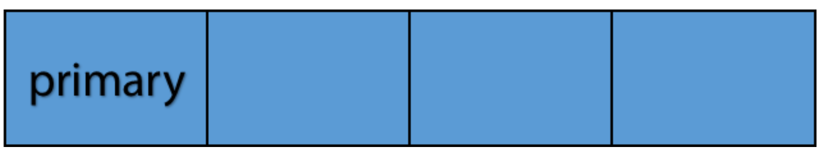
Image Generator(s)
Also called Display Computer(s) or Media Server(s).

- Must be connected to projectors and show image.
- Ensure, that correct resolution is set, usually the projectors native resolution is desired.
- Disable Display scaling.
- Install PatternGenerator using the ProjectionTools Demo installer in "Image Generator" configuration.
- Start PatternGenerator and set it to one of the following layouts:

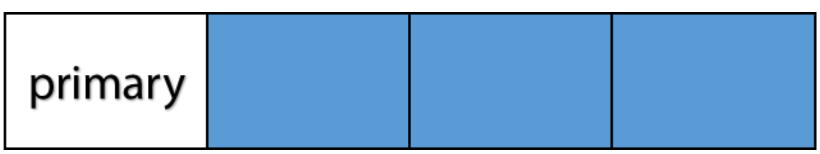
  Main Display
  Opens PatternGenerator in fullscreen mode on main display.

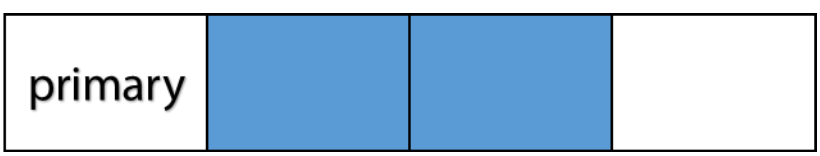
  All Displays
  Opens PatternGenerator on all attached displays

  Secondary Displays
  Opens PatternGenerator on all secondary displays.

  Custom
  Allows to customize the window layout. This allows to show it only on a few attached Displays or even to divide one Display in multiple subregions, for example when a spanned desktop is used and PatternGenerator recognize the whole desktop as one single Display.

Control PC
Usually a separate computer. But in some cases the Display Computer is used as Control PC as well. In that case at least an additional monitor should be attached to control the calibration software without interfering with the projected image.

- Install ProjectionTools Demo (Full or Control-PC setup)
- Install potential camera drivers required for industrial cameras
- Connect camera and check connection. AVT and IDS both install a camera viewer when installing the driver software. Webcams can be checked with the windows camera app.
- Establish and check network connection to Display Computers.

CHAPTER

THREE

CALIBRATION WORKFLOW

The *Creator* is used to capture the distortion of each projection image on the screen surface. In order to do that different dot patterns will be projected for each projector onto the screen while a camera will take pictures from that process.

The captured data is than used in *Mapper2d*, *Mapper3d* or *MapperPM* to define and preview content mapping on a screen.

The following sections describe the complete process from creating a new calibration project to showing a continuous warped and blended image on the screen using *Mapper2d*.

3.1 Preparation

Before starting *Creator* you have to make sure that:

1. Projectors are turned on and running for several minutes.
2. Image Generators connected to the Projectors producing an image in correct resolution.
3. PatternGenerator is installed, configured and running on all Image Generator computers.
4. A network connection between control computer and Image Generator computers is available.
5. The camera is connected to the control computer.

3.2 Create a new project

After opening *Creator*, create a new project by selecting `File/New Project`. The *New Project Wizard* will open up and guide you through the process of creating a new project.

3.2.1 Basic Settings

Enter a project name and select a path for storing the project on the first page.

Project name

Name of the project. A new folder with that name will be created and all project related data will be saved into that folder including a `config.xml` which can be loaded later for reopening the project.

Demo The demo version creates a `config.ptdconfig` instead of a `config.xml`.

Path

The parent path (workspace) in which the new folder with the new project will be created.

Then hit next.

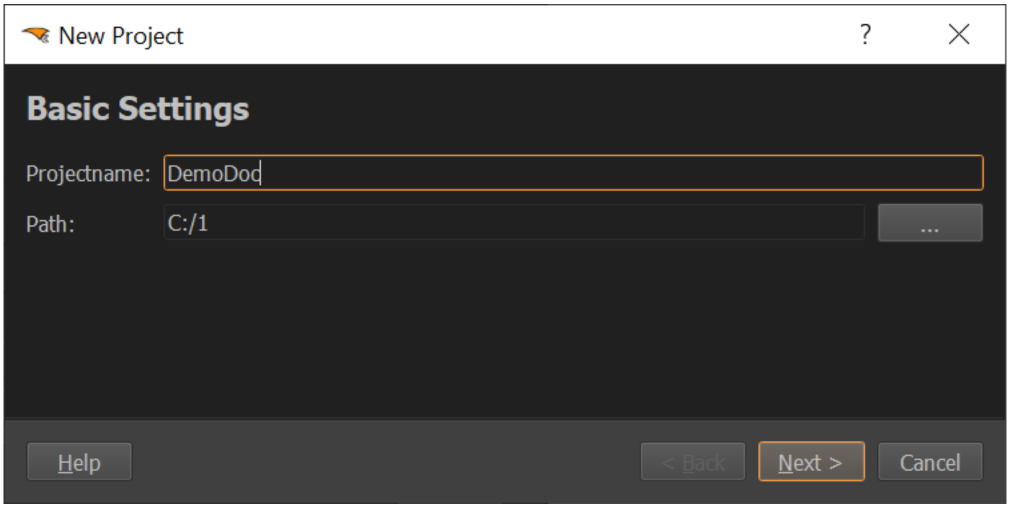


Fig. 1: Basic Settings

3.2.2 Screen Geometry

On the second page in the *New Project Wizard* define your screen shape. You can do this either by entering all screen design values directly or by generating some values from easy to take measurements.

Type
: Select the screen type to use

  Demo The demo version supports type Plane, Cylinder and Sphere Segment.

Angles and Radius
: Design data for Cylinder and Sphere Segment screens. These are automatically generated when *Guess Radius and Angle(s)* is enabled.

Distance Measures
: Several distance measures such as width and height can be adjusted for each screen type. Some of these inputs are generated when *Guess Radius and Angle(s)* is disabled.

Guess Radius and Angle(s)
: Allows to enter measured lengths instead of angles for Cylinder and Sphere Segment screens. This is enabled by default.

When you have finished entering the screen information, proceed to the next page by hitting *Next*.

3.2.3 Projectors Setup

On the third page in the *New Project Wizard* set the number of projectors used and their resolution as well as the IP-address of the **I**mage **G**enerator (Display Computer) where the projectors are connected to.

This allows *Creator* to project test patterns on the projectors using the *PatternGenerator* running on the **I**mage **G**enerator.

Demo The demo version is limited to 3 channels and supports only a subset of configuration possibilities.

Projector Count
: Number of projectors(channels) that should be calibrated

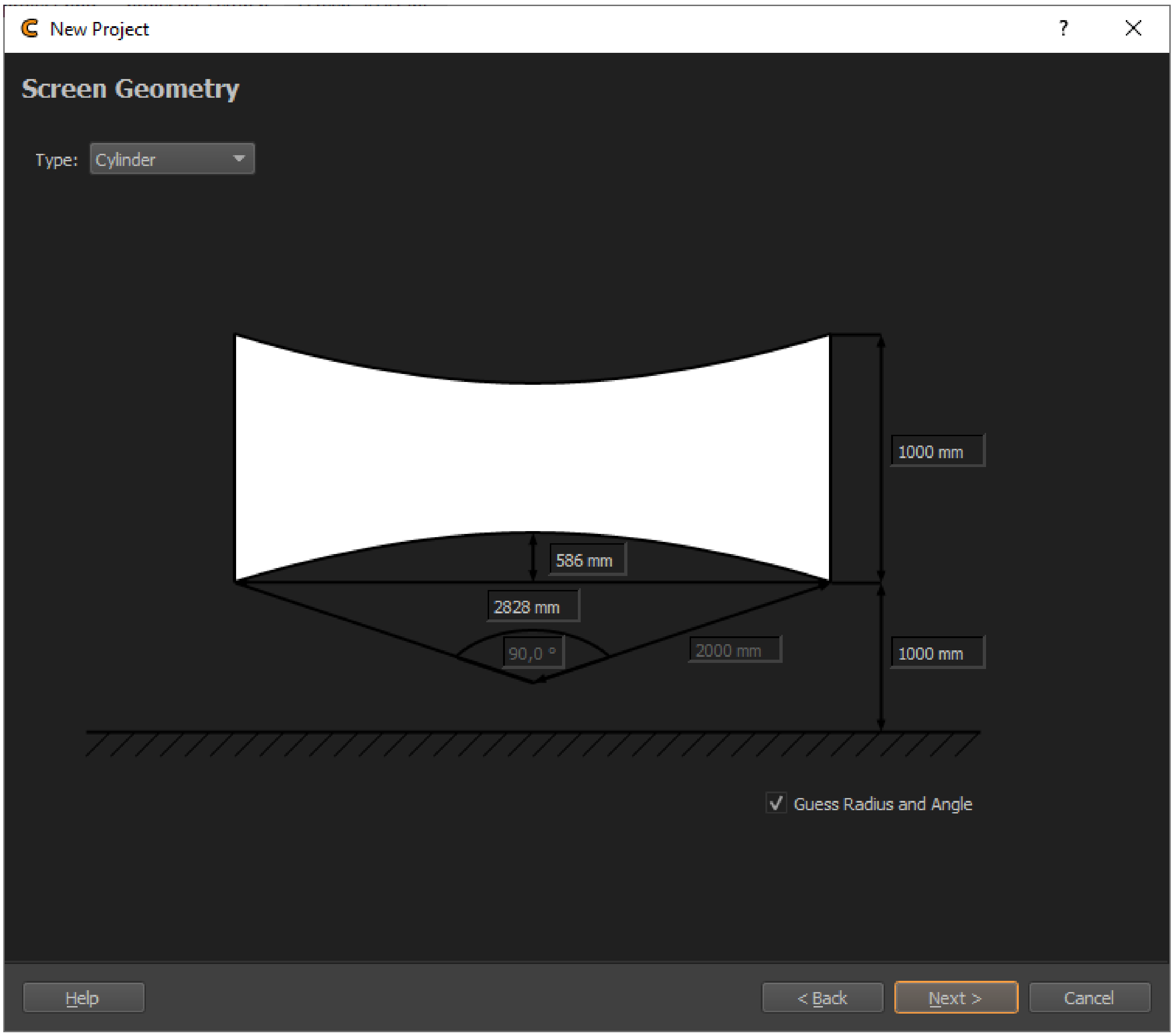


Fig. 2: Screen Geometry

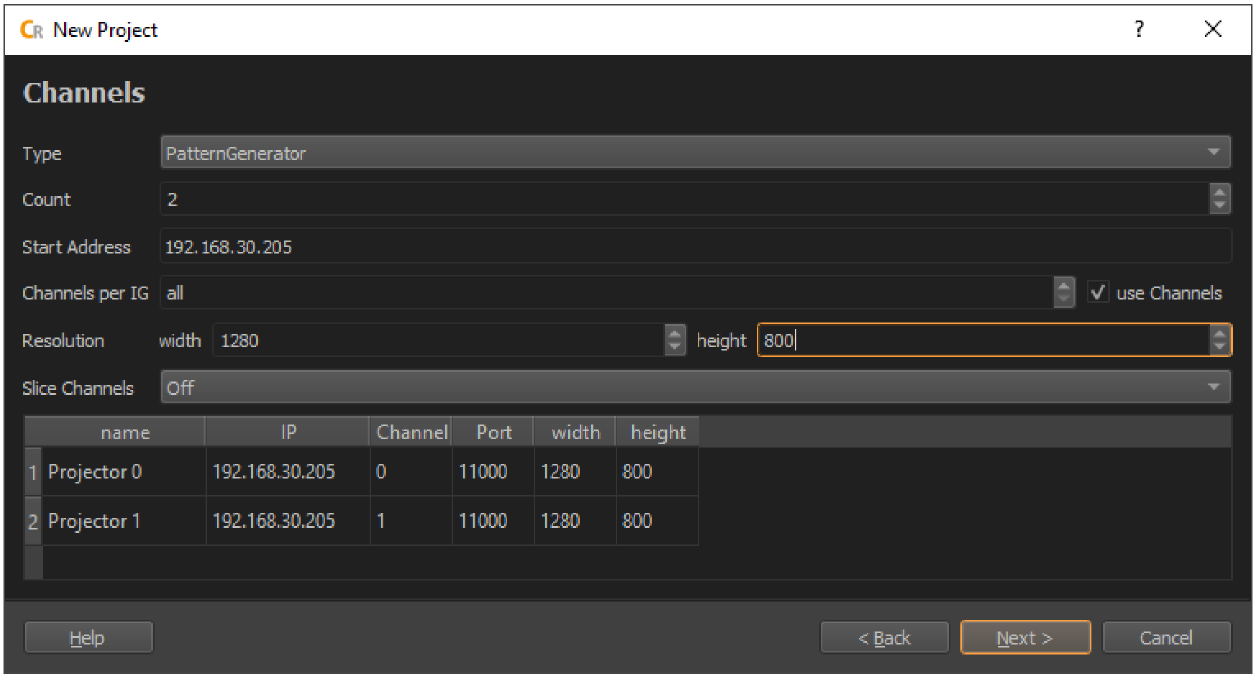


Fig. 3: Projector Setup

IP

IP Address of Image Generator attached to projectors. You can read the IP address of the Image Generator in the info shown in the center of each projector by the running PatternGenerator.

Fig. 4: PatternGenerator infos

Width / Height

Projector resolution. The same setting will be used for all projectors by default. If different resolutions are used in the system, the generated projector list can be modified.

Generated Channel List

This list is automatically generated according to the settings above. The settings for each channel can be further modified in the list.

When you have finished entering the projection channel informations, proceed to the next page by hitting *Next*.

3.2.4 Camera Selection

On the last wizard page, select a connected camera to be used for calibration, then set its lens type and opening angle / Field of View.

Demo The demo version supports only uncalibrated cameras.

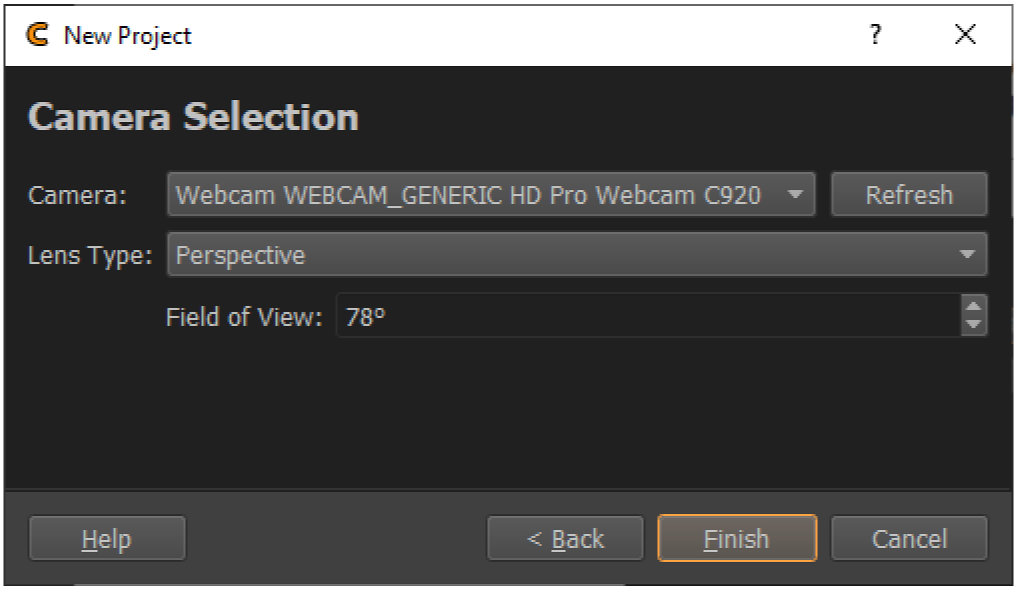


Fig. 5: Camera Selection

Camera Dropdown
List of found, connected cameras, to select from.

Refresh
Search for connected cameras again and update the Camera Dropdown list.

Lens Type
Select between "Perspective" and "Fisheye".

Field of View
Shown for perspective lens type. The diagonal viewing angle of the camera image. This information is usually given by the camera manufacturer.

Opening Angle
Shown for Fisheye lens type. The vertical viewing angle visible on the image, e.g. 180 degrees for normal fisheye fitting in the camera image.

When you have selected the camera and entered its lens properties, you can create the project by hitting the *Finish* button. The wizard is closed, and you get back to the main window, with the newly created project.

3.3 Place and orient the camera

The camera life stream can be seen in the middle of the program window.

To make finding a good camera position easier, project a white test image using the preview toolbar.

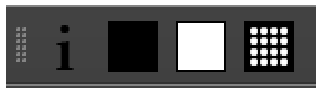


Fig. 6: Preview toolbar

The third button is used to project a white image for selected projectors, which makes it easier to detect the borders of the projection space. The fourth button is projecting the dot pattern, which is also a good pattern to position the camera.

In order to get a precise calculation of the projection surface, now find a good camera position and orientation that captures the whole screen. Typically this would be in the middle, in front of the screen, in a distance that allows to see the whole screen reasonable large in the camera image.

3.4 Adjust camera settings

Click on "Settings…" below currently selected camera in Camera dock to open the Camera Settings dialog.

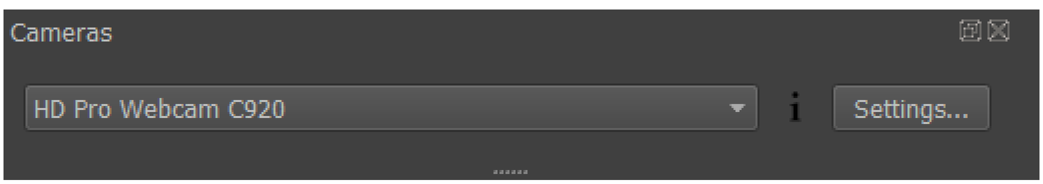
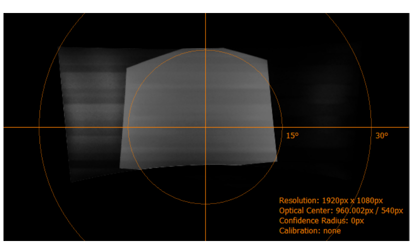


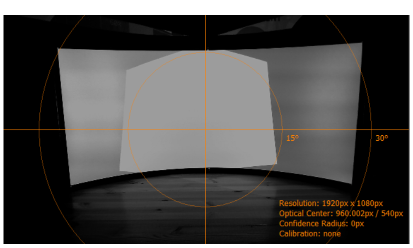
Fig. 7: Cameras dock

The right side shows the last picture taken by the camera.

On the left are the settings available for your camera.

Use the settings on the left side of the dialog and update the camera image by hitting the *Snap* button, until the projection is clearly visible but not too bright.





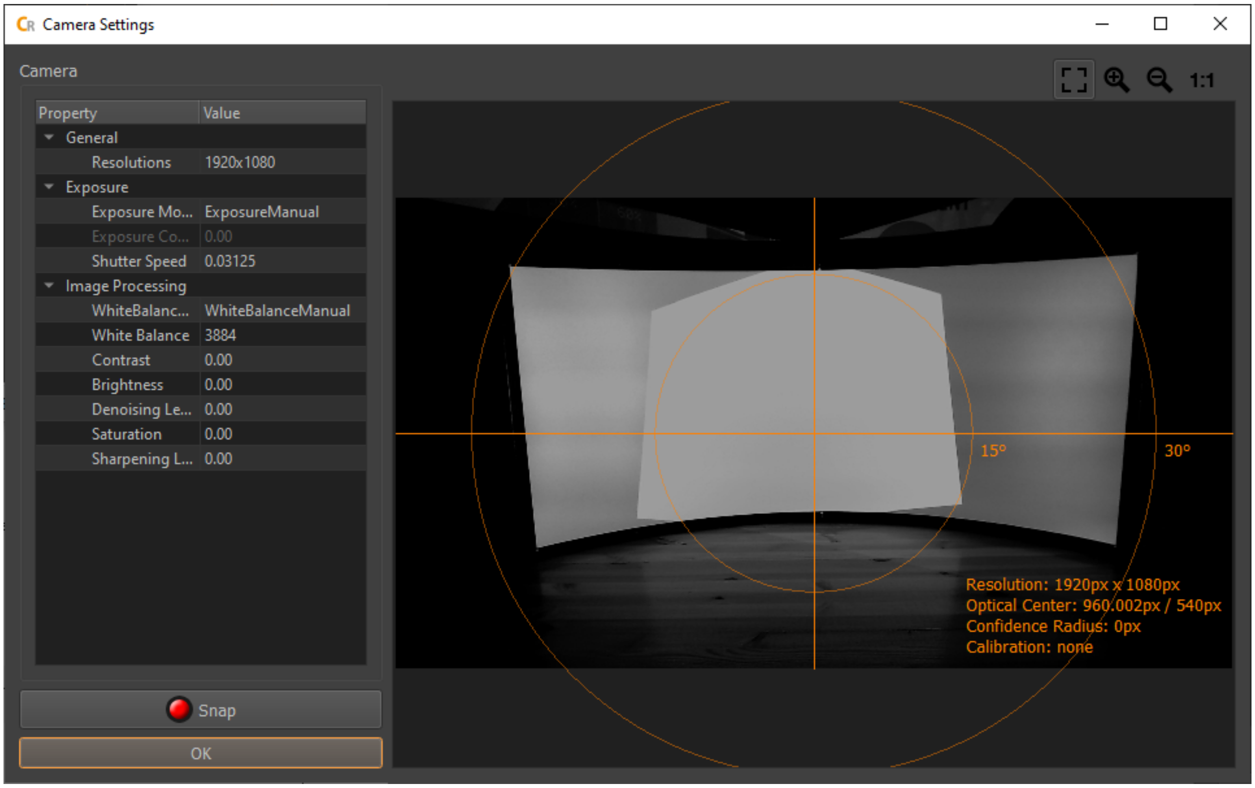
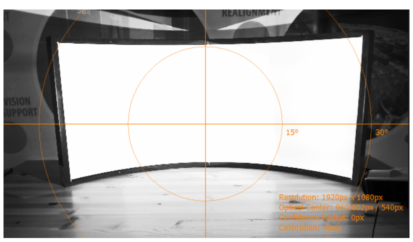


Fig. 8: Camera Settings Dialog



Comparison of camera settins: too dark / good / too bright

When satisfied, you can close the dialog, by pressing the ok button. The live camera view now use your new camera settings.

3.5 Test pattern recognition

In the `Projectors/Dot Pattern` tab hit the button to open the recognition parameters dialog.

After pressing *Test Parameters* the camera will take some pictures and Creator marks each detected dot with an orange cross.

All the points fully projected on the screen should be detected and marked with an orange cross. Cut dots projected on the screen border are usually not detected, that is intended behavior.

If not all of the fully projected points are detected, adjust the threshold and dot min/max radius and test the new parameters again to improve the detection.

By pressing ”ok” the settings can be saved and closed.

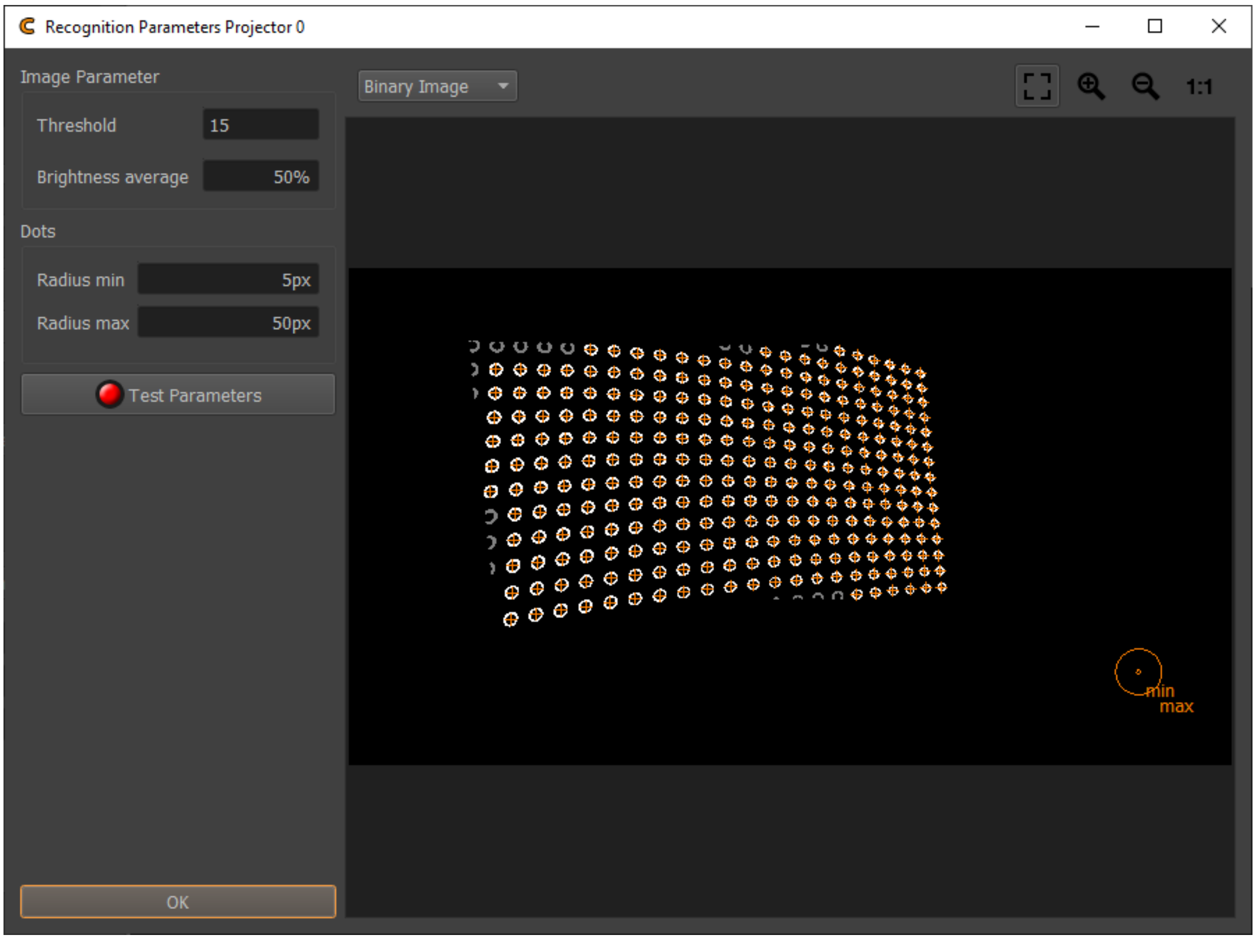


Fig. 9: Recognition Parameters

The recognition settings are adjusted per projector, so if the recognition settings needed to be changed, you might need to do the same for the other projectors.

3.6 Find camera position

We are starting the data capturing by calculating the exact camera position.

Double click on the camera serial number in the positions table or click `Position tab/Find Position...` under positions table. This opens the *Find Position* dialog.

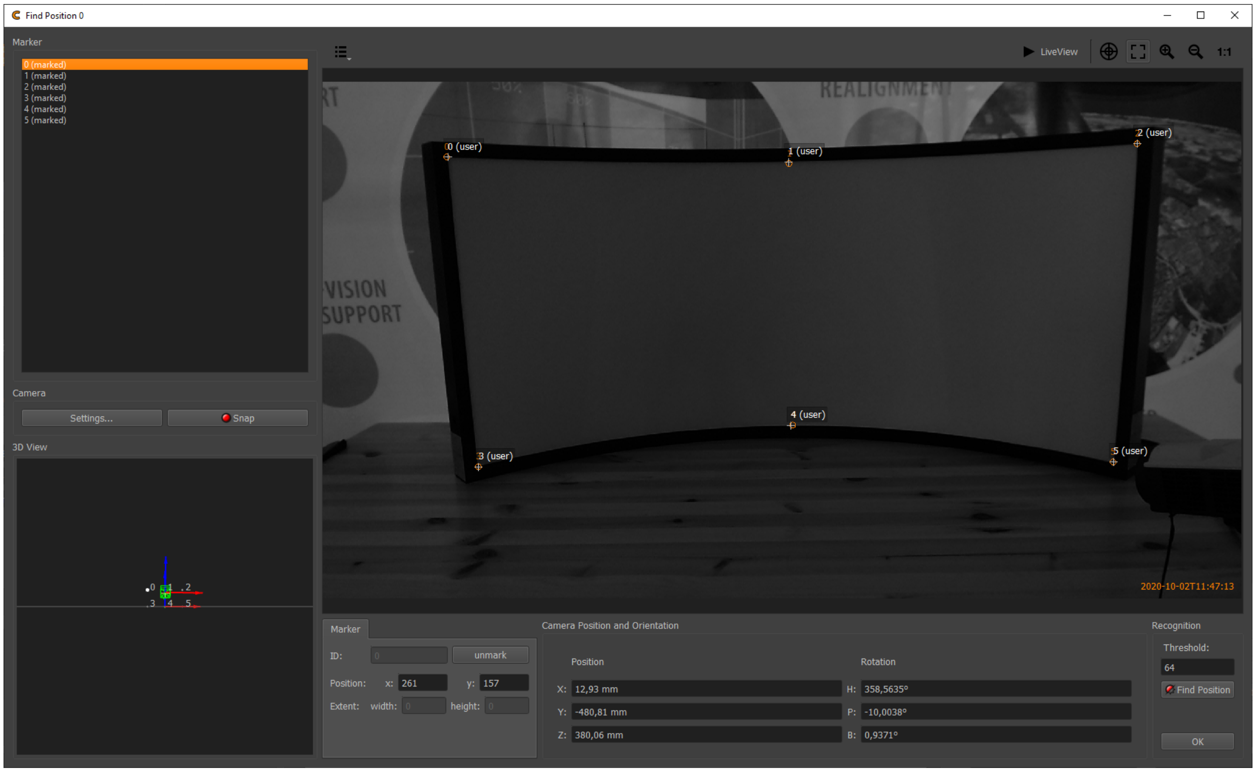


Fig. 10: Find position dialog

The *Position Finder* is used to calculate the camera position and orientation based on reference points (markers) seen by camera.

Demo The demo version is limited to default reference points, generated at the screen corners and the middle of the top and bottom edge of the screen.

Usage:

1. Prepare lighting conditions. For simple passive feature points, such as screen corners, turn on lights or project a white testpattern using the projectors.
2. Snap an image.
3. If the feature points are not clearly visible, change camera settings using the `Camera/Settings...` button on the left side of the dialog. Please note, that the *Find Camera Position* dialog uses a separate set of camera parameters.
4. Select markers in the marker list on the left side and mark them in the camera image using double click.
5. Hit ”Find Position”.

When the calculation has finished, Camera position and orientation are updated (see position/orientation text boxes and 3d view). Also the recognized/defined markers and assumed marker positions in image based on projection of 3d markers are visualized in the camera image.

If problems occur, check if the markers are assigned to the correct position in the camera image and not exchanged. Another potential problem is, when you have not entered a correct field of view for your camera, when creating the project.

When camera position was successfully found, close *Position Finder* using "OK" button.

3.7 Capture test pattern

After dotpattern, recognition and camera settings are adjusted, the image taking process can be started.

In order to take pictures select a complete camera position (click on camera id in positions table). This will automatically select all projectors for this position.

Than press "Take Images and Analyze" button on capture toolbar (second button from left side).

Fig. 11: Capture toolbar

Different variations of the dot grid will be projected while the camera takes pictures.

After all pictures are taken the position table should update and visualize measurement result qualities. Green color means all projected points where detected. A tooltip shows the actual number of points projected and detected.

Double clicking on a cell in position table opens a picture showing the full dot pattern with added orange crosses. These crosses show which dots have been detected.

Missing points on the screen border and beyond the screen are fine. But you should aim for detecting all fully projected dots on the screen. Also you must avoid false positive detections.

Some missing points on the screen or false detections might be solved by simply checking your environment for movable obstacles or disturbing lights and removing them.

If you still have problems, see trouble shooting *Calibration Troubleshooting* to learn how to remove falsely recognized dots.

In rare cases not all dots are recognized after refining all camera settings, recognition parameters and masks, the rule for that case is, that at least 80% of the projected dots should have been recognized. The Mapper will then extrapolate the captured data, to cover the missing areas.

3.8 Generate projection geometry

When camera position is calculated and all projection patterns are taken, use `Capture Toolbar/Generate 3d` (Cube) to reconstruct projection geometry from all captured data.

Fig. 12: Capture toolbar

When calculations are finished, a mesh for each selected projector is shown in 3d view.

The work in creator is finished and the project is ready for use in Mapper2D to show a preview of the result.

Save the project and close Creator now.

3.9 Preview calibration results

Demo The demo version of Mapper2d has no export functionality and supports only the PatternGenerator for displaying content (with watermarks).

Start Mapper2d and open your previously created project using `File/Load Project...`.

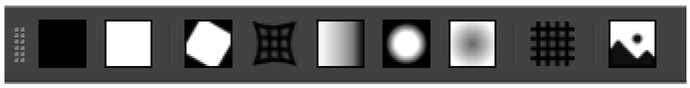


Fig. 13: Mapper2d Preview toolbar. From left to right: Preview Black, White, Cutting, Warping, Shading, Fadeout, Uniformity, Grid, Image.

Select one of the following previews to visualize the results of your calibration.

- Use preview grid to show a quick preview of a grid warped onto the screen.
- Use preview image to select an image and show it warped and blended on the screen.

Fig. 14: Mapper2d showing preview image on PatternGenerator

You have now finished your first calibration. From here you could take it a step further and do for example:

- Adjust the mapping using the mapping editor, to adjust the outline or type of mapping.
- Adjust fadeout and clipping of the screen, to match the screen border more closely.

- Adjust the automatic uniformity correction percentage in `Settings/Shading/Uniformity`
- Disable blending calculation between distinct projection channels by putting projectors into different Blend Groups using `Projectors/Shading/Blend Group`
- Adjust cutting or clipping of individual projection channels and see how blending is automatically adapted.

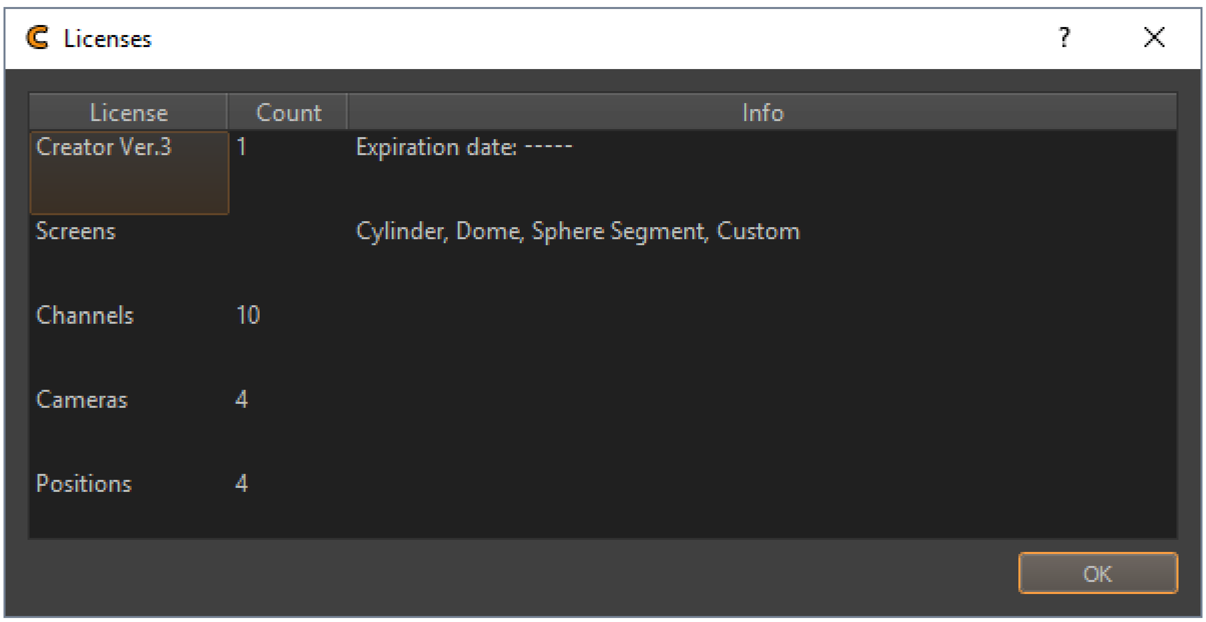
CHAPTER
FOUR

LICENSE

4.1 General

The **domeprojection.com** software package **ProjectionTools** is protected by **CodeMeter** Licensing System. All licenses are stored on your **CodeMeter** stick.

License details of each program can be inspected in `Menu/Help/Lincenses...`.



4.2 License Update

When the license has to be extended or your demo license has to be switched into a full license, the licenses on the **CodeMeter** stick have to be updated.

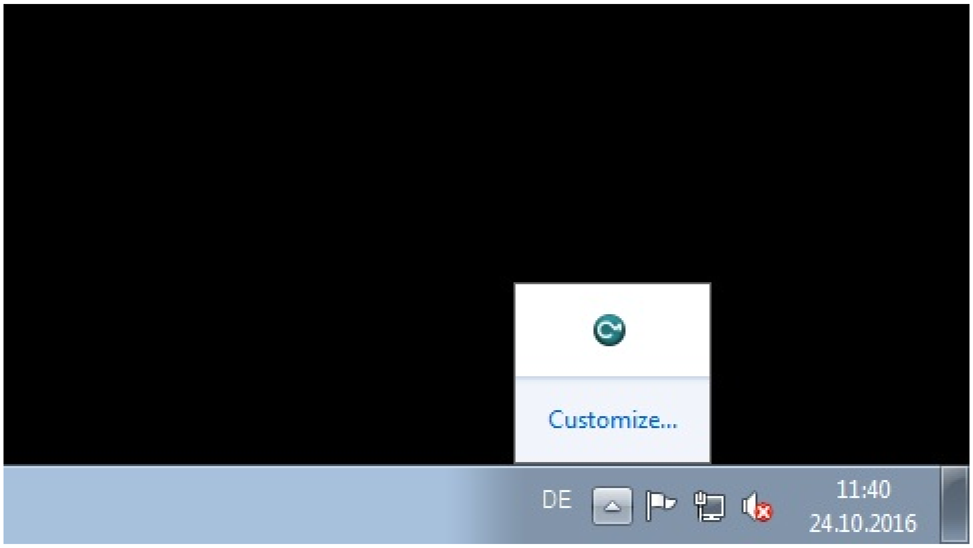
The Update Process consists of three steps.

1. **Create License Context file and send to**
   license@domeprojection.com.
2. **Import the received license update file from domeprojection.com**
   support team.

3. **Create a Receipt and send it to license@domeprojection.com. This**
   is important to verify the license.

4.2.1 Creation of License Context File (WibuCmRaC)

Start by connecting the CM stick to a free USB port at your computer. Download the CodeMeter Runtime Kit from https://www.wibu.com/support/user/user-software.html and install it. After a successfully installation there is a new icon in the quick launch bar.



By clicking on the new icon a new window will open which lists all connected CM sticks.

Select the CM Stick you want to update and press "License Update".

Press "Next" to start the Assistant.

Select "Create license request" and press "Next".

The domeprojection.com license item already exist on your CM stick but has to be extended. Select the corresponding radio button and press "Next".

There can be several licenses from several companies stored on a CM Stick. Tick the checkbox item which contains the domeprojection.com firmcode 102866 and press "Next".

Select a folder where the context file has to be stored. Please do not change the filename. Press "Commit" to save the file.

Send the generated file to license@domeprojection.com.

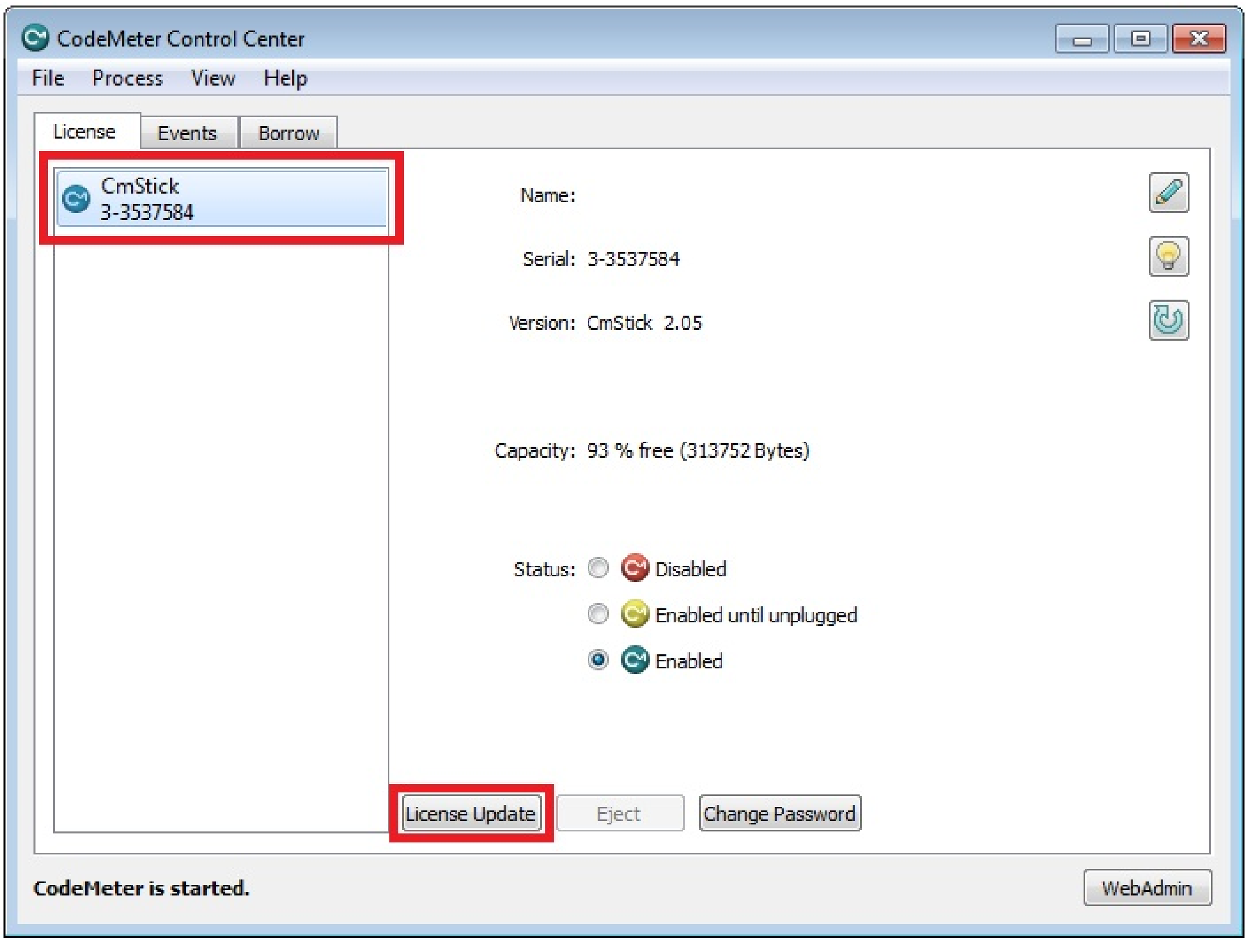
4.2.2 Import of the license Update file (WibuCmRaU)

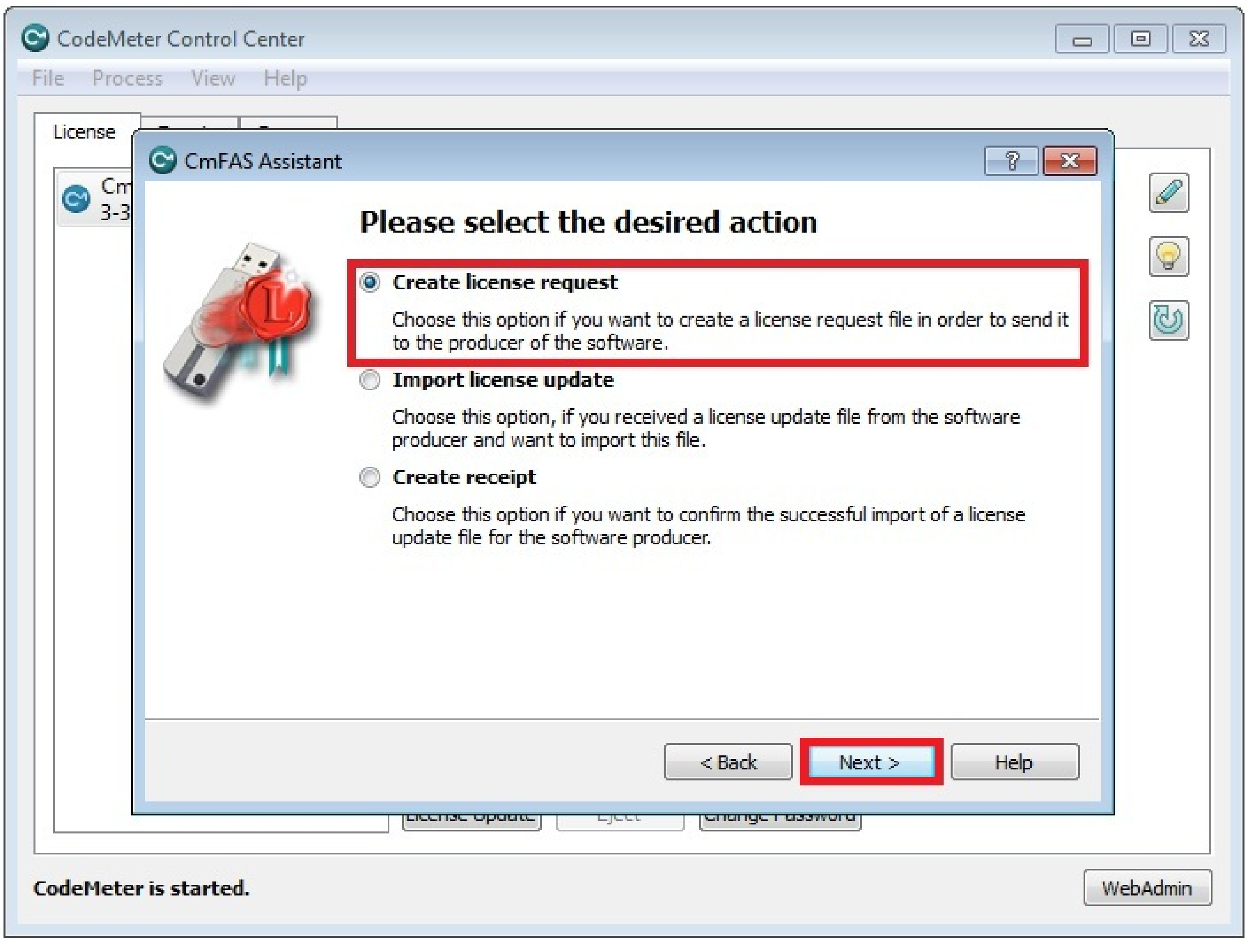
The Update process is nearly the same as creation of a Context file. Open the CodeMeter Control Center, select the CM stick that has to be updated and press "License Update".

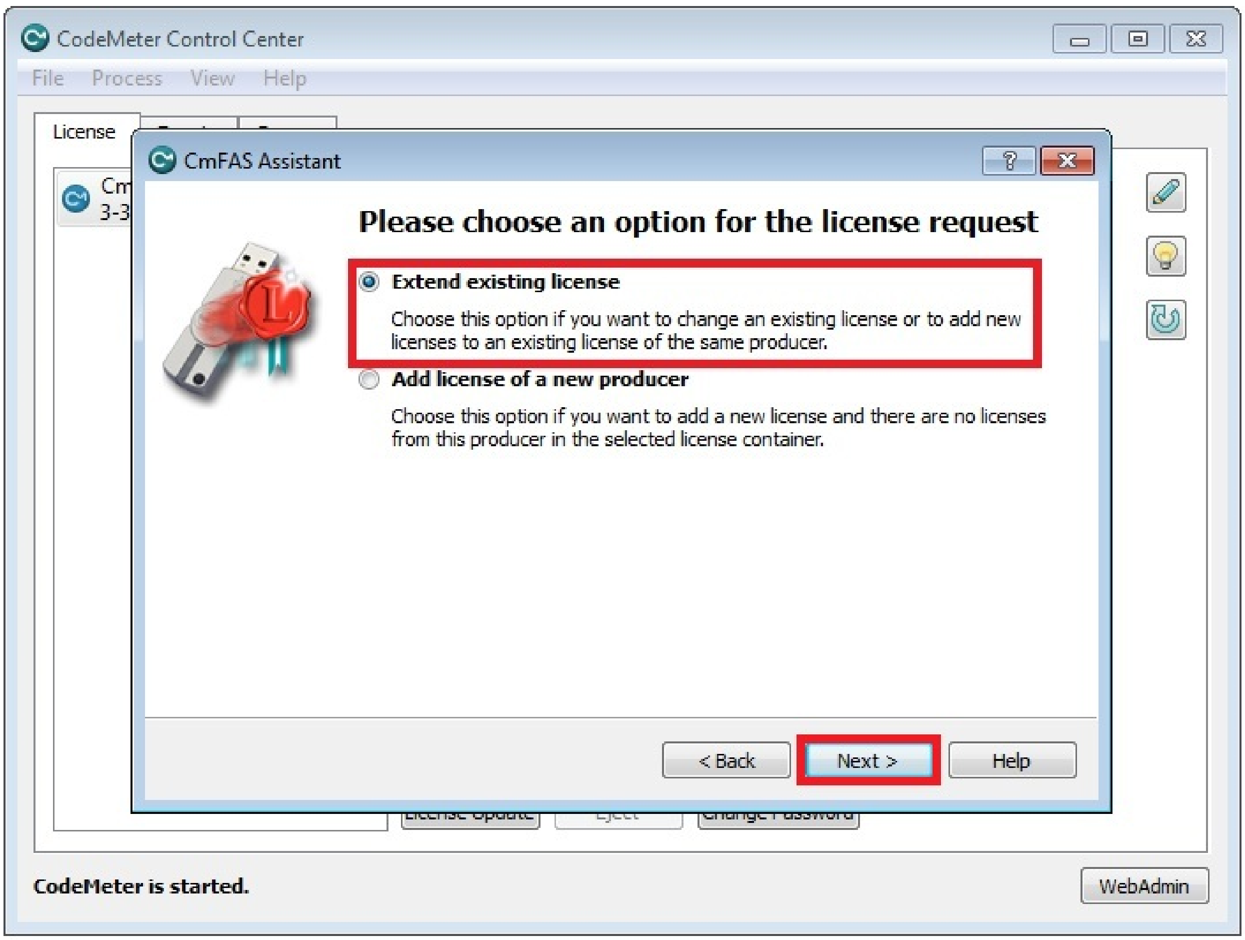
Press "Next" to start the Assistant.

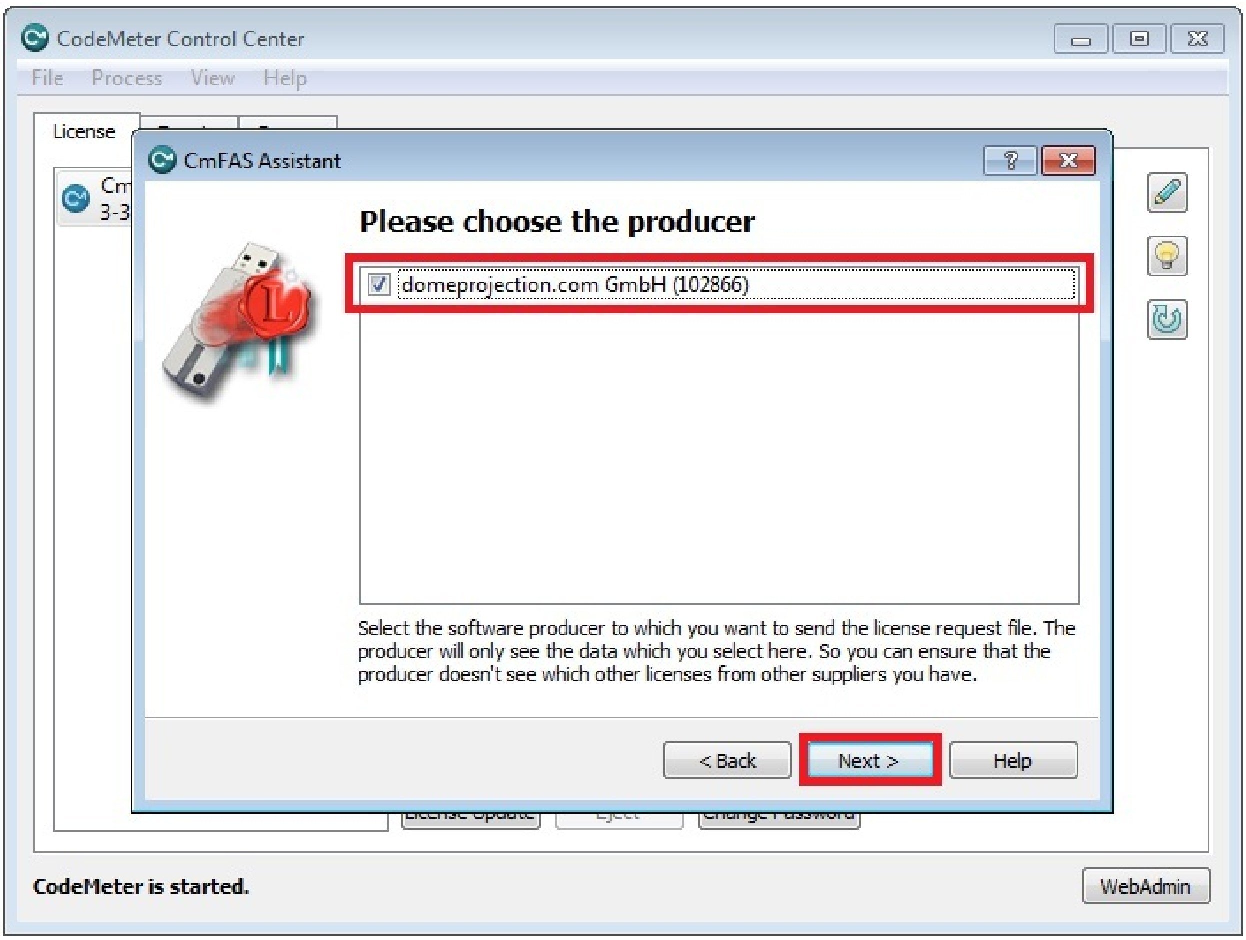
Select "Import new License" and press "Next".

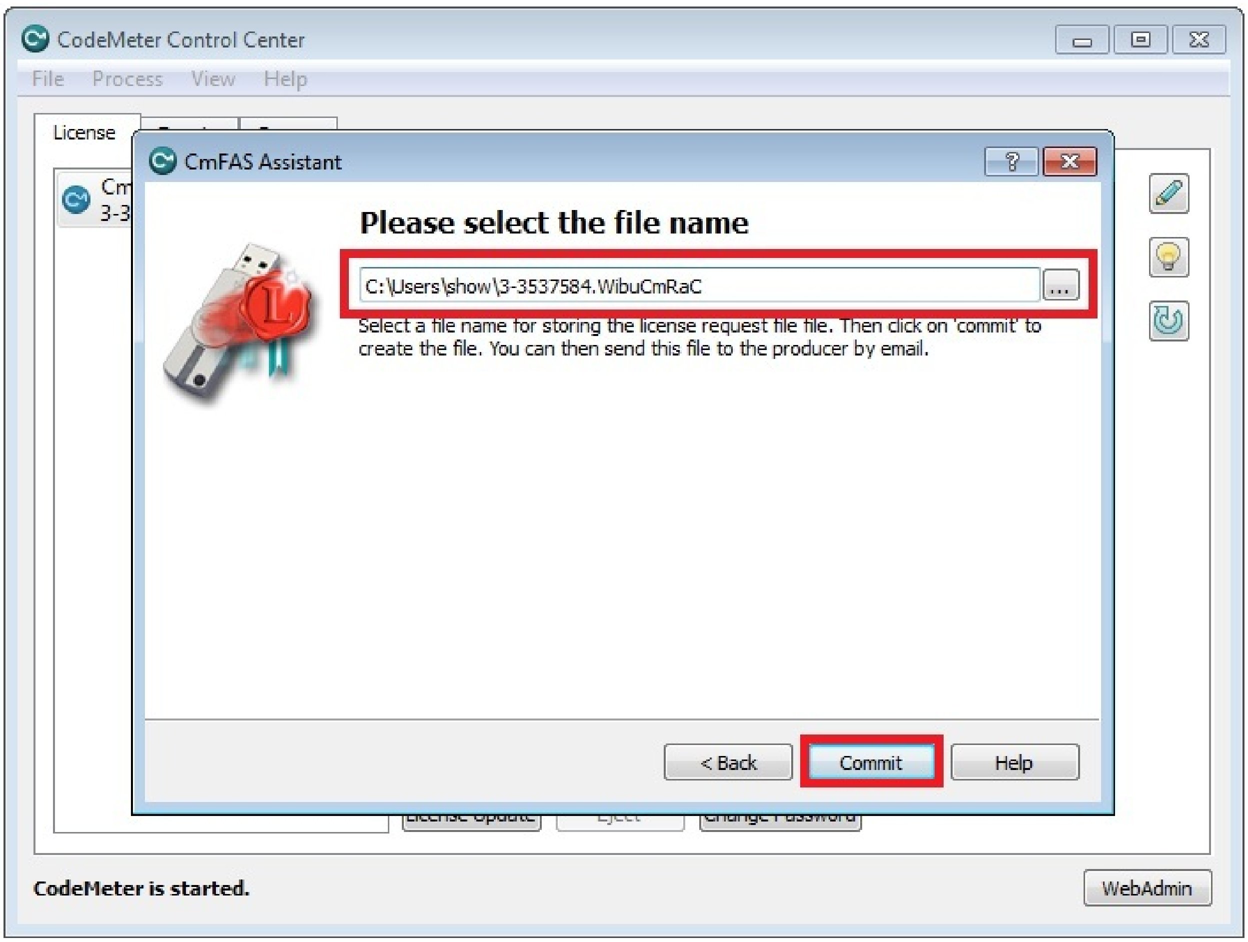
Browse to the Update file that was sent from domeprojection.com and press "Commit".

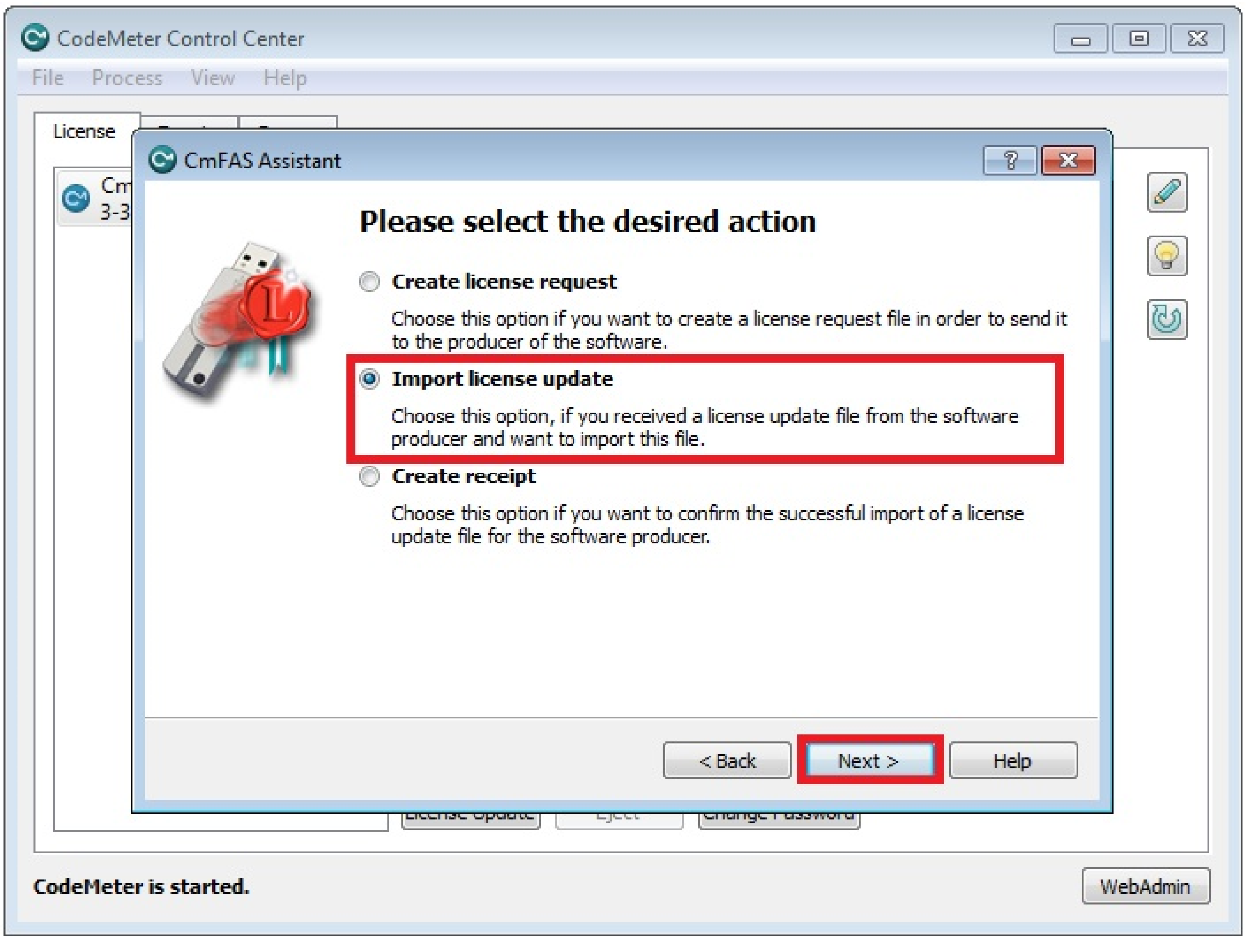

CodeMeter Control Center
File
Process
View
Help
License
Events
Borrow
CmStick
3-3537584
Name:
Serial: 3-3537584
Version: CmStick 2.05
Capacity: 93 % free (313752 Bytes)
Status:
Disabled
Enabled until unplugged
Enabled
License Update
Eject
Change Password
CodeMeter is started.
WebAdmin

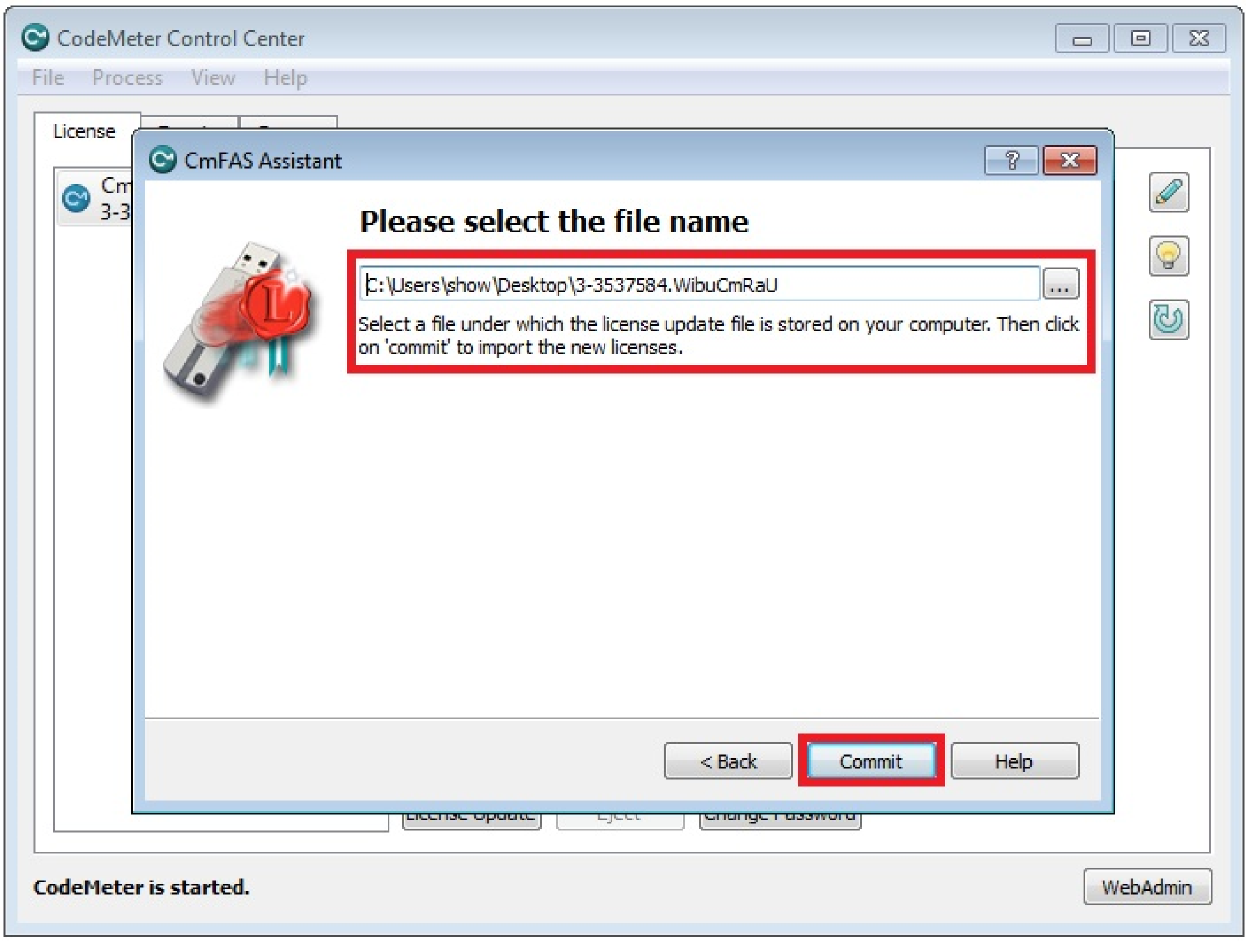

CodeMeter Control Center
File Process View Help
License
CmFAS Assistant
Please select the desired action
Create license request
Choose this option if you want to create a license request file in order to send it to the producer of the software.
Import license update
Choose this option, if you received a license update file from the software producer and want to import this file.
Create receipt
Choose this option if you want to confirm the successful import of a license update file for the software producer.
< Back
Next >
Help
CodeMeter is started.
WebAdmin

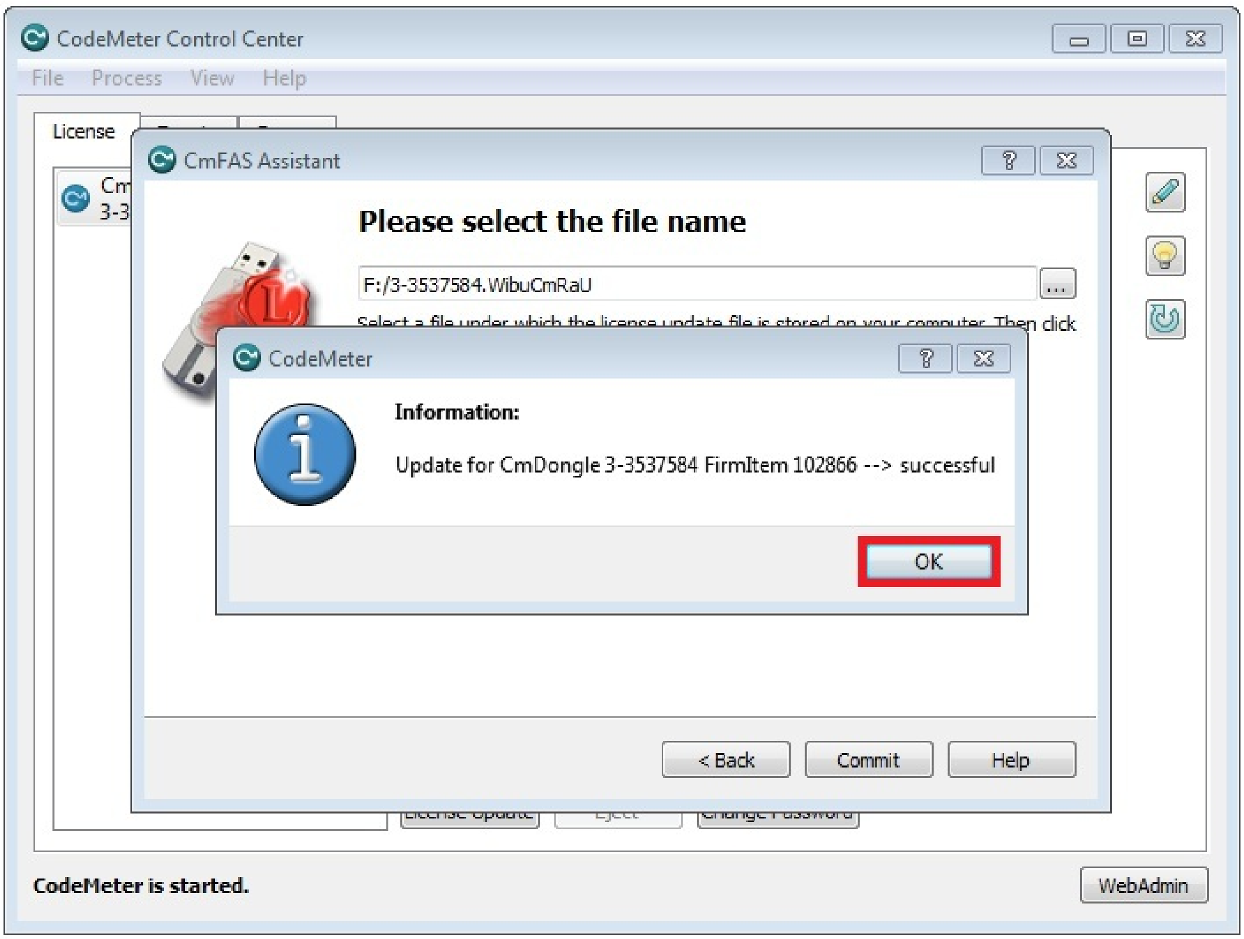

CodeMeter Control Center
File Process View Help
License
CmFAS Assistant
Please choose an option for the license request
Extend existing license
Choose this option if you want to change an existing license or to add new licenses to an existing license of the same producer.
Add license of a new producer
Choose this option if you want to add a new license and there are no licenses from this producer in the selected license container.
< Back
Next >
Help
CodeMeter is started.
WebAdmin


CodeMeter Control Center
File Process View Help
License
CmFAS Assistant
Please choose the producer
domeprojection.com GmbH (102866)
Select the software producer to which you want to send the license request file. The producer will only see the data which you select here. So you can ensure that the producer doesn't see which other licenses from other suppliers you have.
< Back
Next >
Help
CodeMeter is started.
WebAdmin


CodeMeter Control Center
File Process View Help
License
CmFAS Assistant
Please select the file name
C:\Users\show\3-3537584.WibuCmRaC
Select a file name for storing the license request file file. Then click on 'commit' to create the file. You can then send this file to the producer by email.
< Back
Commit
Help
CodeMeter is started.
WebAdmin


CodeMeter Control Center
File Process View Help
License
CmFAS Assistant
Please select the desired action
Create license request
Choose this option if you want to create a license request file in order to send it to the producer of the software.
Import license update
Choose this option, if you received a license update file from the software producer and want to import this file.
Create receipt
Choose this option if you want to confirm the successful import of a license update file for the software producer.
< Back
Next >
Help
CodeMeter is started.
WebAdmin


CodeMeter Control Center
File Process View Help
License
CmFAS Assistant
Please select the file name
C:\Users\show\Desktop\3-3537584.WibuCmRaU
Select a file under which the license update file is stored on your computer. Then click on 'commit' to import the new licenses.
< Back
Commit
Help
CodeMeter is started.
WebAdmin


CodeMeter Control Center
File Process View Help
License
CmFAS Assistant
Please select the file name
F:/3-3537584.WibuCmRaU
CodeMeter
Information:
Update for CmDongle 3-3537584 FirmItem 102866 --> successful
OK
< Back
Commit
Help
CodeMeter is started.
WebAdmin

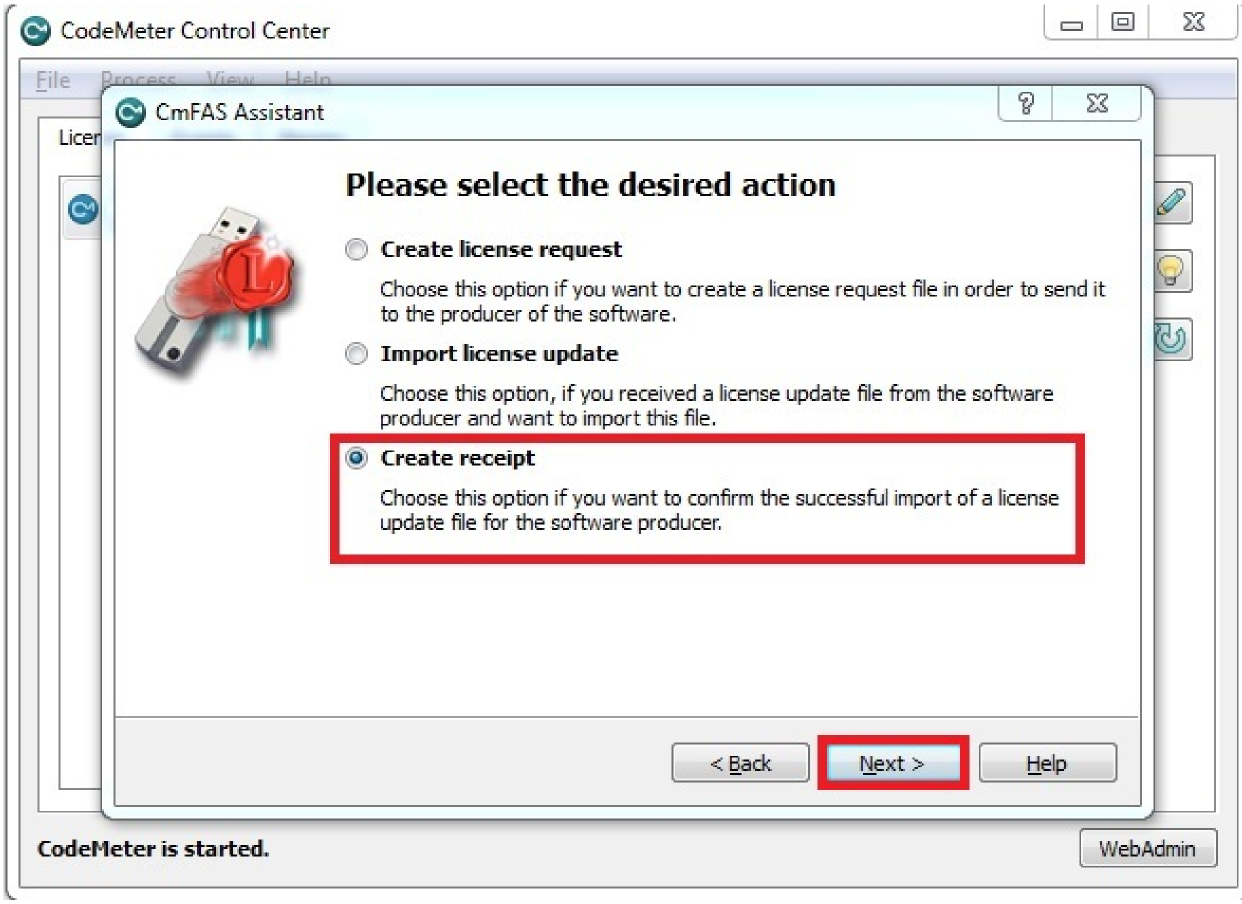
The opening dialog confirms the successfully import of the new license. If the process ends with an error, contact the domeprojection.com support.

4.2.3 Creation of a Receipt (WibuCmRaC)

The final step in updating the license is to create a receipt and send it back to license@domeprojection.com to verify that the import of the license file was successful.

Open the CodeMeter ControlCenter and select the CM Stick and press License Update.

Press "Next" to start the Assistant.

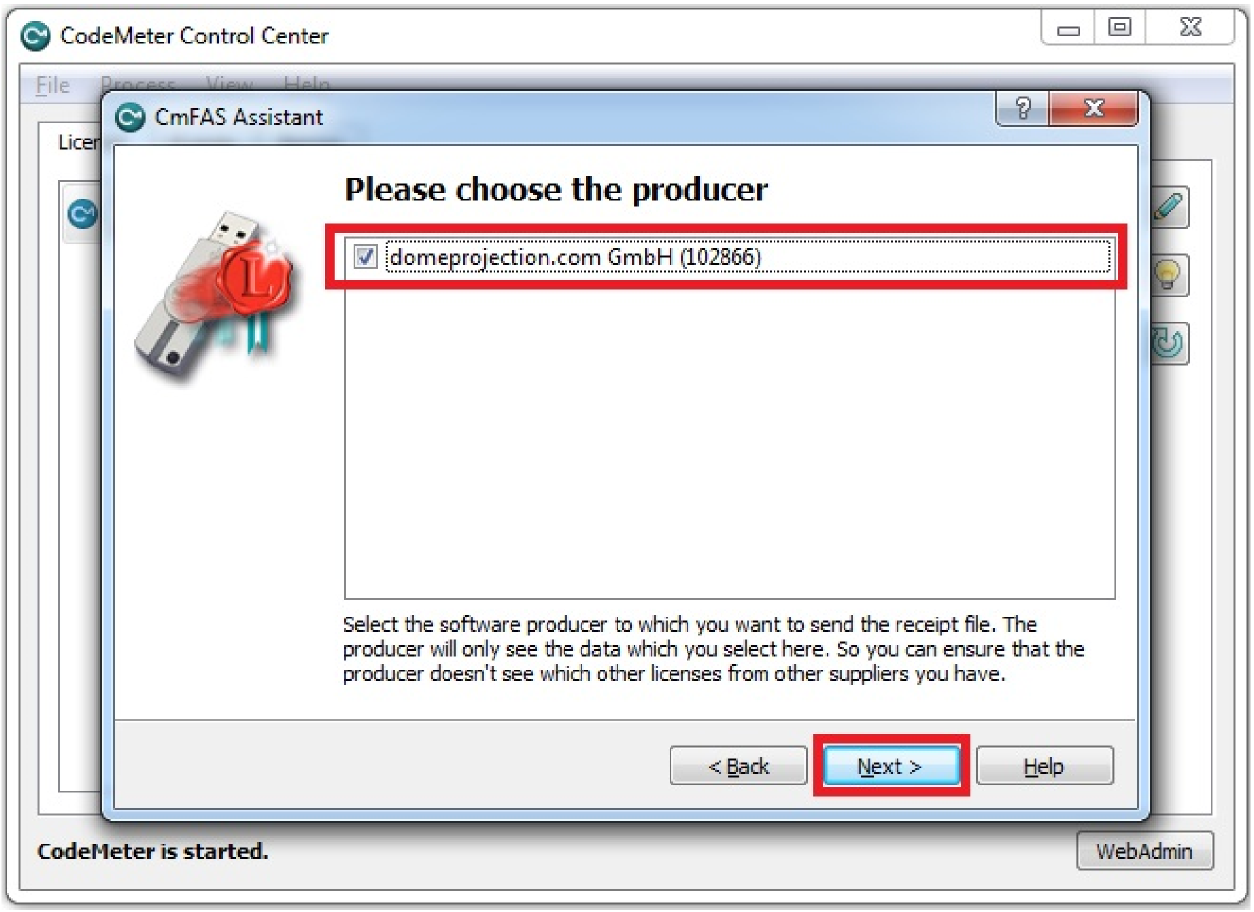


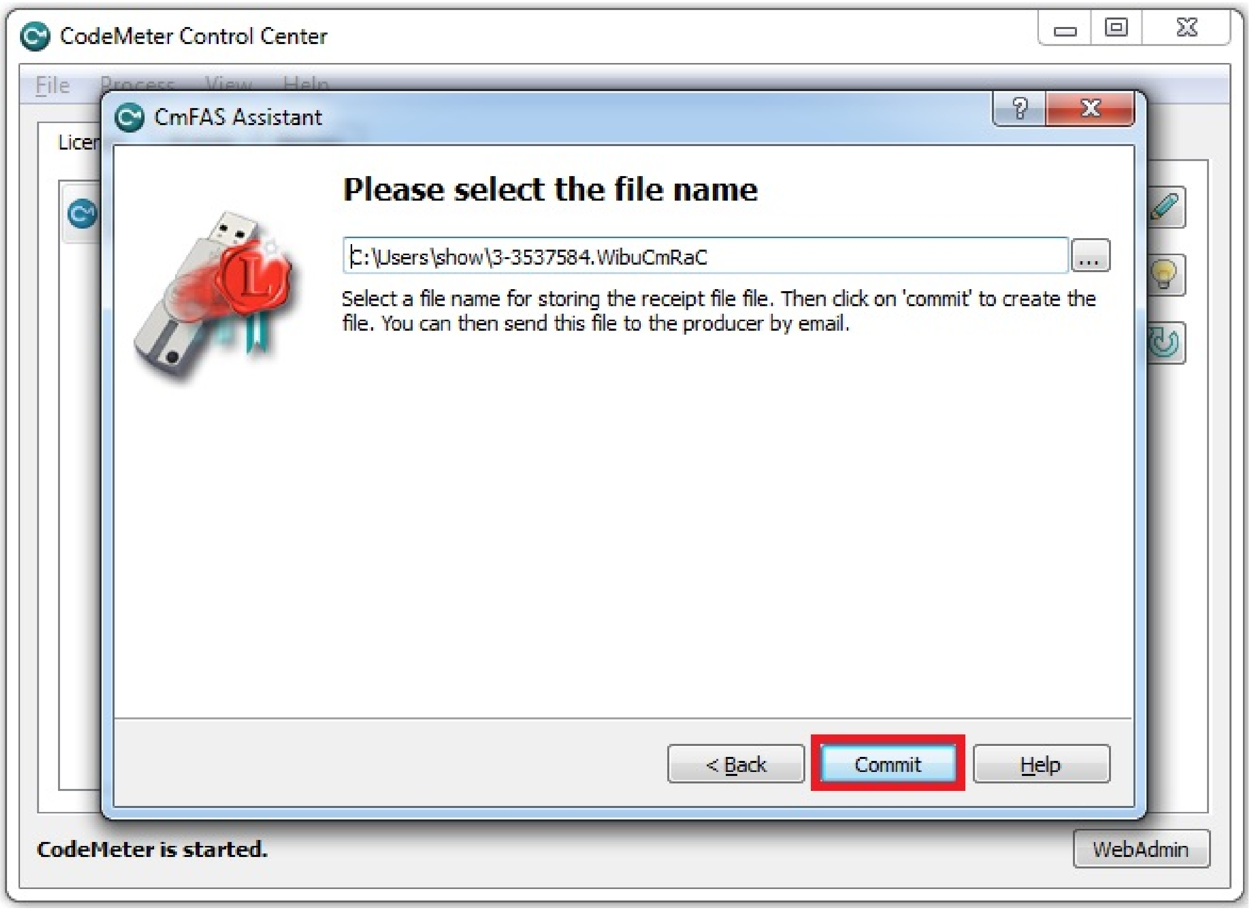
Select "Create Receipt" and press "Next".

Select the domeprojection.com GmbH® firm item and press "Next".

Select a folder where the context file has to be stored. Please do not change the filename. Press "Commit" to save the file.

Send the generated file to license@domeprojection.com.


CodeMeter Control Center
File Process View Help
CmFAS Assistant
Please choose the producer
domeprojection.com GmbH (102866)
Select the software producer to which you want to send the receipt file. The producer will only see the data which you select here. So you can ensure that the producer doesn't see which other licenses from other suppliers you have.
< Back
Next >
Help
CodeMeter is started.
WebAdmin


CodeMeter Control Center
File Process View Help
CmFAS Assistant
Please select the file name
C:\Users\show\3-3537584.WibuCmRaC
Select a file name for storing the receipt file file. Then click on 'commit' to create the file. You can then send this file to the producer by email.
< Back
Commit
Help
CodeMeter is started.
WebAdmin

CHAPTER

FIVE

CALIBRATION PROJECTS

All calibration and setup data is stored inside a project structure. It consist basically of a folder containing a configuration XML file and a referenced database. Depending on the setup additional data is stored inside this folder.

The project is created with Creator, which also captures calibration data. The project is then opened in Mapper2d, Mapper3d or MapperPM for preparing exporting calibration data.

A project is loaded through the File/Load project menu and copied into memory. All changes made (except results from export runs) are only temporary until the project is saved (File/Save project).

You can add the projects file name as argument while starting ProjectionTools applications. Than this project file is loaded during program start automatically.

CHAPTER

SIX

EXPORTERS

Exporters are used to export ProjectionTools calibration data for other hardware and software to apply this information during run-time.

Several widely used media servers and warping/blending solutions are directly supported through specialized exporters. In addition, open-standard data format exports are provided for easy integration into other software.

Exporters can either be run through the export menu or they can be permanently added to a project using the Pipeline Editor (see section *Pipeline Editor*).

There are 4 general export modes for different use-cases, which are covered by our different Mappers:

2D
For showing images, videos, and desktop applications on smooth screen surfaces. Typically used for media servers, and desktop warping.

Exported from *Mapper 2D*.

3D
For showing content rendered from a 3D engine perspectively correct on a smooth screen surface. Typically used for simulators.

Exported from *Mapper 3D*.

DW
DynamicWarping, required for perspectively correct projection according to a moving eyepoint.

Exported from *Mapper 3D*.

PM
ProjectionMapping or VideoMapping, for projecting content on discontinuous surfaces, like buildings, car mock-ups etc.

Exported from *Mapper PM*.

The following sections provide an overview of the available exporters.

6.1 Automization

Sometimes it is not enough to do just a single export. Maybe multiple exports for different eyepoints must be done or exports should be copied/renamed/split onto remote machines or backed up.

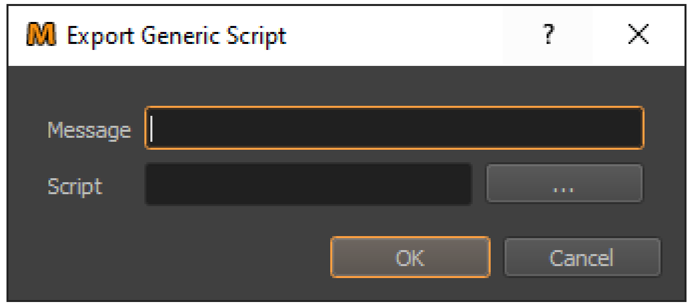
This category contains export steps that can be used to create a more complex export pipeline.

Generic Script
Call a generic batch script.

Set Viewpoint
Allows to change the current viewpoint in Mapper3d. Combining multiple of these steps each followed by an exporter, allows to export for multiple eyepoints in one run.

6.1.1 Generic Script

A pipeline node to simply execute system commands or batch files.



Settings

Message
An optional message that is shown in a message box and need to be confirmed by user before the script is executed.

Script
A system command or batch-file that should be executed.

> **Warning:** Please be aware, that errors inside the scripts are not propagated to the GUI.

6.2 Preview

This category contains the preview exporter, which allows to show a fully corrected image using the PatternGenerator.

This is often used to let the user check the calibration result before doing the actual export.

6.2.1 Export 2d Preview (Preview Warping)

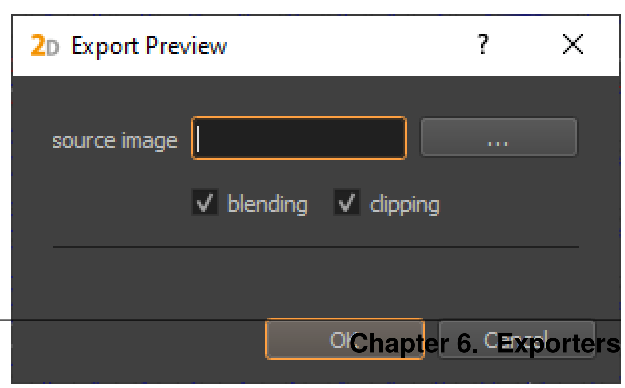
The preview (warping) exporter is used to display a meaningful preview of the generated data. A selected image is cut, warped and combined with blending information according to the calculated information. Those data can be send to the PatternGenerator program where it is displayed as full-screen image, showing the final result.

This functionality depends on running PatternGenerator instances on all image generators. The Mapper will calculate the target images which is send to the clients through a network connection.

Export Settings

Image
The path where the image that shall be displayed is.

Blending
If enabled, the blending will be calculated and exported for each projector.



Clipping
If enabled, clipping data will be calculated, added to the blending images and exported for each projector. Apply previous blending: If checked, the previously calculated blending will be applied instead of recalculating the blending. Can be activated to shorten the calculations.

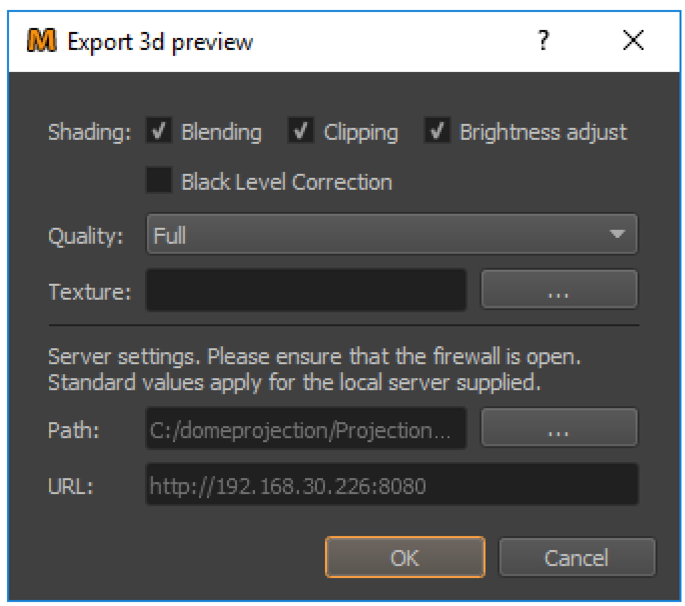
6.2.2 Export 3d preview

The preview exporter is used to display a meaningful preview of the generated data. Using software warping and blending with the PatternGenerator program, a simple 3d scene is displayed which can be judged as final result. The only optical difference should occur through different interpolation algorithms used by warp units or software and can be considered as minor.

This functionality depends on running PatternGenerator instances on all image generators. The Mapper will calculate the blending and warping information which is send to the clients through a network connection. For this the Mapper implements a web-server which is configured with the Preview exporter options.

Note: This mechanism works with other network servers already running. That's what the target path and server URL options are for.

Export Settings



Blending
If enabled, the blending will be calculated and exported for each projector

Clipping
If enabled, clipping data will be calculated, added to the blending images and exported for each projector. It is only usable if blending is enabled.

Brightness adjust
If enabled, uniformity correction is applied.

Black Level Correction
If enabled, black level correction data is calculated and exported as well.

Quality
Allows to adjust the shading resolution to speed up the preview calculations.

Texture
An optional custom image to use for preview.

Path
The path where the result data is exported to.
This has to be the root directory of your network web or ftp server. The path of the internal web-server (etc/docroot) is the default. Usually no changes are needed here.

Server URL
Enter the valid server URL, where the result data is accessible. The internal web server provides the data at port 8080. The current local IP address is the default value. Please make sure the firewall is opened for the port selected.

Setting up an external server

Calculating blending and blacklevel adjustments require lots of computational resources. Projects with many projectors may utilize the processor to the full which can have an impact on the data transmission to the PatternGenerator. This can be the case if the Preview3d exporter fails for no obvious reason. Setting up an external server can resolve this issue.

The Mapper support any URL-based transmission of data. Setting up or using an already existing server (http or ftp for instance) works fine.

1. Install an ftp or http server and configure username/password if necessary (skip if using existing server).
2. Select servers document or ftp root in Preview3d options "Path:".
3. Configure URL which clients will use to download the images.

Examples of URLs:

- Webserver at port 8080 (Mapper3d internal server): `http://host-IP:8080`
- FTP-server with username and password: `ftp://user:password@host-IP`
- FTP-server with username and no password: `ftp://user@host-IP`

Note that the host-IP is the IP-address of the PC where the Mapper is running, and which is accessible from other computers. In most cases this is not 127.0.0.1 or localhost.

We recommend installing FileZilla for its ease of use.

6.3 Generic

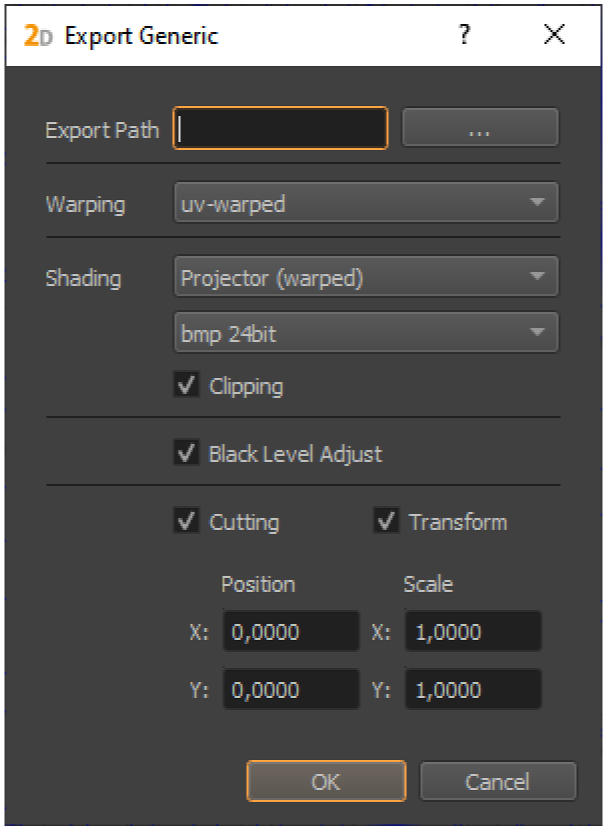
Open standard readable data, for integration into custom software/hardware.

Name	2D	3D	DW	PM	Warp	Blend	BLC
Export Generic	X	X		X	X	X	X
Export Generic Advanced 3D			X		X	X	X
Export DDS	X	X			X	X	X
Export MPCDI	X	X	X	X	X	X	X

6.3.1 Export Generic

The Generic Exporter allows to export to simple and easy to integrate fileformats, and provides many settings to customize your exports.

Export Settings



Export Path:
The folder to which all exported files will be exported.

Warping:
Allows to select between different warping formats:

- none (disabled)
- uv-warped (csv-file)
- vertex-warped (csv-file)
- pixel-warped (warping encoded as pixel color in an image)

See following sections for detailed descriptions about different warping exports.

Shading:
Allows to adjust image format settings.

First select between different warping styles:

- none (disabled)
- Projector(warped, no warping needs to be applied)

- Cut (warping needs to be applied)
- Source (cutting and warping needs to be applied

Second select between different image formats:

- bmp 24bit (shading encoded in color, should be multiplied with content to apply)
- bmp 32bit color (shading encoded in color, should be multiplied with content to apply)
- png 8bit grayscale (shading encoded as gray-values, should be multiplied with content to apply)
- png 32bit black + alpha (shading encoded in alpha, should be overlayed above content to apply)
- xpm 8bit grayscale (shading encoded as gray-values, should be multiplied with content to apply)
- png 16bit grayscale (shading encoded as gray-values, should be multiplied with content to apply) *one channel of 16 bit gray values*

Clipping:
Enable to integrate Clipping information in exported blend-files (clipping editor, clipping-image in project-settings)

Black Level Adjust:
Enable to export Black Level Adjust image. The image should be added to the content in a linear color-space to be applied. As an alternative blendmode, inverse multiply might be a good approximation.

Cutting:
Enable to export cutting information as csv-files

Transform:
Enable to adjust the exported cutting range. This can be used to place cutting rectangles in a bigger context. For a non-uniform scale, the cutting rectangles need to be unrotated.

Export Format

Warping, Frustum and Cutting is exported as CSV (Comma Seperated Values), a commonly used exchange format for table based data.

Filename extension: *.csv
Seperator: ;

First Line contains column names. Following lines the data sets. Additional culumns might be appended in future.

Blending, Black Level Adjust and Pixel Warping is exported in different image formats.

UV-Warping / Vertex-Warping

Warping can be exported as a regular grid of vertices. Each vertex has a position, a texture-coordinate and a grid index. Vertices are ordered line-wise from top-left to bottom-right. The grid index (column, row) of the last vertex in file is equal to the number of rows – 1 and the number of columns – 1.

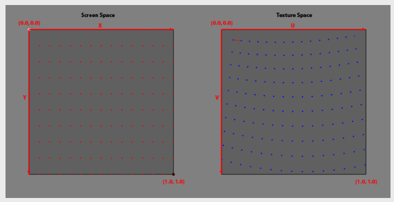
x, y:
position of vertex in normalized screen-space

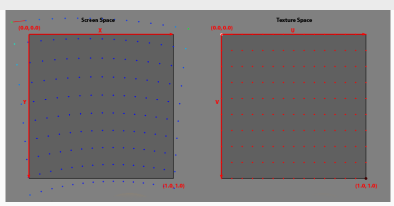
u, v:
texture coordinate of vertex in normalized texture-space

column, row:
column and row index of vertex. The vertex order is will not be shuffled, the column and row index is more intended for convenience. Number of columns and rows can be extracted from last vertex.

This grid can be used to generate a mesh by spanning triangles/quads between adjacent vertices.This is the prefered usage for software warping. The position – texture-coordinate pairs can also be used to extract a polynomial transformation. Examples:

	Visualization	Data

UV-Warping		`x;y;u;v;column;row`
		`0.0000;0.0000;0.0813;0.0715;0;0`
		`0.0714;0.0000;0.1366;0.0769;1;0`
		`0.1429;0.0000;0.1936;0.0812;2;0`
		`...`
		`0.8571;1.0000;0.8517;0.9615;12;9`
		`0.9286;1.0000;0.9232;0.9498;13;9`
		`1.0000;1.0000;0.9929;0.9359;14;9`

Vertex-Warping		`x;y;u;v;column;row`
		`-0.1189;-0.0854;0.0000;0.0000;0;0`
		`-0.0222;-0.0958;0.0714;0.0000;1;0`
		`0.0709;-0.1035;0.1429;0.0000;2;0`
		`...`
		`0.8614;1.0410;0.8571;1.0000;12;9`
		`0.9322;1.0533;0.9286;1.0000;13;9`
		`1.0048;1.0679;1.0000;1.0000;14;9`

Pixel-Warping

Pixel-Warping Encodes warping data in an image. In each pixel, the corresponding uv-coordinate is encoded.

```
R(8 bit): major u
G(8 bit): minor u
B(8 bit): major v
A(8 bit): minor v
```

The 16 bit integer representation maps the float range [-0.5, 1.5] to integer values [0, 65535]. That means 0.0 maps to 16384 and 1.0 maps to 49152. Values outside of [-0.5,1.5] are clamped to the neares allowed value. In the following text the float representations are named u and v the corresponding integer representations are named uInt and vInt.

Encoding:

```
uInt = MAX(MIN(u * 32767 + 16384, 65535), 0);
vInt = MAX(MIN(v * 32767 + 16384, 65535), 0);

r = uInt / 256;
g = uInt % 256;
b = vInt / 256;
a = vInt % 256;
```

Decoding:

```
uInt = r * 256 + g;
vInt = b * 256 + a;
u = (uInt - 16384) / 32767;
v = (vInt - 16384) / 32767;
```

Example:

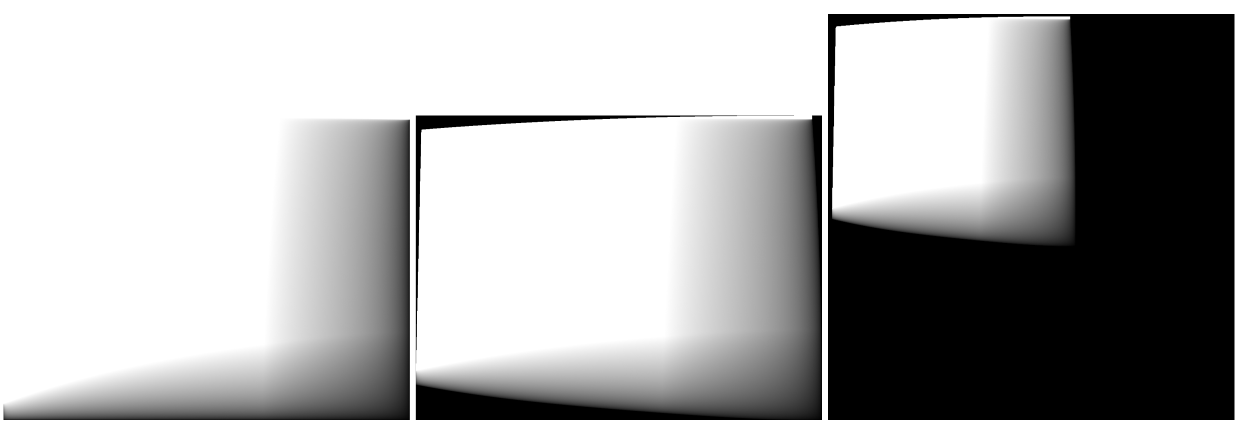
Blending

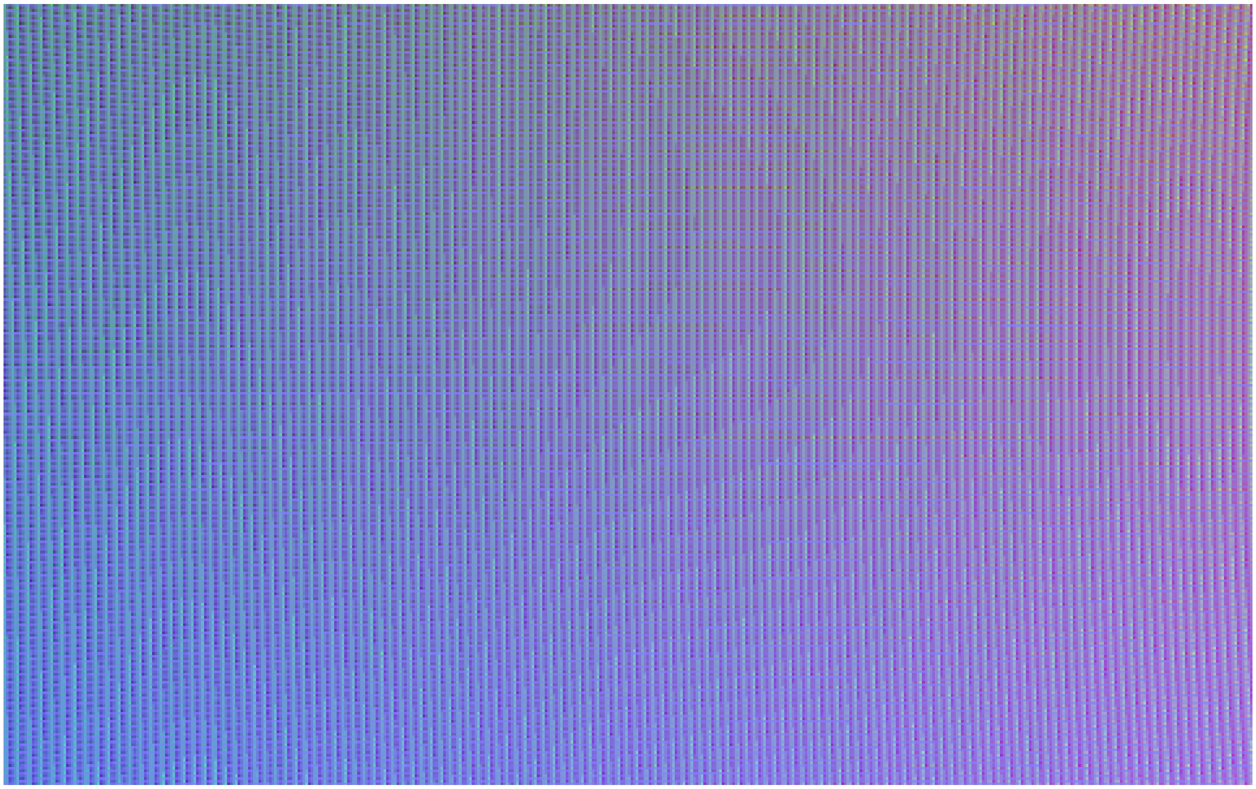
There are three options to export blending data. It can be exported as Projector (warped), Cut, or Source image.

The result of the Projector (warped) blending is an image with the resolution of the projector that is fitting the already warped projector.

Exporting the blend file as cut format, results in an image with projector resolution but in this case the image still needs to be warped.

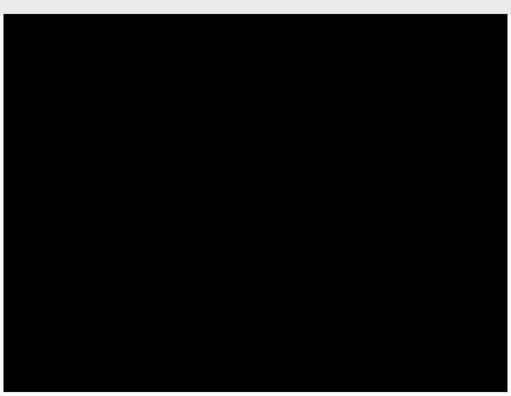
The source export shows the full content space. Cutting and warping still has to be applied to this export.





From left to right: Projector(warped), Cut, Source

Apart from these types of blending, the file format can also be chosen, bmp 24bit, png 32bit color, png 8bit grayscale, png 32bit blacklevel + alpha and xmp 24bit.

Projector (warped) as example	Color	Alpha
bmp 24bit		
png 32bit color		
png 8bit grayscale		
png 32bit black + alpha		
		

Black Level Adjust

The exported black level adjust image is already warped. The image should be added to the content in a linear colorspace to be applied.

$$result = \left(color^{gamma} * (1 - black^{gamma}) + black^{gamma}\right)^{\frac{1}{gamma}}$$

including blending:

$$result = \left(color^{gamma} * blending^{gamma} * (1 - black^{gamma}) + black^{gamma}\right)^{\frac{1}{gamma}}$$

Frustum (3d)

Informations about virtual camera that should be used for one projector.

x, y, z:
position in millimeter (x right, y front; z up)

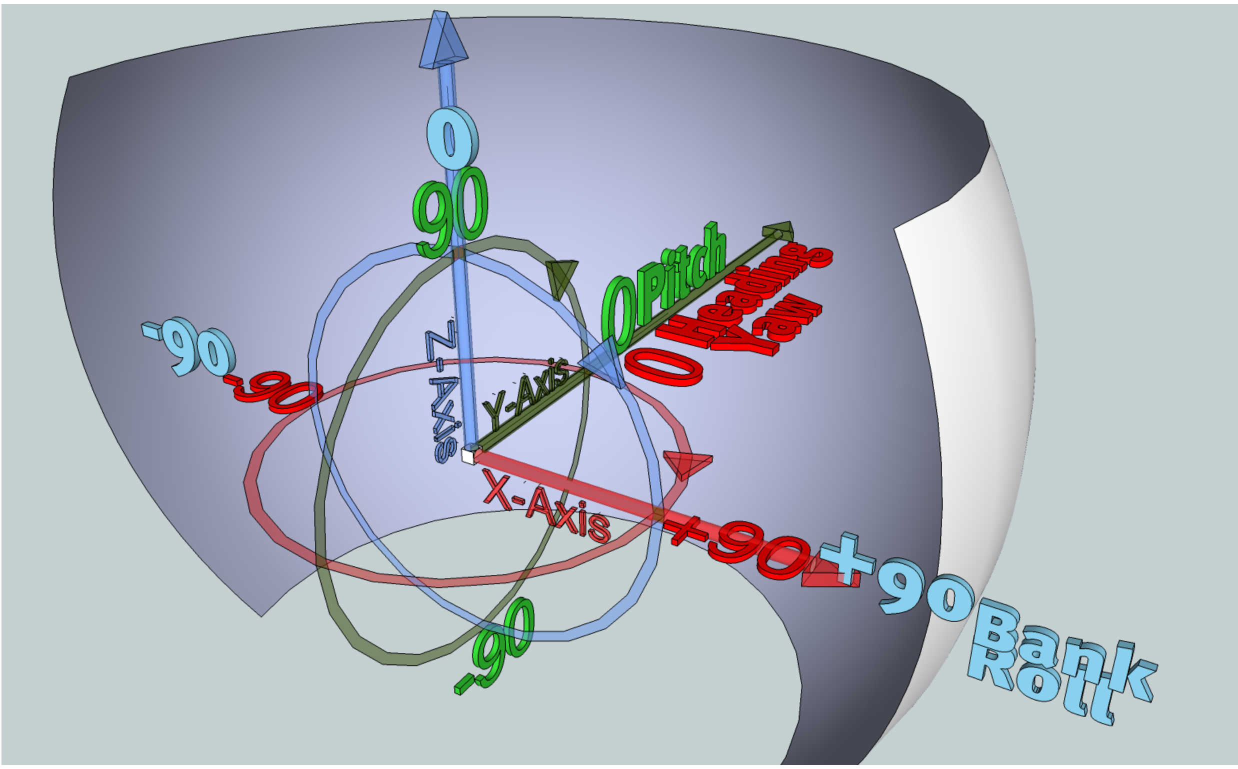
heading, pitch, bank:
orientation in degrees (heading/yaw/z clockwise around vertical axis, pitch/x clockwise around right axis, bank/roll/y clockwise around front axis)

left, right, bottom, top:
opening angles in degrees. Left and bottom typically negative, except for extremely shifted frusti.

tanLeft, tanRight, tanBottom, tanTop:
tangenz values of frustum borders for convenience

width:
width of frustum at distance 1.0 (tanRight – tanLeft)

height:
height of frustum at distance 1.0 (tanTop – tanBottom)



Example:

```
x;y;z;heading;pitch;bank;left;right;bottom;top;tanLeft;tanRight;tanBottom;tanTop;width;height
0.0000000;0.0000000;0.0000000;-15.00;0.00;0.00;-20.0000000;20.0000000;-20.0000000;20.0000000;-0.3639702;0.3639702;-0.3639702;0.3639702;0.7279405;0.7279405
```

Cutting (2d)

TheCutting rectangle is defined in normalized texture-space. The Top left corner of texture-space is (0,0), the bottom right corner is (1,1).

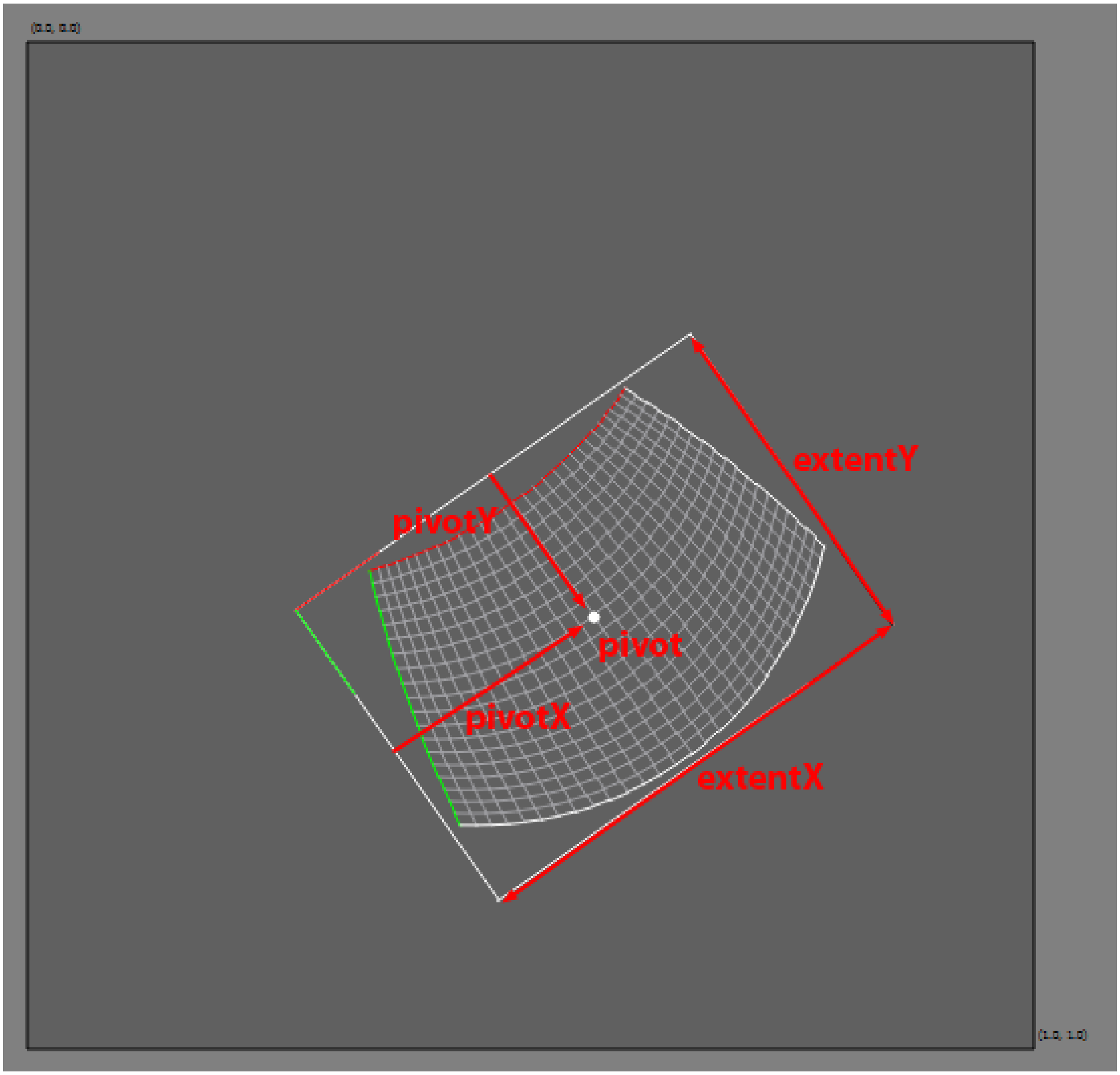
posX, posY:
position of the rectangle

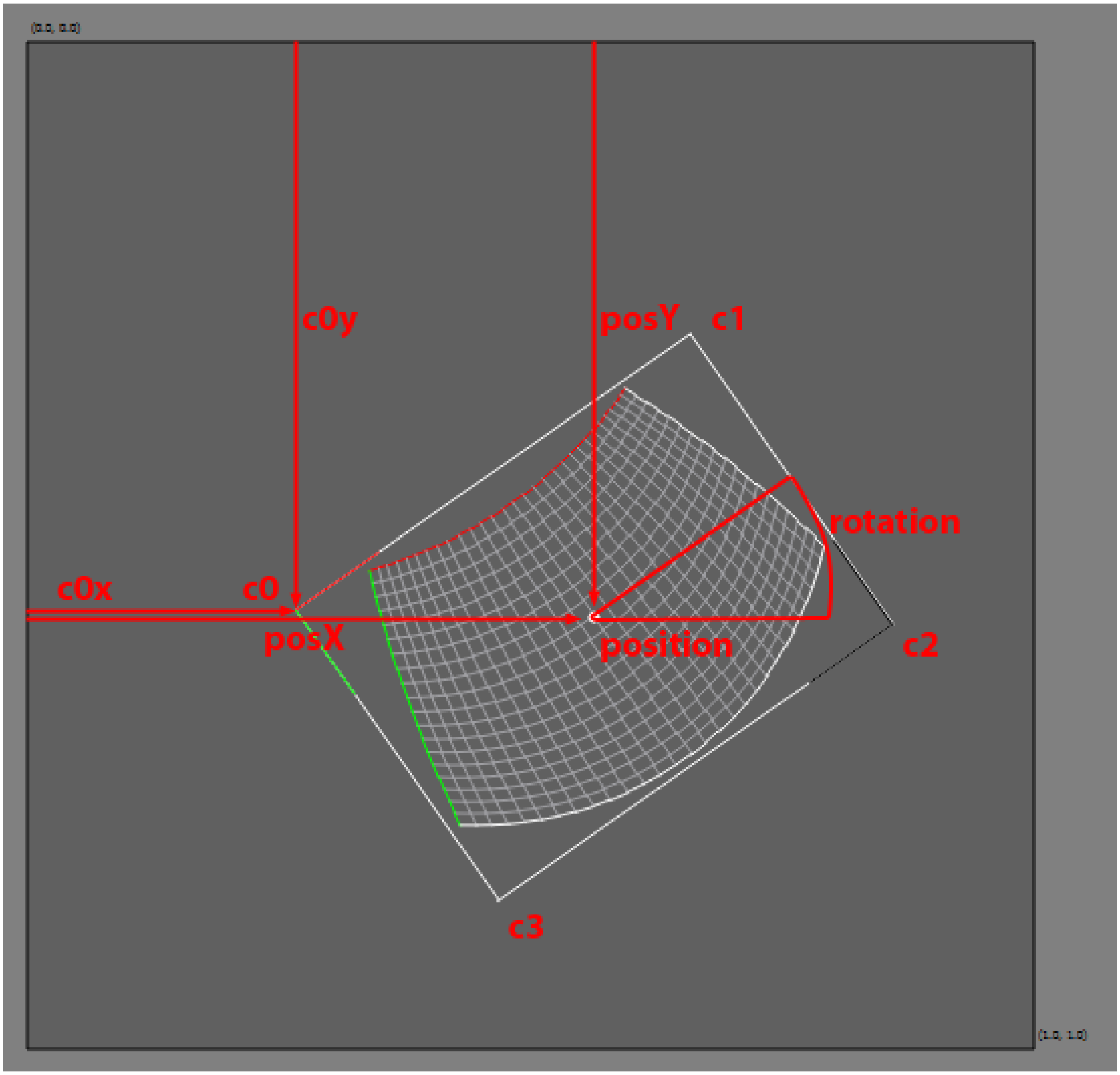
rotation:
rotation of rectangle in degrees clock-wise

extentX, extentY:
rectangles extent (width, height)

pivotX, pivotY:
absolut pivot/anchor/rotation-center of rectangle in local coordinates (The Top left corner is (0,0), the bottom right corner is (extentX, extentY))

c0x … c3y:
rectangle corner positions, clockwise, beginning with top-left corner of rectangle.





Example: From *.csv file:

```
posX;posY;rotation;extentX;extentY;pivotX,pivotY;c0x;c0y;c1x;c1y;c2x;c2y;c3x;c3y
0.5629;0.5713;-35.0000;0.4780;0.3503;0.2390;0.1752;0.2667;0.5649;0.6582;0.2907;0.8591;0.
↪5777;0.4676;0.8519;0.2667;0.5649
```

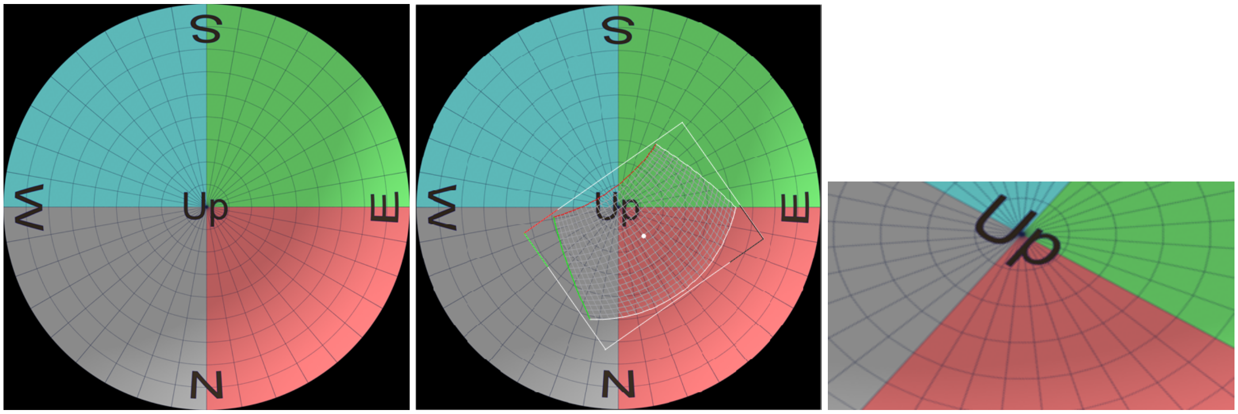
Reformatted for human readabillity:

```
posX: 0.5629
posY: 0.5713
rotation: -35.0
extentX: 0.478
extentY: 0.3503
pivotX: 0.239
pivotY: 0.1752
```

(continues on next page)

(continued from previous page)

```
c0x: 0.2667
c0y: 0.5649
```



From left to right: Example Master, Cutting rectangles overlay, Cutting result

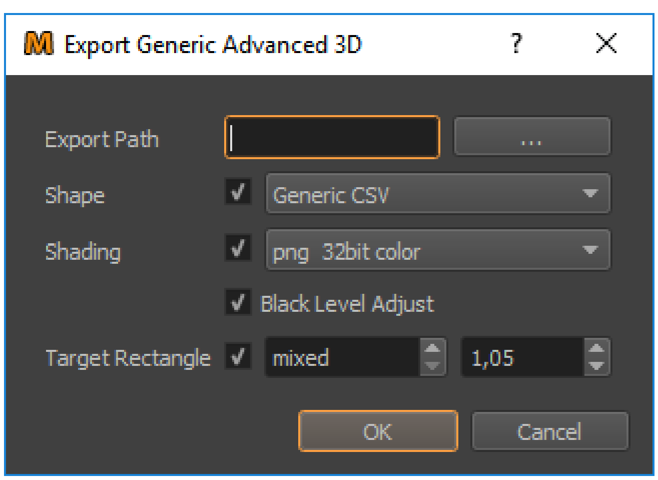
6.3.2 Export Generic Advanced 3D

The Generic Advanced 3D exporter exports data that allows to generate frusti and warping data dynamically during runtime to produce perspectively correct imagery for any viewpoint in a finite volume.

The exported data contains:

- 3D shape of the projection surface for each projector
- Blending information
- Black Level Correction information
- **Target rectangles as a guide to generate frustum settings for any**
  eyepoint

Export Settings



Export Path:
The folder to which all exported files will be exported.

Shape:
Allows to select between different projection shape formats:

- Generic CSV (csv-file)
- **Wavefront OBJ (mesh file format that can be read by many 3d** applications)

Shading:
Allows to adjust image format settings:+

- **bmp 24bit (shading encoded in color, should be multiplied with** content to apply)
- **bmp 32bit color (shading encoded in color, should be multiplied** with content to apply)
- **png 8bit grayscale (shading encoded as gray-values, should be** multiplied with content to apply)
- **png 32bit black + alpha (shading encoded in alpha, should be** overlayed above content to apply)

Black Level Adjust:
Enable to export Black Level Adjust image.

Target Rectangle:
Allows to adjust the conversion of current frustum settings into target Rectangles by setting a distance and scale value. The distance is set to mixed by default, which means the target distances per projector from the frustum settings in the project are used. The scale value is usually a bit larger than 1.0 to avoid content cut-off, when moving the eyepoint around in a dynamic viewpoint system.

Export Format

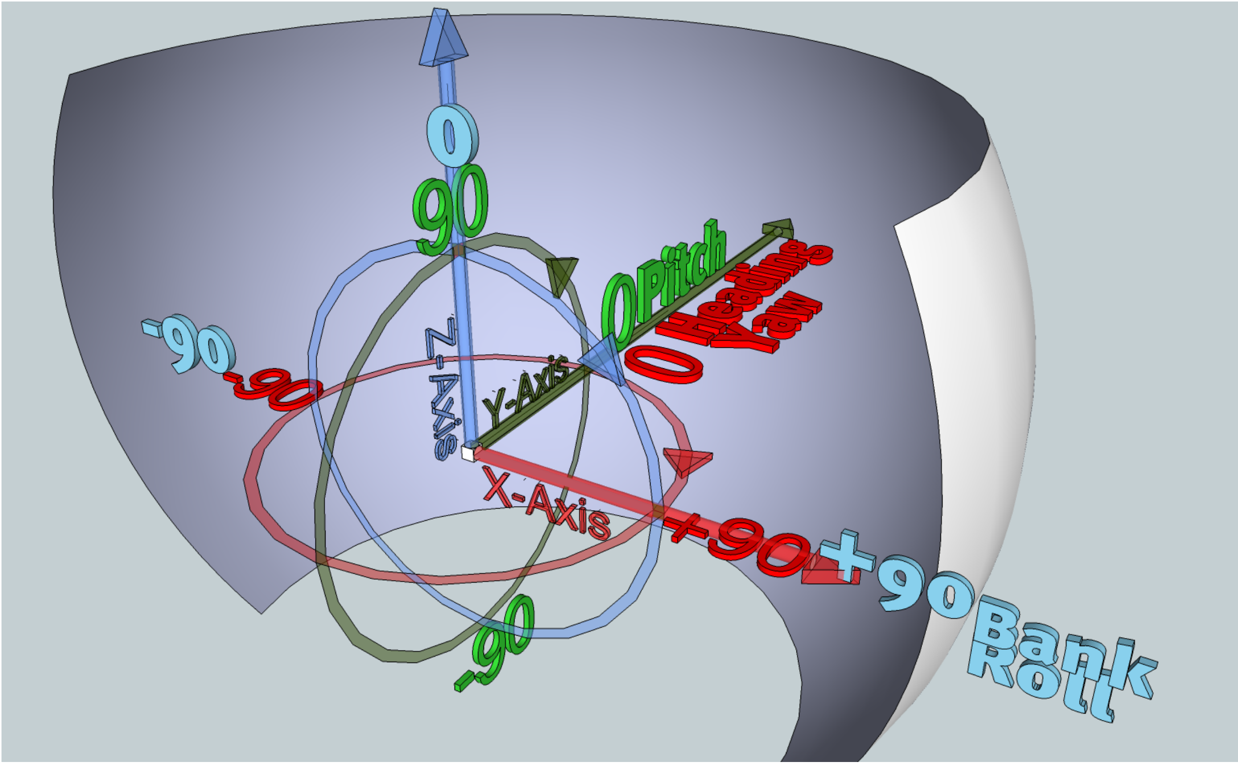
CSV Format

Shape and Target Rectangles can be exported as CSV (Comma Seperated Values), a commonly used exchange format for table based data. Filename extension: *.csv Seperator: ; First Line contains column names. Following lines the data sets. Additional culumns might be appended in future.

Coordinate System

X and y axis on the floor. X-axis pointing to the right, y-axis to the front and z-axis to the top. Rotation order is 1.Heading, 2.Pitch, 3.Bank. Distance measures are in millimeters and rotations are given in degrees.

Texture coordinates are defined as normalized values going from top-left (0,0) to bottom-right(1,1).



Shape

The shape describes where each projector image is shown in 3d space on the physical screen. It furthermore describes which pixel of the projected image is shown where on the physical screen. Two alternative export variants are supported. See following sections.

Generic CSV

The shape can be exported as CSV (Comma Seperated Values), a commonly used exchange format for table based data.

Filename extension: *.csv
Seperator: ;

First Line contains column names. Following lines the data sets.

The file contains a regular grid of vertices. Each vertex has a 3d position, a texture-coordinate and a grid index. Vertices are ordered line-wise from top-left to bottom-right. The grid index (column, row) of the last vertex in file is equal to the number of rows – 1 and the number of columns – 1.

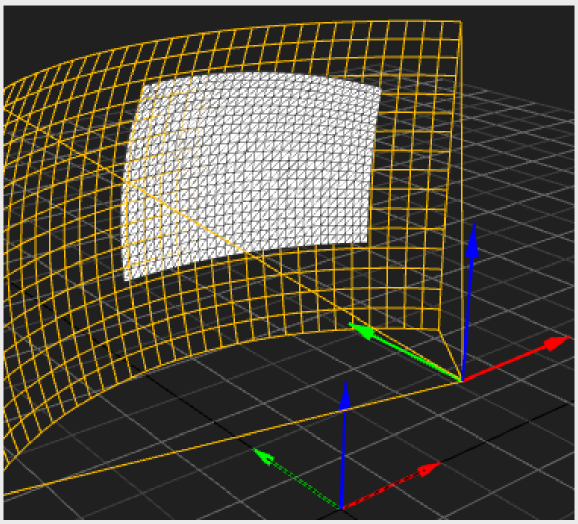
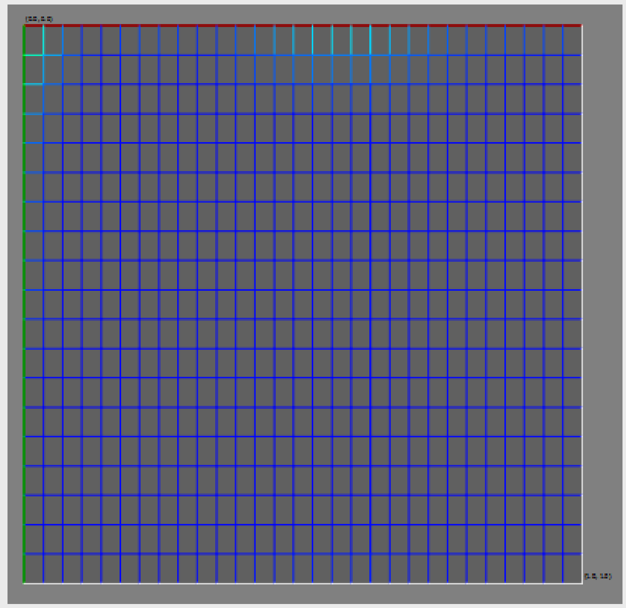
x, y, z:
position of vertex in 3d space (physical screen)

u, v:
texture coordinate of vertex in normalized texture-space (reference to projector image, top-left is 0,0, bottom-right is 1,1)

column, row:
column and row index of vertex. The vertex order is ordered and will not be shuffled, the column and row index is more intended for convenience. Number of columns and rows can be extracted from last vertex.

This grid can be used to generate a mesh by spanning triangles/quads between adjacent vertices.

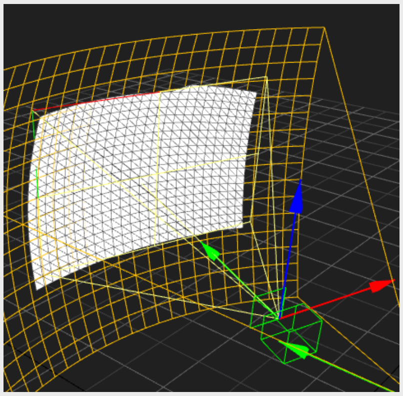
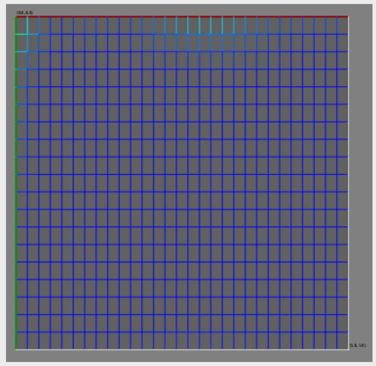
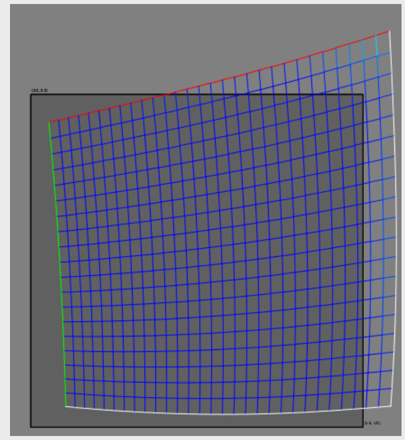
Example:

3D Positions	UV Koordinates
	

CSV Data:

```
x;y;z;u;v;column;row
-284.4113;1958.6552;2684.0044;0.0000;0.0000;0;0
-213.1139;1961.8509;2688.3775;0.0345;0.0000;1;0
-140.8579;1963.9186;2691.7009;0.0690;0.0000;2;0
...
1641.2280;1735.1887;1067.2657;0.9310;1.0000;27;19
1697.7215;1700.2307;1067.1855;0.9655;1.0000;28;19
1752.4338;1664.9009;1067.1924;1.0000;1.0000;29;1
```

The warping mesh for a given camera setting is generated by using the defined uv-koordinates as vertex positions and projecting the 3d shape into virtual camera to calculate the current uv-koordinates.

Viszalization	Vertex Positions	UV Koordinates
		

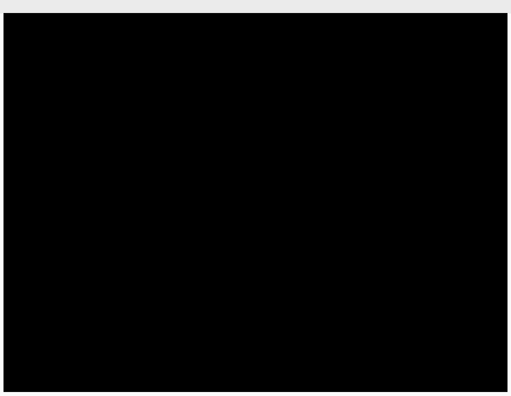
Wavefront OBJ

The shape can be exported as a triangulated mesh in obj file format as well.

Blending

The blending is exported as an image file. The image has the resolution of the projector and is fitting the already warped projector, no more warping needs to be applied to it.

The file format can be chosen between bmp 24bit, png 32bit color, png 8bit grayscale, png 32bit blacklevel + alpha and xmp 24bit.

Projector (warped) as example	Color	Alpha
bmp 24bit		
png 32bit color		
png 8bit grayscale		
png 32bit black + alpha		
		

Black Level Adjust

The exported black level adjust image is already warped. The image should be added to the content in a linear color-space to be applied.

$$result = \left(color^{gamma} * (1 - black^{gamma}) + black^{gamma}\right)^{\frac{1}{gamma}}$$

including blending:

$$result = \left((color * blending)^{gamma} * (1 - black^{gamma}) + black^{gamma}\right)^{\frac{1}{gamma}}$$

Target Rectangle

A rectangle placed in 3d space. Usually fitting as close as possible the shape of the corresponding projector shape. It is meant to be used as a target to generate virtual camera settings for given eye-points.

The camera settings can be generated by:

1. Placing the camera at a given eye-point
2. **Orienting the camera the same as the target rectangle. Use same**
   heading/pitch/bank or face camera along target rectangle's normal and use rectangles up vector for calculating the cameras roll.

3. **Adjusting Frustum left/right/top/bottom to match target rectangles**
   left/right/top/bottom border

The target rectangle is exported as an csv file. It contains some redundant values for convenience and supporting alternative ways to calculate new virtual camera settings.

Description of Values:

x, y, z:
center position in millimeter (x, y ground-plane; z vertical)

heading, pitch, bank:
orientation in degrees (heading/yaw/z, pitch/x, bank/roll/y)

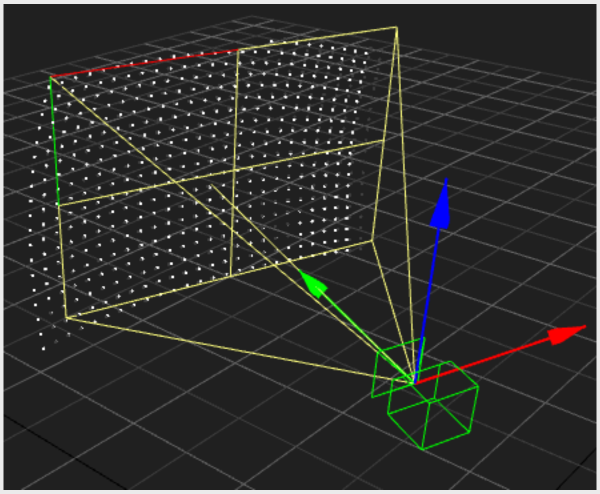
left, right, bottom, top:
distance to corresponding rectangle edges in millimeters. Left and bottom typically negative. Left/Right and Top/Bottom usually have same absolute value.

width, height:
width/height of rectangle in millimeters

normalx, normaly, normalz:
normal of rectangle facing away from viewer, usually inside screen, so it can be used as viewing vector for camera without inverting

c0x, c0y, c0z,. . . c3x, c3y, c3z:
3d positions of rectangle corners. Clockwise beginning with top-left corner

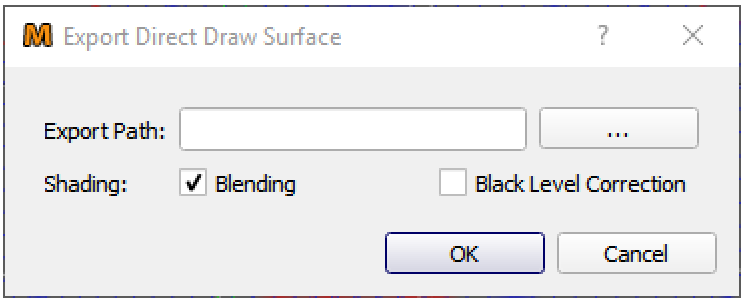
Example:

Visualization	Data
	x: 406.90 y: 904.86 z: 1747.66 heading: 20.00 pitch: 6.82 bank: 0.00 left: -520.56 right: 520.56 bottom: -363.97 top: 363.97 width: 1041.13 height: 727.9416 normalx: 0.3396 normaly: 0.9330 normalz: 0.1188 c0x: -97.05 c0y: 1042.29 c0z: 2109.05 c1x: 881.29 c1y: 686.20 c1z: 2109.05 c2x: 910.85 c2y: 767.43 c2z: 1386.26 c3x: -67.48 c3y: 1123.52 c3z: 1386.26

6.3.3 Export DDS

The DDS Exporter allows to export warping and blending in one floating point dds texture, optimal for pixel shader usage.

Settings



Export Path
The folder to which all exported files will be exported.

Blending
Enable blending export including clipping, uniformity and fadeout.

Black Level Correction
Enable black level correction output.

Format

For each projection channel, one dds file is exported.

The dds files are defined in projector space and resolution.

Each dds file combines warping and blending and black level correction data for one channel.

The dds files have floating point precision.

Channel usage:

red, green
Normalized u, v texture coordinate (coordinate to look up for current pixel)

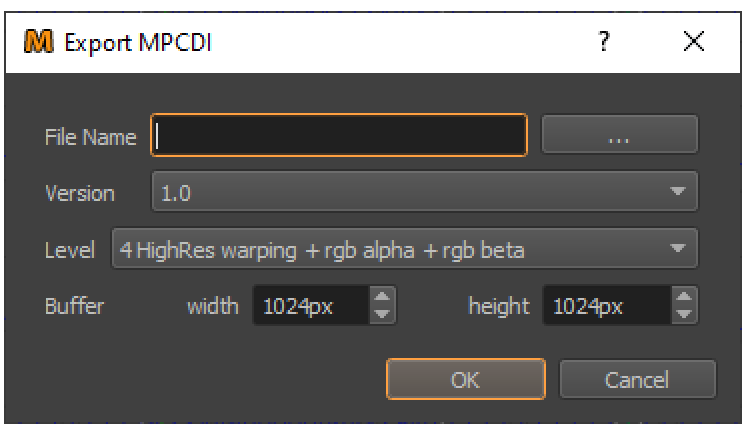
blue
Already warped blending/shading information in linear color space. Set to one when disabled.

alpha
Already warped black level correction in linear color space. Set to one when disabled.

6.3.4 Export MPCDI

The MPCDI Exporter allows to export correction data following the Vesa MPCDI standard (MPCDI: Multiple Projector Common Data Interchange).

Export Settings



File Name:
The place and name of the created MPCDI file.

Version:
Select MPCDI format version.

Level:
Allows to select the exported data and quality according to the 4 levels defined by MPCDI 1.0 standard.

1. Standard warping + monochrome alpha
2. Standard warping + rgb alpha + rgb beta
3. High resulution warping + monochrome alpha
4. High resolution warping + rgb alpha + rgb beta

Geometry:
Allows to select geometry quality for MPCDI 2.0 exports.

Color:
Allows to select blending and black-level correction quality for MPCDI 2.0 exports.

Buffer width/height:
Intended complete source resolution for the whole projection system.

Dynamic Warping:
Allows to switch between standard 3d and dynamic warping export in Mapper3d.

Limitations

MPCDI does not support rotated cutting rectangles for 2D mappings. So assure that cutting rectangles in projects intended for MPCDI export are straight.

For achieving straight cutting rectangles, set bounding box mode to "Unrotated", or can be used, or adjusting the cutting rectangles manually to have zero rotation.

Several companies make use of *ProjectionTools* calibration data using the general purpose export formats.

Name	2D	3D	DW	PM	Warp	Blend	BLC
7th Sense DeltaServer	X	X			X	X	X
DLR		X			X	X	X
Transas		X			X	X	X
Saab JFIST		X			X	X	X
domeprojection nWarp	X	X			X	X	
HHI TimeLab	X				X	X	X
project: syntropy GmbH	X	X			X	X	
Sciss Uniview		X			X	X	
eSigma		X			X	X	
RSA Cosmos		X			X	X	
NITA		X			X	X	
Motekforce		X			X	X	
Diamond Visionics Genesis		X			X	X	X
VI-Grade VI-GraphSim		X	X		X	X	X
Vires		X	X		X	X	X
Oktal		X			X	X	X
LightAct	X				X	X	
Unreal		X	X	X	X	X	X

6.4 Media Servers

Name	2D	3D	DW	PM	Warp	Blend	BLC
AV Stumpfl Wings	X				X	X	
AV Stumpfl Pixera	X			limited	X	X	
Christie Pandoras Box	X				X	X	
Dataton Watchout	X	X		X	X	X	
MX Wendler	X				X	X	X
Ventuz	X	X			X	X	
Ventuz VRS	X	X			X	limited	
Resolume Arena	X				X	limited	

6.4.1 Export 7th Sense Delta Media Server

The export for 7th sense Delta Media Server is done using the generic Exporter.

Delta Media Server supports Frustum Mode Auto Alignment for Dome Projection (Mapper3d) and 2d exports for more simple flat or cylindrical screen setups (Mapper2d).

Delta Server looks for auto calibration data in `c:\AutoAlignment`. Therefor, the exported data should be copied to the appropriate server in the `C:\AutoAlignment` folder.

Export Settings

Use the following settings in the Generic Exporter to export for Delta:

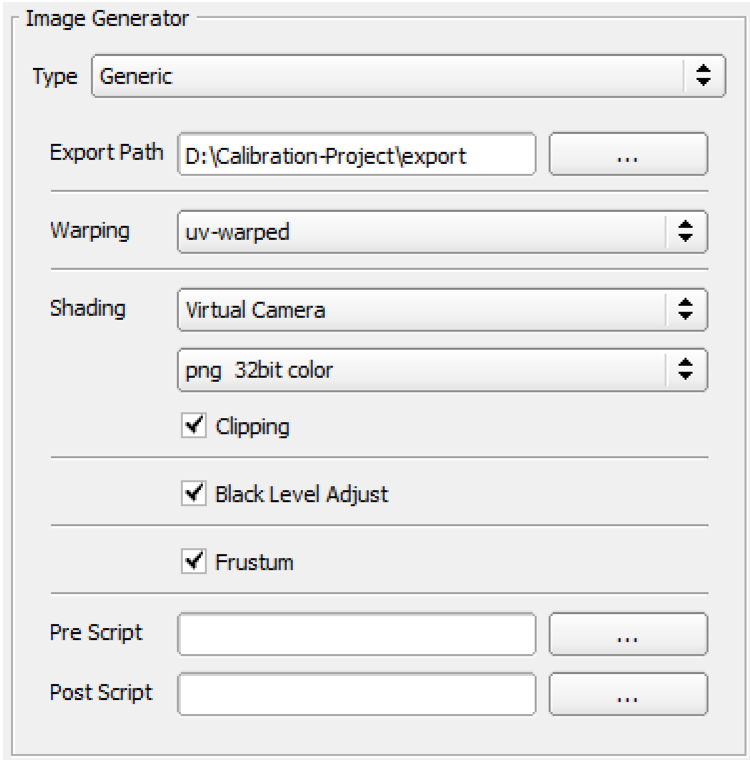
- **Warping type: uv-warped. This is essential if you wish to use**
  BlackLevel Adjustment. Vertex mapping mode will work if
- BlackLevel Adjustment is not required
- **Shading type: Virtual Camera + png 32bit color**
- Select Black Level Adjust if required
- **Enable Frustum/Cutting export**

6.4.2 Export Wings

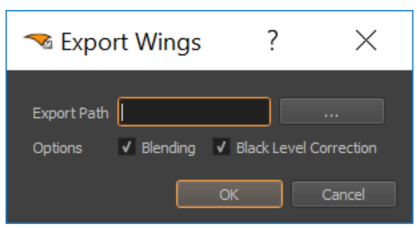
The Wings exporter allows to export warping and blending data for AVStumpfl Wings Player based on generic export formats.

The exported data can be imported in Wings as Generic Calibration.

The correction data is assigned to existing Multidisplay Areas in Wings based on their name. In order to get a correct assignment, the projector names in ProjectionTools Mapper need to be the same as the corresponding Multidisplay Area names in Wings.



Export Settings



Export Path
The folder to which all exported files will be exported.

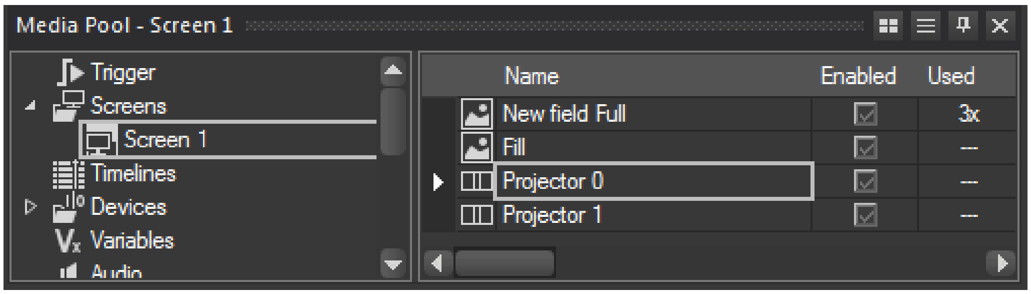
Blending
Enable export of blending including uniformity, fadeout and clipping.

Black Level Correction
Enable Black Level Correction export. In order to work correctly with Wings, the cutting rectangles must completely enclose the corresponding projector, otherwise dark areas outside cutting rectangles will be present in wings.

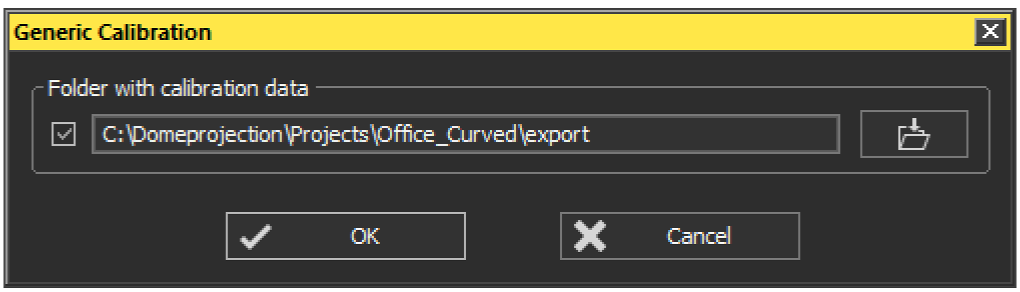
Workflow

1. Create multidisplay areas in wings project
    1. Select screen
    2. Use
    3. Adjust Output Assignment
    4. Adjust the name to match the corresponding projector name in ProjectionTools Mapper.
    5. Repeat adding and adjusting Multidisplay areas according to the amount of channels in the system.

    Here a screenshot of an example setup for a two channel system:



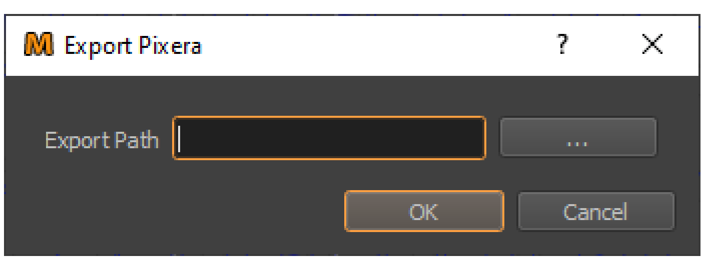
2. Import and activate the calibration data using



6.4.3 Export Pixera

The Pixera exporter allows to export warping and blending data for AVStumpfl Pixera based on MPCDI format.

Export Settings



Export Path
The folder to which all exported files will be exported.

Workflow 2D

1. Create a screen in Pixera.
2. Create projector outputs.
3. Select the screen.
4. Use to load the correction data.
5. Select the exported MPCDI file.
6. Assign the regions to the correct outputs, according to your setup.

Workflow PM

1. Import generated mapping obj file as custom screen in Pixera.
2. Add the screen to the project by dragging into 3d view.
3. Create projector outputs.
4. Select the imported screen.
5. Use to load the correction data.
6. Select the exported MPCDI file.
7. Assign the regions to the correct outputs, according to your setup.

Limitations

Pixera does not load lens distortions of PM exports yet (as of Pixera version 1.4.13).

6.4.4 Export Pandoras Box

Pandoras Box Exporter supports export of warping and blending as well as setting up the virtual cameras. Mapper2d and Mapper3d comes with a version of `PB Automation` which is used to update the camera settings directly. Please check http://coolux.de/root/downloads/support/SDK/PandorasBoxSDK.zip for the latest version of `PB Automation`.

Requirements

Pandoras Box Exporter has the following requirements:

Mapper Version	Pandoras Box Product	Minimum PB Version
Mapper2d	PlayerCompact PlayerSoftware Player	V6.0 Rev15432
Mapper3d	Server	V6.0 Rev15432

For legacy pre split content support see section *[presplit] <#presplit*.

The exporter creates the following files:

- **A set of `warping_*.X` files containing the warping that should**
  be placed in the mesh slot of the corresponding outputs.
- **A set of `shading_*.png` files containing blending information.**
  These files must be placed in the output blend slot. Ensure that the Warped checkbox is ticked.

- **A set of `frustum_*.csv` files containing the camera position**
  and orientation as well as the FOV, offset and roll information. These files are needed only if `automation` is disabled.
- **A set of `layer_*.X` files which define layer geometry to fill**
  the default camera exactly. These files are used for legacy pre split content support only. see section *[presplit] <#presplit* for detailed information.

Export Settings

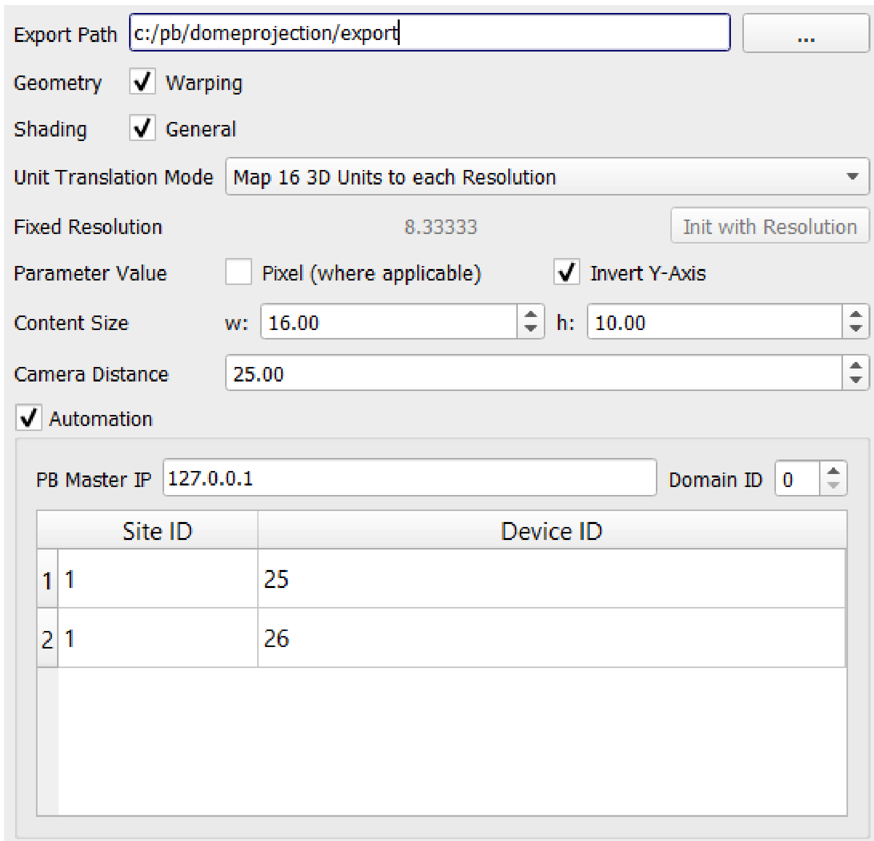


Fig. 1: 2D Settings

Export Path:
A folder where the exported files should be saved. This folder should exist.

Geometry:
Enable to export `warping_*.X` and `layer_*.X` files defining the warping and layer mesh.

Shading:
Enable to export (`shading_*.png`) masks containing monochrome blending, clipping and shading information.

Unit Translation Mode:
Select the unit translation mode configured in Pandoras Box. You will find this configuration under in Pandoras Box.

Init with Resolution:
This option is available only when `Unit Translation Mode` is set to `Use Fixed Relationship`. Choose the resolution configured in Pandoras Box. See `Compositing Pass` in Pandoras Box under .

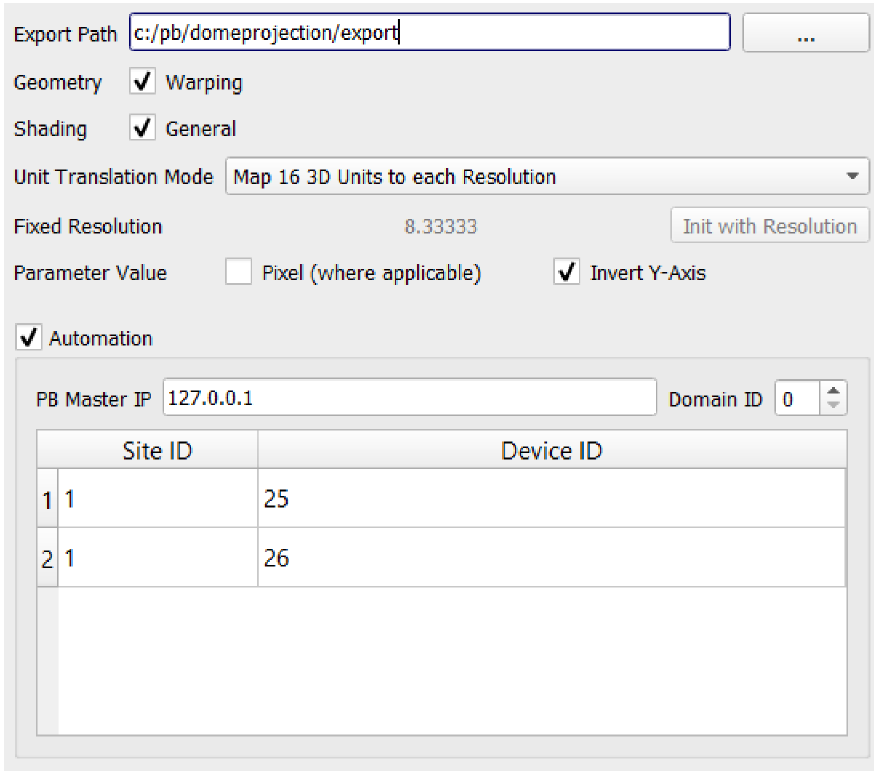


Fig. 2: 3D Settings

Parameter Value:
: Adapt the settings appropriate to the Pandoras Box configuration under `Parameter Value Readout` which can be found under .

Content Size (Mapper2d only)
: Enter the content width and height either in pixels (when `Parameter Value Pixel(where applicable)` is ticked) or in generic units.

Camera Distance (Mapper2d only)
: Enter the camera distance to the content either in pixels (when `Parameter Value Pixel(where applicable)` is ticked) or in generic units.

Automation:
: If enabled, the Pandoras Box exporter tries to update the cameras by use of PB Automation. Note that Pandoras Box Exporter internally uses Pandoras Box generic units. For this it is necessary that the interpretation of Automation Param Input values is set to generic units. See section `Parameter Value Readout` under for details.

PB Master IP:
: Enter here the IP address of the Pandoras Box master instance. Only necessary when `Automation` is enabled.

Domain ID:
: Enter the Pandoras Box master Domain ID. You will find the Domain ID in Pandoras Box under . Only necessary when `Automation` is enabled.

Mapper2d and Mapper3d creates for each projector an entry in the automation table. If `Automation` is enabled, it is necessary to configure the `Site ID` and `Device ID` values. Row 1 is for Projector one, row 2 for projector two and so on. Enter here the appropriate camera device and site IDs. You will find these values in the `Device Tree` in Pandoras Box (e.g. [1.25] Camera ([Site ID.Device ID])). If Automation is disabled you have to copy the values from the generated `frustum_*.csv` files to the appropriate camera devices.

Example of a two channel system (one device two outputs) with Mapper2d

The following section describes a very simple example setup and the workflow to create a proper result in Pandoras Box. The starting situation is shown in table *1 <#starting_situation_mapper2d_pandoras_box_example*

Table 1: starting situation

content size	3600x1800px
display resolution	2560x1600px
generic unit to px	2560/16 = 160
content size in generic units	3600/(2560/16)x1800/(2560/16)px = 22.5x11.25

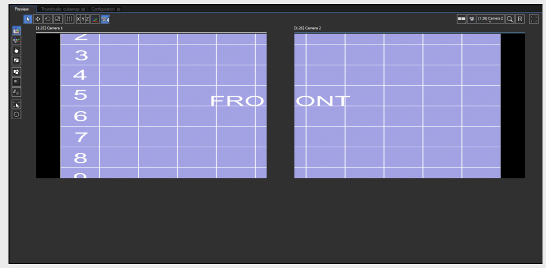
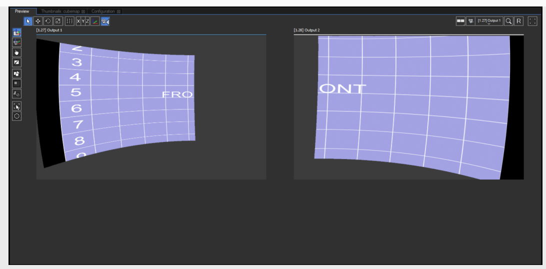
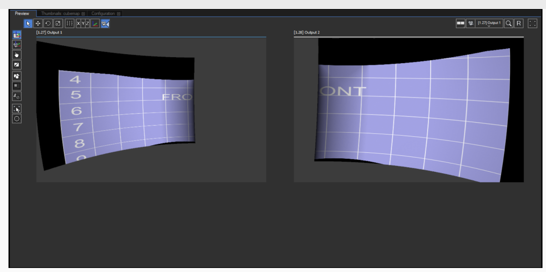
Table *2 <#configuration_mapper2d_pandoras_box_example* shows some different configuration options. In option 2 for example the mapping has to be configured as 2:1, the cutting rectangles can be rotated and the uv scale has to be set to 1x0.5. In the exporter the content size have to be set to 22.5x22.5 generic units (see table *1 <#starting_situation_mapper2d_pandoras_box_example* for the conversion between pixels and generic units) and the camera distance can be set to the default value. In this case no scaling in Pandoras Box is necessary.

Table 2: configuration options

2-7	M apper2d					Pand oras-Box
2-7	mapping config ura-tion			e xporter config ura-tion		Layer
2-7	Mapping	Cutting	UV scale	Content Size	Cam d is-tance	Imag eScaleY
1	1:1	rotated	1 x 1	22.5 x 22.5	25	1
2	2:1	rotated	1 x 0.5	22.5 x 22.5	25	1
3	2:1	un ro-tated	1 x 1	22.5 x 11.25	25	1
4	2:1	rotated	1 x 1	22.5 x 22.5	25	2

Table *3 <#workflow_mapper2d_pandoras_box_example* shows to steps to apply the expor data to Pandoras Box.

Table 3: Workflow appying export data to Pandoras Box

Step	Pandoras Box
(only when Automation was disabled during export) Open `frustum_*.txt` files and copy the values to the corresponding cameras.	
Import exported data to the Pandoras Box project by dragging the export folder from Assets-tab to Project-tab.	
Drag `warping_*.X` to mesh slot of corresponding output. The resulting image should now appear warped in preview window.	
Drag `blending_*.png` to blend slot of corresponding output. The resulting image should now appear warped and blended in preview window.	

Presplit Content Setup

The cutting rectangles in Mapper2d must match the cutting used in the corresponding Pandoras Box project. (There should be only one projector per device.)

A matching cutting layout can be achieved in multiple ways:

- editing the cutting rectangles in Mapper2d by hand
- use
- **use ProjectionTools Cutter to create presplit content based on**
  cutting rectangles from Mapper2d (strongly recommeded for dome content)

Setup Pandoras Box for presplit content

The cutting rectangles in Mapper2d must match the cutting used in the corresponding Pandoras Box project. (There should be only one projector per device.)

A matching cutting layout can be achieved in multiple ways:

- editing the cutting rectangles in Mapper2d by hand
- use Extras!Layout Cutting Rectangles…
- **use ProjectionTools Cutter to create pres plit content based on**
  cutting rectangles from Mapper2d (strongly recommended for dome content)

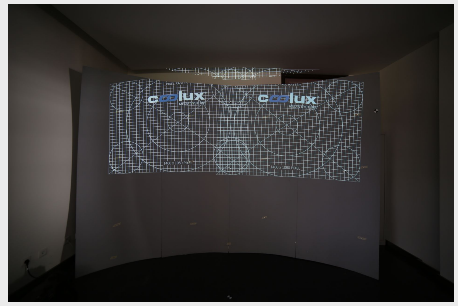
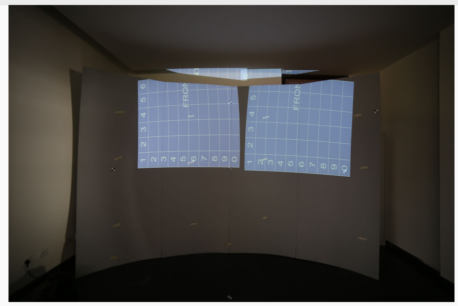
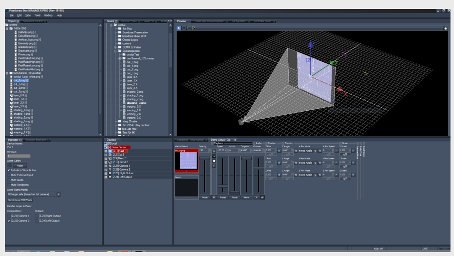
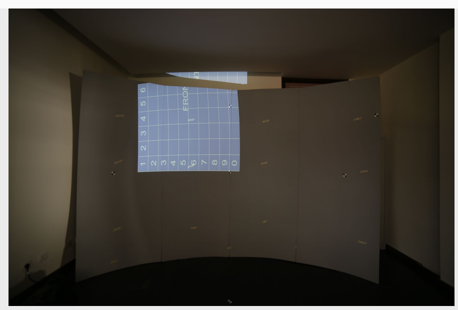
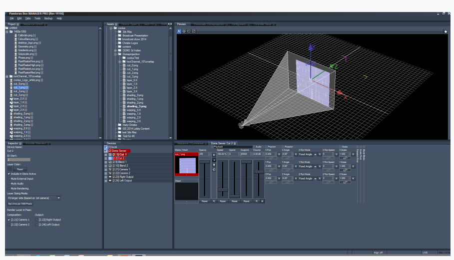
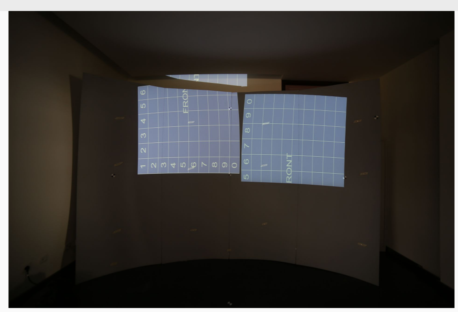
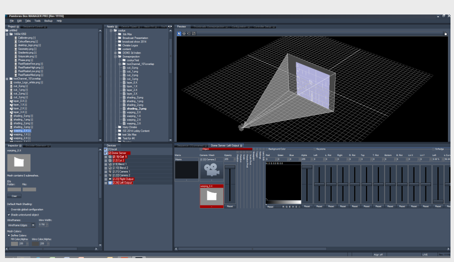
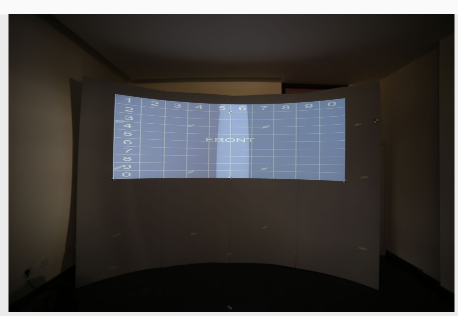
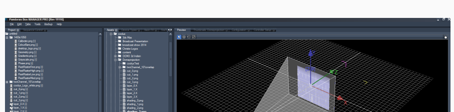
In order to setup Pandoras Box for pre split content, a sample pre split content should be available to make setup easier to verify. A fast way to create a pre split still image is to use A file dialog opens and requests an image and an output path. The source image is than sliced and the subimages are stored in the output folder. Import the sliced image into your Pandoras Box project.

For pre split projects all the cameras will stay at their default positions in Pandoras Box. All cameras are placed and oriented the same way with no shift.

The exported data must be imported into the Pandoras Box project and applied to the corresponding layers and cameras.

1. **Import data to the Pandoras Box project by dragging the export**
   folder from Assets-tab to Project-tab.
2. **(optional) Drag `layer_*.X` to mesh slots of all layers in the**
   corresponding device, that should contain presplit content or the shading images. Images placed on these layers should now perfectly match the cameras view (in Pandoras Box 5 this is optional since the layers match the default camera by default).
3. **Drag `warping_*.X` to mesh slot of corresponding output. The**
   resulting image should now appears warped in preview window.
4. **Drag `shading_*.png` to top most layer in corresponding devices**
   and set opacity to 255. One ore more edge should get dark, depending on the overlap with other projector

Example of a two channel system (one device two outputs).

Step	Pandoras Box	Screen
Original output from two projector project using standard test pattern		
Presplit content loaded		
Presplit content assigned to correct camera		
All presplit content loaded and assigned		
Warping assinged to corresponding outputs		
		

6.4.5 Export Watchout

The WATCHOUT Generic exporter allows to export warping and blending data for Dataton Watchout based on generic export formats.

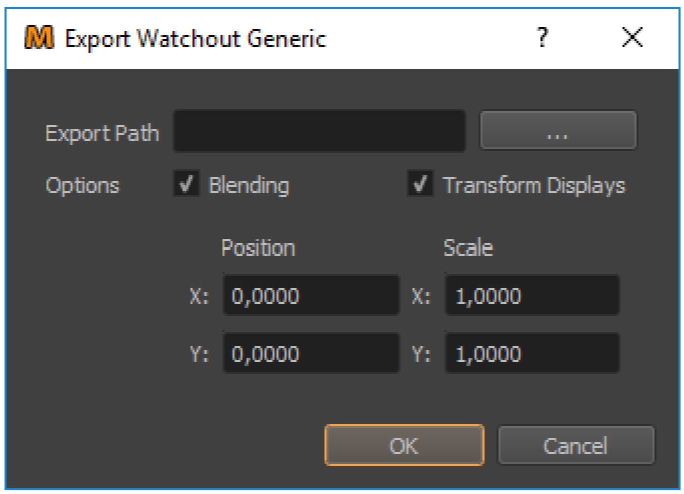
Watchout 2D Display/Projector and 3D Mapping Projector are supported. Use Mapper2d for 2D exports, Mapper3d for 3D exports and MapperPM for projection mapping exports.

The exported data can be imported by Watchout as Display/Projector setup.

Requirements:

- Requires Watchout 6.2 or newer
- Unrotated cutting rectangles recommended for non-dome setups

Export Settings



Export Path
A folder where the exported files should be saved. This folder should exist.

Blending
Export blending information. This includes clipping, fadeout and uniformity information as well.

Transform Displays
For scaling the projector layout to fit a desired content size, enable the Transform option. Please be aware, that there is another position and scaling option during import into Watchout, which will add to the transformation defined here.

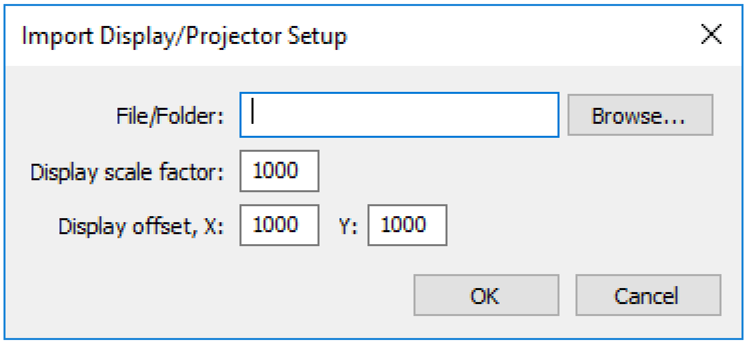
Position x/y
Defines the offset of the whole projector arrangement from the origin in the normalized mapping space.

Scale x/y
Defines the scaling of the normalized mapping space. Enter the X/Y dimension of the desired media content. Non-uniform scaling is supported for unrotated cutting rectangles only.

Import Data in Watchout

Import the projector setup at once into WatchOut Production by utilizing .

The following dialog shows up:



File/Folder
: Select the folder, where the Mapper2d export data is saved.

Display scale factor
: The display scale factor converts the normalized mapping space of the Mapper2d to pixel values in WatchOut, 1000 is the default. This is multiplied by the scale factor defined in Watchout Generic export. If you scaled up the export already set this to 1.

Display offset x,y
: Defines the offset of the imported projector setup in pixel from the origin. This is added to the offset defined in Watchout Generic export.

The projection setup will be loaded and the warping and blending files are automatically applied to the displays (see Figure 2). All blending files are then visible in the Media section.

Preparation for Stage Online

Before enabling the online stage, make sure to go through the following steps:

1. Correct content placement: Set the Anchor Position of the content to Top Left and enter the same X/Y values as Initial Stage Position that were used as Display offset during import. In the example for the 4k dome, a 4000x4000 pixel test image is placed with its top left corner at 1000,1000 to match the imported display layout.
2. Connect each Display to the corresponding output channel on the media server. This option is available in the display .
3. Enable blending for each display. This option is available in . Untick the enabled field and tick it again.

Automatic Updates of Correction Data

It is possible to automatically update the correction data in watchout, by just exporting new correction files from Mapper2d or Mapper3d. However this requires some additional settings in Watchout.

1. must be set to automatic.
2. needs to be enabled.

With these settings, Watchout recognizes, when the calibration files on disk where rewritten and automatically applies the new correction data.

Known issues

- On import the blending mask is applied and enabled, but it must be re-enabled in to have an actual effect.
- When changing/updating a blend file the old blend mask must be deleted by hand in . The new file must be applied by dragging and dropping it in the mask preview area. Otherwise the new blend file might be correctly shown in the mask preview, but the old file will still be used for blending.
- Automatic updates in watchout currently have problems with updating the display informations, so do not override the cutting and frustum files for automatic updates, for example by exporting in a different folder than is used by Watchout for loading the correction data and than copying the data except cutting and frustum files with a batch-script to the folder used by Watchout.
- Further glitches during automatic updates might be overcome by not updating all files at once, but with a delay after each file.

Presplit Video

The importand thing about presplit video in combination with Mapper2d is that cutting-rectangles must match presplit. The displays could even look stretched on WATCHOUT stage and the result on screen will still match.

Presplit Video with defined overlap

Presplit video is often cut in a simple horizontal or vertical layout with constant overlap between projectors. Mapper2d can generate such kind of cutting-rectangles with .

The cutting-rectangles can also be edited by hand. The auto-generate feature must be disabled for user defined cutting rectangles (disable "Auto Generate" below projector list in cutting-tab).

Arbitrary presplit Video generated with Cutter

If the video-material is not yet presplit you can use the Cutter to cut the source images according to the cutting rectangles shown in Mapper2d. Cutter can cut image-sequences, producing multiple sub-image-sequences (one per projector) which can be used to encode a video-file for each projector with video-editing software.

The Cutter needs information about the cutting-rectangles which can be exported through.

6.4.6 Export MXWendler

The MXWendler exporter allows to export data for MXWendler Mediaserver.

Warping, Blending and Black-level adjust are fully supported.

MXWendler does not yet support cutting-rectangles. Due to this limitation, all cuttingrectangles must be identical and enclose the complete 2d-mapping area. Use with 100% overlap to get this kind of none-cutting-rectangles.

All data is exported to the selected export path. This path can be imported through a wizzard in MXWendler Mediaserver. Please refer to MXWendler documentation for further information about the import of the data.

6.4.7 Export Ventuz

The Ventuz exporter exports geometry files (`ShapingData_*.dea`), blending files and a text file that includes all the frustum settings of the virtual cameras.

Configuring the Desktop

In order to have a multi projector setting for a Ventuz presentation the windows desktop has to be set to a span view including all displays that want to be used.

Workflow

First step is to make the usual measurements with the Creator. After generating the 3d Geometry the Creator can be closed, the Mapper3D opened and the project loaded.

In the Mapper 3D virtual cameras will be placed for all displays. All Cameras should have the same position only the rotation angles and frustum setting shall differ between the virtual cameras.

When the setup is satisfying the export itself has to be set up; . Here the export path has to be defined as well as what should be exported. Warping, Frustum values and general shading is essential, Black level adjust (BLA) is not yet supported by Ventuz.

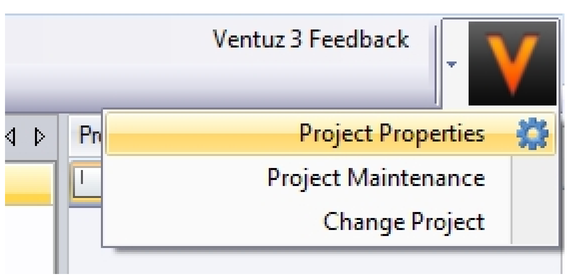
General information for importing into Ventuz

The warping will not be done within the original Ventuz scene but an additional production layout scene. Two templates for a three projector setup can be found within the Mapper3d template folder. Depending whether or not decimal expansion use a comma or a dot the `Ventuz3_Template-ger.vza` (for comma) or `Ventuz3_Template-eng.vza` (for dot) archive is chosen.

After importing the archive into the project certain things have to be modified and set.

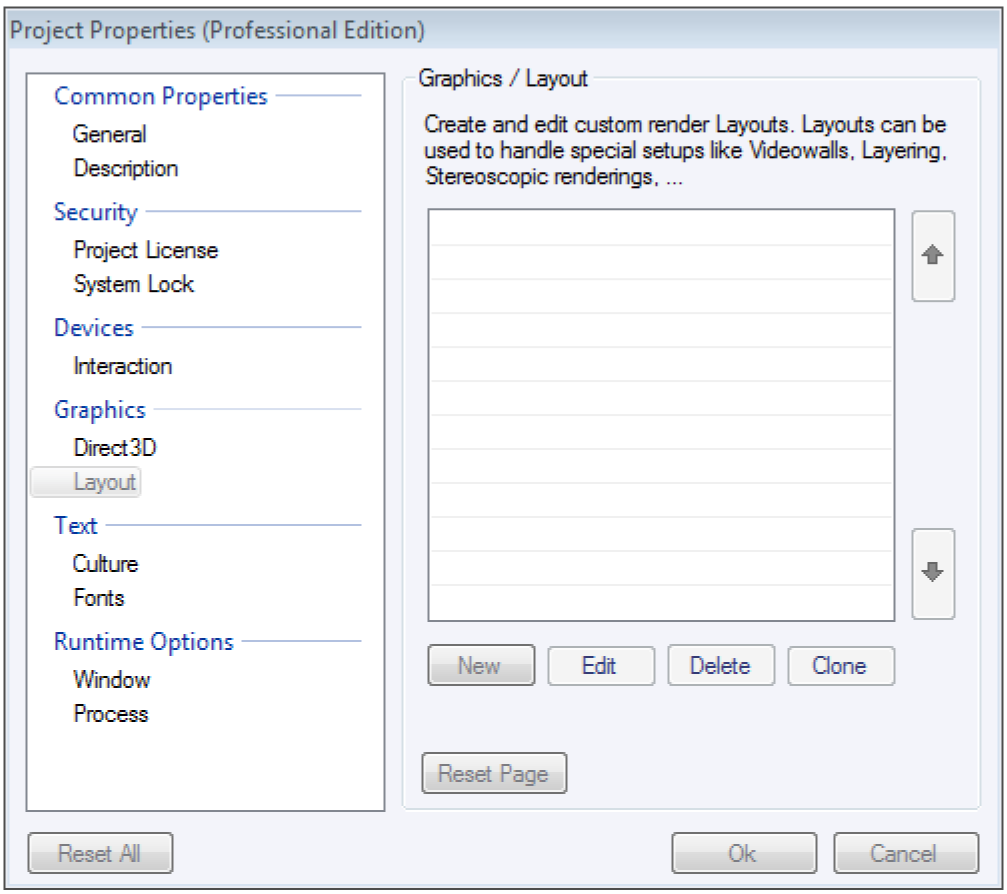
Setting a new Render layout Scene

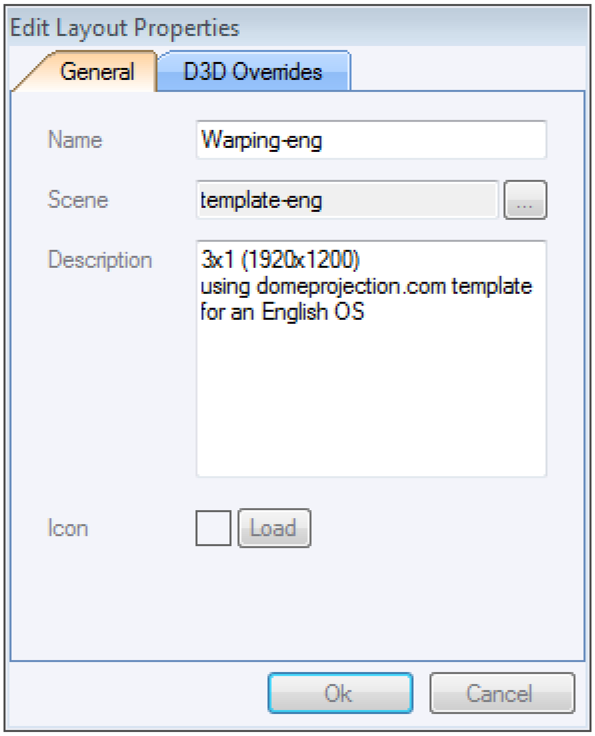
After Importing the provided template it should be set to be the default render layout to ensure that our production will be rendered with the generated warping. The settings for render layouts can be found in the project properties on the right to of the Ventuz window.

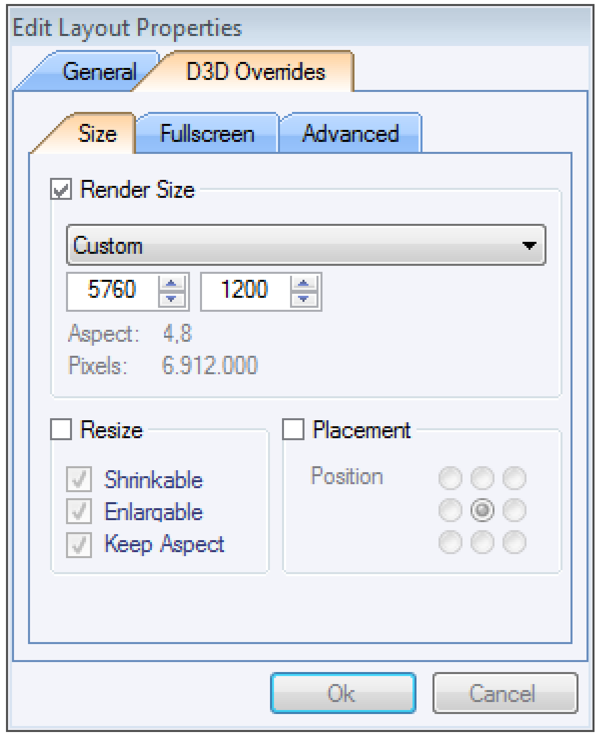


Here, different layouts can be set or modified within the Graphics subsection. By clicking on new, a new layout can be generated, by double clicking on an existing one layout settings can be modified.

After creating a new Layout it can be given a name and a scene has to be chosen for the new render scene. Afterwards the render size must be set to fit the real desktop setting. In this example, 3 projectors are used with a resolution of 1920x1200 and they are all horizontally aligned therefor the resolution of the render scene has to be 5760x1200.


Project Properties (Professional Edition)
Common Properties
General
Description
Security
Project License
System Lock
Devices
Interaction
Graphics
Direct3D
Layout
Text
Culture
Fonts
Runtime Options
Window
Process
Graphics / Layout
Create and edit custom render Layouts. Layouts can be used to handle special setups like Videowalls, Layering, Stereoscopic renderings, ...
New
Edit
Delete
Clone
Reset Page
Reset All
Ok
Cancel



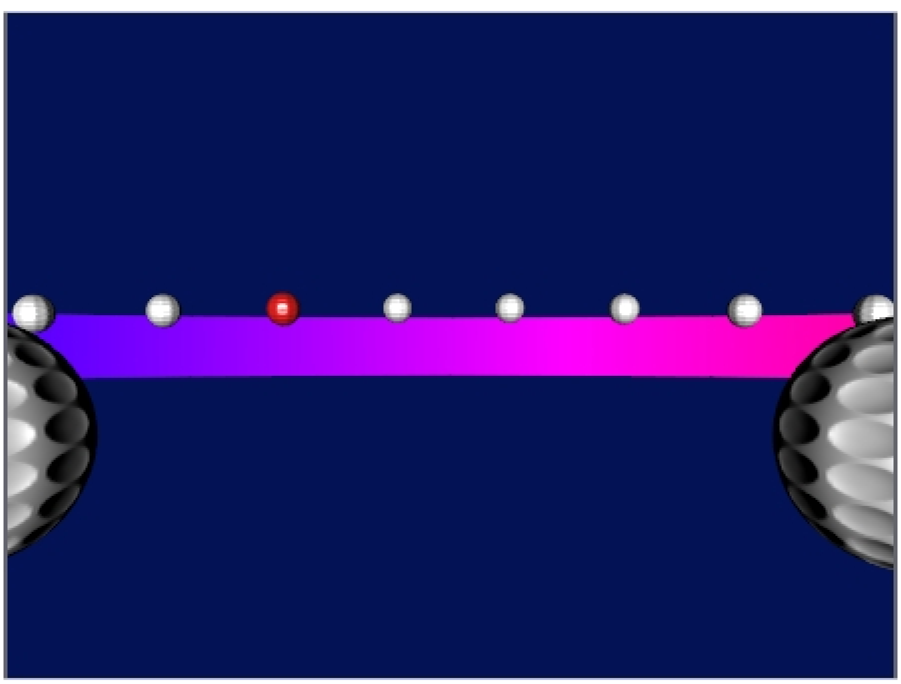


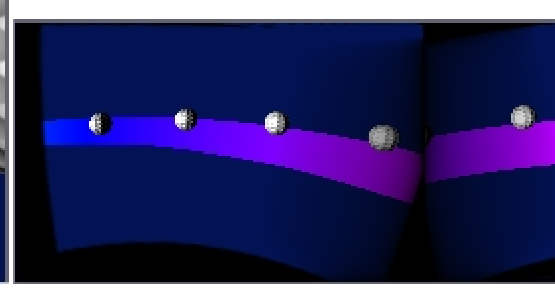
The Next step is to define this new render scene as default render scene, by checking the check box in front of the scene) which means that every project that will be exported as a presentation will be mapped onto this render scene.

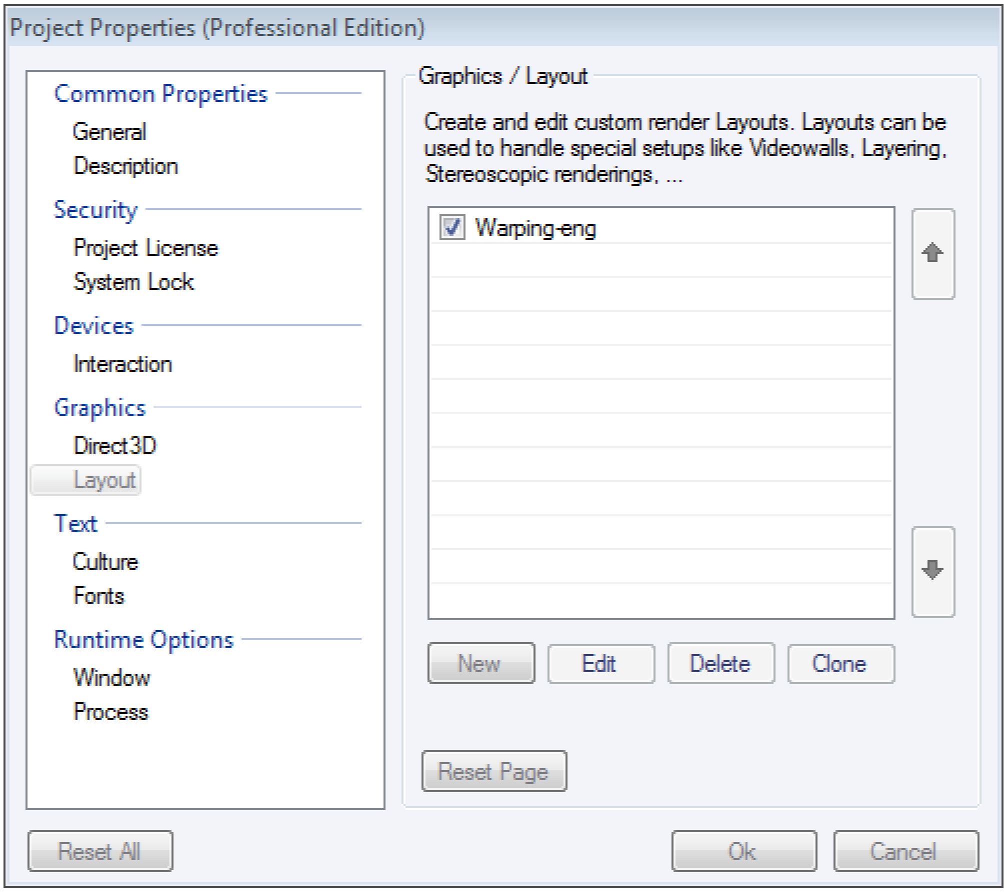
In order to see the result of the warping the output scene has to be active and the stage editor window has to be activated (View -> Stage Editor). Per default it should show up on the left side. Here the render scene can be chosen.

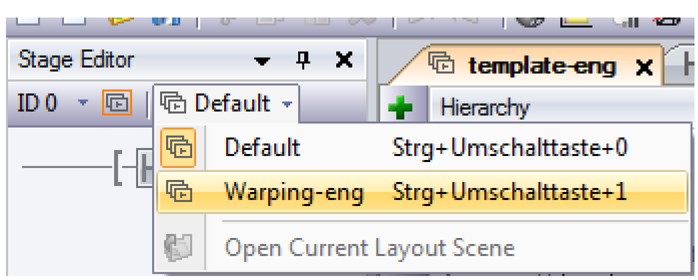
If the layout scene has to be to reedited, choose "open current Layout Scene" a new tab will open showing the layout Scene.

In the render window the view of the scene should be changed now from a plain one to a longer split one



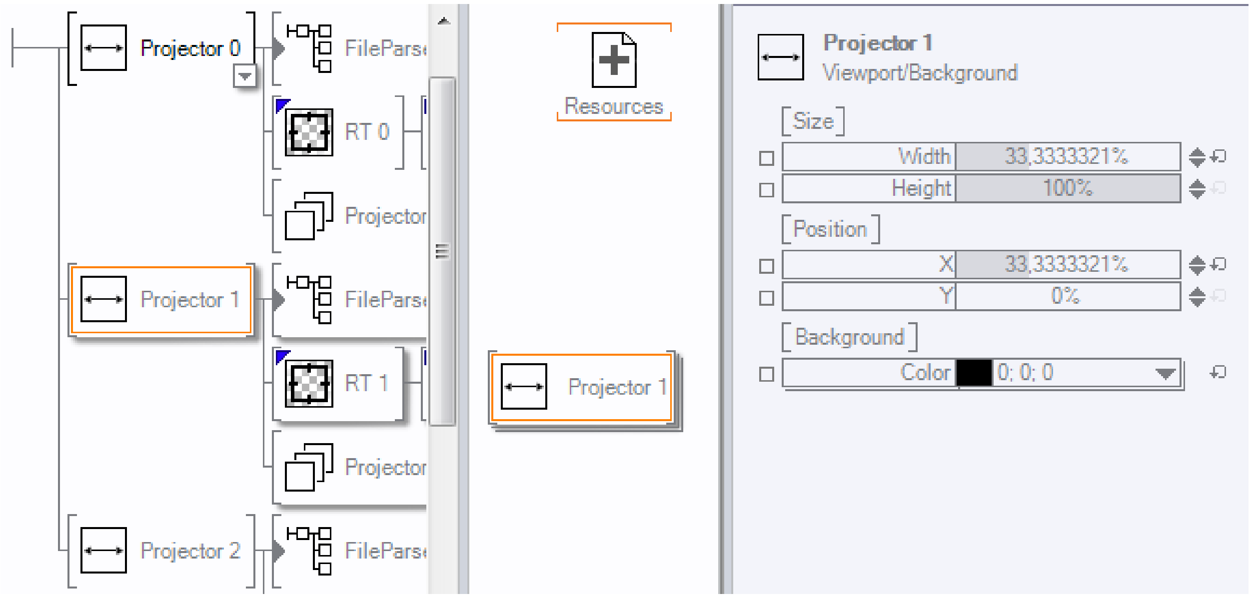



Project Properties (Professional Edition)
Common Properties
General
Description
Security
Project License
System Lock
Devices
Interaction
Graphics
Direct3D
Layout
Text
Culture
Fonts
Runtime Options
Window
Process
Graphics / Layout
Create and edit custom render Layouts. Layouts can be used to handle special setups like Videowalls, Layering, Stereoscopic renderings, ...
Warping-eng
New
Edit
Delete
Clone
Reset Page
Reset All
Ok
Cancel


Stage Editor
template-eng
ID 0
Default
Hierarchy
Default
Strg+Umschalttaste+0
Warping-eng
Strg+Umschalttaste+1
Open Current Layout Scene

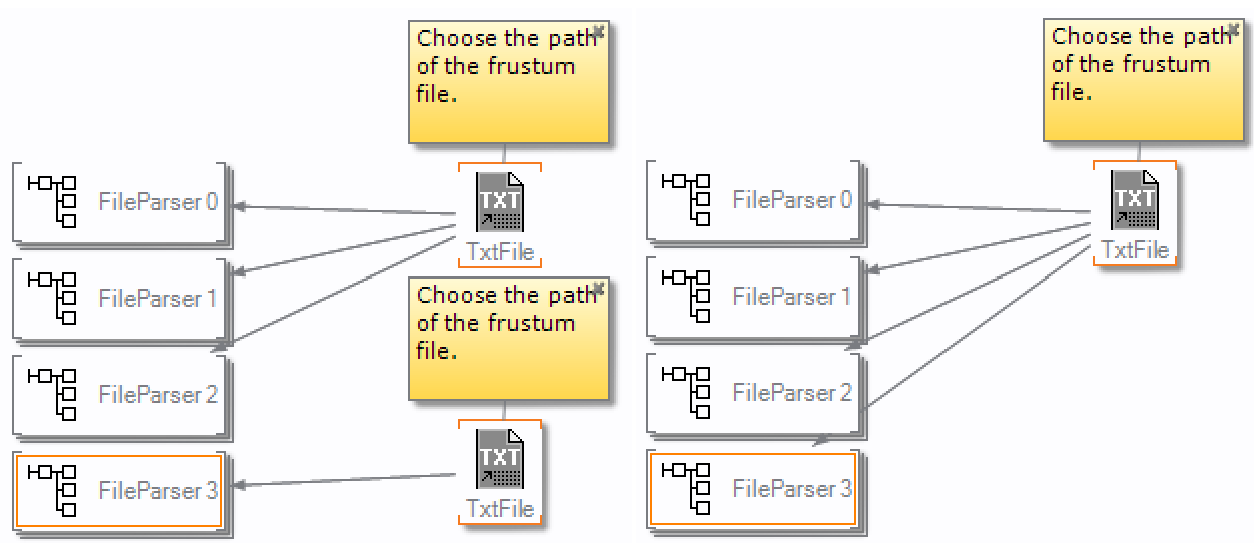
Changing the render layout

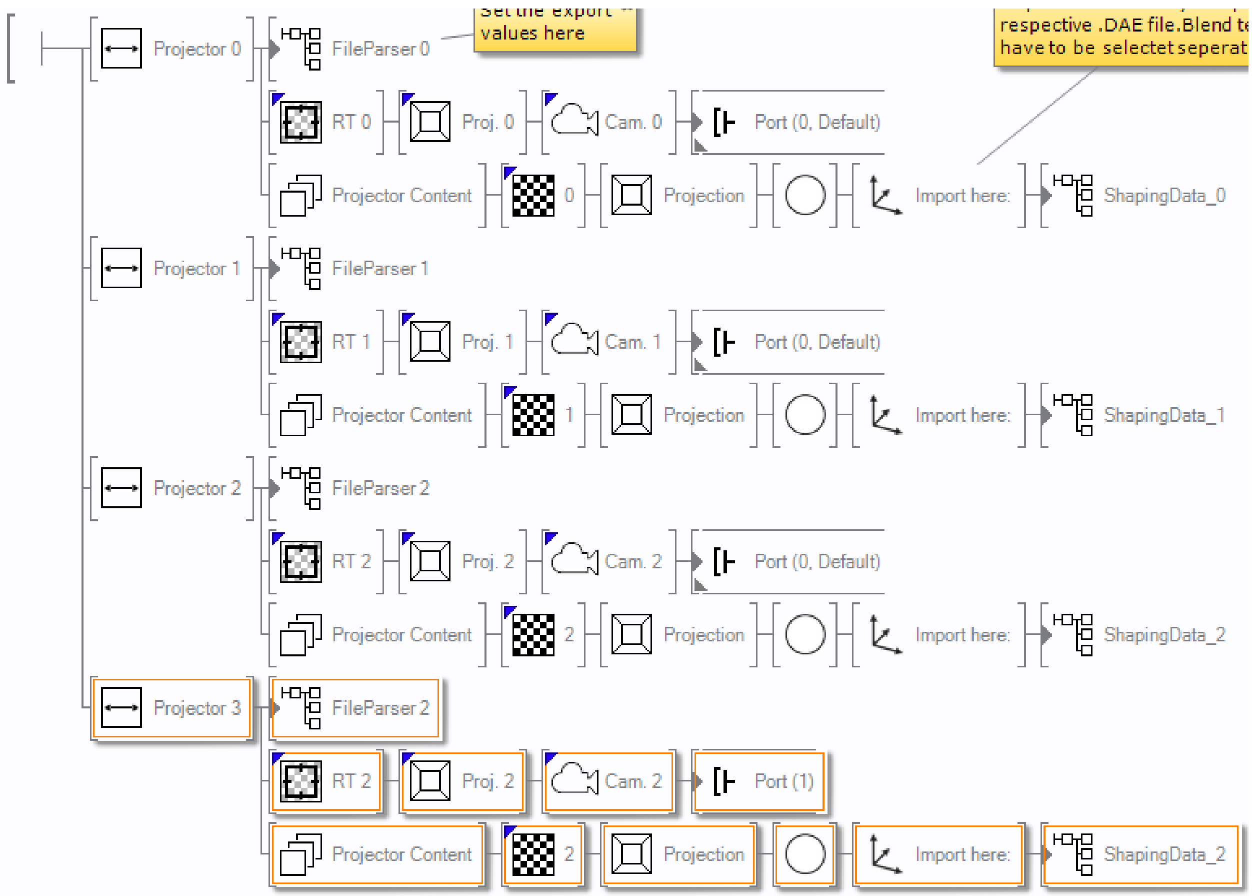
In case the projectors are not horizontally aligned or there are more or less than 3 projectors in the project the template can easily be modified. For different layouts just change the viewport positions and sizes but be aware that this setup should always represent the real setup of the windows desktop.



If there are more than 3 Projectors just copy the whole sub-tree starting with the viewport.

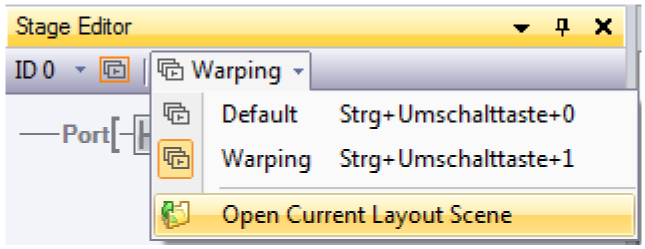
Be aware that nodes will be copied that have a connection to a node of copied group. In this case a text file node that become visible when clicking on the file parser. It is important to delete this copied TxtFile node and create a link from the added file parser to the original TxtFile node. Otherwise it is possible that the wrong data will be displayed.



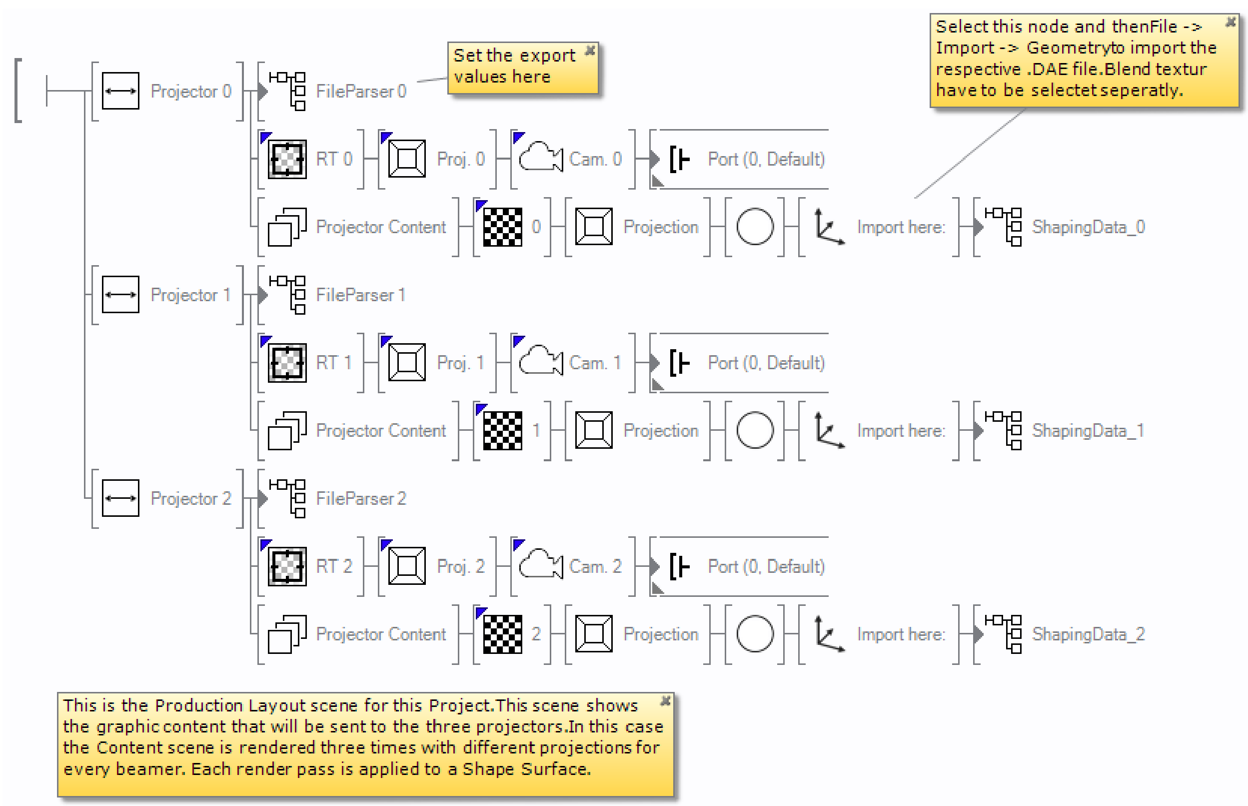

values here
respective .DAE file.Blend
have to be selectet seperat
Projector 0
FileParser 0
RT 0
Proj. 0
Cam. 0
Port (0, Default)
Projector Content
0
Projection
Import here:
ShapingData_0
Projector 1
FileParser 1
RT 1
Proj. 1
Cam. 1
Port (0, Default)
Projector Content
1
Projection
Import here:
ShapingData_1
Projector 2
FileParser 2
RT 2
Proj. 2
Cam. 2
Port (0, Default)
Projector Content
2
Projection
Import here:
ShapingData_2
Projector 3
FileParser 2
RT 2
Proj. 2
Cam. 2
Port (1)
Projector Content
2
Projection
Import here:
ShapingData_2

Importing warping files and setting the virtual camera

If not already open, open the render layout scene (Stage Editor window) by first choosing the layout that has to be changed as being the active layout and than clicking on "Open Current Layout Scene"



The following picture shows the scene hierarchy with 3 view-ports (one for each projector). The view-ports are set to be all horizontally aligned and the nodes that are attached to them will define the warping and camera setup.

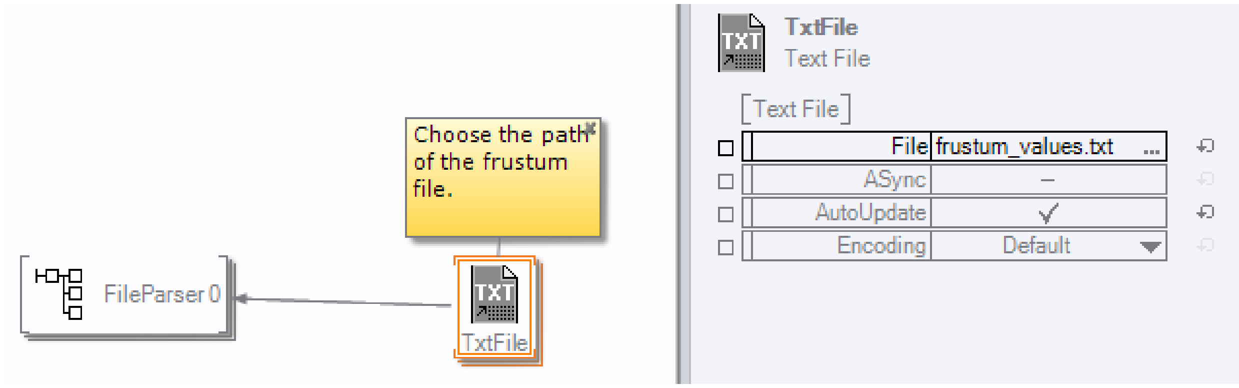


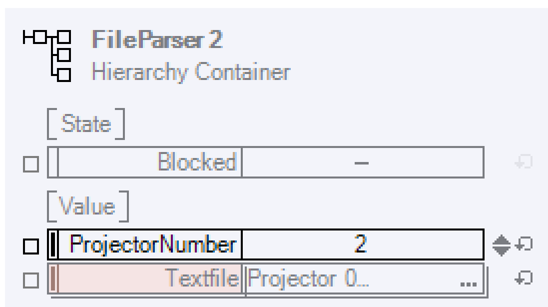
In order to import the warping correctly, following values have to be changed to set the proper field of view. The first thing to do is to import the `frustum_value.txt` file. To do so any of the fileParser nodes has to be selected to bring up the TxtFile node within the content window. There the text file can be chosen.

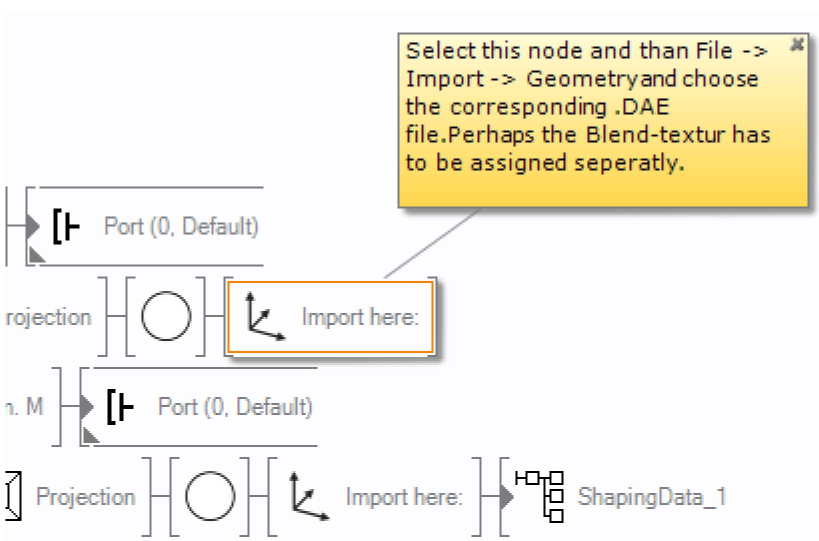
It has also to be checked if each FileParser was the right projector number assigned to.

After selecting the `frustum_value` text file and setting the projector numbers the warping can be imported. First the old shaping data has to be deleted, than the `shapingData_x.dae` file has to be imported by selecting the "import here:" node an than .

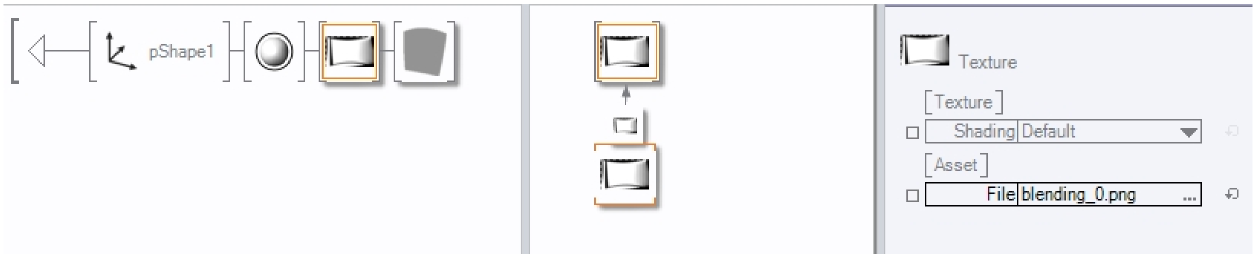
A import dialog will be shown, were nothing has to be changed just click import. Next will be ask were to save the ventuz geometry file, here the old file can be overwritten.


Choose the path of the frustum file.
FileParser 0
TxtFile
TxtFile
Text File
Text File
File
frustum_values.txt
ASync
AutoUpdate
Encoding
Default


FileParser 2
Hierarchy Container
State
Blocked
Value
ProjectorNumber
2
Textfile
Projector 0...


Select this node and than File -> Import -> Geometry and choose the corresponding .DAE file.Perhaps the Blend-textur has to be assigned seperatly.
Port (0, Default)
rojection
Import here:
Port (0, Default)
Projection
Import here:
ShapingData_1

Afterwards the correct blending file has to be set within the `ShapingData_x` container (to get into the container double click on the small arrow in front of the ShapingData node). By default the blending files that are already in the Images folder will be taken, change it to the new created one by clicking on the dots in the File array, a dialog will open with which the new blending file can be selected.

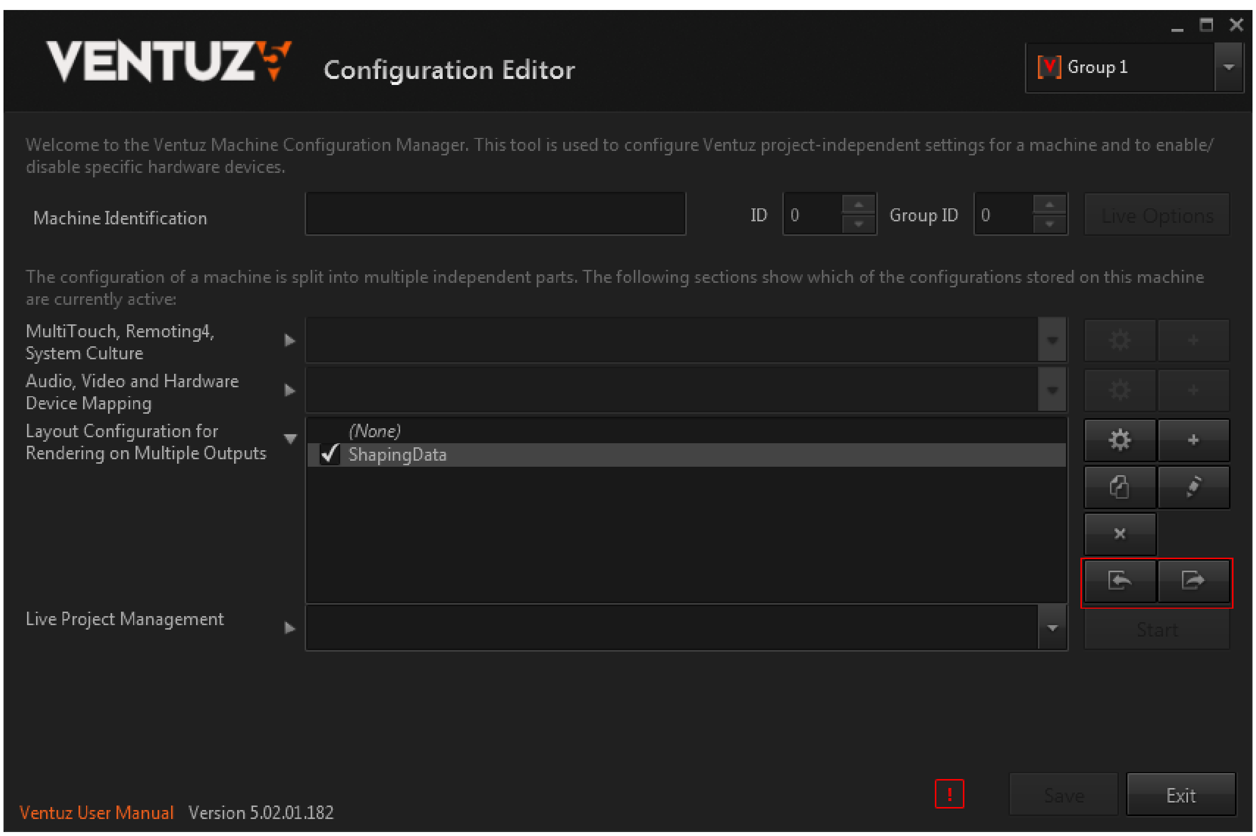


After Setting all values and importing all data this scene has to be saved in order to use this changed layout for any export.

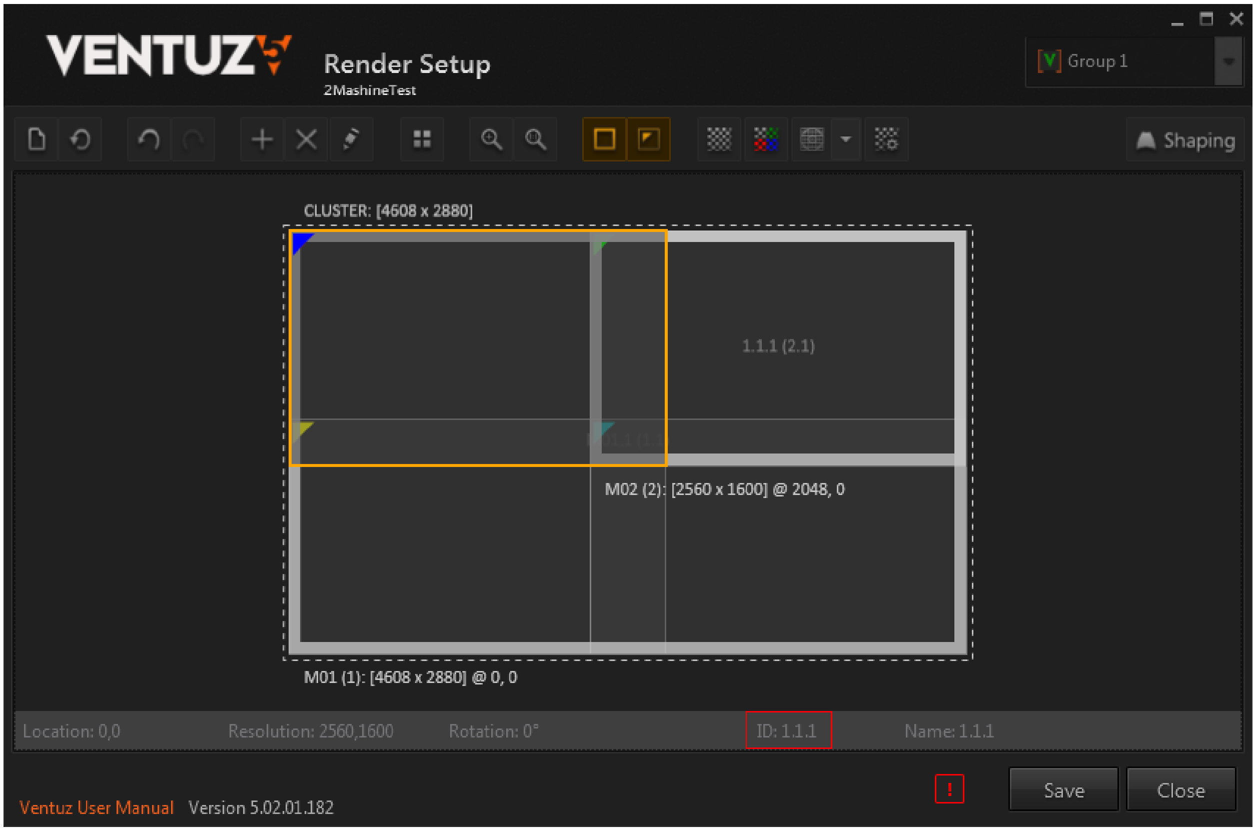
Please note: an example project (ExampleProject.vpa) which contains both templates, already set up as render layout, and a demo scene can also be found within the Mapper2D/Mapper3D `templates/ventuz` folder.

6.4.8 Ventuz VRS

The Ventuz VRS Exporter allows to patch Ventuz Configuration Editor vrs files. These files can be imported in Ventuz Configuration editor.



The mapping between ProjectionTools channels and Ventuz channels is defined based on each outputs *systemId*.

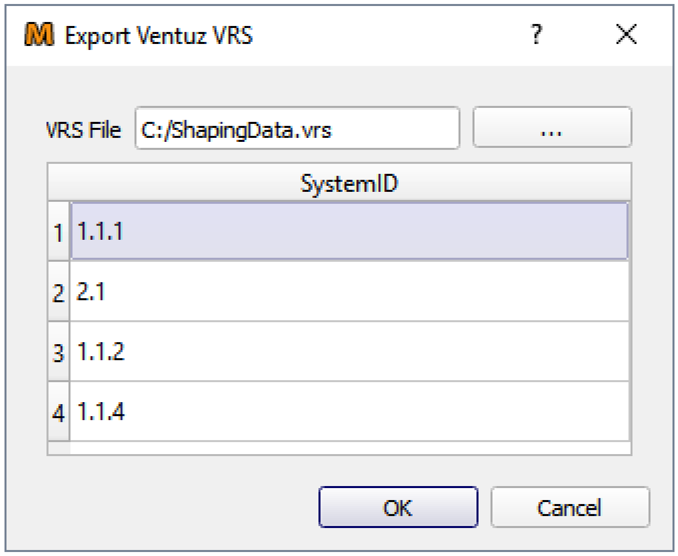


The cutting rectangles layout in Mapper2d must perfectly match the ventuz render setup, to get a matching result. Use to get unrotated cutting rectangles with defined overlaps.

Export Settings

VRS Name:
The place and name of the Configuration Editor file to patch.

SystemIDs:
The mapping between ProjectionTools channels and Ventuz channels is defined based on each outputs *systemId*.



Limitations

The exporter writes warping information only. The blending is calculated/updated by Configuration Editor, thus the projectors should be placed in a standard layout with defined overlaps.

6.4.9 Export Resolume

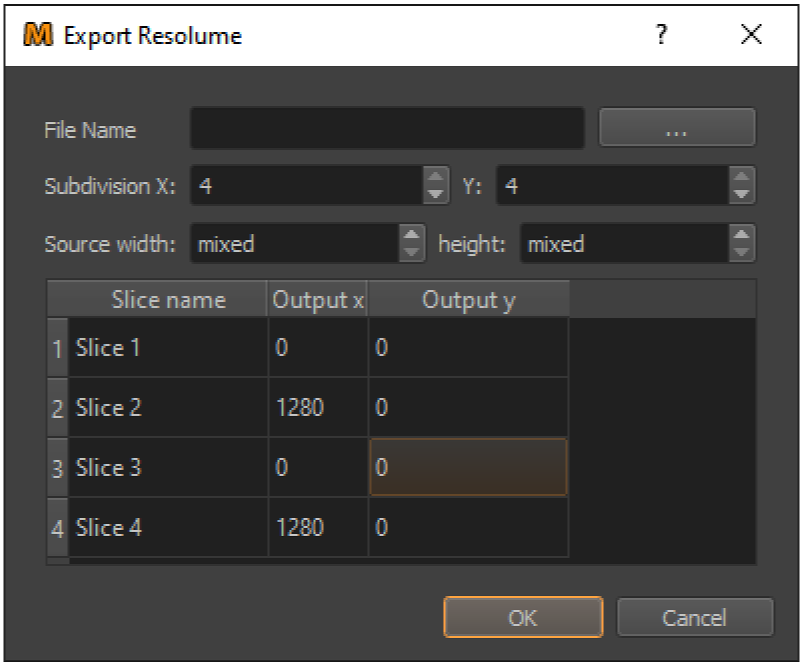
The Resolume Exporter allows to export warping into Resolume Arena (Tested on version 7.1).

The blending is calculated by Resolume, so for exact blending results, the cutting in Mapper2d needs to be unrotated and within projectors.

The data exchange is done by patching slices with matching names in Resolume Advanced Output Preset (Resolume slice name = ProjectionTools projector name).

The slice input region is defined by current mappings shading resolution and each projectors cutting setup.

Export Settings



File Name:
A *Resolume Arena* Advanced Output Preset to patch.

Subdivision X/Y:
Resolume subdivision level. Best quality achieved on highest setting. When there are performance issues in Resolume, reduce subdivison level here or afterwards in Resolume.

Source width/height:
Resolume input source resolution. When set to mixed, the source resolution is defined by mappings shading resolution associated with each channel. In standard projects with only one mapping, it is this mappings shading resolution.

Slice name:
Assign the correct slice in Resolume Advanced Output Preset. Make sure that all slices have unique names in Resolume.

Output x/y:
Optionally offset the slice in output. For example, when one display output of the computer is split for multiple projectors.

Workflow

1. Prepare an Advanced Output template in Resolume
    1. **Create an Advanced output configuration, containing as much**
       slices, as needed.
    2. Give each slice a unique name.
    3. Save the configuration as Preset.
2. **Ensure all cuttings are unrotated, by either setting to unrotated**
   (default) or by using .

3. Export
   1. **Select the previously exported Advanced Output Preset in the**
      Resolume exporter.
   2. **Assign each ProjectionTools projection channel to the**
      corresponding resolume slice by entering the correct slice name.
   3. **Adjust potential output offsets, in cases where multiple slices**
      are sharing one output. For example multiple projectors attached to one output of the computer using a splitter.
   4. Run the export.
4. Import data into Resolume
   1. Load the patched Preset in Resolume Advanced Output again.
   2. Save and close Advanced Output editor.

Limitations

Due to limited blending capabilities in Resolume, projectors should be organized in a column/row fashion, and the cutting needs to be unrotated accordingly.

When multiple slices are sharing one output, the warping should be kept inside the projection channel to avoid overspill. This can be achieved by ensuring the cutting rectangles for each projector are kept inside the area covered for the projector in Mapper2D 2D view.

Sometimes, resolume does not reimport an Advanced Output Preset when it does not have a new name. In that case give a new name to the patched Preset before importing it again, or restart Resolume.

Image based Blending

Even though it is not officially supported, there is a workaround possible to bring image based blending into Resolume, using its layer mask functionality.

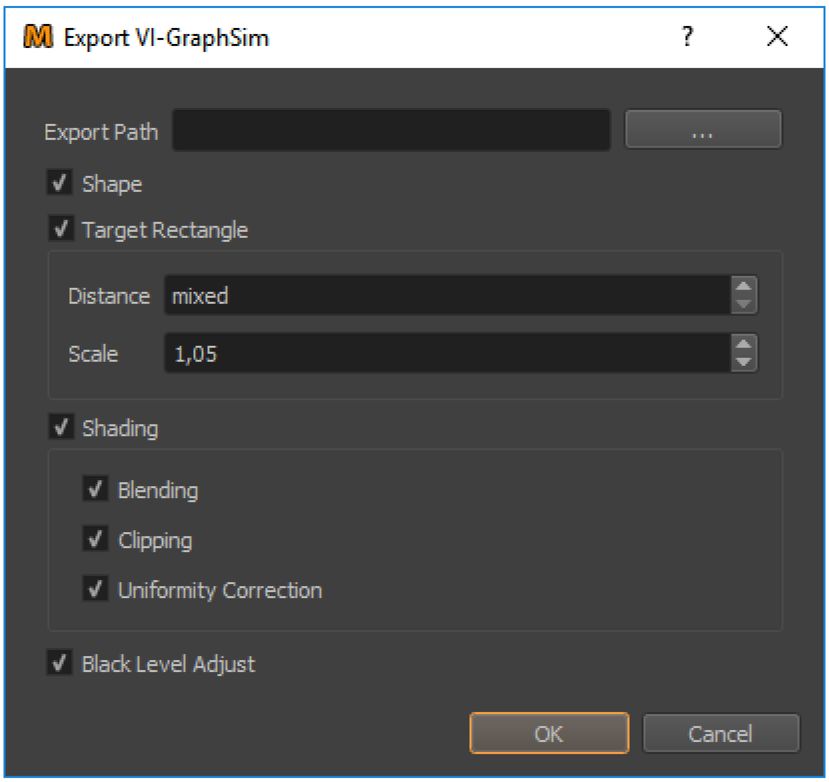
1. Preparation in Resolume
   1. Create a layer for each channel
   2. Put the content into each layer
2. Export
   1. Use the generic exporter, to export shading as uncut 8bit png
3. Import data into Resolume
   1. locate the blend files
   2. **drag and drop the correct blend files onto its corresponding**
      layer, a mask selection will appear.
   3. Choose luminance as blend mode

6.5 Image Generators

Name	2D	3D	DW	PM	Warp	Blend	BLC
DrillSim		X			X	X	
OSC Even		X			X	X	
VI-Grade VI-GraphSim		X	X		X	X	X
Unity	X	X	X	X	X	X	X
X-Plane		X			X		

6.5.1 Export VI-GraphSim

The VI-GraphSim exporter supports export of dynamic warping, blending and black-level-correction data to VI-Grade VI-GraphSim.



Export Settings

Export Path:
The folder to which all exported files will be exported. Data for each channel will be put in corresponding subfolders.

Shape:
Enable to export data, based on which dynamic warping is calculated during runtime.

Target Rectangle:
Toggle export of target rectangles, which are used to dynamically generate frustum settings for any given eyepoint during runtime.

Distance:
The distance is set to mixed by default, which means the target distances per projector from the frustum settings in the project are used.

Scale:
The scale value is usually a bit larger than 1.0 to avoid content cut-off, when moving the eyepoint around in a dynamic viewpoint system.

Shading:
Allows to toggle export of shading files, which may contain multiple layers of shading:

Blending:
If enabled, the blending will be calculated and exported for each projector

Clipping:
If enabled, clipping data will be calculated, added to the blending images and exported for each projector. It is only usable if blending is enabled.

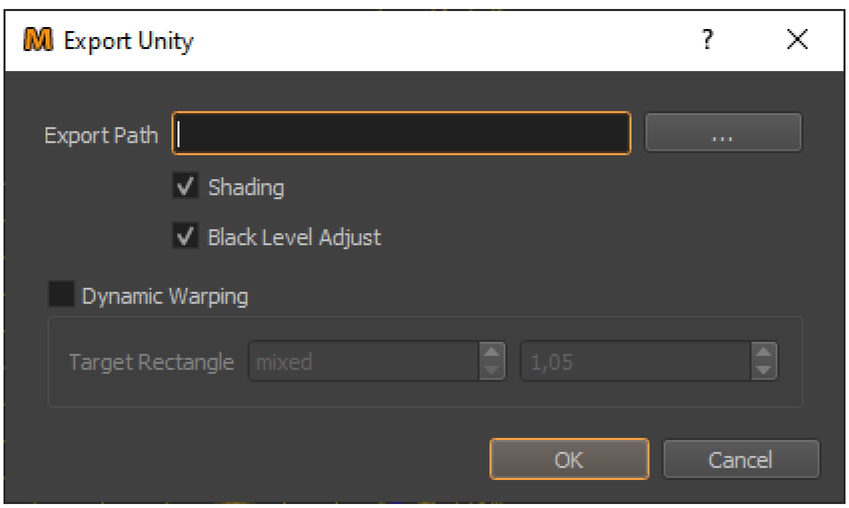
Brightness adjust:
If enabled, uniformity correction is applied.

Black Level Adjust:
Enable to export Black Level Adjust image.

6.5.2 Export Unity

The Unity Exporter allows to export warping, shading and black level correction for use with DPUnityPlugin.

Export Settings



Export Path
The folder to which all data files will be exported.

Shading
Enable shading calculation and export.

Black Level Correction
Enable black level correction export.

Transform
An optional 2d transform to adjust the area where the orthographic cameras in unity are looking at, when exporting from Mapper2d.

Dynamic Warping
Allows to switch between static and dynamic warping, when exporting from Mapper3d.

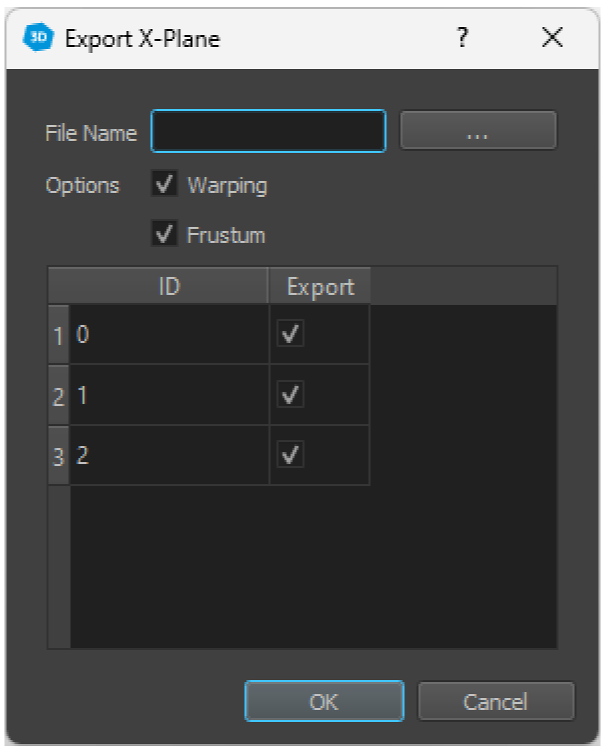
Target Rectangle
Allows to adjust the conversion of current frustum settings into target Rectangles by setting a distance and scale value.

The distance is set to mixed by default, which means the target distances per projector from the frustum settings in the project are used.

The scale value is usually a bit larger than 1.0 to avoid content cut-off, when moving the eyepoint around in a dynamic viewpoint system.

6.5.3 Export X-Plane

Export Frustum settings and warping to X-Plane.



Export Settings

File Name
`X-Plane Window Positions.prf` to be patched. Usually placed at `[X-Plane Installation]/Output/preferences`.

Options

Warping
Enable to update warping correction.

Frustum
Enable to update frustum settings.

Table

ID
The ID of the X-Plane window.

Export
Enable to export for that channel.

Limitations

Only frustum settings and warping are supported. A simple edge blend can be manually set and adjusted in X-Plane.

For more advanced correction including blending and black level correction, use the X-Plane plugin and the *domeprojectionSDK exporter*.

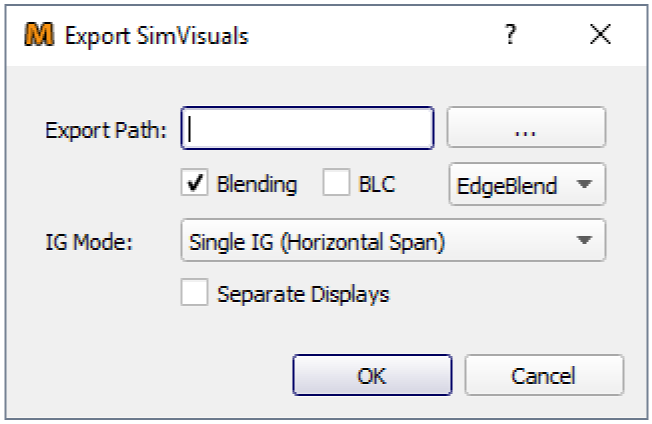
6.6 Warp Software

Name	2D	3D	DW	PM	Warp	Blend	BLC
Immersaview SimVisuals	X	X			X	X	X
domeprojection nWarp	X	X			X	X	
Scalable Desktop	X				X	X	
domeprojectionSDK		X	X	X	X	X	X
VIOSO VWF	X	X	X	X	X	X	X

6.6.1 Export Immersaview SimVisuals/Warp

Export for Immersaview's software warping solution.

Export Settings



Export Path:
folder where data will be exported to.

Blending:
enable/disable blending.

BLC:
enable/disable black level correction.

Blending Type:
Select type of blending encoding.

EdgeBlend:
simple edge blending for straight projection layouts. This has several limitations: Blending-edges should be straight. Use Extras → Layout Cutting Rectangles in Mapper2d, and avoid using pitch and roll for virtual cameras in Mapper3d. Cutting-rectangles and camera frusti should be completely inside the projection area, otherwise some of the edge-blend would be missing. Avoid using Fadeout and Clipping since this could create undesired artefacts.

BlendMap:
(recommended): flexible image based blending supporting full ProjectionTools blending capabilities for arbitrary projection layouts.

IG Mode:
how channels are distributed on image generators. One SimVisuals file will be generated for each IG.

Single IG:
(Horizontal Span): only one IG

Multiple IGs:
(One Projector Each): each IG is connected to exactly one projection channel.

Single IG (Grid Span):
The number and organization of displays on each ig can be defined.

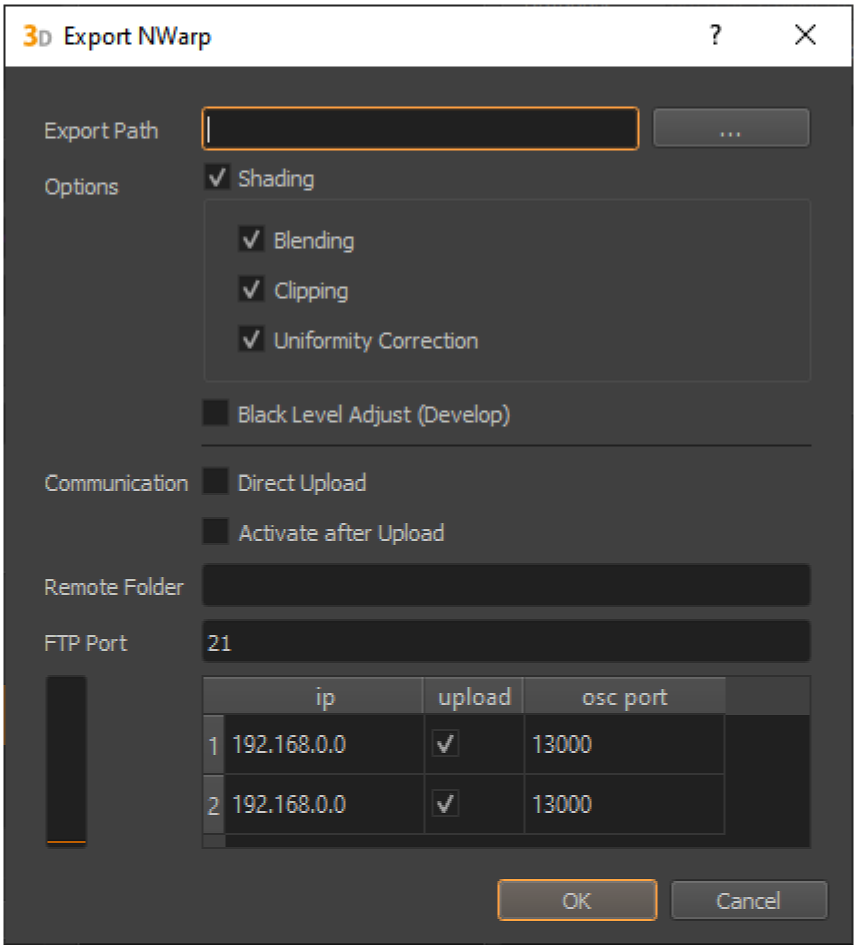
Separate Displays:
Select if displays are handled as separate displays in windows. Leave unchecked if they are combined using graphics drivers, such as a "Spanned Desktop", or Nvidia's "Mosaic" or "Surround" modes.

Workflow

1. Export data using SimVisuals exporter.
2. **Distribute data to all igs c:/ProgramData/ABAS Labs/SimVisuals**
   (importing data through SimVisuals web interface might skip blend maps.
3. Select correction data through SimVisuals web interface.
4. Enable desktop warping if needed.

6.6.2 Export NWarp

The nWarp exporter supports export and upload of warping and blending data to nWarp.



Export Settings

Export Path
The local folder to which all exported files will be exported.

Shading
Toggle export of shading files.

blending
Enable to add Blending information in exported shading file.

clipping
Enable to integrate Clipping information in exported shading file (clipping editor, clipping-image in project-settings)

uniformity
Enable to add Uniformity information in exported shading file.

Cutting only (night mode)
Disable blending in shading files, usually needed when optical blend masks are used.

Direct Upload
Enable direct upload of correction data to nWarp installations.

Activate after Upload
If active, the uploaded data will be applied immediately, otherwise only the data is uploaded to the client machines, for later activation.

Remote Folder
A folder relative to the ftp directory on the client machines. This allows export of multiple corrections to the nWarp clients between which can be switched later. This can be used for example to switch between day and night mode, or to export separate configurations for 2D and 3D. (Optional)

FTP Port
The network port, on which the ftp server is running on client machines. The default is 21, but it can be changed in nWarp and the nWarp exporter if this port is already used for another service.

Connection Table
Communication parameters for each channel

ip
Network address

upload
can be unchecked to exclude from direct upload

osc port
Network port for additional communication with nWarp. This port is used to activate the uploaded data.

Limitations

When used for 2D Mapping, cutting rectangles must be unrotated and well aligned with display layout for nWarp to warp desktop properly.

In order to generate compatible cutting use . There standard overlaps matching graphics driver settings or 100% overlap to disable cutting can be used.

6.6.3 Export ScalableDesktop

ScalableDesktop exporter supports export of warping and shading for one ScalableDesktop computer with multiple displays attached and organized in a regular grid.

Requirements

- All displays must have the same resolution.
- Displays must be ordered line wise in a regular grid.

Export Settings

Export Path
A folder where the exported files should be saved. The folder should exist.

Columns
Number of displays in a row. Native desktop-resolution is calculation based on this.

Rows
Number of rows. Native desktop-resolution is calculated based on this.

Warping
Enable to export "ScalableDataOrthographic.ol" which contains the geometric information.

Shading
Enable to export shading images "ProjectorAlphaMask-blend0.bmp" containing, blending, clipping and shading information.

Import to ScalableDesktop

1. Override the corresponding files in: `[ScalableDesktop-Programfolder]\DEI\SystemData\LocalCalibration`
2. Re-Engage the warping.

6.6.4 Export domeprojectionSDK

The domeprojectionSDK Exporter allows to export warping, shading and black level correction for use with domeprojectionSDK 4.0 or higher.

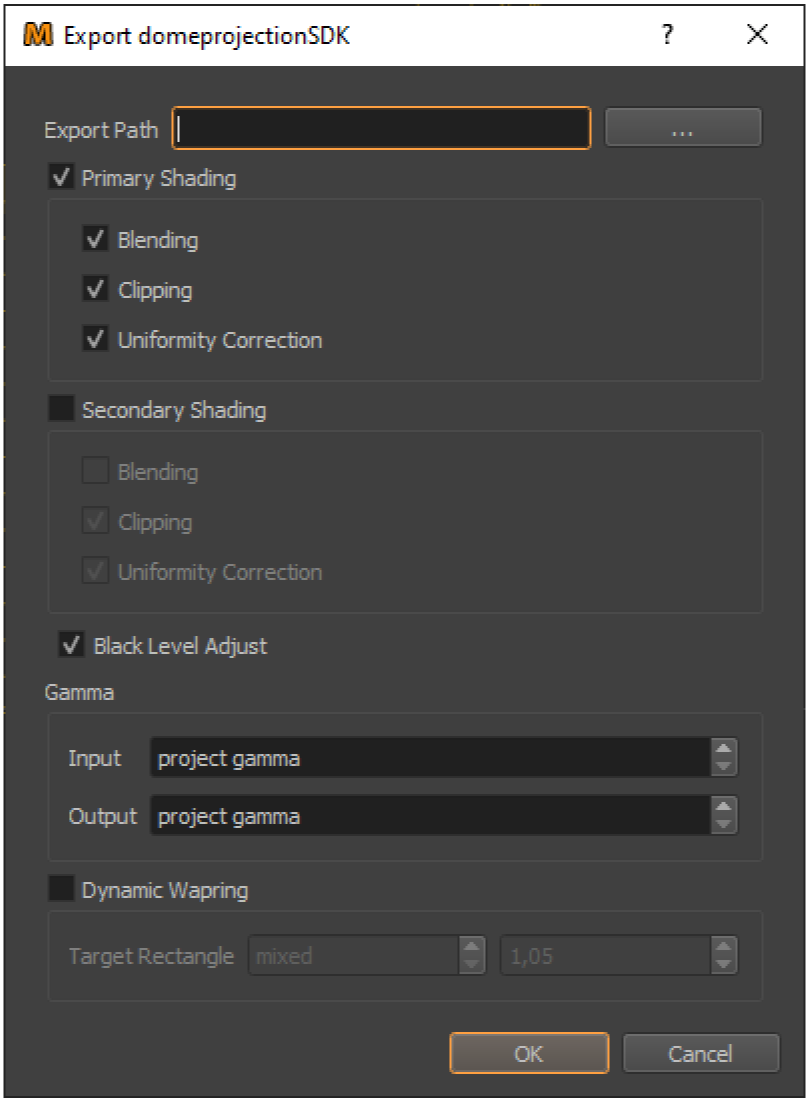
It supports export of two shading sets for later switch during runtime. One configuration is typically used for day scenes and the second one for night scenes where optical masks might be used.

Export Settings

Export Path
The folder to which all data files will be exported.

Primary Shading
Enable primary shading export including blending, clipping and uniformity.

blending
Enable to add Blending information in exported shading file.


Export domeprojectionSDK
Export Path
...
Primary Shading
Blending
Clipping
Uniformity Correction
Secondary Shading
Blending
Clipping
Uniformity Correction
Black Level Adjust
Gamma
Input
project gamma
Output
project gamma
Dynamic Wapring
Target Rectangle
mixed
1,05
OK
Cancel

clipping
Enable to integrate Clipping information in exported shading file (clipping editor, clipping-image in project-settings)

uniformity
Enable to add Uniformity information in exported shading file.

Secondary Shading
Enable secondary shading export including blending, clipping and uniformity.

blending
Enable to add Blending information in exported shading file.

clipping
Enable to integrate Clipping information in exported shading file (clipping editor, clipping-image in project-settings)

uniformity
Enable to add Uniformity information in exported shading file.

Black Level Correction
Enable black level correction output.

Gamma
Gamma settings

Input
The gamma value of the source image

Output
The gamma value of the resulting output image

Dynamic Warping
Allows to switch between static and dynamic warping.

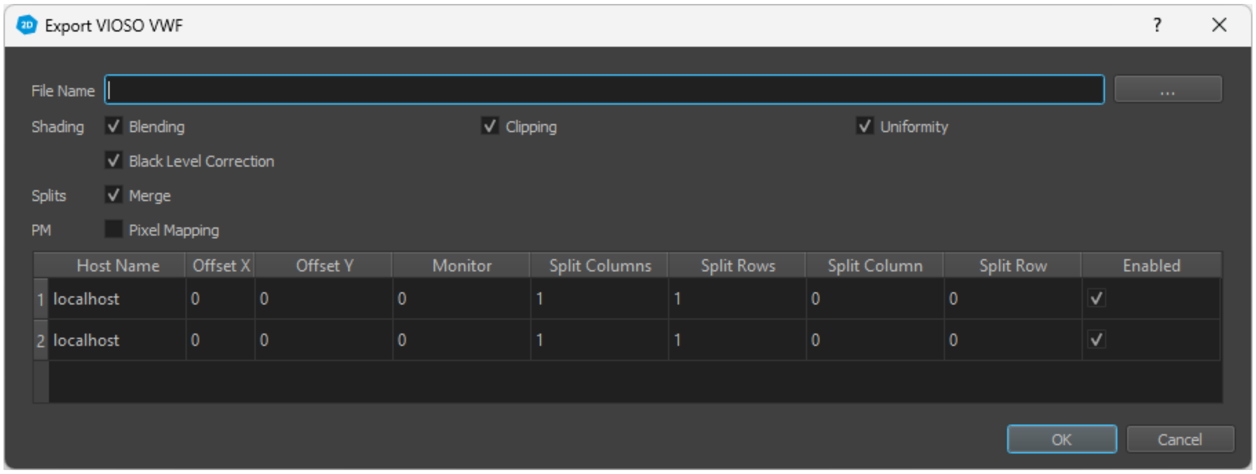
Target Rectangle:
Allows to adjust the conversion of current frustum settings into target Rectangles by setting a distance and scale value.

The distance is set to mixed by default, which means the target distances per projector from the frustum settings in the project are used.

The scale value is usually a bit larger than 1.0 to avoid content cut-off, when moving the eyepoint around in a dynamic viewpoint system.

6.6.5 Export VIOSO VWF

The VIOSO VWF exporter supports export of warping, blending and black level correction for VIOSO WarpBlend API.



Export Settings

File Name
The name and place of the created VWF file.

Shading
Toggle shading features.

Blending
Enable to add Blending information in exported shading file.

Clipping
Enable to integrate Clipping information in exported shading file (clipping editor, clipping-image in project-settings)

Uniformity
Enable to add Uniformity information in exported shading file.

Black Level Correction
Enable to add Black Level Correction information in exported shading file.

Splits

Merge
Enable to merge multiple channels in to one correction map. Used for displays transparently split for multiple projectors, e.g. in Nvidia Mosaic mode.

PM

Pixel Mapping
Convert projection mapping data to 2d pixel mapping data. This allows 2d media players to play back uv-mapped content directly.

Channel Table
Split parameters for each channel.

Host Name
Network address of the pc, correction data should be used on.

Offset X/Y
Offset of the channel on the desktop.

Monitor
Monitor/display number of the channel. Keep the same non-zero monitor number for splits that should be

merged, use distinct numbers otherwise.

Split Columns/rows
Number of splits in x/y direction, that should be merged.

Split Column/row
Index of the split the channel should be assigned to.

Enabled
Can be unchecked to exclude from export.

6.7 Warp Hardware

Name	2D	3D	Warp	Blend	BLC
3D Perception nBox	X	X	X	X	
Barco WB	X	X	X	X	X
Barco Sim7	X	X	X	X	X
Barco Pulse	X	X	X	X	X
Barco HDX	X	X	X	limited	
Calibre / DP	X	X	X	X	X
Christie Twist	X	X	X	limited	
Domeprojection Luna	X	X	X	X	X
Westar Warper4k	X	X	X	X	
Zeiss Velvet	X	X		X	
Norxe Unify	X	X	X	X	
Digital Projection Nexus	X	X	X	limited	

6.7.1 Export 3D-Perception

The 3D-Perception exporter supports export of warping and blending for 3D-Perception warp units.

It supports nBox and the older discontinued UTM warp units.

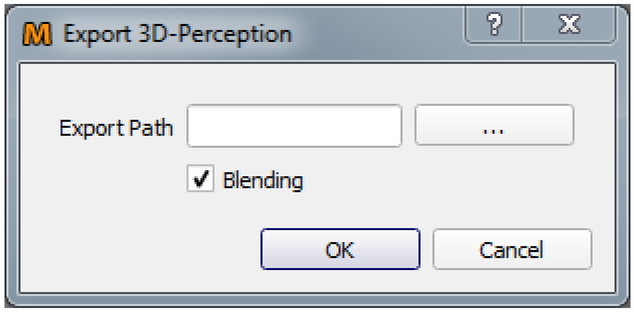
It supports 3D engine setups as well as 2D MegaWall setups.

Limitations

3D-Perception nBox/UTM supports warping and blending, but be aware that the nBox/UTM reduces the blending information roughly to a quarter of the projector resolution. So, sharp edged clippings or fadouts defined in the ProjectionTools will produce jagged edges in the projection.

The UTM has less color precision, which leads to blending artefacts in dark areas and the edge of blend zones.

Export Settings



Export Path
An existing folder where the warping and blending data will be stored by the exporter.

Blending
Activate, to export blending information.

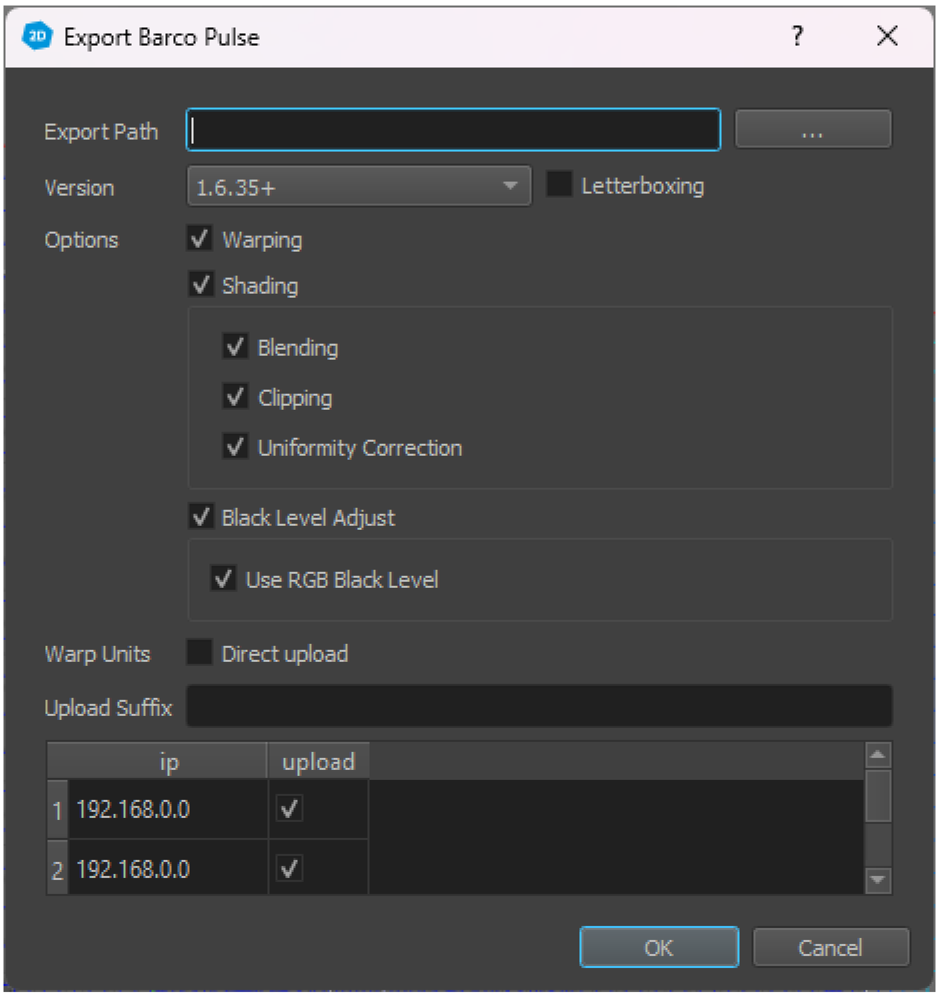
Usage

The exported data is meant to be imported in 3D Perception nControl to be applied on all channels.

1. Prepare nBox processors in 3D-Perception nControl for data import
   1. add Geometry Adjustement to nBox processor
   2. add Blend Map Adjustment to nBox processors
2. Export data using 3D-Perception exporter
3. Load and setup geometry correction for each nBox processor
   1.
   2. select corresponding `warpmap3DP\_*.csv`
   3.
   4. settings 0,0 to 1,1
4. Load blending data for each nBox processor
   1.
   2. select corresponding `blending\_*.png`

6.7.2 Export Barco Pulse

The Barco Pulse exporter supports export of warping, blending and black-level adjustment for Barco Pulse platform projectors, such as the F70 and F90.


Export Barco Pulse
Export Path
...
Version
1.6.35+
Letterboxing
Options
Warping
Shading
Blending
Clipping
Uniformity Correction
Black Level Adjust
Use RGB Black Level
Warp Units
Direct upload
Upload Suffix
ip
upload
1 192.168.0.0
2 192.168.0.0
OK
Cancel

Export Settings

Export Path:
Before the warping, blending or black level correction data can be uploaded it has to be saved locally to the computer. The export folder must exist before exporting. All data necessary for the upload will be saved there.

Version:
Select the Barco Pulse firmware version to export for.

Warping:
Enable "Warping" to export warping information to an XML file, "Warping.xml".

Shading:
The shading information is exported to an image file, "alpha.png".

blending
Enable to add Blending information in exported shading file.

clipping
Enable to integrate Clipping information in exported shading file (clipping editor, clipping-image in project-settings)

uniformity
Enable to add Uniformity information in exported shading file.

Black Level Adjust:
The black level adjustment information is exported to another image file, "beta.png".

Use RGB Black Level
Send Black Level Color tweaking information to the projector in form of an additional RGB value.

Letterboxing:
Activate if the projector is setup to use letterboxing for input-signals not matching the projectors' native aspect ratio.

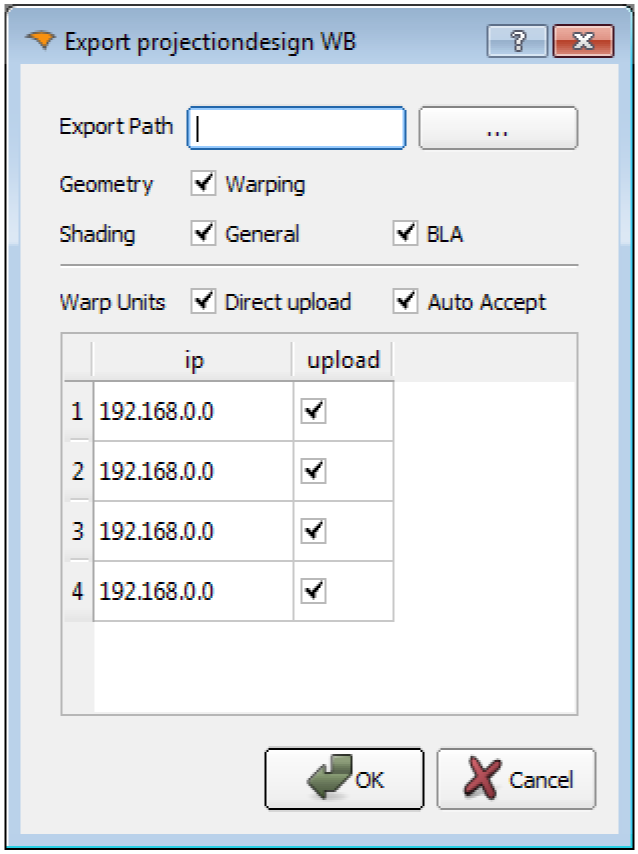
Direct upload:
enable to upload the new warping and blending directly to the projector.

Upload Suffix:
If a value is provided it will be appended to the name of each file in the exported data set, preceded by an underscore. For example a value entered of "pilot" will change the name of the file containing the warping data to "Warping_pilot.xml". This is useful if you would like to have multiple correction data sets stored on the projectors for different scenarios.

Table with ip-addresses:
Enter the ip address of each projector so that export can be directly uploaded. If a projector is unchecked it will be excluded from the direct upload.

6.7.3 Export Projectiondesign WB

The Projectiondesign WB exporter supports export of warping, blending and black-level adjust for the formerly Projectiondesign, now Barco WB units.



Export Settings

Export Path:
A folder where the exported files should be saved as a projectiondesign WB backup. The folder should exist. Subfolders for each projectiondesign WB are generated with contents compatible to proNET.site backup format.

Geometry:
Enable "Warping" to export warping information.

Shading:
All shading is combined in one file, the "shading.cct". Enable "General" to include blending, ramps and clipping (multiplicative color correction), otherwise full white is exported. Enable "BLA" to export Black Level Adjustment.

Direct upload:
enable to upload the new warping and blending directly to the projectiondesign WB

Auto Accept:
enable to store the directly uploaded warping and blending as default configuration

Table with ip-addresses:
Enter the ip address of each projectiondesign WB, so that export can be directly uploaded. If a warp unit is unchecked it will be excluded from the direct upload.

Upload backup-folders to projectiondesign WB

The exporter creates folders for each WB, that can be uploaded to WB using ProNet.Site's WB calibrator.

Important: The Mesh resolution should be 17x17 at maximum, for uploading the warping using pro.Net software and maybe editing the warping manually.

Steps:

1. Start ProNet.Site
2. open Control Panels ->Predefined -> WB calibrator
3. drag used WB's from Device Pool to Device View
4. select one WB in Device View
5. **open File -> Restore Complete Calibration Setup .. , select**
   corresponding export folder and click "Start"
6. **when the upload process has finished, the restore dialog can be**
   closed by pressing "Done"
7. in order to see the result, press "Online (Ctrl+O)"-button

Limitations

Projectiondesign WB can not rotate by 90 degrees using warping. You will get an error "Propably Foldover" during upload when your warping contains large amount of rotation.

Projectiondesign WB is limited in the mesh resulution, that can be uploaded. This is no big problem, since the WB does spline interpolation instead of linear interpolation, which results in higher quality with less denser meshes. The exporter limits the mesh resolution to 32x32 vertices and ignores higher mesh resolution settings in the project. For projectiondesign WB with firmware prior to mips-system-008.0001.06.14.tgz a mesh resolution with maximum of 13x13 should be used.

6.7.4 Export Barco Sim7

The Barco exporter supports export of warping, blending and black-level adjust for Barco sim7 projectors (and units which are using the sim7 platform, like MCM-50 and MCM-400).

Export Settings

Export Path:
Before the warping, blending or black level adjust data can be uploaded it has to be saved locally at the computer. The export folder should exist. All data necessary for the upload will be saved there.

Warping:
Enable "Warping" to export warping information.

Shading:
The shading information is exported to a image file, the "alpha.tiff".

BLA:
The black level adjustment informations is exported to another image file, the "beta.tiff".

Direct upload:
enable to upload the new warping and blending directly to the Barco projector

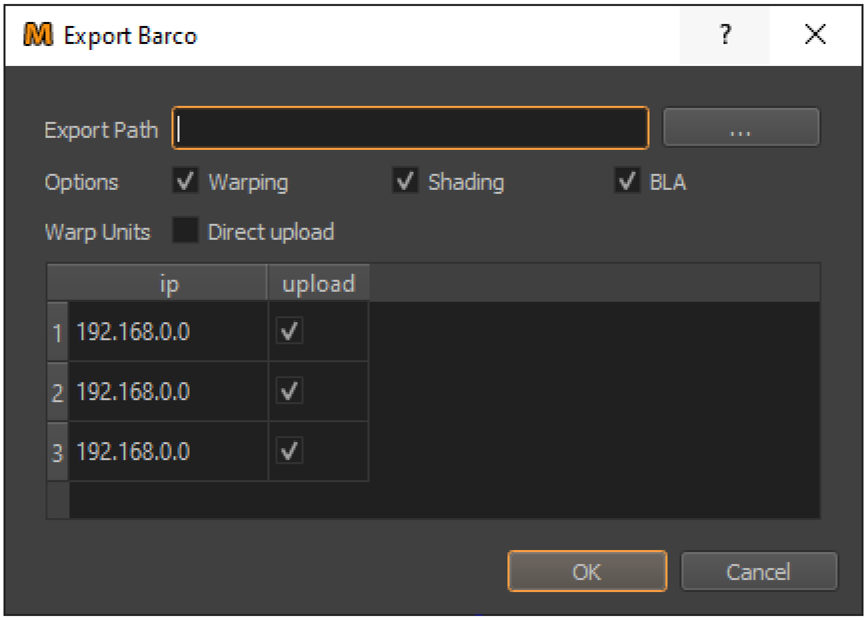
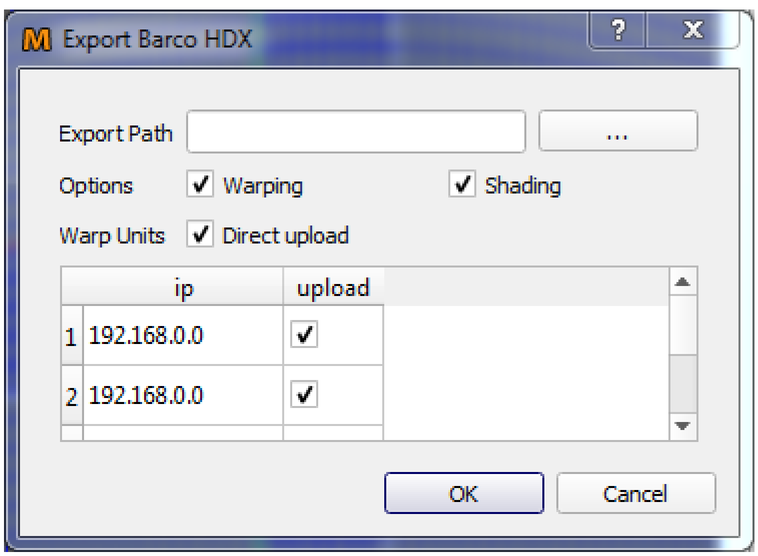


Table with ip-addresses:

Enter the ip address of each projector, so that export can be directly uploaded. If a projector is unchecked it will be excluded from the direct upload.

6.7.5 Export Barco HDX



The Barco HDX exporter supports export of warping and simple edge blending for Barco HDX/HDF and HDQ projectors.

Export Settings

Export Path:
Before the warping, blending or black level adjust data can be uploaded it has to be saved locally at the computer. The export folder should exist. All data necessary for the upload will be saved there.

Warping:
Enable "Warping" to export warping information.

Shading:
The edge blend information is send directly to the projector (only available, when Direct Upload is enabled).

Direct upload:
enable to upload the new warping and blending directly to the Barco projector

Table with ip-addresses:
Enter the ip address of each projector, so that export can be directly uploaded. If a projector is unchecked it will be excluded from the direct upload.

Limitations

Barco HDX supports only simple edge blends (defined width warped along with content).

In order to get a reasonable blending result, content should have straight overlaps and should not be warped beyond projector edges.

In a Mapper2d project keep cutting rectangles unrotated and straight. can be used to create such cutting in a fast way.

In a Mapper3d project keep virtual cameras pitch and roll at zero.

6.7.6 Export Calibre

The calibre exporter supports export of warping, blending and black-level adjust.

Export Settings

Export Path
Before the warping, blending or black level adjust data can be uploaded it has to be saved locally at the computer. The export folder should exist. All data necessary for the upload will be saved there.

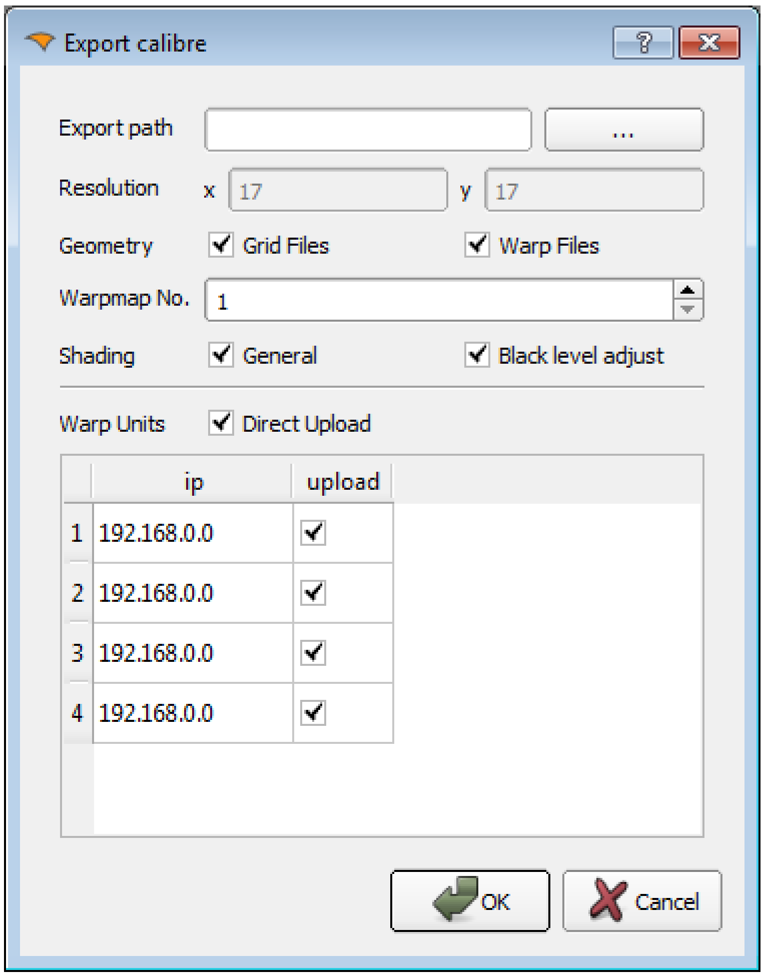
Resolution
The resolution fields are fixed to 17x17. This is due internal regulations of the calibre units. The field is still shown for reference and to support future changes.

Geometry
Enable "Grid Files" to export the warping information for usage with the calibre Warp Generator tool. This files may be edited through this tool and uploaded from there. Note: this files are not exported directly to the units. Enable "Warp Files" to export the warping information for direct upload. This files can't be edited manually.

Shading
Enable "General" to export the blending data. Enable "Black level adjust" to export the black level adjust data.

Direct upload
enable to upload the new warping and blending directly to the calibre units.

Table with ip-addresses
Enter the ip address of each calibre unit, so that export can be directly uploaded. If a unit is unchecked it will be excluded from the direct upload.

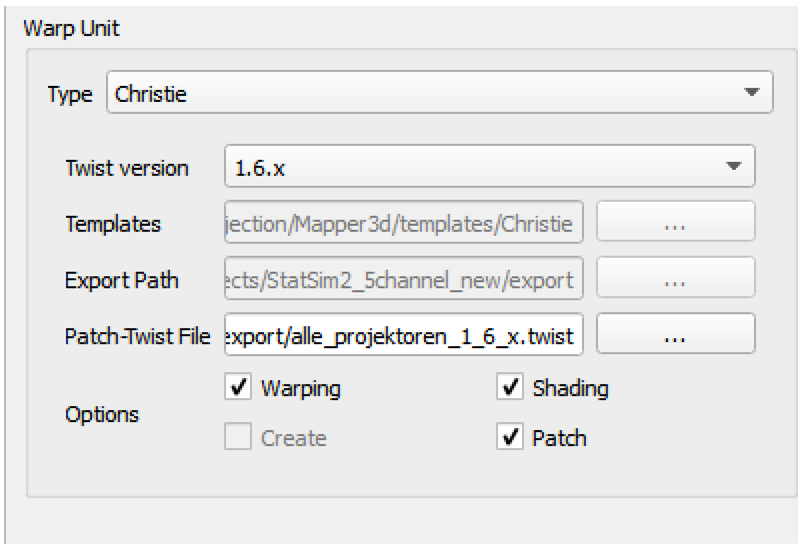

Export calibre
Export path
...
Resolution
x
17
y
17
Geometry
Grid Files
Warp Files
Warpmap No.
1
Shading
General
Black level adjust
Warp Units
Direct Upload
ip
upload
1 192.168.0.0
2 192.168.0.0
3 192.168.0.0
4 192.168.0.0
OK
Cancel

6.7.7 Export Christie

Exports data for Christie projectors. The supported features depend on the Twist version used. Currently we support Twist 1.5.x and Twist 1.6.x. The files for those versions are not compatible and can't be converted directly. Please be aware that you usually need Twist Pro. The grid size will be limited to 10x10 otherwise and the program will refuse to load the files. The 1.6.x blending feature will be without effect if no Pro version is used.

The suggested workflow is using the 1.6.x version of Twist Pro (update if necessary) to create a new file. The projectors have to be visible on the network for this task (projector MAC-adresses are used for identification internally). Ensure that the projector names match between Twist and Mapper3d. You can rename them in both programs. Save this file and select it for "Patch-Twist File", activate Warping, Shading, Patch and run the export process. Reopen this resulting *.twist file and upload the data to the projectors.

Export Settings



Twist version
Choose the matching Twist version. The settings will differ in its effects.

Templates
Path where Exporter should look for "footer.xml" to append to exported .twist file. An example footer.xml is placed in Mapper Installation subfolder "templates/christie". No changes are usually needed for a default installation (1.5.x only).

Export Path
Path where Exporter should store exported *.twist files (1.5.x only). Patch-Twist File: select an already existing *.twist file to be patched. Only warping/shading information is replaced.

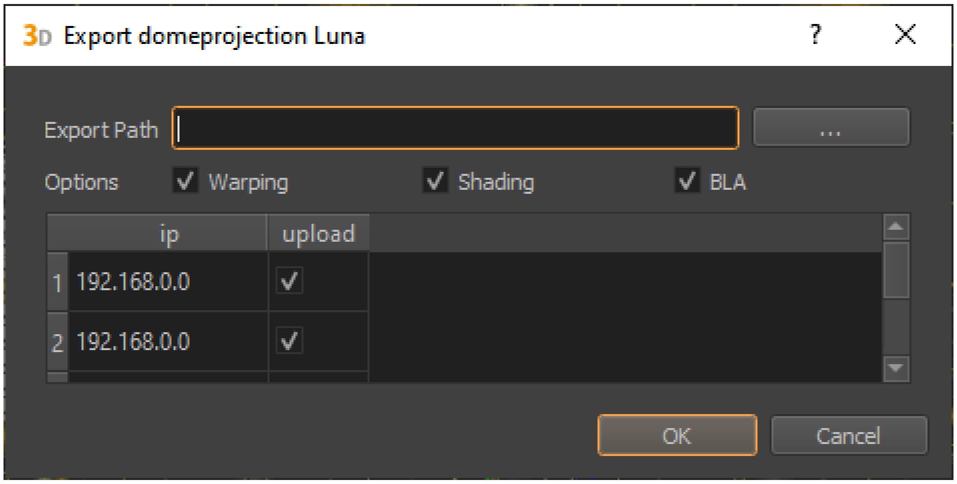
Warping
Export/patch the warping information.

Shading
Patch the shading information for spherical blend (1.6.x only).

Create
Create a new *.twist file (1.5.x only).

Patch
Modify an already existing *.twist file.

6.7.8 Export Domeprojection Luna



The Domeprojection Luna exporter supports export of warping, blending and black-level correction for domeprojection Luna warpbox.

Export Settings

Export Path
Before the warping, blending or black level adjust data can be uploaded it has to be saved locally to the computer. The export folder should exist. All data necessary for the upload will be saved there.

Warping
Enable "Warping" to export warping information.

Shading
Enable "Shading" to export blending and uniformity correction data.

BLA
Enable "BLA" to export black-level correction data.

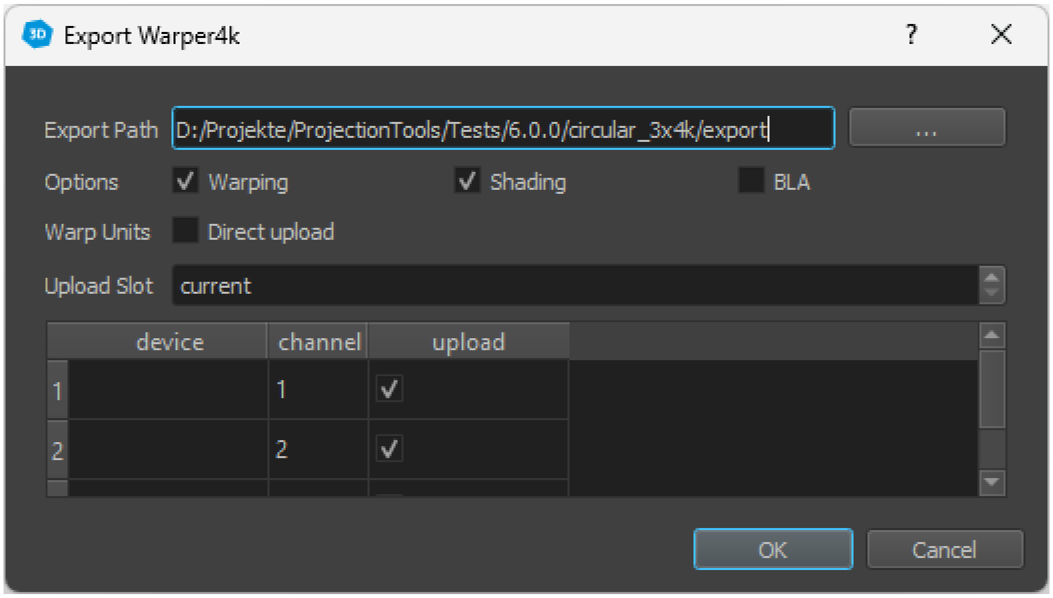
IP
Enter the ip address of each projector, so that export can be directly uploaded. If a projector is unchecked it will be excluded from the direct upload.

Upload
enable to include corresponding warpbox for direct upload.

6.7.9 Export Westar Warper4k

The Warper4k exporter supports export of warping, blending and Black-Level correction for westar Warper4k warp units.

Minimum Firmware Version: 10.2



Export Settings

Export Path
Before the correction data can be uploaded it has to be saved locally to the computer. The export folder should exist. All data necessary for the upload will be saved there.

Warping
Enable "Warping" to export warping information.

Shading
Enable "Shading" to export blending and uniformity correction data.

BLA
Enable "BLA" to export black-level correction data.

Direct upload
Enable to upload the new warping and blending directly to the warp unit.

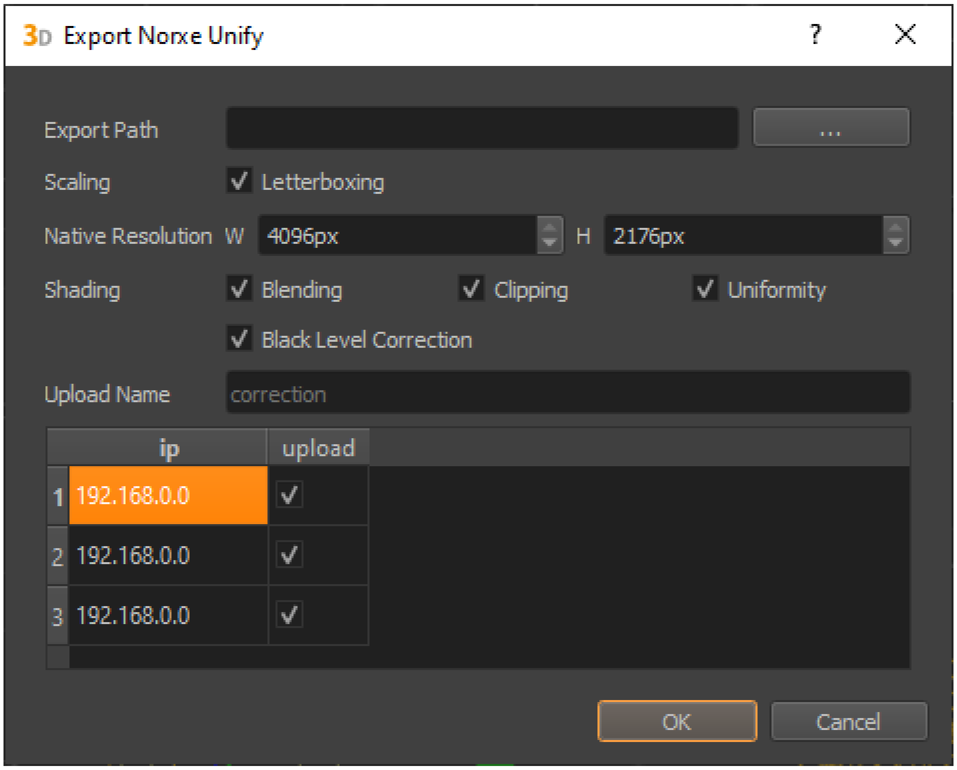
Upload Slot
Warper4k allows to store multiple corrections on one channel. Select the slot, to store the correction data on. This can be used for later switching on the warp unit.

Device
Enter the device name of each warpbox. When empty, the first warpbox found will be used. The correct names can be retrieved using the manufacturer software Wink or Mesh4k. A unique part of the full name is sufficient for matching.

Channel
Number of channel in warp unit (each warpbox can have up to 5 channel, starts with 1).

Upload
If a warp unit is unchecked it will be excluded from the direct upload.

6.7.10 Export Norxe Unify



The Norxe Unify exporter supports export and upload of warping, blending and black level correction for Norxe Unify projectors.

- Requires Firmware 1.3 or newer.
- Black Level Correction not yet tested.

Export Settings

Export Path
Before the correction data can be uploaded it has to be saved locally to the computer. The export folder should exist. All data necessary for the upload will be saved there.

Scaling
Select how non-native content is scaled. Activate letterboxing, when "Fill Aspect" is used on projector

Native Resolution
Set the native projector chip width and hight here (depends on projector type). This is important to do the correct scaling of the exports.

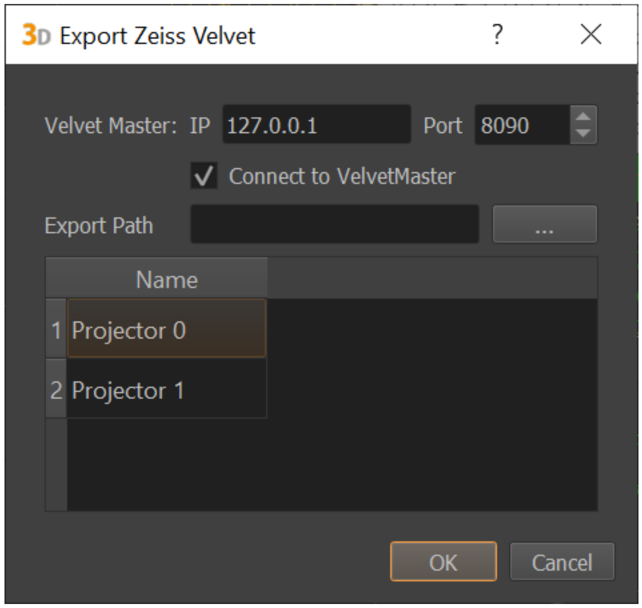
Shading
Select which layers should be included in the exported shading file.

Black Level Correction
Select if black level correction should be exported as well.

Upload Name
Allows to use custom names for the uploaded correction file. Thus multiple corrections can be stored on the projector for different scenarios.

Table with IP-addresses
Enter the ip address of each projector, so that export can be directly uploaded. If a projector is unchecked it will be excluded from the direct upload.

6.7.11 Export Zeiss VELVET



The Zeiss VELVET exporter supports blending for Zeiss VELVET projectors. Communication with the projectors is handled by the VELVET Master program.

Export Settings

VELVETMaster:
Settings for communication with the VELVET Master program

IP
IP-Address of computer running the VELVET Master program

Port
VELVET Master communication port (default 8090)

Connect
The exporter will connect to the VELVET master program if activated. Deactivate for simulation purposes.

Export Path:
Before the blending correction data can be uploaded it has to be saved locally to the computer. The export folder must exist before exporting. All data necessary for the upload will be saved there.

Table with Names:
Enter the Projector names. These names must be the same as used inside VELVET master for a given projector.

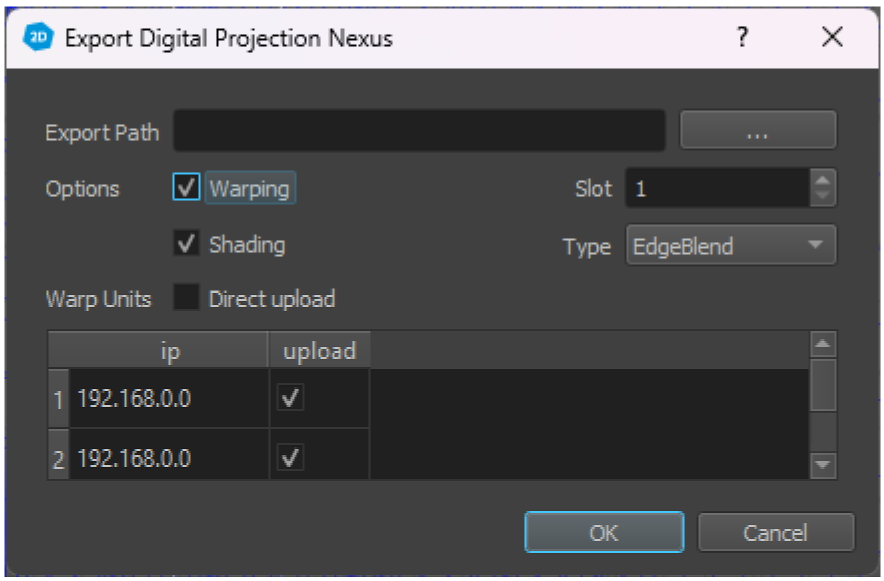
VELVET Master

Currently all program versions are supported. The program must be running when using the exporter. Please refer for more details to the VELVET Master documentation.

6.7.12 Export Digital Projection Nexus

Exports data for Digital Projection projectors with Nexus hardware. Tested on E-Vision 10000i WU.

Export Settings



Export Path
Path where Exporter should store exported *.dbf and *.dct files.

Warping
Export the warping/distortion information.

Upload Slot
Select the slot to upload the warping data to.

Shading
Export the shading information.

Type
Either as simple *Edge Blend* or image based *Blend Map*.

Direct Upload
Enable to upload correction data directly to projectors.

Channel List

ip
IP address of the projector.

upload
Activate upload for this projector.

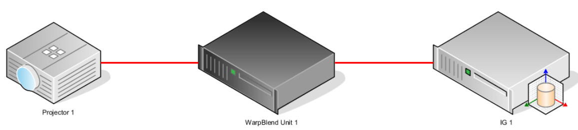
CHAPTER SEVEN

ULTRA HIGH DEFINITION PROJECTORS

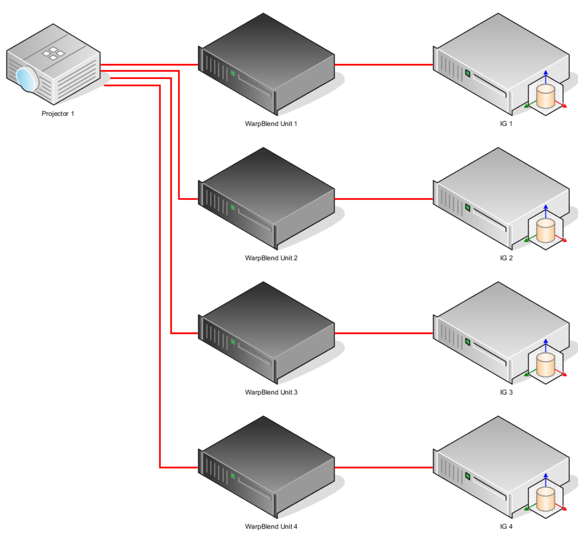
Ultra high definition projectors are usually fed by multiple input signals defining sub-tiles of the projector. These signals might even be generated by multiple computers or warped independently. This makes it impossible to handle these projectors as one single standard channel.

ProjectionTools support several solutions for this situation depending on the use-case.

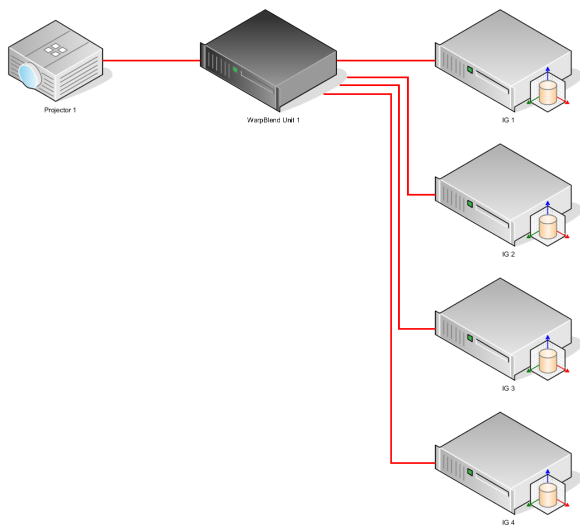
1. Projector is fed by one computer and only one warping/blending set is needed. Use a **normal channel** with corresponding high resolution.



2. Projector is fed by one or multiple computers, with one **warping/blending set per sub-channel** needed. Use **Touching Channels** (see section *Touching Channels*).



3. Projector is fed by multiple computers, with only **one warping/blending set for the whole projector** needed. Use **Sliced Channels** (see section *Sliced Channels*).



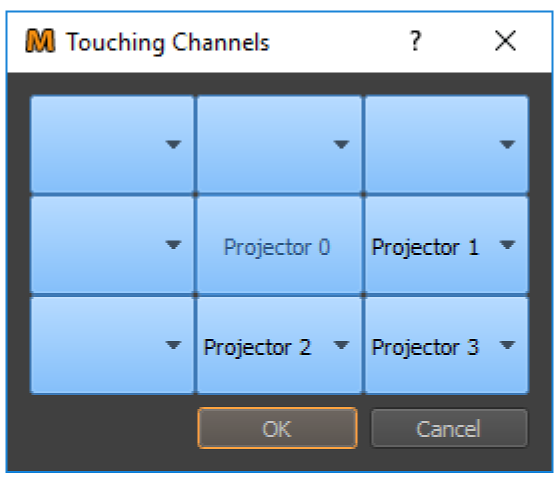
7.1 Touching Channels

Subdividing a projector into multiple calibration channels in order to get multiple warp/blend sets is sometimes needed for high resolution or extreme wide-angle projectors. Handling all subchannels as normal channels would lead to a valid calibration result, but there might be some artifacts left:

1. Noticable discrepancies of warping at the hard edges between adjacent tiles, since measured data is not available at the edge of each tile
2. Blending artifacts (narrow dark stripes) between adjacent tiles

The definition of touching channels, removes these artifacts by:

1. Geometry information of touching channels is used to create a consistent warping at tile borders
2. Blending calculations are disabled between touching channels.



In the Touching Channels editor the neighboring channels can be selected. Each channel can have up to eight neighbors.

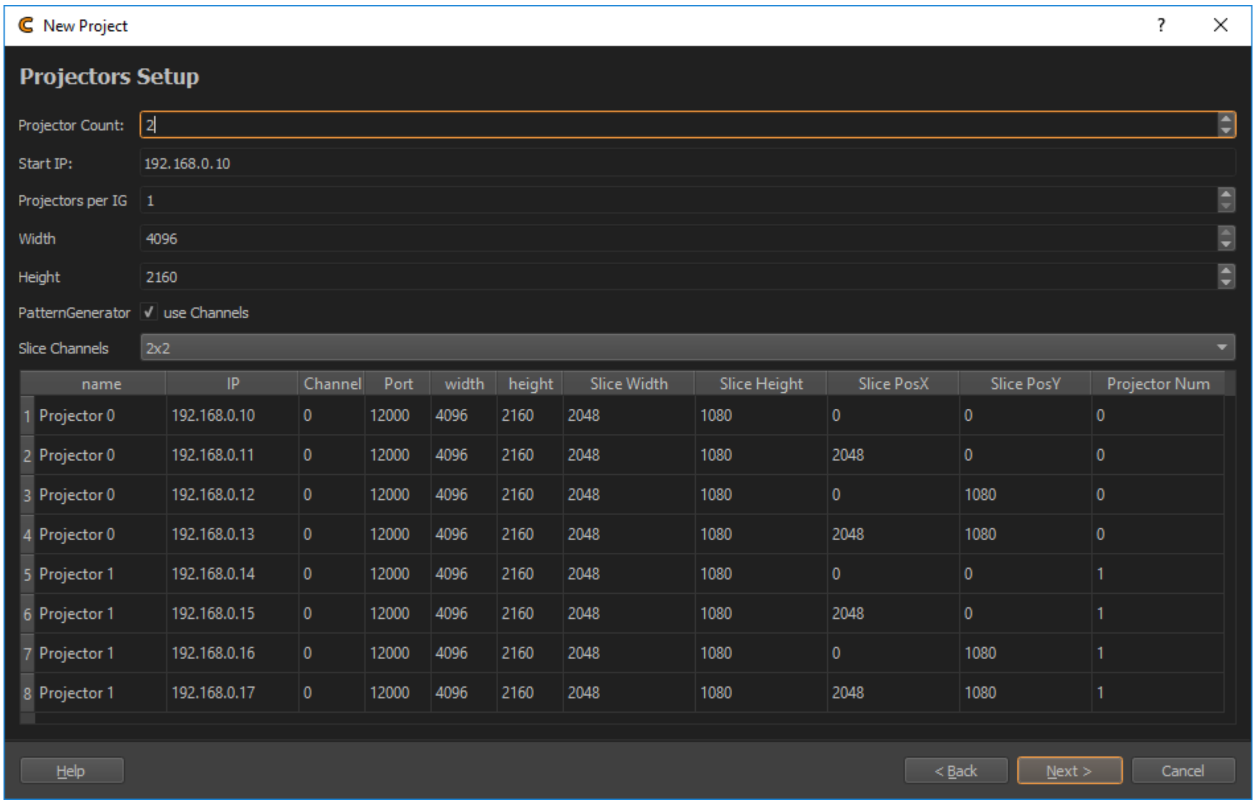
The project settings allow to adjust a "Touch Margin" value as well. It has a default value of 0.2 and defines how much data of the touching channels is taken into account during geometry calculation. While taken zero information of touching channels into account leads to warping discontinuities at the tile edges, using too much data of touching channels might lead to problems with polynomial definition of warping (The overall warping of the complete projector might be too complex to be encoded in one polynomial warping description).

7.2 Sliced Channels

When a projector is fed by multiple computers, with only one warping/blending set for the whole projector needed, the projector must be regarded as one channel with multiple PatternGenerator instances for showing test patterns.

With Sliced Channels multiple PatternGenerators are assigned to each channel.

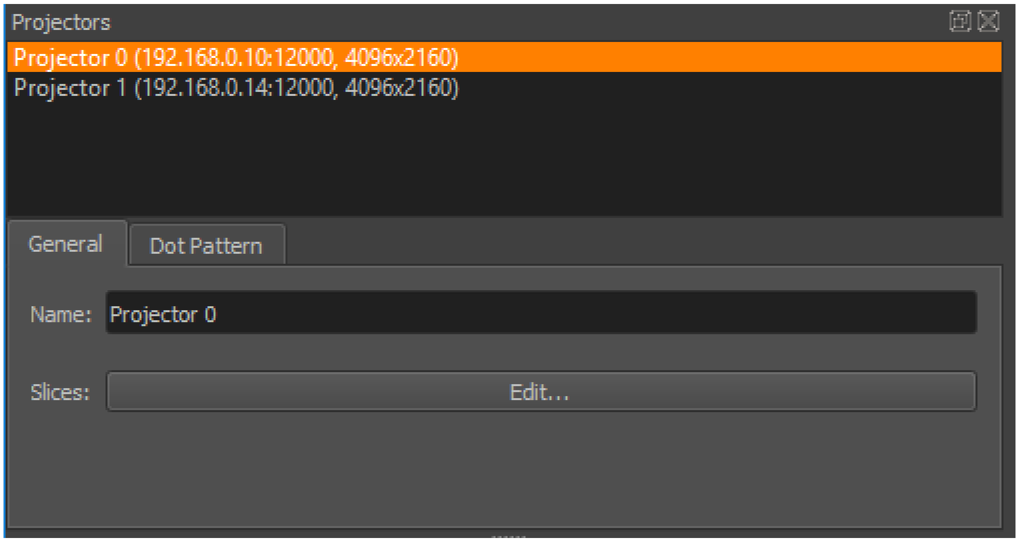
This can be activated when generating a new project in Creator.

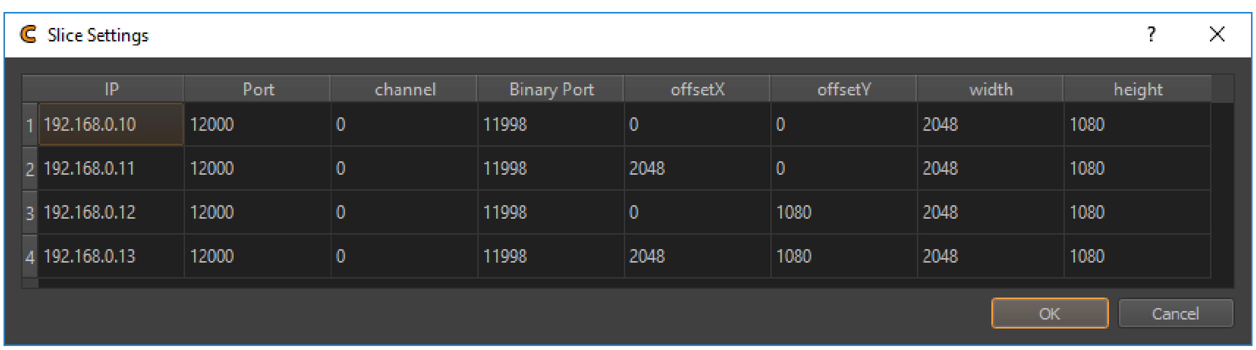


Activate "Slice Channels" with the required layout (1x2, 2x1 or 2x2). The channel list is generated accordingly. The generated list can be manually adjusted to change for example the ip-address of the individual sub-channels.

In the generated project, each projector is seen as one whole channel.

Opening the slice editor, shows the connections to the sub-channel PatternGenerators and their individual resolutions.


Projectors
Projector 0 (192.168.0.10:12000, 4096x2160)
Projector 1 (192.168.0.14:12000, 4096x2160)
General
Dot Pattern
Name:
Projector 0
Slices:
Edit...


Slice Settings
IP
Port
channel
Binary Port
offsetX
offsetY
width
height
1 192.168.0.10 12000 0 11998 0 0 2048 1080
2 192.168.0.11 12000 0 11998 2048 0 2048 1080
3 192.168.0.12 12000 0 11998 0 1080 2048 1080
4 192.168.0.13 12000 0 11998 2048 1080 2048 1080
OK
Cancel

CHAPTER

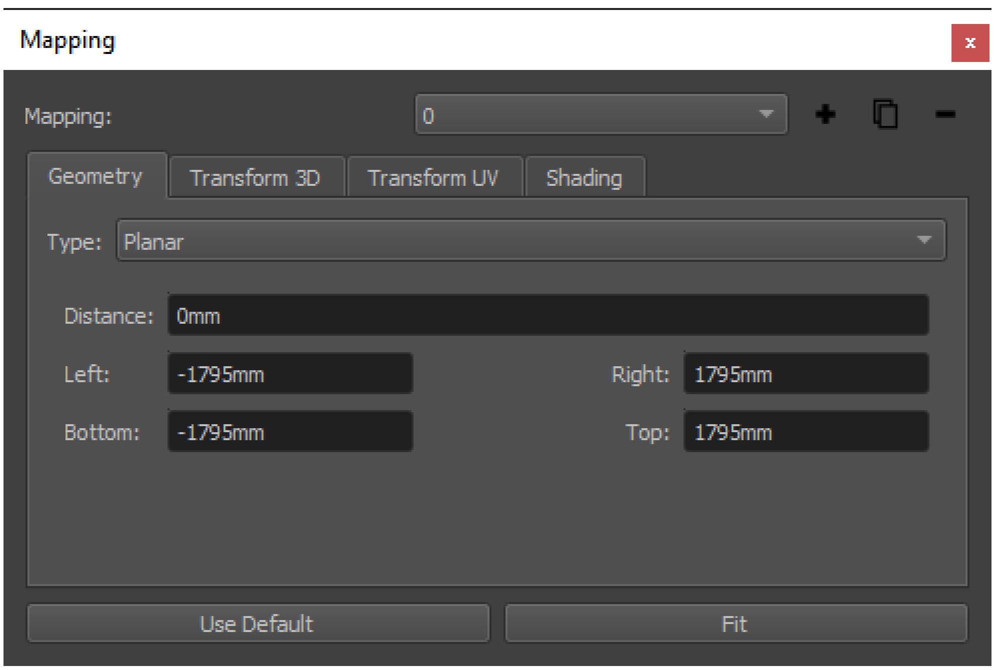
EIGHT

MAPPING

The mapping projects the curved projection screen into 2d, it maps a 2D coordinate to any 3D coordinate on the screen. The 2D mapping of the projection, is used to define clipping and fadeout in 2d and for calculating the blending between projection channels.

By default, a mapping similar to the screen shape defined during project setup is used, but it can be fully customized and significantly differ from designed screen shape.

The Mapping dock allows to select and setup a mapping that best fits the screen and suits the content that should be shown.



Mapping:

Selection:
If multiple mappings are defined in the project, select the current mapping for editing.

Add Mapping:
Add a new mapping to the project.

Duplicate Mapping:
Duplicate the currently selected mapping.

Remove Mapping:
Remove the currently selected mapping. This is only possible when more than one mapping are present in the project.

Geometry:
General mapping settings

Type:
Select between standard mapping and reference mapping types.

Type related Settings:
Settings for currently selected mapping type.

Transform3D:
Place mapping in 3D-Space.

Transform UV:
Transform resulting uv-coordinates (texture coordinates).

Shading:
The shading-tab of the mapping-settings dialog allows to set several global parameters that influence blending calculations. (see section *Shading* for details)

Use Default:
The Use Default button selects a mapping type and transform matching the screen settings that where defined during the calibration in Creator.

Fit:
Fit the currently selected mapping to available calibration data by adjusting its parameters and Transform 3D.

8.1 Mapping Types

Several standard mapping types are supported plus one general mapping mode, that allows to import custom mappings.

Standard Types:
Standard mapping types are fast to setup and quite flexible to adjust in size, aspect-ratio and also their bounds.

Perspective:
typically used to project imagery that is rendered using perspective virtual cameras. This produces perspective correct projections on curved screens for a designed eyepoint.

Planar:
typically used for planar screens

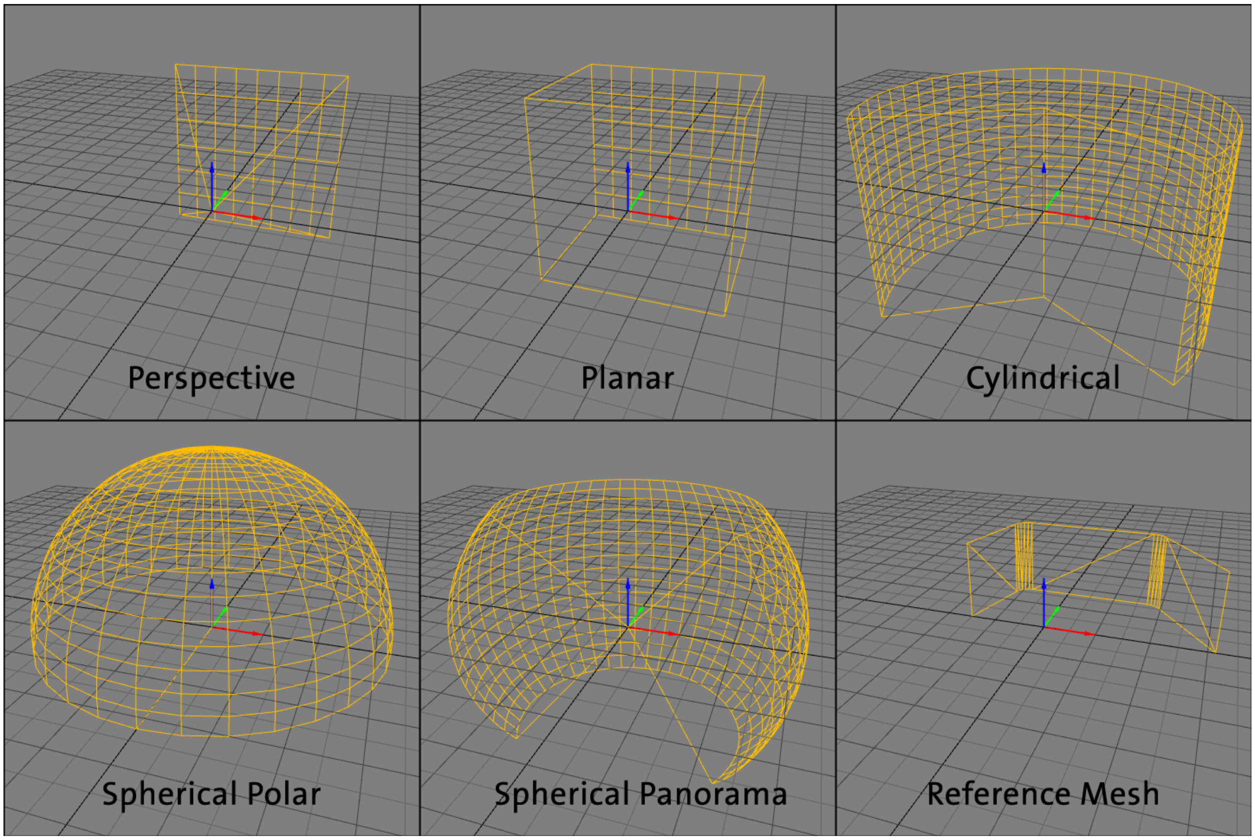
Cylindrical:
typically used for cylindrical screens

Spherical Polar:
typically used to project domemaster files/ polar images on domes

Spherical Panorama:
typical used to project panoramas on a sphere segment

Torus:
Used for curved screens with two different radii in horizontal and vertical direction.

Reference Mesh:
For very special screen shapes and projection layouts a standard mapping does not suffice. In these cases it is possible to define the mapping in an external 3D Modelling software, and import the mapping information in the form of a uv-mapped reference model.



The mapping type reference mesh allows to import such 3d geometry from external files (e.g. obj, stl, ply, 3ds). The reference model should contain only one mesh with a continuous uv-mapping. It is recommended, that the reference mesh is larger than the used screen, to ensure that mapping is defined for the whole projection area.

Import:
Allows to import a mesh from external files (e.g. obj, stl, ply, 3ds). Coordinate transformations can be adjusted in a dialog during import.

Export:
Allows to export the current mesh as obj file. Coordinate transformations can be adjusted in a dialog during export.

Trace Mode:
Defines how 3d coordinates of measured projectors should be projected on the reference mesh to lookup uv-coordinates.

Mesh Info:
Showing complexity and available data of current mesh.

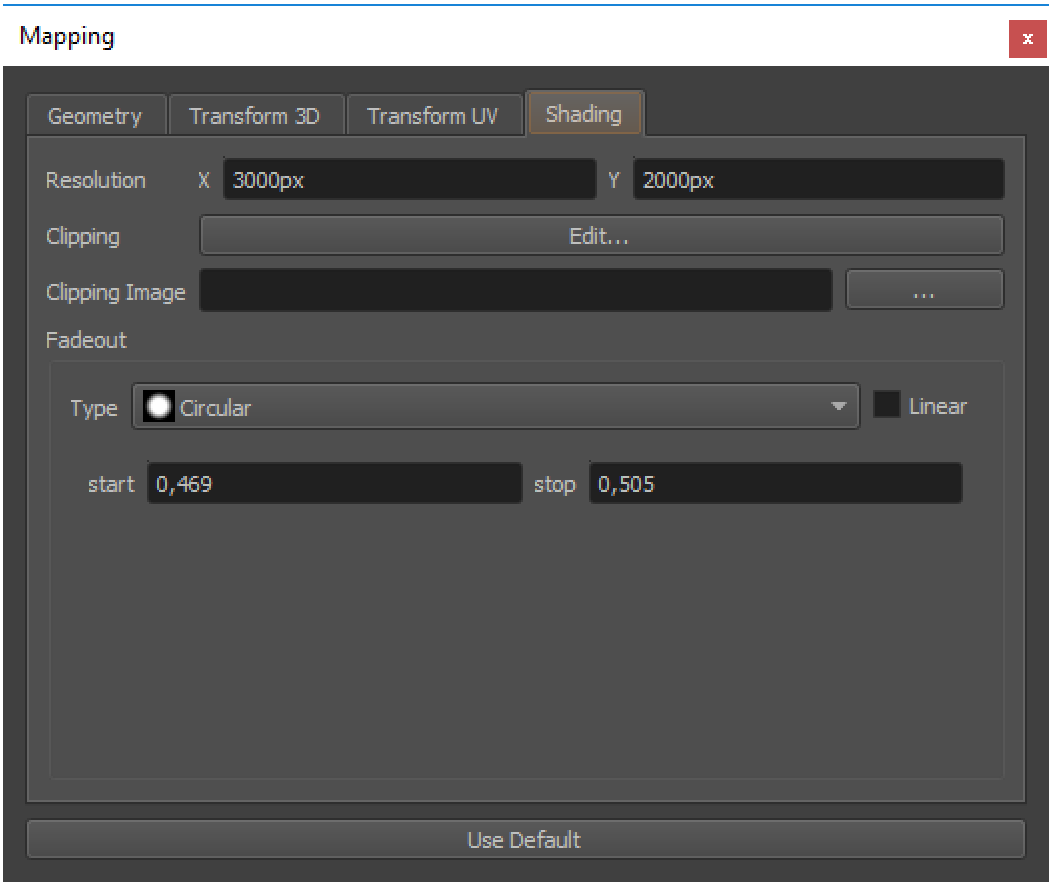
Generate UVs:
Generate simple planar uv-coordinates along one selectable projection axis.

Generate Normals:
Generate vertex normals by interpolating adjacent triangle normals.

Flip Faces:
Negates normals and flips triangles to point in opposite direction.

8.2 Shading

The shading-tab of the mapping-settings dialog allows to set several parameters that influence shading calculations.



Resolution X/Y:
Image width and height in pixels used for export blending source (unwarped). Also used for rastering of clipping data.

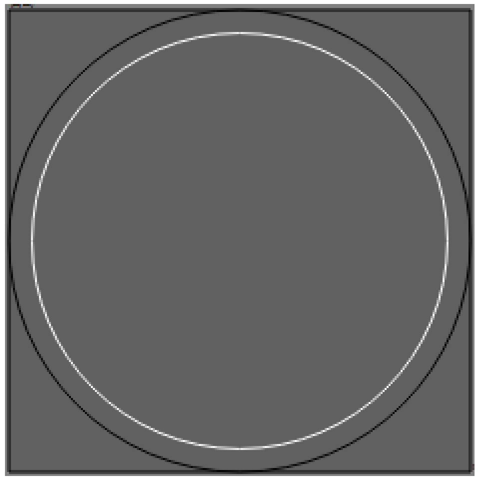
Clipping:
Edit clipping in a separate editor. See clipping editor section.

Clipping Image:
An additional image that will be multiplied with the calculated blending and vector based clipping.

Fadeout:
Fadeout allows to limit the projection area to a rectangular or circular area.

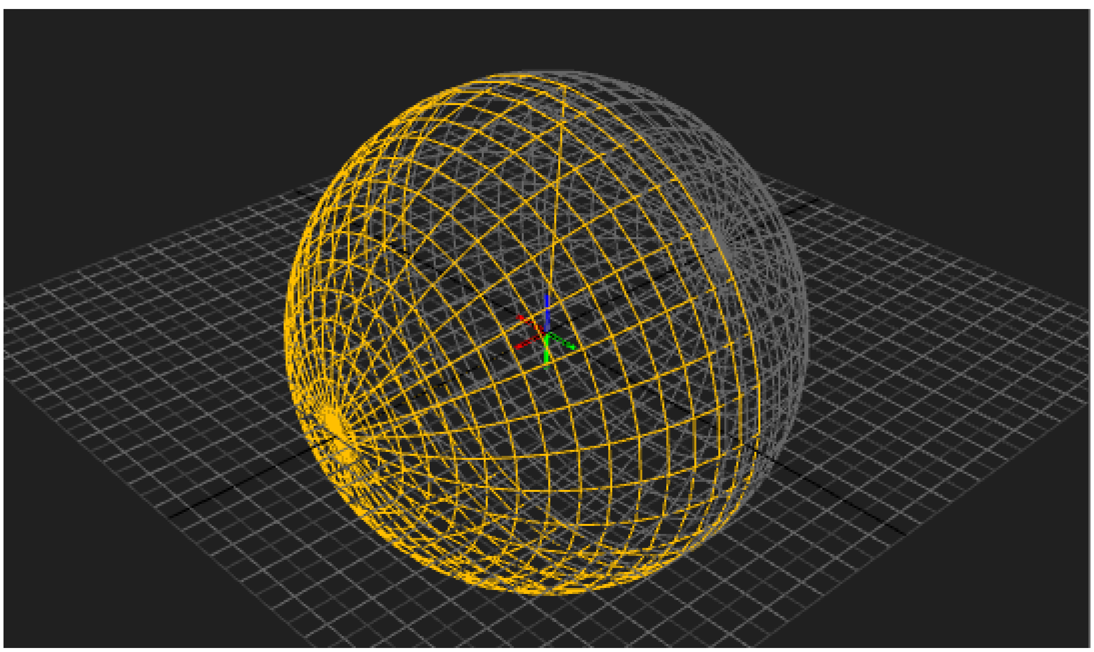
The fadeout is previsualized in the 2d-view by a white outline marking the fadeout-start and a black outline marking the fadeout-end.

Fadeout Linear:
Optionally set the fadeout falloff curve to linear, which make it usable for blending between multiple mappings (see section *Multiple Mappings* for details about using multiple mappings)



8.3 Multiple Mappings

Multiple mappings can be used to cover complete projection system. For example a full sphere could be covered with two polar mappings, or a projection on a cylindrical wall and the floor could be covered by using a cylindrical and a planar mapping.



Each mapping has its own shading settings (clipping and fadeout), and each projection channel is assigned to one mapping.

In order to add new mappings use .

When multiple mappings are in the projects, each projector can be assigned to one mapping and a mapping selector appears in the mappings dock to select the current mapping.

CHAPTER

NINE

SHADING

Besides automatic geometry correction, ProjectionTools supports to adjust the shading of projection channels in several ways. The most important correction is automatic calculation of blending between multiple channels. Beyond that, several other corrections are supported, which are described in the following sections.

9.1 Blending

ProjectionTools can automatically generate blending information of arbitrary number of projectors overlapping in any way. In contrast to some other systems the blending information is calculated for each projector pixel individually. By doing so ProjectionTools is not depending on a grid layout of projectors with corresponding left, right, bottom and top edge blends.

Blending is calculated from captured geometry information. From that information the overlapping of projectors is known and a smooth transition between projection channels can be calculated.

For blending to work correctly it is critical to have a clean gamma-curve in the projectors and to use the same gamma for blending calculations (see section *Shading*)!

Often it is possible to select between gamma curves in the projector, but not all are clean gamma-curves. Some are optimized curves for increased contrast, that might not work for blended multi projector setups.

9.1.1 Possible problems:

Blend zones are too dark:
Gamma setting in the project settings is lower than actual projector gamma. Either increase gamma in project or decrease gamma in projector.

Blend zones are too bright:
Gamma setting in the project settings is higher than actual projector gamma. Either decrease gamma in project or increase gamma in projector.

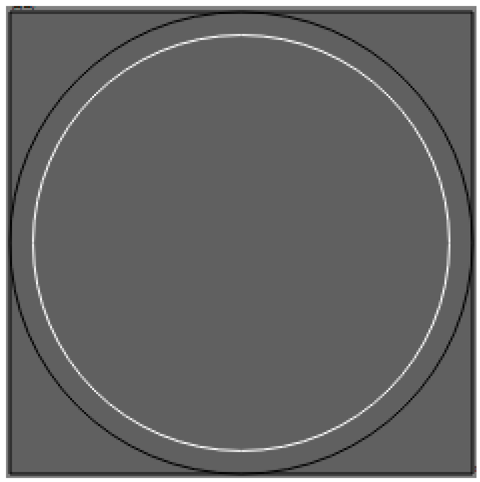
Blend zones are brighter or darker depending on content:
In that case the projector produces no clean gamma curve. You need to select a different gamma setting in the projector. If this is not possible you will not get perfect content independent blending with this projector.

9.2 Fadeout

In a multi channel projection system the uncorrected projectors usually project beyond the desired projection area (either the screen or a sub-area), broducing an irregular outline. For a finished setup the outline should usually be a clean smooth line following the physical screen edge.

The fastest way to produce such clean outline is to activate a fadeout on the currently used mapping (see section *Shading*). This limits the projection to a rectangular or circular area.

The currently used fadeout is previsualized in the 2d-view by a white outline marking the fadeout-start and a black outline marking the fadeout-end.



While a hard cut off is usual, even wider smooth transitions can be generated with a fadeout setting.

The transition can either be standard to appear smooth or set to linear, which make it usable for blending between multiple mappings. For example to blend two polar mappings with an overlap to fill a complete 360° x 180° sphere screen.

For creating more complex outlines see following section *Clipping*.

In the exports, fadeout is usually encoded in the blend files, by multiplying blending and fadeout information. So it is naturally applied during runtime along with the blending and no special support is required.

9.3 Clipping

Sometimes the outline of a screen is irregular, there are openings in the screen or obstacles in the projection. These situations can not be covered by a standard fadeout anymore.

ProjectionTools provide a method for clipping such areas.

The clipping is adjusted in the *Clipping Editor*, which allows to draw vector shapes interactively on the screen (see section:ref:*ClippingEditor*).

The clipping is usually defined on the mapping for all projectors at the same time (see section *Shading*).

It is also possible to clip single projectors individually, such that these areas are projected only by neighboring projectors (see section *Shading*).

In the exports, clipping is usually encoded in the blend files, by multiplying blending and clipping information. So it is naturally applied during runtime along with the blending and no special support is required.

9.4 Brightness Uniformity Correction

The brightness of one projector might vary from one edge to the other possibly resulting from a non-orthogonal projection angle or curved screen shape.

ProjectionTools can compensate this brightness variation, by integrating a correction map in the exported blend-files. This way bright areas in the projector can be dimmed to reach the same level of brightness as the dark areas.

These brightness correction maps can be automatically generated by *ProjectionTools*. The automatic generation takes the stretching of the projected image into account which is usually the biggest reason for non-uniform brightness. (stretched parts distribute light on a bigger area and get darker. Shrunken parts focus light on a smaller part and get brighter)

There are two ways of generating the maps automatically:

1. Enable automatic global uniformity calculation in . It allows to adjust the degree of correction. 100% meaning full uniform brightness as the darkest point in the projection. 50% meaning brightness is reduced for all areas brighter than the medium brightness. 0% meaning there is no correction at all. Disabling the automatic calculation leaves the last calculated correction maps in the Brightness Adjust setting of each projector for further manual editing.
2. Use on a set of selected projectors. This is a one time calculation. Resulting correction maps are stored in Brightness Adjust setting of each projector for further manual editing. This feature can be used to compensate the uniformity of each projector separately. So that brightness differences between projectors can be adjusted in other ways, e.g. changing projector lamp-power or iris.

If global automatic generation of uniformity correction is turned off, Uniformity correction maps can be manipulated and viewed in the Uniformity Correction Editor (). See section *Uniformity Correction Editor*

In the exports, uniformity correction is usually encoded in the blend files, by multiplying uniformity correction and clipping information. So it is naturally applied during runtime along with the blending and no special support is required.

Warning: Be aware that software Uniformity correction potentially not only significantly reduces brightness of the projection. It also reduces the dynamic range of the image signal (reducing the number of available digital gray-levels).

9.4.1 Uniformity Correction Editor

Uniformity Correction Editor allows to manually adjust uniformity correction maps for each projector.

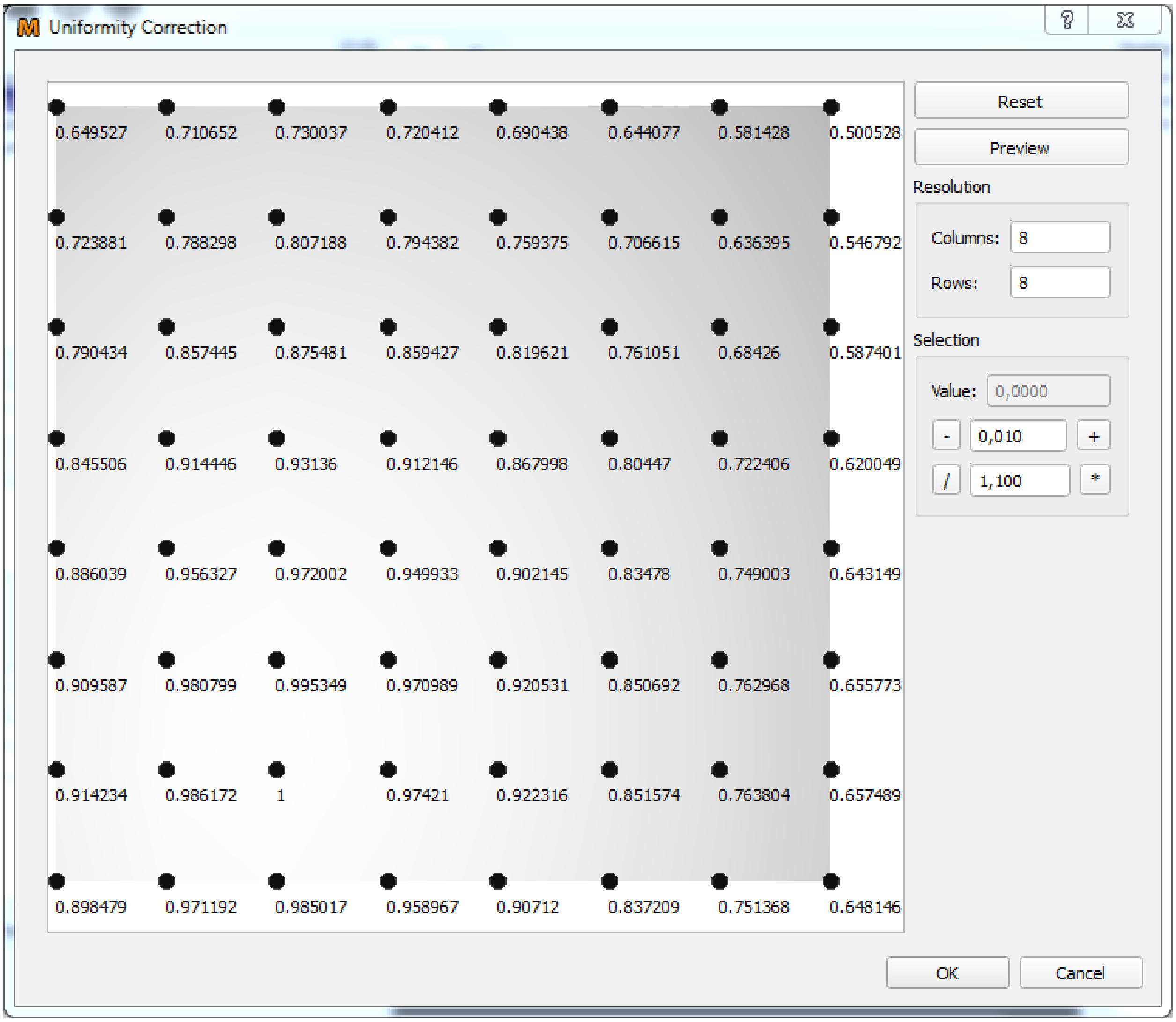
Be aware that brightness correction values are linear! Correction values around or below 0.5 are quite usual. Even if the preview looks already quite dark the result on the projector is probably far less visible.

Reset:
Reset the grid resolution to 3x3 and all correction values to 1.0.

Preview:
Show the current correction on PatternGenerator.

Columns / Rows:
Changes the number of points that define the uniformity correction.

Selection:
Allows to manipulate the values of selected grid points. Values can be overridden, shifted or scaled.


Uniformity Correction
0.649527 0.710652 0.730037 0.720412 0.690438 0.644077 0.581428 0.500528
0.723881 0.788298 0.807188 0.794382 0.759375 0.706615 0.636395 0.546792
0.790434 0.857445 0.875481 0.859427 0.819621 0.761051 0.68426 0.587401
0.845506 0.914446 0.93136 0.912146 0.867998 0.80447 0.722406 0.620049
0.886039 0.956327 0.972002 0.949933 0.902145 0.83478 0.749003 0.643149
0.909587 0.980799 0.995349 0.970989 0.920531 0.850692 0.762968 0.655773
0.914234 0.986172 1 0.97421 0.922316 0.851574 0.763804 0.657489
0.898479 0.971192 0.985017 0.958967 0.90712 0.837209 0.751368 0.648146
Reset
Preview
Resolution
Columns: 8
Rows: 8
Selection
Value: 0,0000
- 0,010 +
/ 1,100 *
OK
Cancel

Tip: If a colorimeter is used for brightness measurements, the correction values can be directly derived from the luminance measurement differences.

Example:

- Luminance measured on left side 22 (darkest part of the projector)
- Luminance measured on right side 44
- The right side of the projector is two times brighter than the darkest part of the projector. So the correction for the right side should be 0.5.
  44 * 0.5 = 22

9.5 Black Level Correction

Projectors typically produce no perfect black. They expose still some light to the screen when the input signal is full black. In overlapping areas the resulting black level is even higher depending on the number of projectors overlapping. While this effect is neglectable for many media installations, it becomes disturbing in night scene content in planetarium and simulation applications.

A software black level correction can not remove the black level, but it can greatly reduce the heterogeneous appearance of the projection where overlapping areas stand out compared to non-overlapping areas. This is achieved by increasing the black level to one uniform level on the whole projection.

There are two calculation modes available, which can be switched and setup in (see also section *Shading*):

Standard BLC:
A simple model for correction calculation, where user manually defines:

Max Ovlerap:
Maximum number of projectors overlapping at any point. Typical is 2 for a linear setup of projectors in one row or 4 for a grid of projectors with multiple lines and rows.

Black level:
The amount of light the projector exposes for black images. The corresponding preview can be used to help adjusting this value.

Advanced BLC:
Automatically calculates maximum overlap and regards uniformity and projector clipping information. Brightness and contrast settings for each individual projector are used to calculate their actual brightness and black level distribution.

In the exports, black level correction is usually encoded separately, since special calculations are required to apply this correctly.

Note: Be aware, that several media servers and 3d-engines have none or only limited black level correction support.

9.5.1 Projector Shadow Removal

In some cases it might happen, that projector light is blocked by some obstacle. Usually at the edge of projectors in very tight setups. This is usually not an issue for normal day light blending, where the problematic projector is cut off before the shadowing begins.

For black level correction the shape and placement of this shadowing must be exactly known in order to compensate the missing black level using surrounding projectors. If the shadow is not compensated at all, there will be a dark hole in the projection of night scenes. If the shadow is assumed too big, there would be a bright area around the initial shadow.

ProjectionTools support the compensation of these shadows by allowing the user to define these shadows in each projector and later use that information during black level correction calculations.

Usage:

1. Select a single projector with shadowing in the projector list.
2. Open .
3. Draw a black shape matching the shadow in the projector.
4. Make a preview using *Mapper3d* Preview3d Exporter, with Black Level Correction enabled.
5. The drawn shadows will be used the next time you export black level correction. (**Note:** Currently the "useShadowMaps" option must be set in genericExporter configuration)

Tip: Invert the scene in Clipping Editor to draw a white shadow shape on a black background. This provides a good visual feedback during matching the drawn shape with the actual shadow. When the shape is finished, invert the scene again to have a black shape (shadow) on a white background again.

CHAPTER TEN

CUTTING

While a mapping defines the overall placement of 2d content on a projection screen, cutting defines which parts of the content need to be rendered for each projection channel.

Cutting rectangles are auto generated by default. This way, they are automatically placed where the mapping of the projector is in the texture with some scale-factor (defined in project settings) increasing its size and auto rotated to best fit.

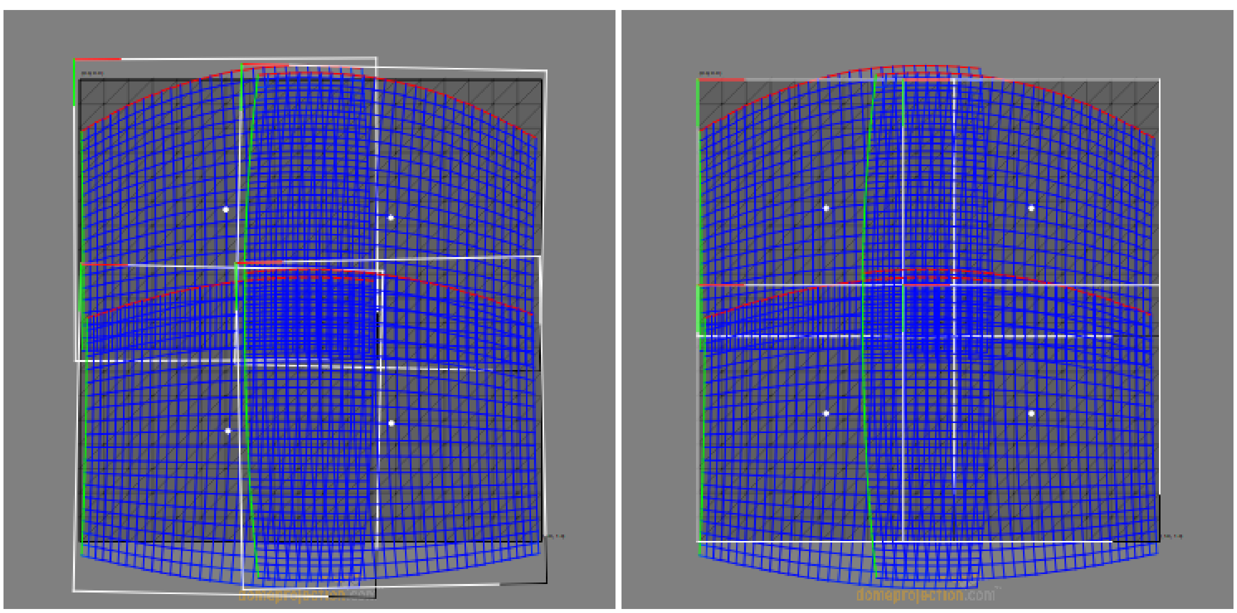
The auto generation can be disabled to allow user defined cutting rectangles, e.g. when they are already predetermined by design and content production. Another reason for disabling auto generation is when the cutting rectangles should no more change, e.g. when using pre-split video. For manual editing of cutting rectangles in side projector settings see section *Cutting*.

Cutting rectangles can also be placed in a regular grid with defined relative overlaps (see following section *Layout Cutting Rectangles*).

Cutting information can be transferred between projects using `Menu/Extras/Export Cutting Rectangles...` and `Menu/Extras/Import Cutting Rectangles...`.

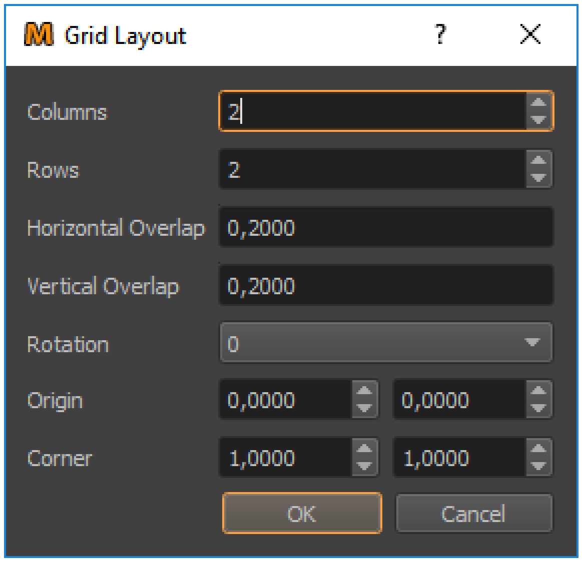
10.1 Layout Cutting Rectangles

allows to layout cutting-rectangles in clean columns and rows with defined overlap. It is typically used for video content that is already cut or when an exporter that is used has special demands on the cutting of the content.



provides three ways of layout. A simple horizontal or vertical row of cutting rectangles and a grid with mutliple columns and rows.

The most flexible layout is the grid, whose settings are described here.



Columns/Rows:
Number of Columns and Rows. Cuttings are generated row-wise from left to right.

Horizontal/Vertical Overlap:
Amount of overlap between cutting rectangles. Normalized value relative to cutting rectangle width/height.

Rotation:
Orientation of cutting rectangles. Can be used for projectors in portrait mode. Angle in degrees, clockwise.

Origin/Corner:
Cutting rectangles can be layed out into a subregion of the content space. This region is defined by origin and corner as normalized coordinate.

CHAPTER

ELEVEN

ABOUT CREATOR

Creator is a tool to measure projection systems with digital cameras. Creator generates data that is the basis for Mapper2d/3d to calculate warping and blending information and create exports for different devices/applications.

Creator needs to capture testpatterns on the projectors. For that purpose it needs:

1. A testpattern generation program running on display computers attached to the projectors (PatternGenerator
2. network connection to display computers to communicate with the testpattern generation program
3. a calibrated camera attached to the computer, where Creator is running on

The following chapters describe the UI components of Creator, the basic workflow of doing calibrations and the PatternGenerator software that is needed to produce the testpatterns on projectors.

MAIN WINDOW OVERVIEW

Fig. 1: Default workspace

Creator has a fully configurable workspace. Above figure shows the default configuration with the typical widgets open.

Menus

File Menu
Create, Load and save projects. Adjust global project settings.

Tools Menu
Additional tools and advanced operations on loaded project.

View Menu
Workspace and theme management.

Help Menu
Help, Support and Program information.

Toolbar
The toolbar provides quick access to several preview and capture actions.

Hardware
On the left are docks for all the components involved in the project listed.

Projectors
The projectors dock widget shows a list of all projectors in the current project and allows to edit projector related settings.

Cameras
Each project has at least one camera. In the cameras dock widget the cameras of a project can be viewed and their settings adjusted.

Screen
Settings, describing the overall screen shape.

Reference Points
Known 3d coordinates used for calculating camera positions.

Camera view/*3D View*
In the center of the window is a camera-view and 3d-view available between which the user can switch.

Positions
On the right side is the configuration of the calibration process visible.

All dock widgets can be arranged, stacked, opened and closed by user. The workspace layout is saved persistently.

It is also possible to revert to the default workspace using `View/Default Workspace`.

All available dock widgets can be found in the menu. They are described in the following sections.

The theme can be switched in `View/Theme`. An application restart is needed for a theme switch to take effect.

For using the maximum workspace on the desktop, a full screen mode can be enabled using View `Menu/Toggle Fullscreen Mode`.

12.1 Previews Toolbar

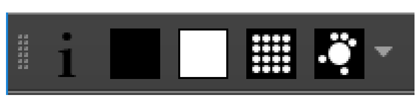


Fig. 2: Preview toolbar

Identify
show info on selected projectors

Projector dark
make selected projectors black

Projector light
make selected projectors white, others black

Selected Projectors Gray
show dot pattern on selected projectors

Project Codemarker
Show codemarker on all projectors. Press drop-down-button for more options (codemarkers, simple points, simple points with cross and label).

12.2 Capture Toolbar

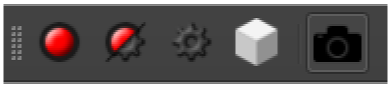


Fig. 3: Capture toolbar

Take Images
Take test-image sequences with selected camera for selected projectors, without further image analysis. During capturing process, neither cameras nor projectors should be moved.

Take Images and Analyze
Take test-image sequences with selected camera for selected projectors, and analyze images. During capturing process, neither cameras nor projectors should be moved.

Analyze Images
Analyze images for selected position and projectors. This can be used to analyze previously taken images again after change of recognition parameters or masks. It is much faster than taking images again, and no attached cameras are required.

Generate 3D
Reconstruct projection geometry by analyzing all images taken for projectors, camera positions and screen geometry information.

Toggle Camera Connection
Enable/Disable camera connection. New images can only be taken, if camera connection is active.

12.3 Camera view

The camera view shows a live stream from currently active camera.

If the camera is turned off, switch it on using `Capture Toolbar/Toggle camera connection` (see section *Capture Toolbar*).

Navigation
The view can be dragged with the left mouse button.

Scaling
Several scaling options are available at the top right corner of Camera View.

12.4 3D View

The 3D view provides a three dimensional overview of the current calibration setup.

This includes the theoretical screen, reference points, camera positions and measured projection geometry.

The current selection of projectors, camera position and reference points is regarded. Unselected elements are dimmed or hidden.

Visualization Options
A drop down menu on the top left corner allows to select multiple visualization options.

Screen
Theoretical/imported screen shape

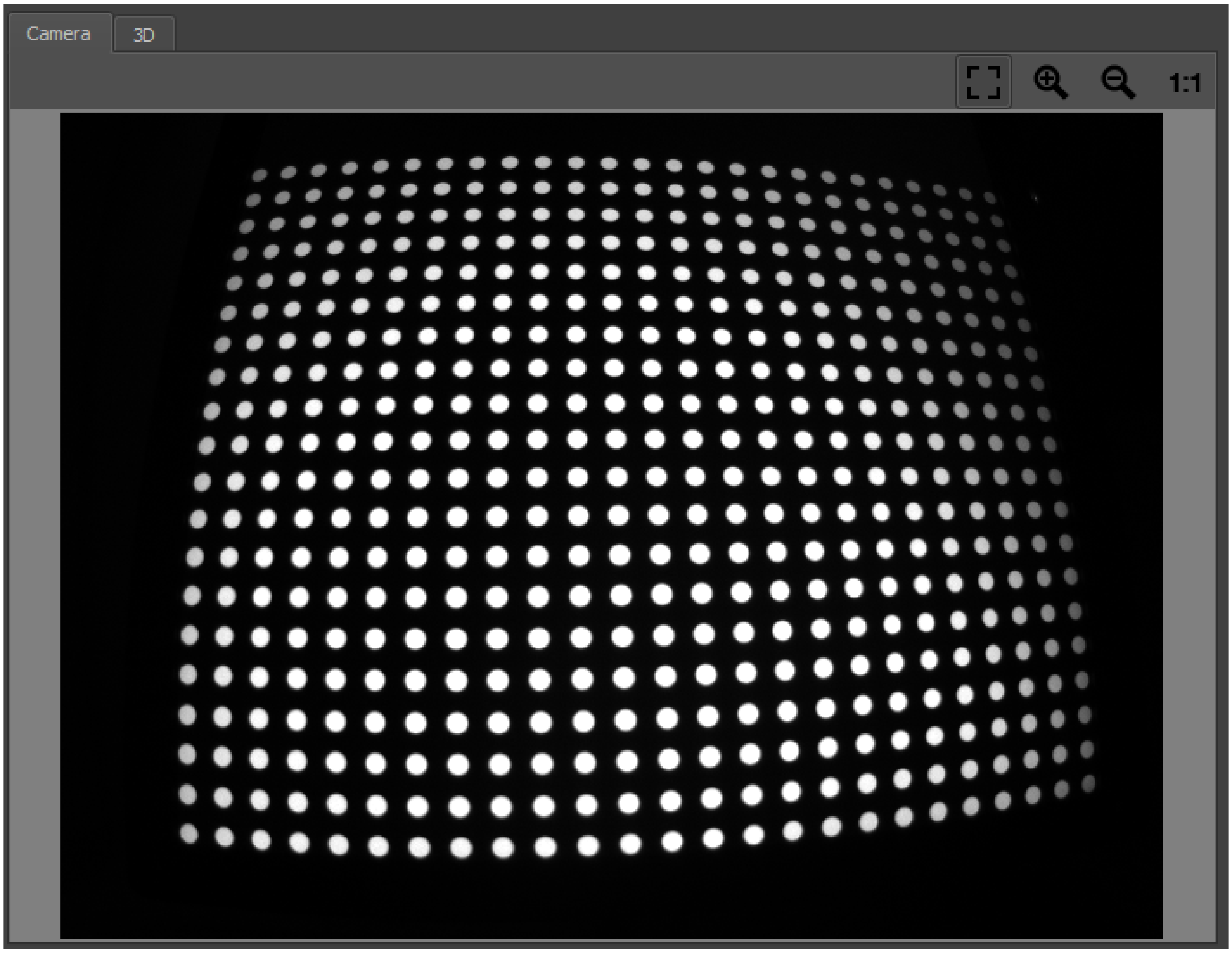


Fig. 4: Camera View

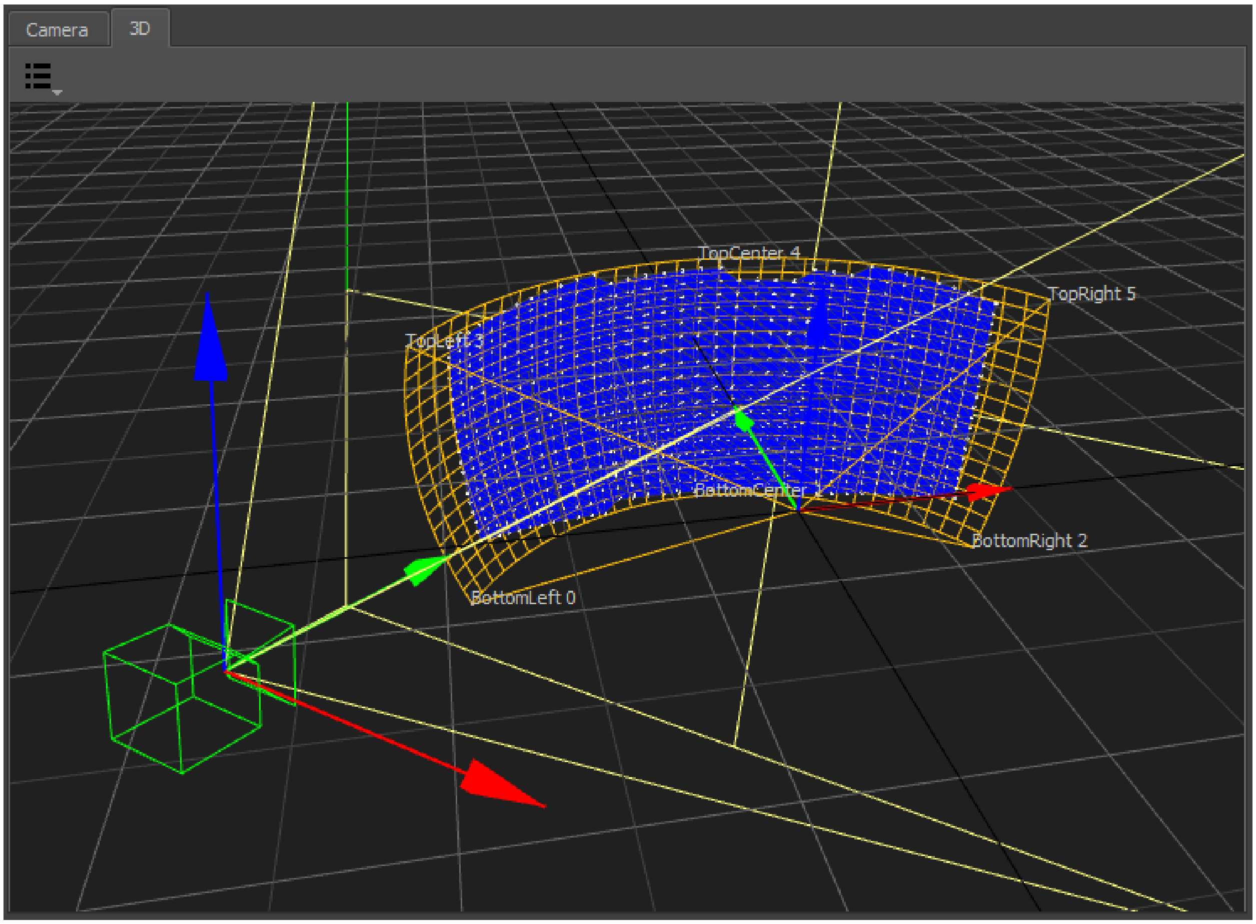

Camera
3D
TopCenter 4
TopRight 5
TopLeft 3
BottomCenter 1
BottomRight 2
BottomLeft 0

Fig. 5: 3D View

Reference Points
Imported/generated reference points

Geometry
Generated 3d shape of each projector as mesh

Measured Points
Measured 3d positions of captured points for each projector.

Perspective
Switch to predefined orthographic views or the default perspective camera position.

Navigation
Navigate the 3d view using the mouse.

Rotate
`Left mouse-button`

Move
`Middle mouse-button`, `Alt+Shift+LMB`

Zoom
`Right mouse-button`, `Alt+Ctrl+LMB`

12.5 Project Settings

12.5.1 General

Calibration Mode
Defines what testpatterns are shown on projectors and captured by cameras to analyze the projection geometry.

Classic Dot
A sequence of dot-patterns is used.

Concentric Circles
In addition to the sequence of dot-patterns an image showing a ring for each dot is used. This allows to automatically detect cutted dots.

Projection Delay
Allows to adjust the delay between showing testpatterns and taking images with the camera. Increasing this value might solve issues, with images taken too soon, but slows down the capturing process.

Synchronization Port
This defines the UDP port for PatternGenerator feed back. It is used to sync the camera system to the PatternGenerator draw loop (/bufferSwap). Has to be the same as configured in PatternGenerator.

Recognition
Global recognition parameters used for all channels and camera positions.

Remove statistical Outliers
Removes points, that are significant more distant to their neighbors than the average distance between neighboring points in the camera image. (Statistical Outlier Removal)

n Sigma
Points with distance to neighbors n-times standard deviation larger than average distance are removed.

Generate 3D
When all testpatterns are captured, a 3d model of the projection will be generated. There are different strategies

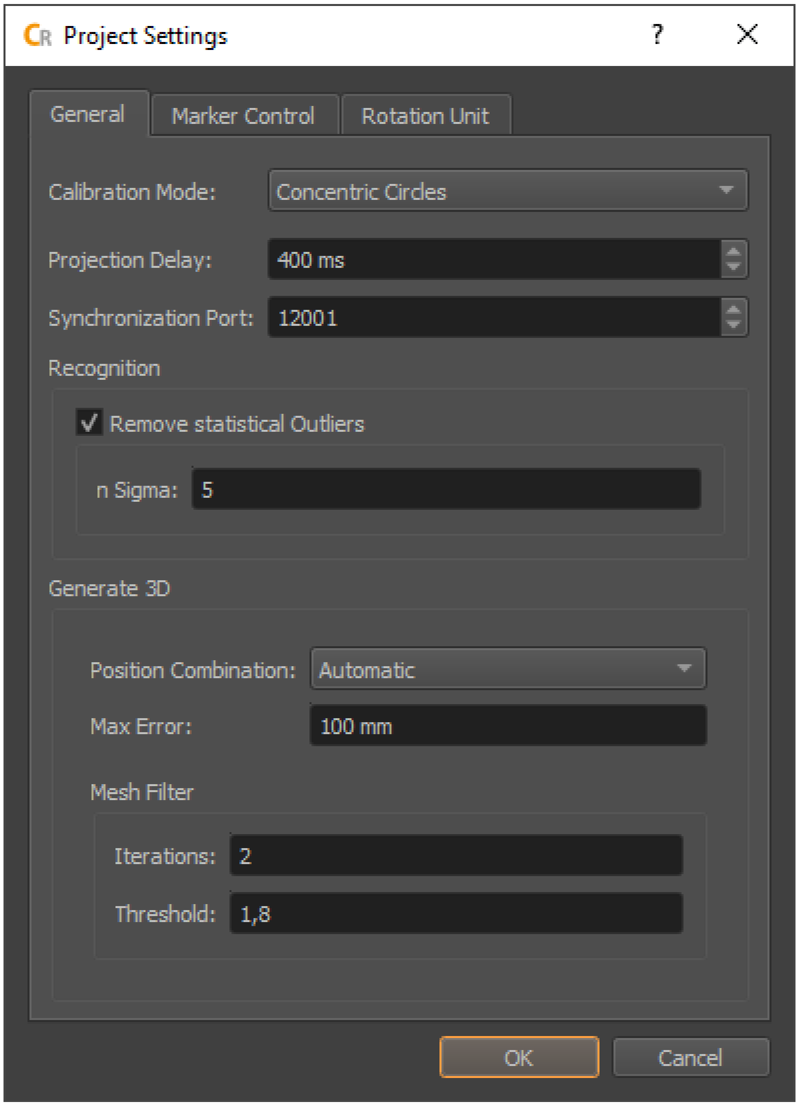


Fig. 6: General Settings

possible which have their pros and cons depending on calibration situation. The strategy and its settings can be adjusted here.

Position Combination
Select how calibration patterns seen from multiple camera positions are combined.

Automatic
Reconstruct a 3d surface using stereo vision, when possible (*Triangulate*). Parts that are only seen by one camera position or where camera positions are too close to each other are generated by tracing the screen and potentially blending multiple camera positions (*Blend*).

Blend
Trace recognized patterns on assumed screen surface for each camera position separately. Than blend the resulting 3d positions of patterns captured from different camera positions. Use this option, when your camera is placed on one position and just rotated, not all parts of the screen are seen multiple times or the screen setting contains already an imported scan.

Triangulate
Reconstruct a 3d surface using stereo vision, disregarding the assumed screen shape. Discrepancies between generated screen surface and assumed screenshape are color coded in the 3d view. Use this option when you plan to reconstruct the actual 3d shape of the screen-surface.

Max Error
Maximum allowed error during triangulation. Triangulated points with larger error will be discarded.

Mesh Filter
Generate 3D generates a point cloud first and then generates a mesh on it. This mesh can contain degenerated triangles. Degenerated triangles are usually stretched extremely along one direction. The mesh filter removes such degenerated triangles that have an noticeable longer edge length than the average triangles.

Iterations
Number of iterations the filter is applied, or off.

Threshold
Triangles with $edgelength > average * threshold$ will be removed.

12.5.2 Marker Control

Creator and Align can directly control active markers. These markers can be automatically detected by position finder (see section *Position Finder*)

`Project Settings/Marker Control` allows to adjust the communication settings.

Type
Type of marker control

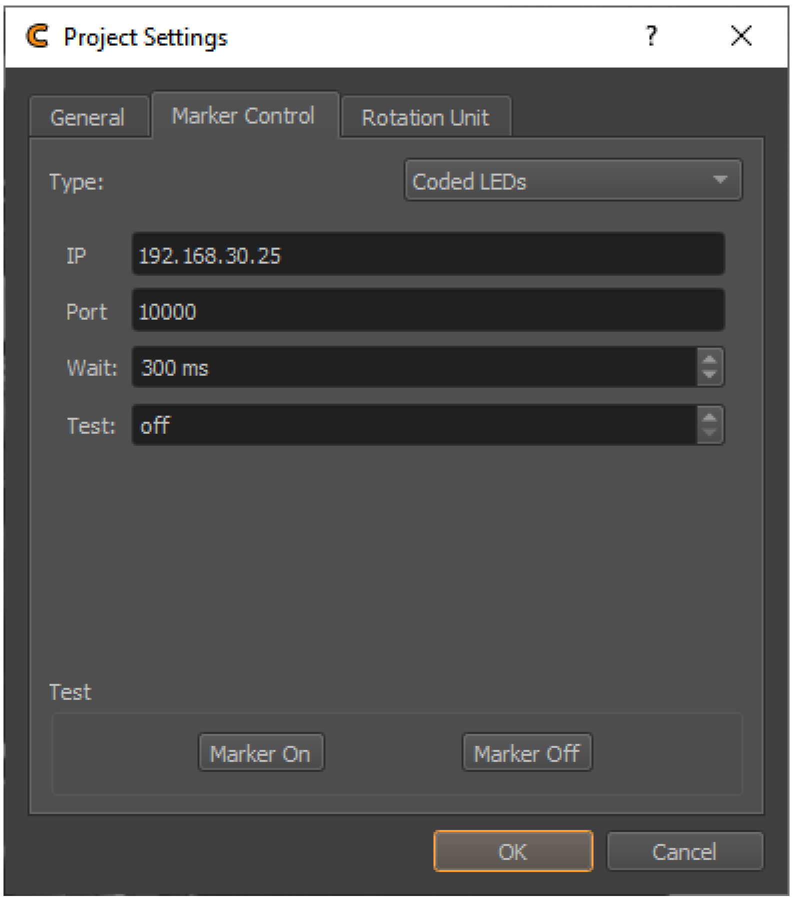
None
Marker control disabled.

Manual
Request user to turn markers on and off.

Script
Generic batch script to integrate custom automizations.

Markers On/Off
Select the batch script that turns the markers on/off.

Wait
Often it takes some time until the markers are actually switched, after the batch script returned. The delay can be adjusted here.


Project Settings
General
Marker Control
Rotation Unit
Type:
Coded LEDs
IP
192.168.30.25
Port
10000
Wait:
300 ms
Test:
off
Test
Marker On
Marker Off
OK
Cancel

Aviosys
Network controlled power plug.

User / Password
Login required for this power plug. Initialized with factory defaults.

IP
Network address of power plug.

Port
Communication port used on power plug. Initialized with default port.

Wait
Often it takes some time until the markers are actually switched. The delay can be adjusted here.

Netio
Network controlled power plug.

User / Password
Login required for this power plug. Initialized with factory defaults.

IP
Network address of power plug.

Port
Communication port used on power plug. Initialized with default port.

Wait
Often it takes some time until the markers are actually switched. The delay can be adjusted here.

Plugs 1/2/3/4
The netio support multiple power plugs. Select which plugs should be switched.

Coded LEDs
Micro controller enabled LEDs supporting to control and identify each individual LED.

IP
Network address of power plug.

Port
Communication port used on power plug. Initialized with default port.

Wait
Delay between setting the LEDs and capturing images.

Test
Enable individual LEDs for testing purpose, and identification.

URL
General interface for Network controlled power plugs.

Markers On/Off
Select the URLs that turn the power plug on/off. Example on/off URLs for an Aviosys:

```
http://admin:12345678@192.168.0.5/Set.cmd?CMD=SetPower+P60=1
http://admin:12345678@192.168.0.5/Set.cmd?CMD=SetPower+P60=0
```

Wait
Often it takes some time until the markers are actually switched. The delay can be adjusted here.

3D Disto
Leica 3D Disto. This measurement device with integrated laser pointer can be used to point at reference

points of the project automatically. This works by finding its position relative to the project coordinate system and then pointing at the known 3d positions of reference markers in the project.

Connect
Establish connection to 3D Disto software. Make sure 3D Disto software is running on the local machine and connection to 3D Disto established.

Raw Rotation
Allows to rotate the 3D Disto in its native coordinate system.

Transform
Defines the corrent position and rotation of the 3D Disto relative to Creators coordinate system. Use for estimating the transform based on an axis or three points.

Wait
Waiting time between pointing at a reference point and taking images.

TCP
General interface for any type of TCP/IP controlled devices.

IP
Network address of marker control device.

Port
Communication port of device.

Marker On/Off
Network message to send for switching the markers on or off.

Wait
Often it takes some time until the markers are actually switched. The delay can be adjusted here.

Add Endline
Add endline control sequence to the message (\r\n) in case this is needed.

Test Marker On/Off
Turn active markers on and off using current automization settings.

12.5.3 Rotation Unit

Creator and Align support cameras mounted on a motorized rotation unit, which is a common alternative to fisheye cameras and multiple perspective cameras for capturing screens with a large field of view.

For example, one perspective camera mounted on a rotation unit could cover a full 360 degrees cylindrical screen.

`Project Settings.../Rotation Unit` allows to setup and test communication with an installed rotation unit.

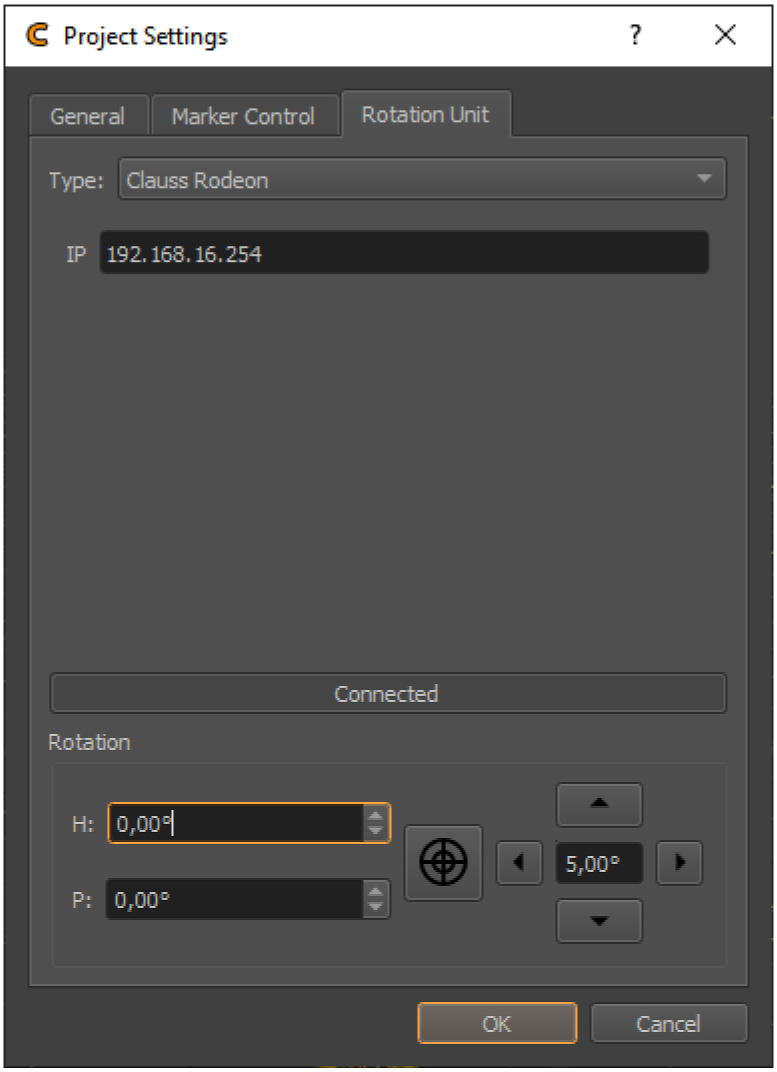
Type
Type of rotation unit.

None
No rotation unit available.

Clauss Rodeon
Motorized rotation unit from Clauss, controllable over network.

Connect
Connect to currently selected rotation unit. Allowing to test rotation.

Rotation
Rotation control for currently selected rotation unit. This is for testing only. For setting permanent orientations use `Positions Editor/Position/Target` heading and pitch angles.


Project Settings
General
Marker Control
Rotation Unit
Type:
Clauss Rodeon
IP
192.168.16.254
Connected
Rotation
H:
0,00°
P:
0,00°
5,00°
OK
Cancel

CHAPTER

THIRTEEN

CALIBRATION PROJECTS

ProjectionTools manage calibrations as projects. A calibration project is shared between all ProjectionTools applications, such as Creator, Align, Mapper2d and Mapper3d.

Each project is a folder containing a configuration XML file, calibration data and all pictures taken during calibration process. This project folder contains all relevant data and can be transfered between computers.

The project can be managed through the file menu:

New Project
: Creates a new project using the project creation wizard. (see *New Project Wizard*)

Load Project
: Loads an existing project. The project configuration XML file needs to be selected, which is placed in the main folder of each project. By default it is named `config.xml`.

Recent Projects
: Allows to reopen recently created or loaded projects.

Save Project
: The configuration of currently opened project will be saved.

The project contains information about the system components, the process and the calibration results. involved camera, screen-shape and channels involved.

System Components

  Projectors
  : Information about projector resolution and testpattern generation and recognition.

  Cameras
  : The calibration cameras used to capture the testpatterns.

  Screen
  : The general shape of the screen.

  Reference Points
  : Measured or generated points for camera orientation.

  Marker Control
  : Optional control for active markers, that can be turned on and off automatically.

Positions
: The calibration process consisting of one or multiple camera positions.

Results
: A reconstructed point cloud and mesh of each projection channel, based on measured calibration patterns. It is visible in 3D View and used by Mapper2D and Mapper3D to calculate warping and blending for export.

These project components are described in the following sections.

13.1 Collect Support Data

Calibration projects can get quite big, since all the captured camera images are kept for later use. While this is good to analyse and optimize the calibration offline this might be too much data to transfer over Internet.

`Help/Collect Support File...` allows to pack relevant project data in an archive that can still be opened in Creator but has not the massive data masses produced during image taking. It is typically requested from *domeprojection.com* for support.

For opening the support file again, unpack it (it is a zip archive) and than open it like a normal project.

- The support project allows to see the complete calibration process including the result images, to check for errors.
- It is not possible to process images again (e.g. for testing different recognition settings), since not all captured pattern images are available.
- It contains all data required to use Mapper2D and Mapper3D for calculating warping/blending and doing exports.

13.2 Projectors

Projectors reflect one projection channel each. Usually one channel is used per projector. In some setups with 4k projectors, there might be more channels in the project than actual projectors.

The projectors dock widget shows a list of all projectors in the current project and allows to edit projector related settings.

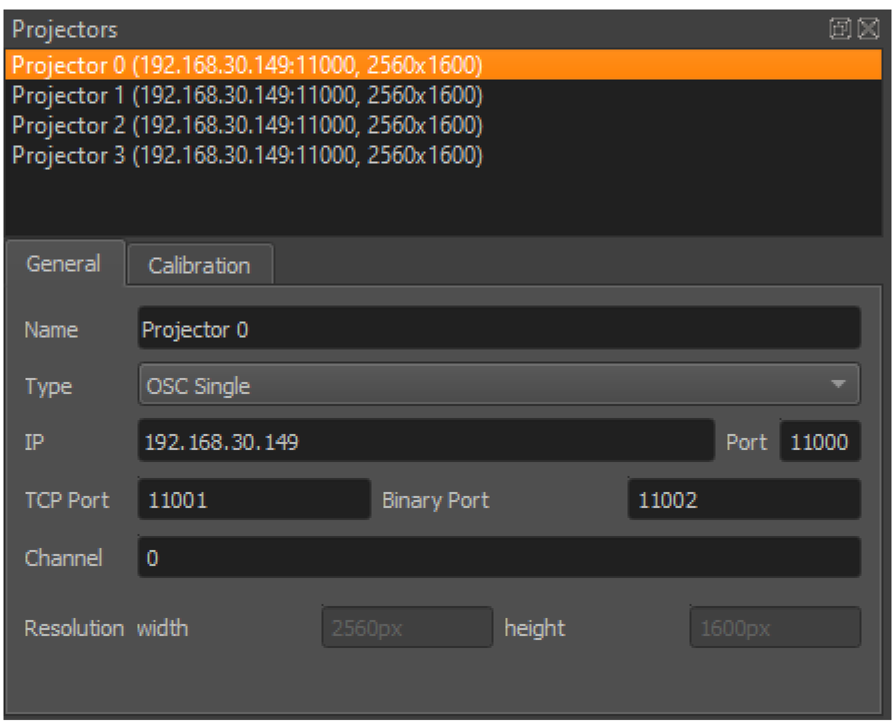


Fig. 1: Projectors Dockwidget

13.2.1 List

A list shows all projectors in the project. Including name, ip, port and resolution.

This widget allows multi-selection of projectors.

Several other views in the application update according to the current projector selection.

Settings of currently selected projectors are editable in the tabs below the list.

Not all settings do support multiple projectors at once, these are grayed out when multiple projectors are selected.

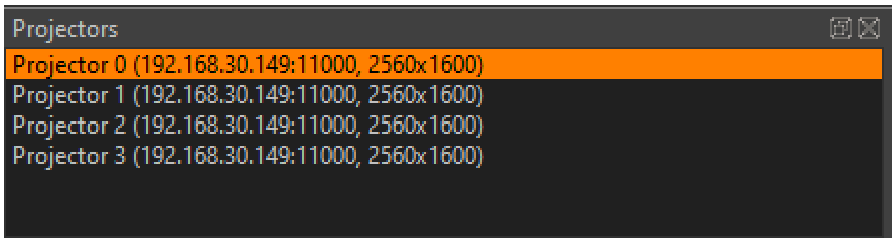


Fig. 2: Projectors list

13.2.2 General

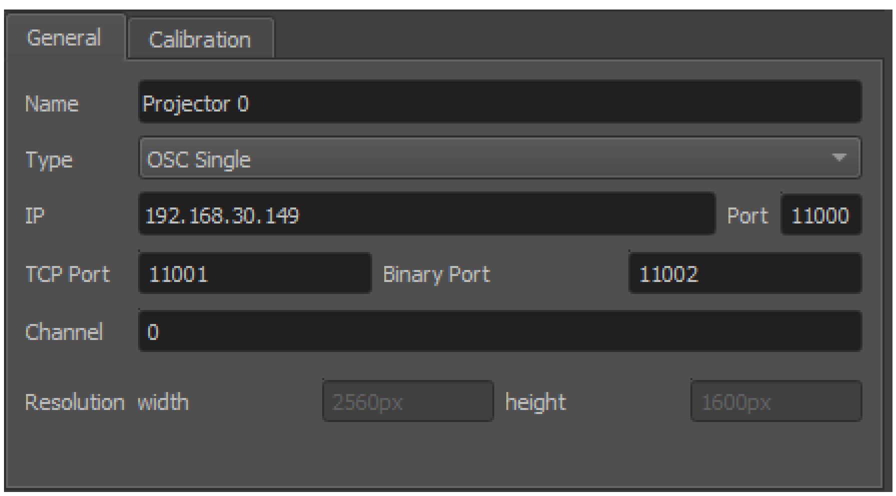


Fig. 3: General settings

Name
Arbitrary string describing the projector

Type
Interface to use for showing testpatterns.

OSC Single
Default PatternGenerator based interface. Works with up to date PatternGenerator.

OSC Multi
ProjectionTools channels are virtually split into multiple PatternGenerator channels. Works with standard PatternGenerator.

OSC Legacy
Can be used for very old PatternGenerator installations, or installations on limited/embedded hardware. The preview functionality is limited.

NDI
Provide testpatterns as one NDI-stream per channel. This can be used, if it is not possible to install PatternGenerator on the Mediaservers. Several Mediaservers support recieving and showing NDI-Streams. The preview functionality is limited.

Norxe Unify
Send testpatterns as image directly to Norxe Unify projectors. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Barco Pulse
Send testpatterns as image directly to Barco Pulse projectors. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Luna
Send testpatterns as image directly to domeprojection Luna warp units. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Warper4k
Send testpatterns as image directly to Westar Warper4k warp units. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

IP
network address of computer where PatternGenerator software is running on

Port
port to communicate with PatternGenerator. By default 11000. If multiple PatternGenerator run on one computer different ports need to be used.

Channel
channel number, only used for PatternGenerator virtual where one *PatternGenerator:* instance shows patterns for multiple projectors

Width and height
Have to be the same as the physical projector resolution used in the projection and displayed here for reference only (not editable).

13.2.3 Dot Pattern

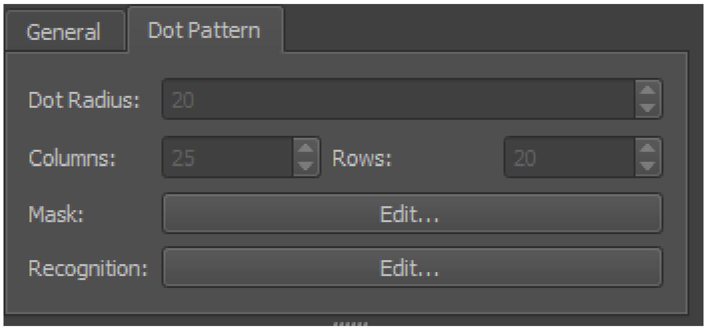


Fig. 4: Dot pattern

Dot Radius
: Radius of projected dots in pixels. Might need to be changed depending on how big the points are seen in the camera image.

Columns/Rows
: Number of dot columns and rows.

Mask Edit
: Allows to edit the Dot Pattern.

Recognition Edit
: Allows to edit and test recognition parameters in an editor with visual feedback.

13.2.4 Recognition Settings

The recognition settings editor allows to edit and test recognition parameters with visual feedback.

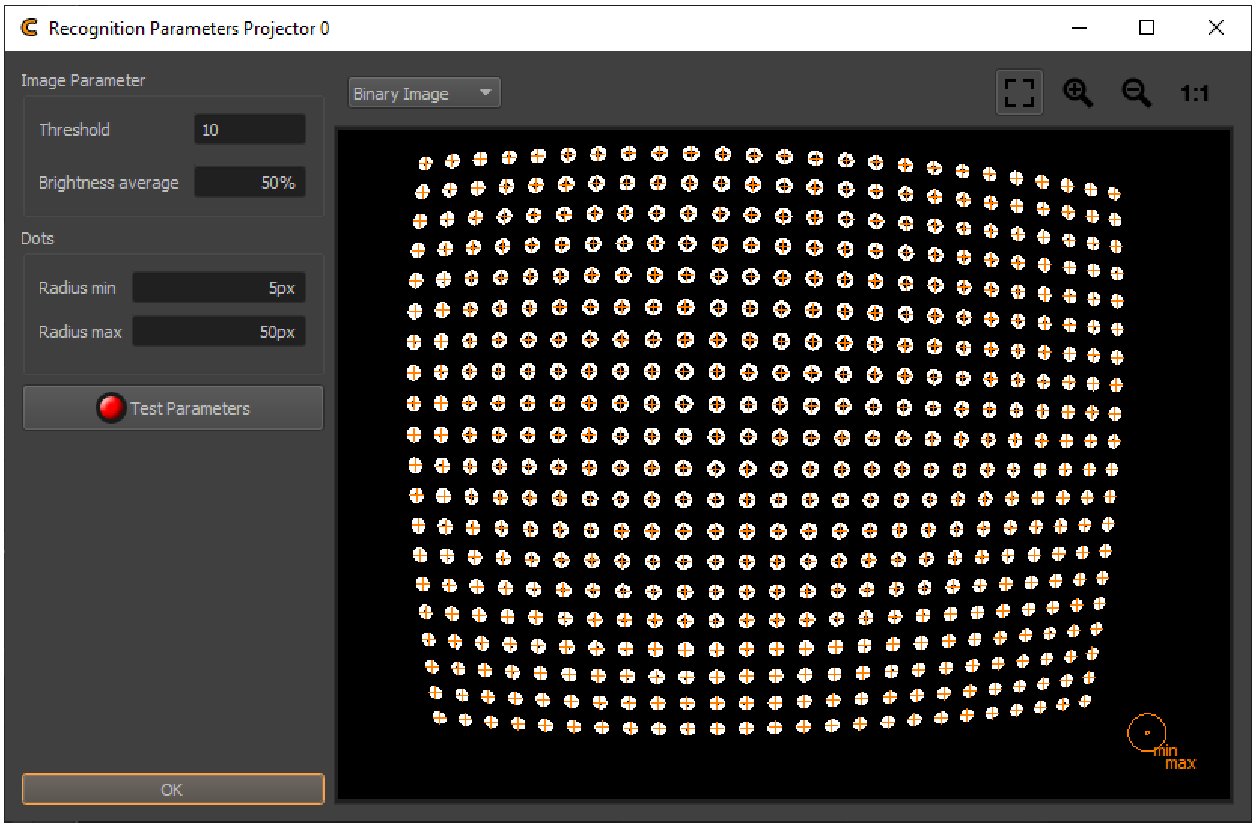


Fig. 5: Recognition parameters

Threshold
: Circles are searched in the camera images. The search starts with binarisation and edge detection in the image. Threshold defines the binarisation threshold. The effect can be seen in the Binary image layer.

Brightness average
: Fades average image between black and white image. Pointcode detection uses the average image as adaptive binarisation threshold.

Radius min/max
: The minimum and maximum radius of dots in camera image in pixels. Only dots within this range are detected.

When concentric circles are activated at `Project Settings/Calibration Mode`, the inner and outer contour of the projected rings need to be in this range. The camera image contains an overlay in the bottom right corner, visualizing the current radius min/max setting.

Test Parameters
Take images with camera and show results. The Editor allows to show several images from the recognition process:

Layer Selection
Select between multiple images showing different stages of the detection process.

Black Image
First image taken with camera. Should contain no dots.

White Image
Second image taken with camera. Should contain dots.

Average Image
Average of Black and White Image

Binary Image
Black/White Image. Dots should be full white, rest should be black, otherwise check threshold and camera parameters.

Contour Image
Shows contours around each dot. Each dot should have exactly one closed contour.

Orange crosses are drawn on every detected point center.

13.2.5 Change projector Resolution

The projector resolution is setup during project setup in the project creation wizard (see section *New Project Wizard*). All calibration data is tied to that resolution, so that on a resolution change all data would need to be captured again.

To change the projector resolution select the projectors whose resolution should be changed and use `Tools Menu/ Change Projector Resolution...`, than capture and calculate all calibration data again.

13.3 Cameras

Each project has at least one camera. In the cameras dock widget the cameras of a project can be viewed and their settings adjusted.

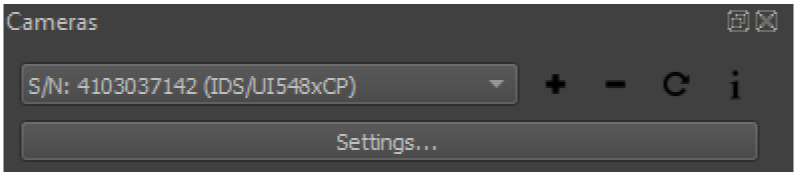


Fig. 6: Cameras dock

Combobox
Allows to select current camera for editing and showing its life stream. When adding new positions, the currently selected camera will be used for the new position. When selecting positions, this combobox will automatically update to the camera of the selected position (see section *Positions*).

Add Camera
Adds another camera from a camera database to the project (see section *Camera Database Browser*).

Remove Camera
Removes currently selected camera and corresponding positions from project. Only possible when multiple cameras are in project.

Replace Camera
Replaces the currently selected camera. This will also update positions using the current camera to use the new camera. Please note, that all data captured with the old camera will be removed and need to be recaptured.

i
Shows general information about selected cameras type and lens.

Settings
Allows to adjust camera parameters in a separate Editor. See following section or further details.

13.3.1 Camera Settings

The Camera Settings dialog allows adjustment of camera settings, mainly in order to adjust the brightness of captured images.

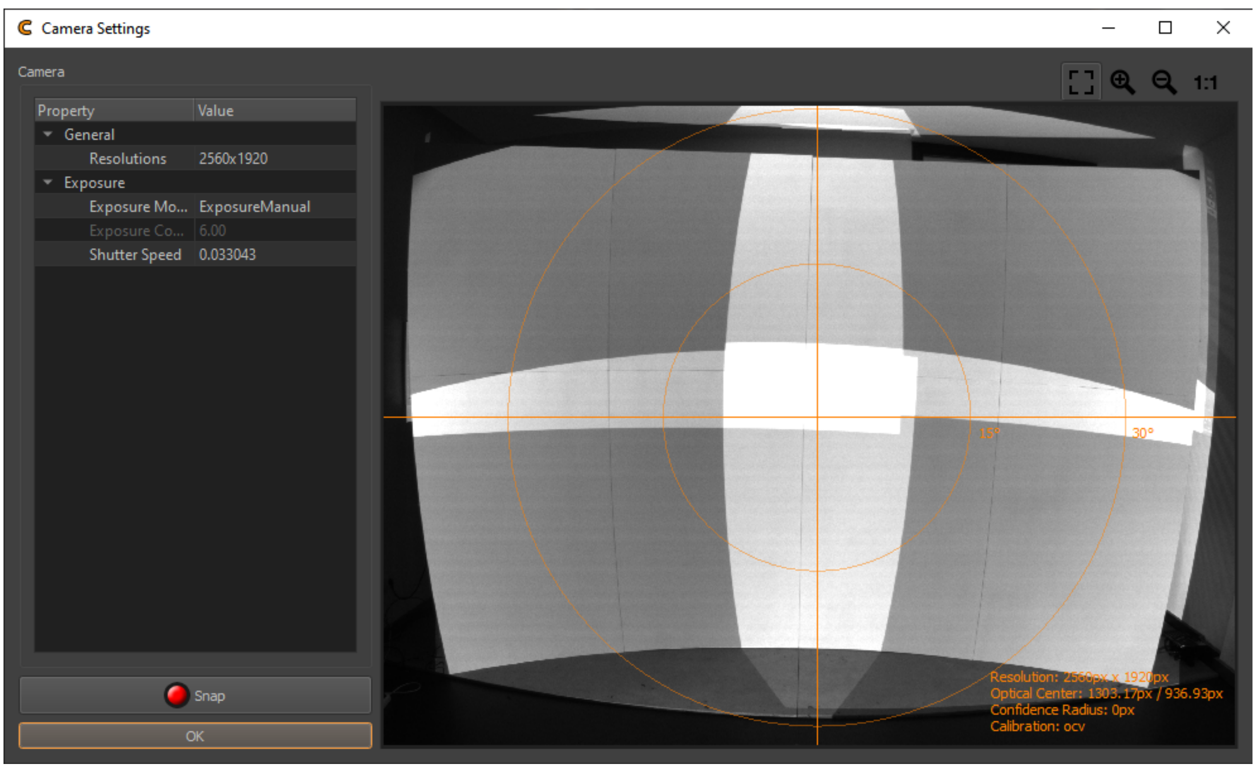


Fig. 7: Camera Settings

Parameters
The editable camera parameters depend on the camera type. Here a list of some typical parameters.

Exposure
Settings influencing the brightness of the image.

Exposure Mode
Select between manual and automatic exposure. Due to the type of image sequence we capture, it is advised to use manual mode, so constant camera settings are maintained during image capture.

Shutter Speed
The time the shutter is open to take one image. Higher values result in brighter images

Gain/ISO
Gain of camera signal, high values result in grainy images. Low values preferred.

Aperture
Adjust the lens opening. Higher values reduce the lens opening and result in darker images.

Focus
Settings influencing image sharpness and zoom.

Focus Mode
Select between fixed and automatic focus. Fixed focus is highly recommended.

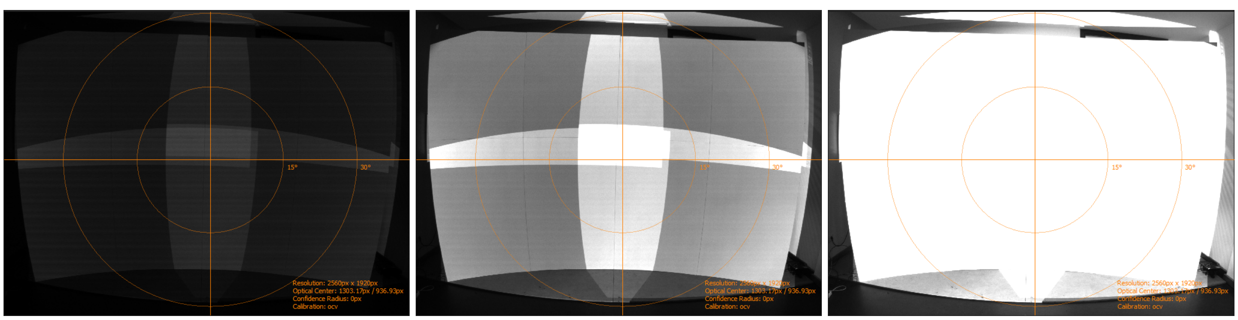
Digital Zoom
Should be deactivated.

Image Processing
Usually these settings should be deactivated.

Snap
Capture a new camera image using current settings.

Visualization
An overlay on the camera image visualizes the field of view and the principal point. Additional information about camera resolution and calibration is shown in the bottom-right corner.

The camera parameters should be set such that the projection is clearly visible but not too bright.



Comparison of camera settings: too dark / good / too bright

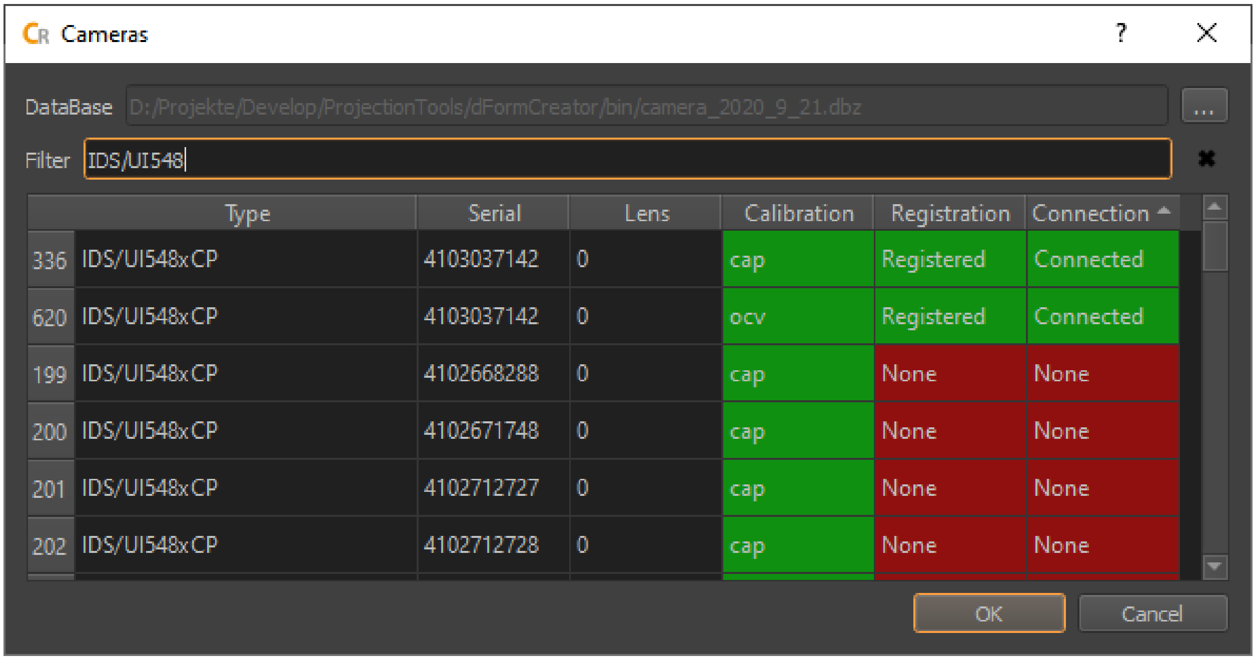
13.3.2 Camera Database Browser

The camera database browser allows to open and browse a camera calibration databases.

Its filter and sort functionality facilitates finding specific cameras, usually for adding them to calibration projects.

General use

1. Open a database file, using the button on top-right corner
2. Search for a specific serial, type, or connection status using the filter or sort the database contents based on a data column by clicking on its header.
3. select one or more lines in the table



4. hit ok, for use of the selected cameras and their calibrations in a project

Database
The camera database currently open. Open a new one using the open button on the right.

Filter
An optional filter string. Text data from all columns is used. Wildcard (*) usage is supported.

Type:
Camera manufacturer and type.

Serial
Camera body serial number.

Lens
Lens serial if known, otherwise 0 for perspective, 1 for fisheye lens type.

Registration
Shows, if camera is registered to currently active license dongle. Only cameras registered to current dongle can be used for capture in *Creator*/*Align*.

Connection
Shows if the camera is currently connected to the system.

13.4 Screen

The screen describes a theoretical screen shape. Information about the general screen shape is used e.g. for reference marker generation, calculating projection geometry and selecting a default mapping.

The screen information is entered using an assistant during project creation (see section *New Project Wizard*), but it can still be reviewed and adjusted in projects Screen dock widget.

13.4.1 Screen Editor

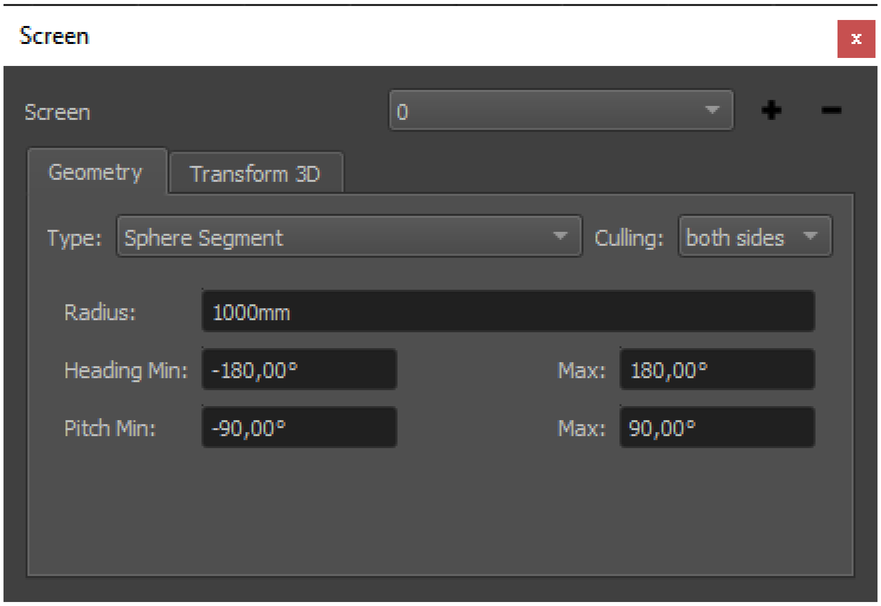


Fig. 8: Screen geometry

Select Screen
If multiple screens are defined in the project, select the current screen for editing.

Add Screen
Add a new screen to the project.

Remove Screen
Remove the currently selected screen. This is only possible when more than one screen are present in the project.

Geometry
General screen settings

Type
Depending on available license, select between different screen types

- Plane
- Cylinder
- Dome
- Sphere Segment
- Mesh
- Torus

Culling
select on which side of the screen is projected. By default both sides are activated.

Procedural Shape Settings
The standard shapes like Plane, Cylinder, Dome and Sphere Segment are procedurally generated. Their shape can be further adjusted using parameters to adjust their size and outline.

Mesh Settings
The mesh is usually imported from obj files generated by external software (scans or designs).

Import
Import a mesh from external files (e.g. obj, stl, ply, 3ds). Coordinate transformations can be adjusted in a dialog during import.

Export
Export the current mesh as obj file. Coordinate transformations can be adjusted in a dialog during export.

Mesh Info
Showing complexity and available data of current mesh.

Generate UVs
Generate simple planar uv-coordinates along one selectable projection axis.

Generate Normals
Generate vertex normals by interpolating adjacent triangle normals.

Flip Faces
Negates normals and flips triangles to point in opposite direction.

Transform 3D
Place screen in 3D-Space. Screen-geometry can be positioned, rotated and scaled. X, Y axis lying on ground, Z-axis pointing upward.

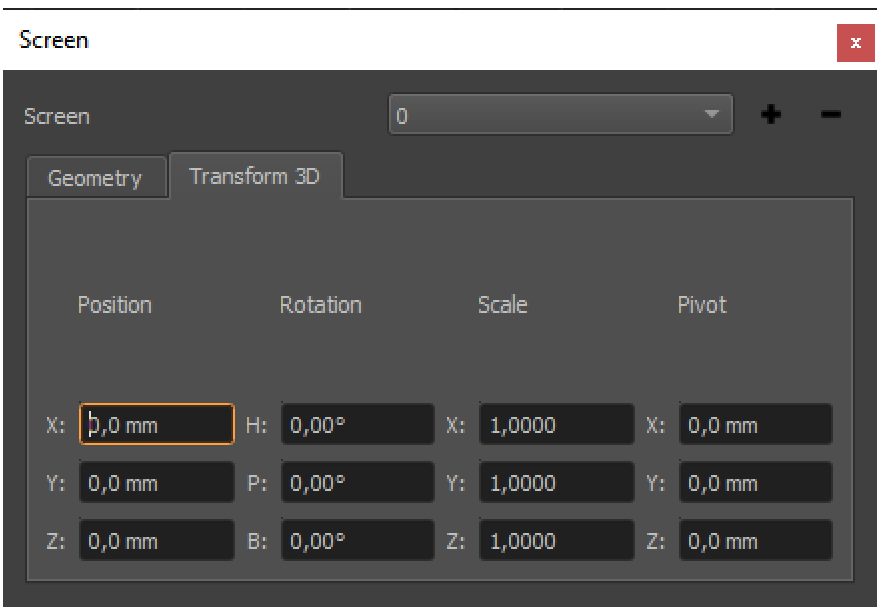


Fig. 9: Screen transform

13.4.2 Screen Assistant

The screen assistant allows to setup screen geometry based on simple input values on top of a graphical representation.

It is available in `Menu/Tools/Screen Assistant`.

The screen assistant supports the following screen types:

- plane
- cylinder

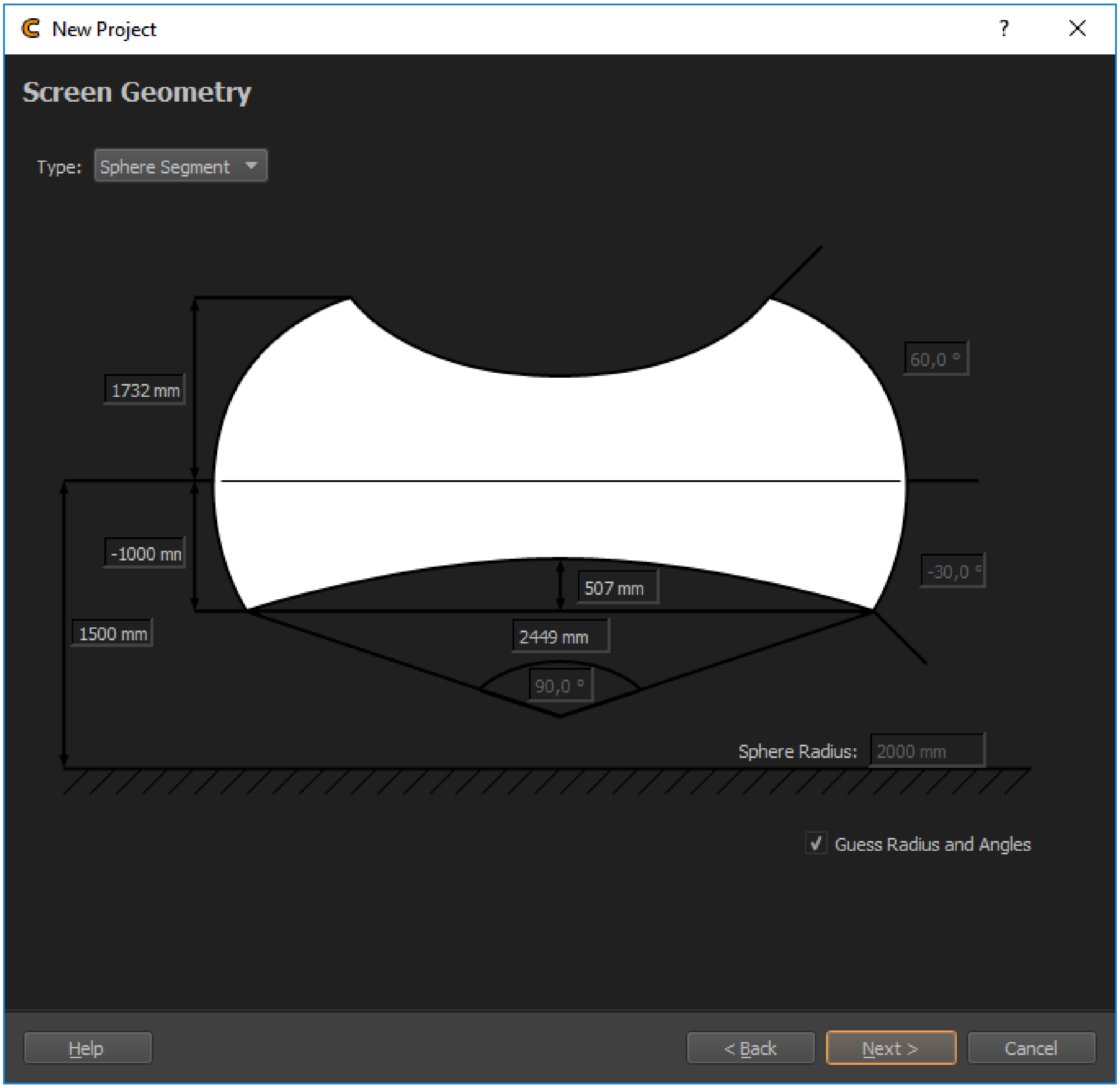


Fig. 10: Screen assistant

- dome
- sphere segment.

13.4.3 Screen Fitting

The fitting dialog allows to automatically calculate screen parameters based on measured points on the screen-surface.

It is available in `Menu/Tools/Screen Fitting`.

For the calculation the general screen type is necessary (automatically set, based on the project), and a set of points (by default reference points currently available in the project).

Note: Reference points usually have some additional points in the list, that are not lying on the screen surface. These points must be removed from the points list in the fitting dialog before fitting the screen.

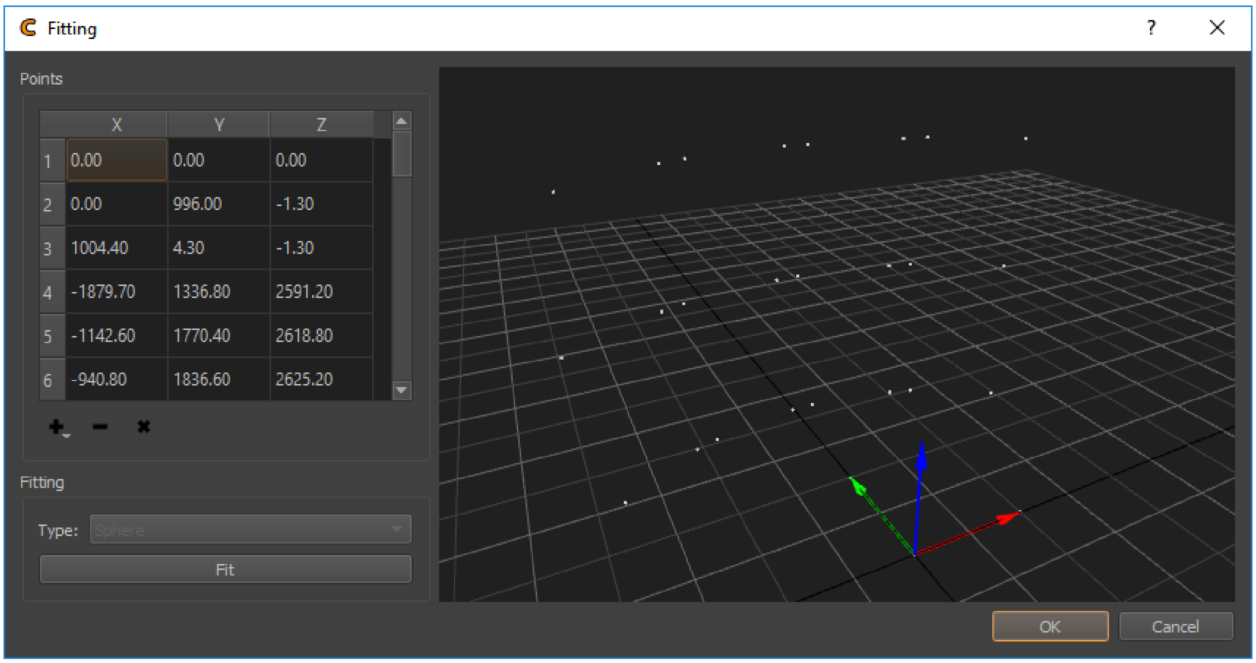


Fig. 11: Screen Fitting Dialog

+

Import points (multiple formats available)

- text file containing one point coordinate at each line ([id] x y z)
- Leica Disto 3D csv export
- obj file

-

remove selected points (only points on the screen surface should be contained in the list, If there are additional points in the import, these must be removed)

x

Clear the complete point list

Fitting Type
Shows the general screen-type (detected from project, either plane, cylinder or sphere)

Fit Button
Fits the screen-geometry to markers

13.5 Reference Points

Reference Points are known 3d-positions. They are usually related to visually detectable features, such as screen corners or any type of marker such as LEDs or Laserpoints.

They are used to calculate the position of calibration cameras (see section *Position Finder*) and give calibration results a scale and relation to the real setup.

A default set of reference points is generated on project creation, based on screen information given (see figure *Reference Points Visualization in 3D View*). This is usually sufficient for single camera position calibrations. For calibrations involving multiple camera positions, exact measured markers should be imported.

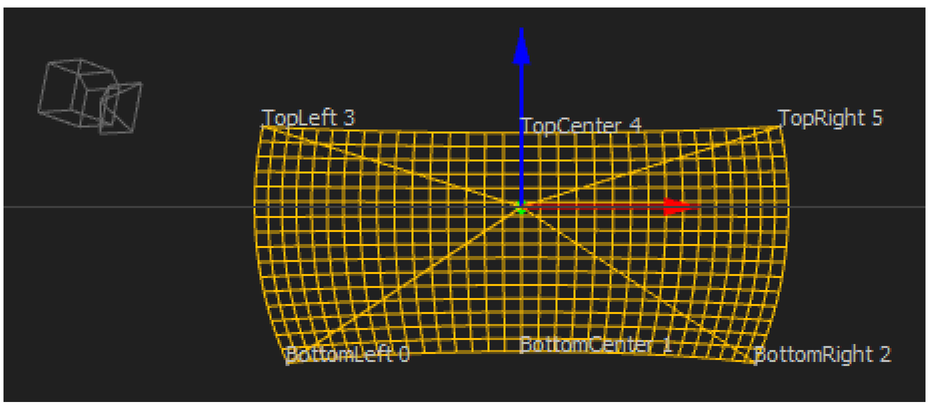


Fig. 12: Reference Points Visualization in 3D View

The reference points editor allows to view, generate and edit reference points.

List of Points
The list shows all reference points in the current project with their related 3d-position. Select points in this list for editing, removing or highlighting in different views.

List of Points Context Menu
A context menu allows to manipulate marker selection and manipulate multiple selected markers at once.

Index to Codemarker ID
Convert continuous index codes to CodeMarker IDs. Allows to apply an index shift, e.g. if the Reference point with code 3 should be the first Codemarker (with Codemarker ID 32), apply a shift of -3.

Shift Codes…
Add/removes given value to codes of selected markers.

Select New Markers
Selects reference points that are marked as new. These markers are not yet used for position finding since their own position is not yet calculated or valid.

Add Points ( **)**
Opens a drop-down menu with several options to add markers:

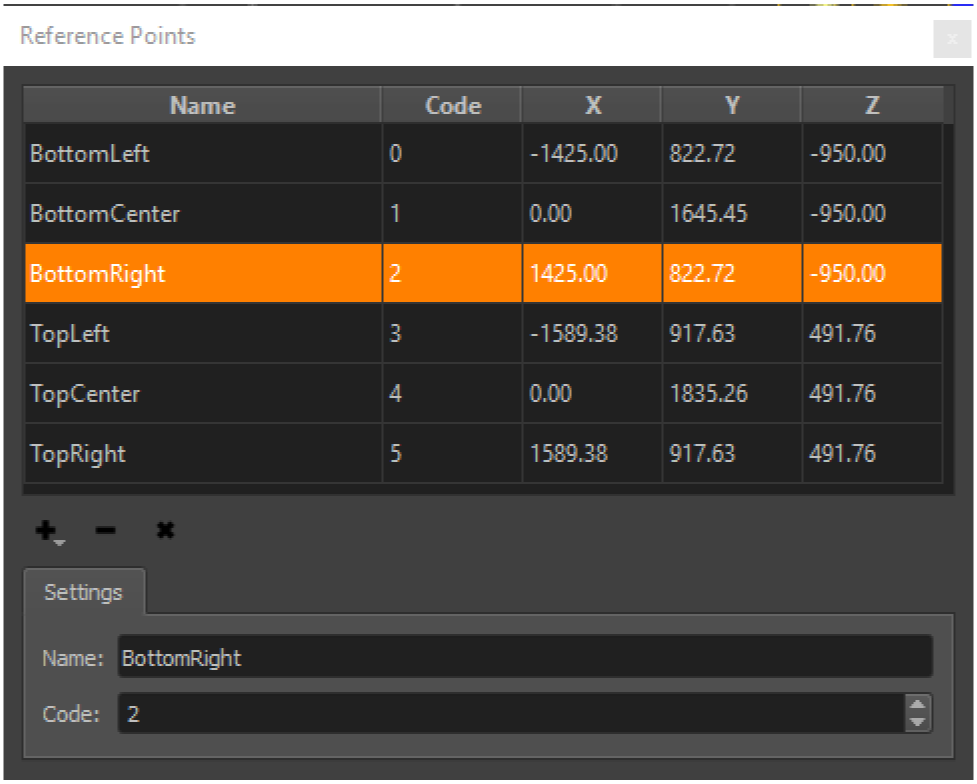


Fig. 13: Reference Points editor

Add single Marker
: Allows to manually add a single marker at a user defined position.

Generate Markers
: Generate reference points based on the ideal geometrical shape of the screen. This is usually sufficient for single camera position calibrations, but not recommended for multiple camera position calibrations.

  Procedural
  : For standard shapes like Plane, Cylinder, Dome and Sphere Segment a selectable number of marker rows and columns are generated automatically. Their shape can be further adjusted using parameters to adjust their size and outline.

  Mesh
  : For low-poly meshes (up to 100 triangles) the reference points are generated automatically at each vertex.

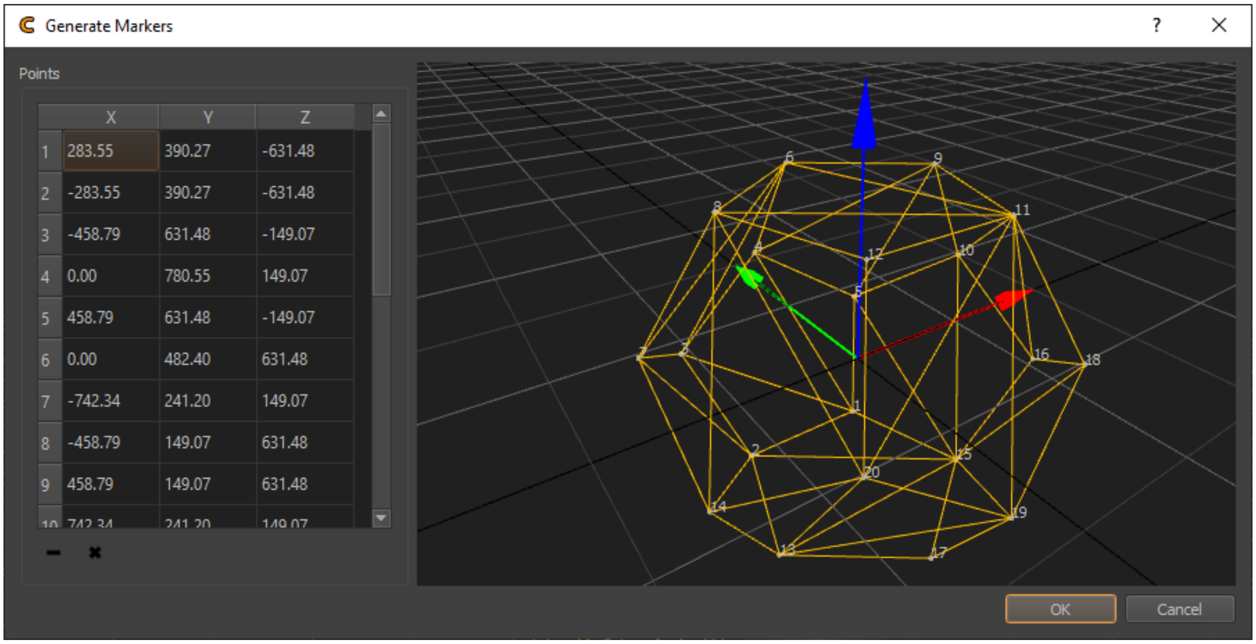
    For larger meshes, a dialog opens, that allows custom placement of markers on the current screen mesh, by clicking on the mesh in the 3d-view (snaps to close vertices).

Add new Markers
: Add a selectable number of new markers, that are marked as new. These can be triangulated later, to calculate their actual position.

Import Leica DST 360
: Import a proprietary format generated by Leica DST 360.

Import Leica 3D Disto
: Import a proprietary format generated by Leica 3D Disto. Please see appendix *Leica 3D DISTO* for details.

Measure Leica 3D Disto



Measure points directly using a custom dialog and a Leica 3D Disto connected to the computer. See Pointer 3D *Pointer 3D* for further details.

Import Leica Nova
Import a proprietary format generated by Leica Nova (MS50).

Import Points txt
Imports points from a generic textfile. No header expected. Whitespaces and comma are allowed as alternative separators.

```
id;x;y;z
```

Import Excel xlsx
Imports points form an excel sheet. The header row has to contain the targets for the columns.

code	x	y	z
1	0	0	0
2	1000	0	0
3	0	0	1000
…			

Delete Points ( )
Remove selected reference points.

Clear Points ( )
Clear complete reference points list.

Settings
Allows to adjust the name and code of selected reference points.

Name
A user given, descriptive name. Multiple reference points can have the same name.

Code
A unique number given to each reference point. When reference points are marked in Position Finder, the reference points are referenced by their code. So reimporting or exchanging reference points keeping the same code will replace the old reference points and the Position Finder references the new points.

Export
The Tools menu in Creator allows to export all reference points of the current project as .txt or .csv file. ()

Triangulate
`Tools Menu/Triangulate selected Reference Points...` in Creator allows to calculate or update the 3d position of reference points.

These reference points must be marked in at least one positions Position Finder. This would generate the new coordinate by tracing the current screen shape. When the reference point is marked on multiple positions, the 3d position is calculated by triangulating from these camera positions, ignoring the screen. This allows calculate correct 3d position for reference points, that are not placed directly on the screen surface.

13.6 Positions

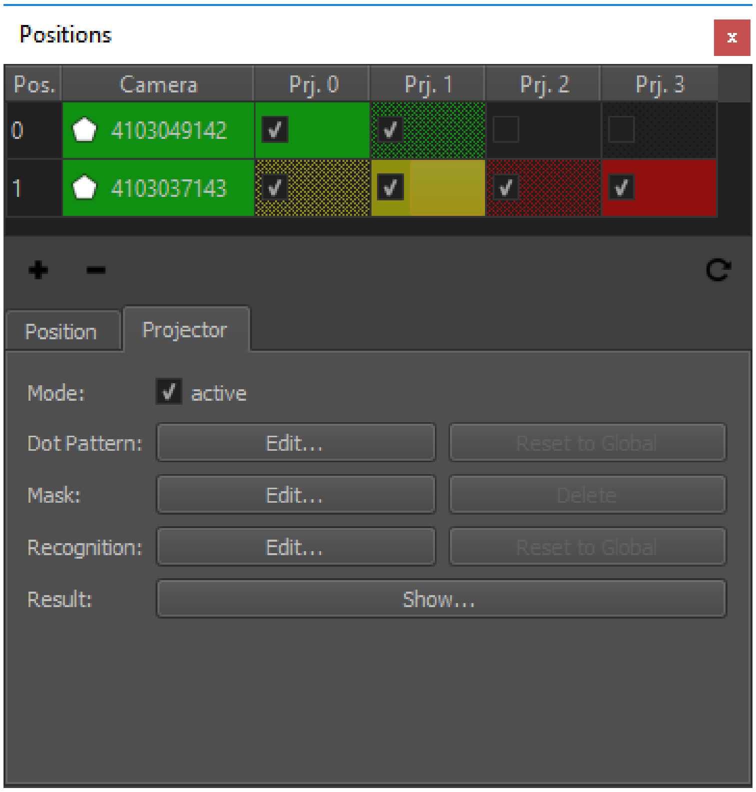
For capturing calibration data of a projection system, a camera is placed in front of the screen.

For small systems one camera at one position might be sufficient, to see the whole screen with all channels.

For bigger systems one camera might not be able to see the whole screen and all channels from one position anymore. In such situations the camera needs to be put in multiple places to capture the whole screen piece wise. If it is planned to calibrate such system multiple times there might even be different cameras fixed installed at multiple camera positions.

Creator organizes the calibration process in positions. Where each position holds information about the camera used, the position and orientation of the camera, the projection channels to be captured and adjustments of the calibration pattern.

The Positions editor gives a tabular overview of all positions and their related channels.

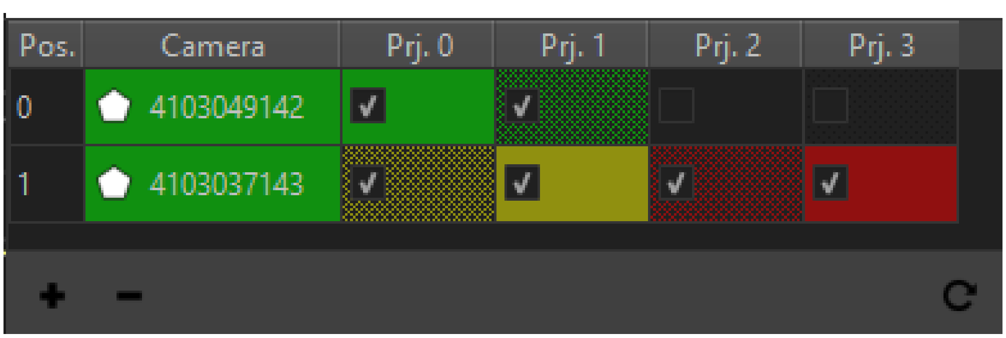


The positions are usually added one by one during the first calibration of a system.

Process per position:

1. Place camera
2. Select visible channels
3. Add position
4. Capture data
    1. Find camera position
    2. Capture calibration dot pattern for all selected channels

13.6.1 Positions Table



Cell Color

Quality estimate of measurement result based on comparing the number of detected and the number of projected dots.

Green
The same amount of dots where detected as where projected.

Yellow-Red
When less than 100% of the projected points where detected, the color gradually changes from yellow (99% detected) over orange to red (0% detected).

Red
No points, or more than projected points where detected.

Cell Fillpattern
Dithered if dot pattern where overridden, solid otherwise.

Polygon Icon
Shown if a mask is defined.

Checkmark
A cell is checked, if a projector is activated for calibration on a distinct position.

Selection
The selection in the positions list updates creators general projector and camera selection. Selecting a position or camera will automatically select all active projectors of this position and the assigned camera. Selecting a projector will select this projector and the camera of related position.

Tooltip
Shows how many points where detected and how many points where projected.

Doubleclick Camera or Position
open PosFinder for camera position

Doubleclick Projector
Open calibration result for projector. (see section *Result View*)

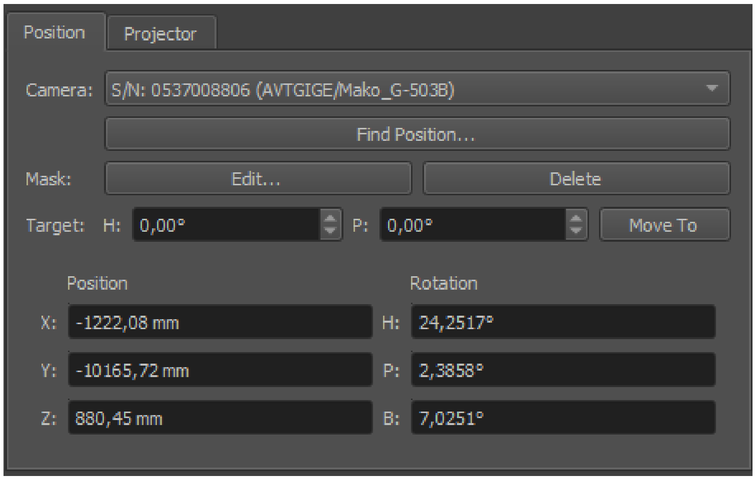
Context Menu
Quick access to camera/projector related editors.

Add Position
add new position with currently selected camera and projectors

Remove Position
user defines exact position of marker/feature in image. No image analysis is done for this marker

Update Position List
refresh positions table

13.6.2 Position Tab



Camera
Select the camera that should be used on this position.

Find Position
Find camera position and orientation using Position Finder (see chapter *Position Finder*).

Mask Edit
Edit a mask that is applied to the camera image to avoid false point recognitions, e.g. reflective surfaces or flashing projector lenses. It can be combined with projector masks. (see section *Mask Editor*)

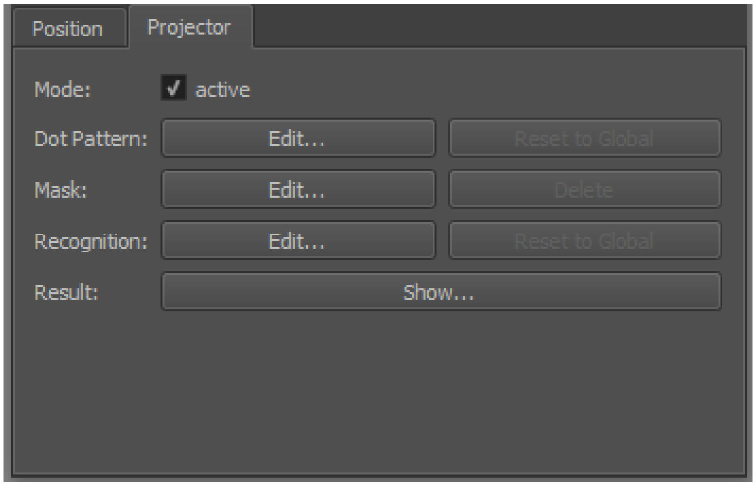
Mask Delete
Delete mask and use complete camera image for detection.

Target H/P
Set target heading and pitch for motorized rotation unit.

Target Move To
Move rotation unit to currently set target rotation.

Position/Rotation
Camera Position and Orientation on this position.

13.6.3 Projector Tab



Active
Set if selected projector on selected position should be active for calibration.

Dot Pattern Edit
Override dot pattern for current projector on current position. (see section *Dot Pattern Editor*)

Dot Pattern Reset to global
Remove dot pattern override and use global dot pattern settings for current position.

Mask Edit
Edit a mask that is applied to the camera image to avoid false point recognitions, e.g. reflective surfaces or flashing projector lenses. It can be combined with position mask. (see section *Mask Editor*)

Mask Delete
Delete mask and use complete camera image for detection.

Recognition
Allows to override recognition settings for current projector on current position.

Recognition Reset to Global:
Removes the override.

Show Result
Shows a result image where recognized points are marked with a cross and row/column number (see section *Result View*). If errors in the order are visible or less than 85% of points where recognized the camera parameters, recognition-parameters and masks should be checked and image taking or/and image analysis must be repeated.

CHAPTER FOURTEEN

NEW PROJECT WIZARD

New projects can be created using Creators menu entry `File/New Project...`.

A wizard will open and request all necessary information. A new project path with sub-folders and configuration project files will be created. Following subsections describe the available options on different pages of the project creation wizard.

14.1 Basic Settings

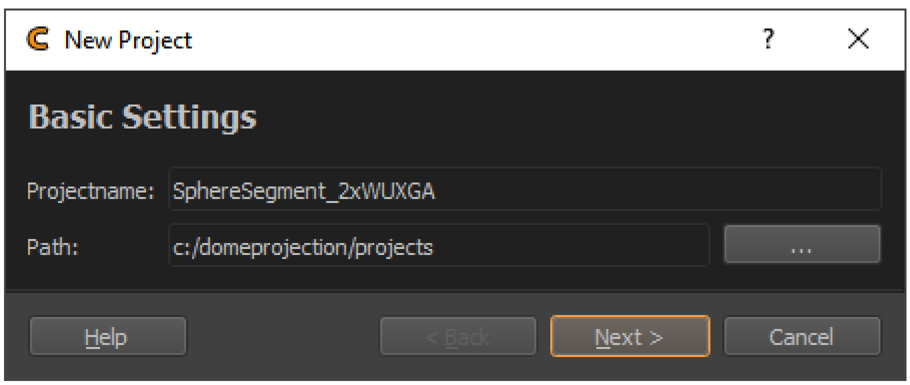


Fig. 1: Basic Settings

Projectname
Name of the project. Subfolder with this name will be created.

Path
Folder where the new project should be created (subfolder will be created, based on project name)

14.2 Screen Geometry

Here the screen type and parameters should be set up.

Type
Select the screen type to be used.

- Plane
- Cylinder

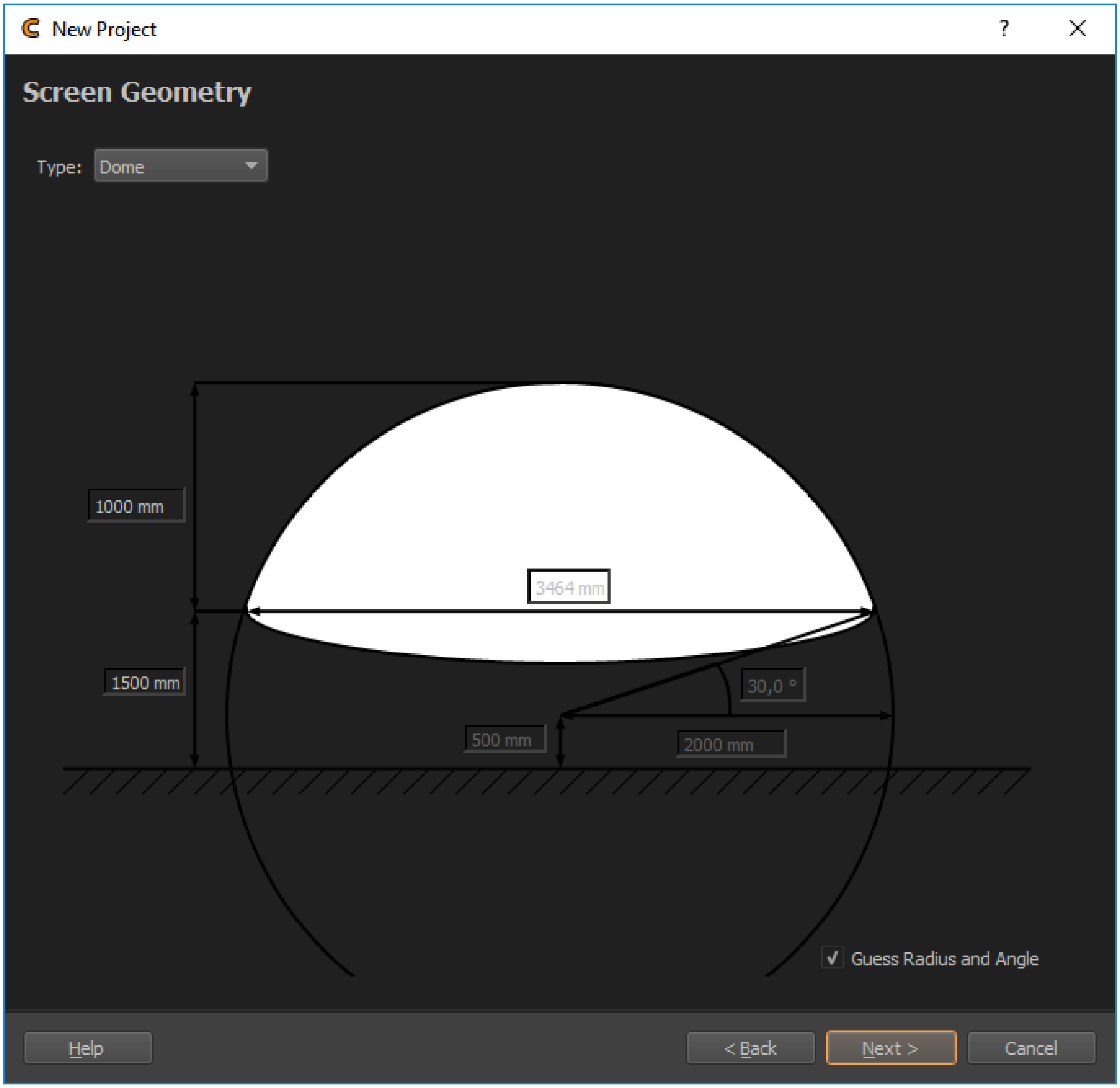


Fig. 2: Screen Assistant

- Dome
- Sphere Segment
- Custom

Angles and Radius
Design data for Cylinder and Sphere Segment screens. These are automatically generated when *Guess Radius and Angle(s)* is enabled.

Distance Measures
Several distance measures such as width and height can be adjusted for each screen type. Some of these inputs are generated when *Guess Radius and Angle(s)* is disabled.

Guess Radius and Angle(s)
Allows to enter measured lengths instead of angles for Cylinder and Sphere Segment screens. This is enabled by default.

Depending on the license type it is also possible to import custom screen shapes from mesh files.

File
Mesh file in one of the supported formats.

- WaveFront Object (*.obj)
- Stereolithography (*.stl)
- Stanford Polygon Library (*.ply)
- 3ds Max (*.3ds)
- AutoCAD DXF (*.dxf)
- Autodesk (*.fbx)
- glTF (*.gltf *.glb)
- Collada (*.dae)
- LightWave (*.lwo *.lws)
- Modo (*.lxo)
- Blender (*.blend)

Units
Adjust units used in file.

Axis
Select axis orientation used in file.

14.3 Channels Setup

During calibration, the Creator needs to project test patterns on all channels (typically, but not limited to projectors). On this page the type of pattern generation, the number of channels, their resolution and communication information can be set.

By setting the “Channel Type”, ”Count”, ”Start IP”, Channels per IG” and resolution a list of channels is generated. The generated list of channels can be modified directly as well.

Type
Interface to use for showing testpatterns.

- PatternGenerator (default)

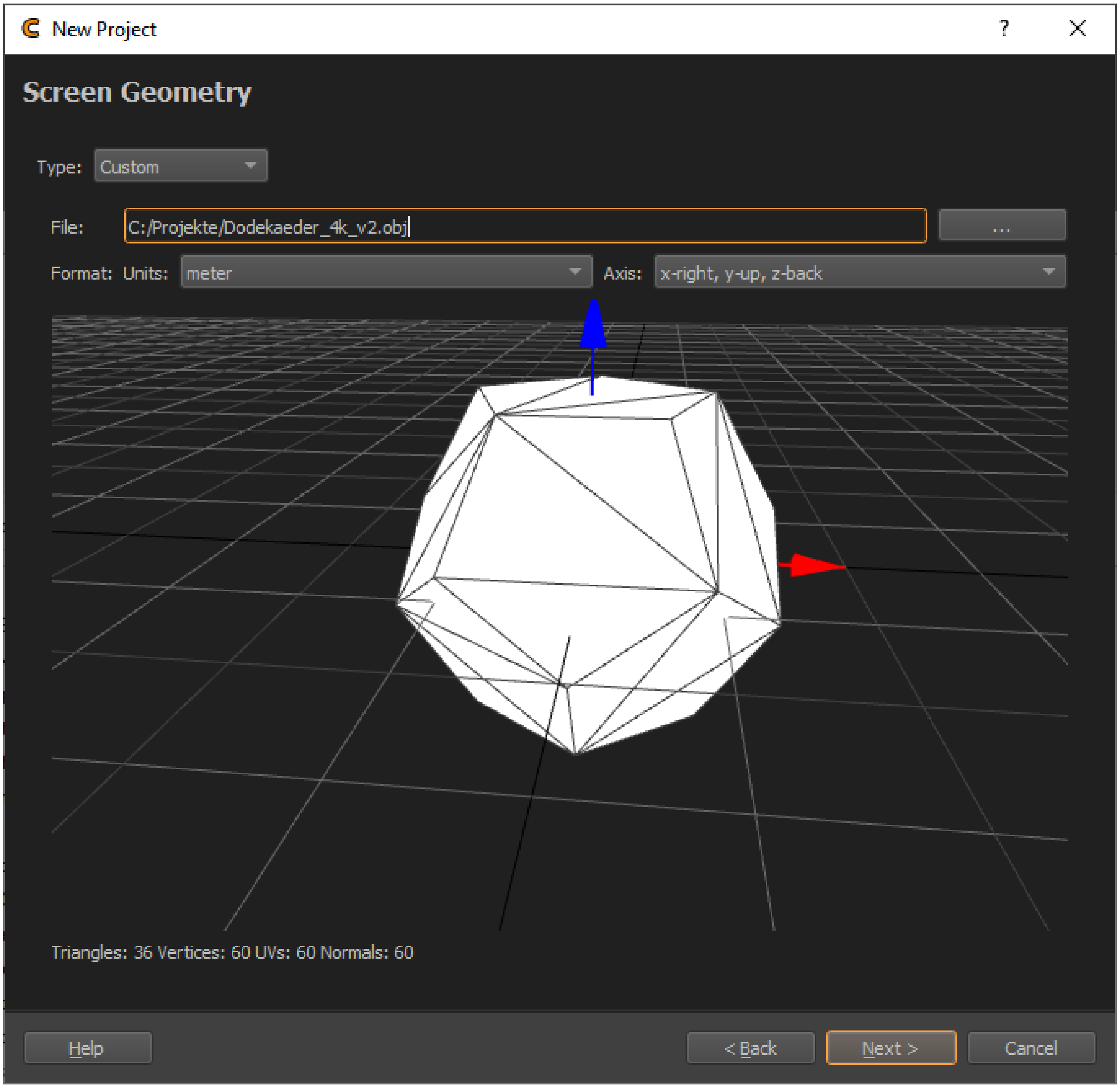


Fig. 3: Screen custom

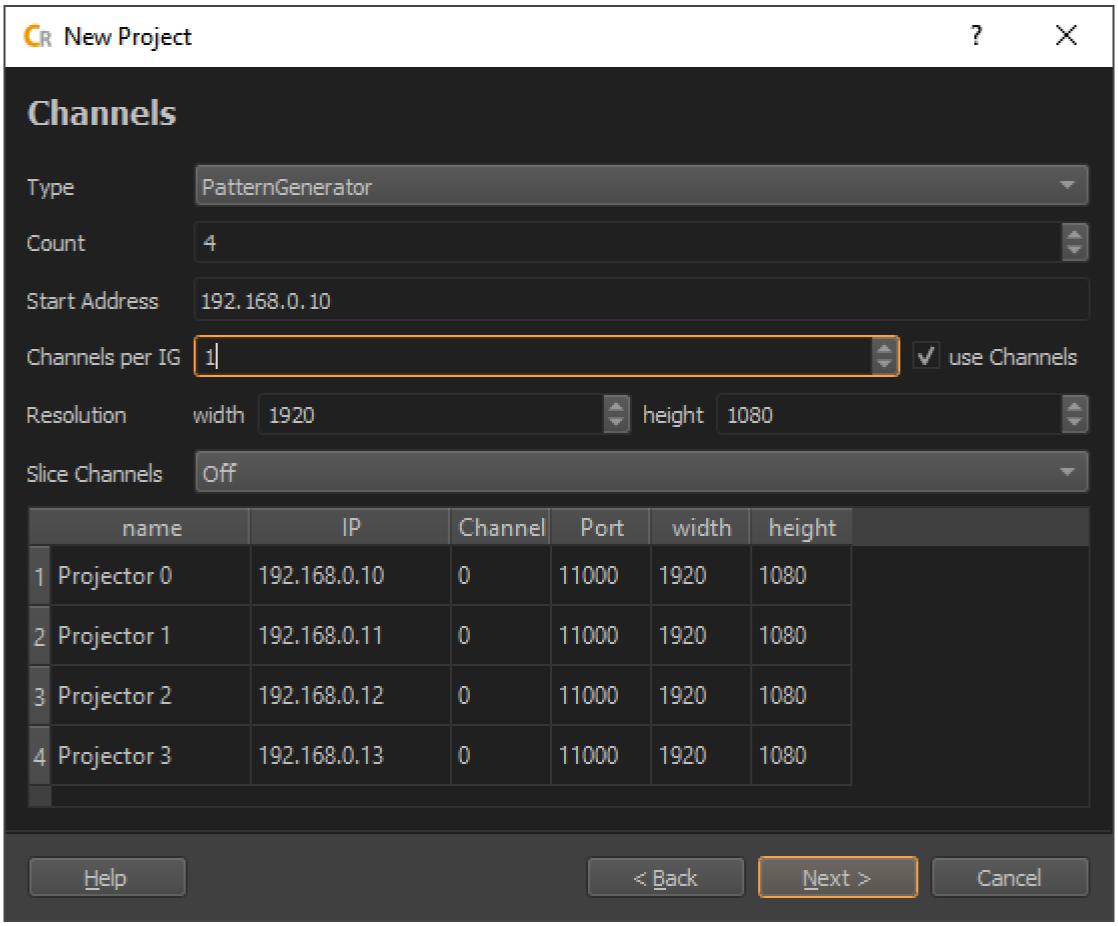


Fig. 4: Projector Setup

- NDI
- Norxe Unify
- Barco Pulse
- Luna
- Warper4k

Count
Number of projectors(channels) that should be calibrated

Start Address
IP Address or name of pattern generating device used on first channel. In case of PatternGenerator usually the ip of the image generator pc attached to the first channel. In case of channel type Norxe Unify or Barco Pulse the IP of the projector. In case of NDI a name for the NDI stream. Number in Address is automatically incremented for additional Channels.

Channels per IG
Defines how many channels are attached to each Image Generator (multiple channels in the generated list will get the same ip address).

Resolution Width / Height
Channel resolution. The same setting will be used for all channels by default. If different resolutions are used in the system, the generated channels list can be modified.

PatternGenerator use Channels
Activated by default. Should only be deactivated, if multiple PatternGenerator instances are running on one Image Generator (in that case multiple ports need to be used for communication).

Slice Channels
Activate for channels, where **pattern generation needs to be split** across multiple pattern generators, **but only one correction data set** must be generated. For example multiple computers are attached to one projector and only one warping/blending set needs to be generated for each projector. Multiple standard configurations are available for selection.

Generated Channel List
This list is automatically generated according to the setting above. The settings for each channel can be further modified in the list.

IP Column
network address of computer where PatternGenerator software is running on

Channel Column
channel number, used for PatternGenerator showing patterns for multiple projectors inside one instance

Port Column
Port to communicate with PatternGenerator. By default 11000. If multiple PatternGenerator run on one computer different ports need to be used

Width / Height Columns
Resolution of projector

14.4 Camera Selection

Use Camera Calibration
Activate to use camera intrinsic calibration information (recommendet). If you have an uncalibrated camera, this must be turned off. Depending on this setting one of the following forms will be visible.

14.4.1 Calibrated Camera Selection

When "Use Camera Calibration" is checked, a list of available camera calibrations will be shown.

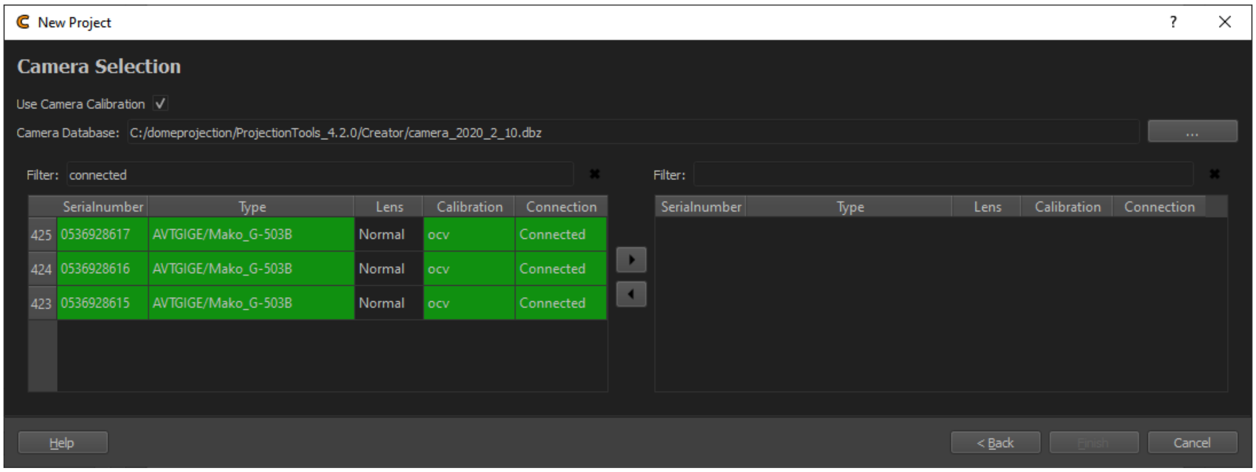


Fig. 5: Camera List

Here the camera/cameras can be selected, that should be used in the new project. In order to add cameras to the project do the following:

1. Select a Camera Database file, when not found automatically.
2. Select cameras in the left list
3. Use the right-arrow to add selected cameras to the right list

Camera DataBase File
Database containing camera calibration informations. When camera database is placed in Installation folder, it is found automatically.

Filter:
Allows to quickly find cameras in the list, e.g. by serial, type or connection state. Just enter the known information and the corresponding list is filtered dynamically.

Cross
Quickly remove current Filter.

Right-Arrow
Add selected cameras to project

Left-Arrow
Remove selected cameras from project

14.4.2 Uncalibrated Camera Selection

When "Use Camera Calibration" is unchecked, the following form will be shown.

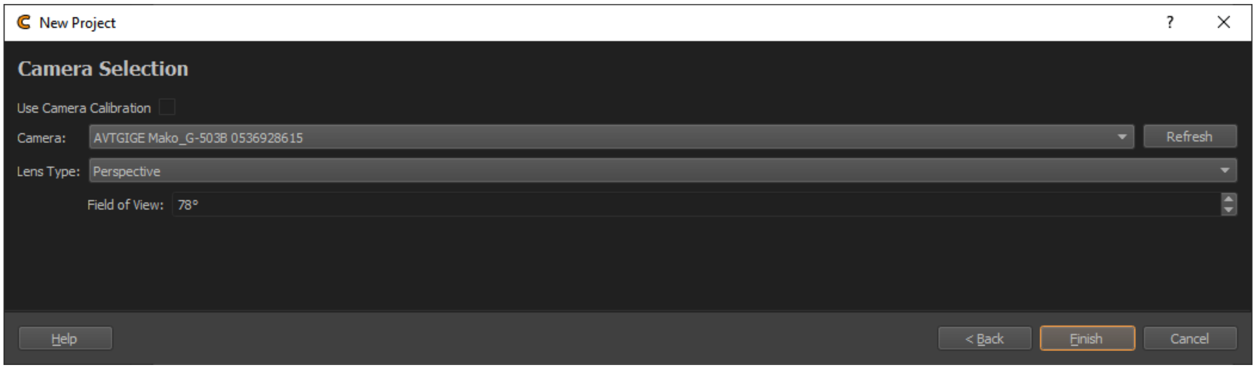


Fig. 6: Camera selection

Here connected cameras are shown and information about the used optics must be entered.

Camera Dropdown
List of found, connected cameras, to select from.

Refresh
Search for connected cameras again and update the Camera Dropdown list.

Lens Type
Select between "Perspective" and "Fisheye".

Field of View
Shown for perspective lens type. The diagonal viewing angle visible on the camera image. This information is usually povided by the camera/lens manufacturer. Alternatively it can be calculated using the following formula:

```
FOV = 2*atan(0.5*diagonal / distance)
```

Opening Angle
Shown for Fisheye lens type. The vertical viewing angle visible on the image, e.g. 180 degrees for normal fisheye fitting in the camera image.

CHAPTER FIFTEEN

ADJUST ORIGIN

All data of a calibration project is oriented according to a defined coordinate system. In simple projects, this origin might be a default position defined during project creation. Or it might be implicitly defined by reference markers imported into creator.

Adjust Origin allows to change this origin in position and orientation.

15.1 Manual Transform

The transform based tool can be found under `Tools/Adjust Origin...`.

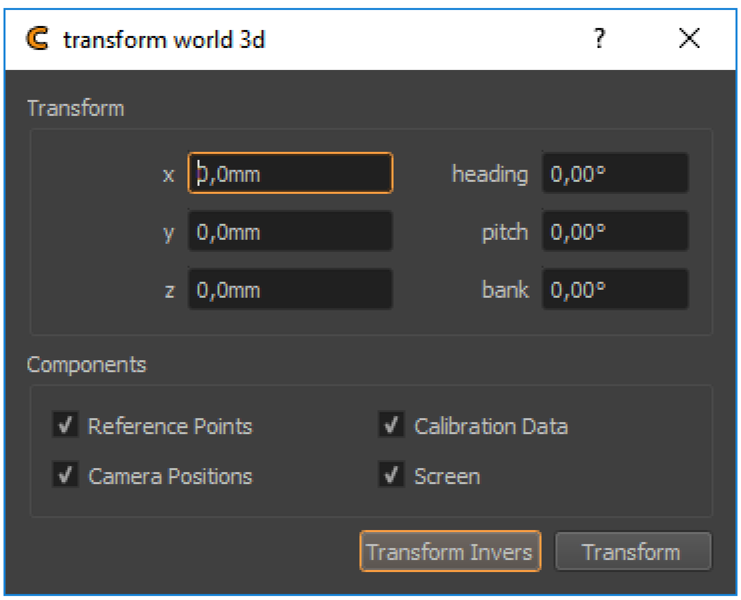


Fig. 1: Transform World 3d dialog

Transform
: Set the offset translation and rotation.

Components
: Select the components, that should be transformed. All on by default.

Transform Invers
: Removes the given transformation and makes the entered position and orientation the new origin of the calibration project.

Transform
Offset the calibration by given position and orientation.

Warning: Mapping and Viewpoint settings in Mapper might need to be adjusted manually after transform.

15.2 Adjust Origin 3 Points

Adjust Origin 3 Points allows to reorient the calibration project according to 3 reference points. The first point defines the new origin and the second and third point define the new orientation.

The project can be rescaled using this tool as well.

The tool can be found under `Tools/Adjust Origin 3 Points...`.

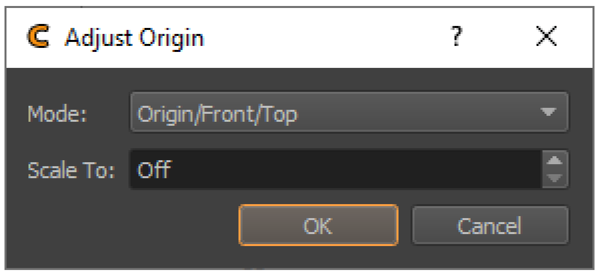


Fig. 2: Adjust Origin 3 Points dialog

Mode
Select the intended position/direction of the 3 points.

- Origin/Front/Top
- Origin/Front/Right
- Origin/Right/Top

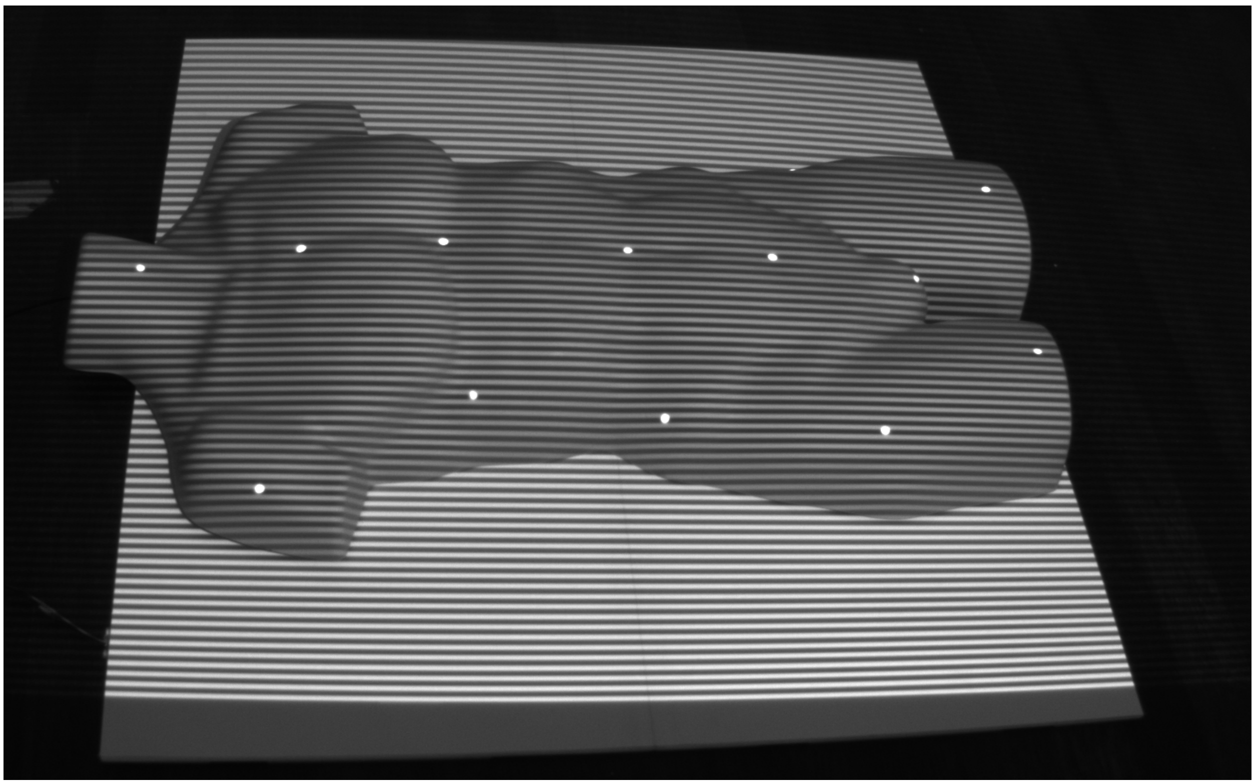
Scale To
An optional target length between first and second reference point can be given here.

Warning: Mapping and Viewpoint settings in Mapper might need to be adjusted manually after transform.

CHAPTER

SIXTEEN

HIGH RESOLUTION SCANNING



While not necessary for most projection systems, there are some cases, where scanning the screen shape in high resolution is useful.

For example projection mapping on detailed discontinuous shapes requires knowledge of the exact 3d shape of the object or scene to project on. If this shape is not known in advance and no appropriate scanners are at hand, this shape can be constructed directly with ProjectionTools.

The scanning process requires at least one projector (for projecting the structured light) and two camera positions (for triangulating the 3d shape).

The achievable resolution is related to the projector and camera resolution.

A higher resolution and greater coverage of the objects can be achieved with multiple projectors projecting from different sides and additional cameras or camera positions.

16.1 Settings

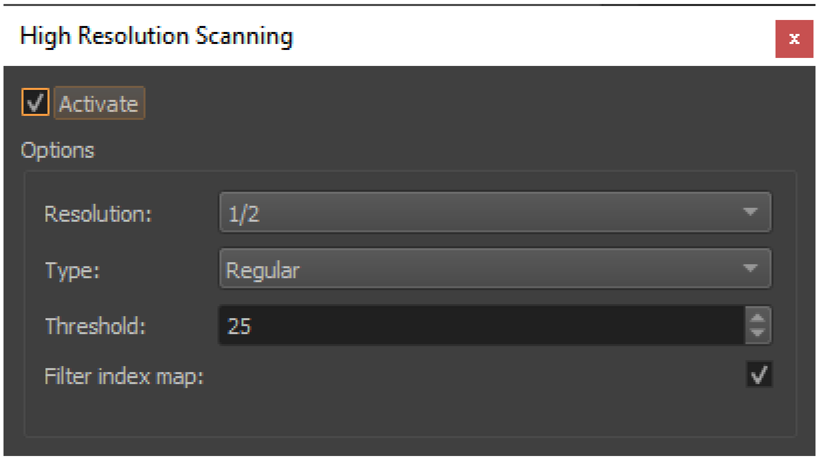


Fig. 1: High Resolutio Scanning Settings

Activate
Activate high resolution scanning during standard capturing process.

Resolution
Select scanning resolution, relative to projection channel resolution.

Type
Select the pattern and algorithm used for scanning.

Regular
Regular gray code, projecting a sequence of rough to fine striped images.

XOR-04
A modified version, always projecting fine striped images. This produces more constant lighting conditions during the whole sequence. Well suited for scenes with much cross-reflection, but less robust against aliasing. Make sure the camera has enough resolution to capture the finest lines safely.

Threshold
Binarisation threshold used for analysing the captured images.

Filter index map
Removes noise in the captured index map. Might remove fine details.

16.2 Usage

The capture process can be included in a standard calibration project with at least two camera positions, following these steps:

1. Open the High Resolution Scanning dock using
2. Activate High Resolution Scanning
3. Select resolution and check if the pattern is clearly visible in the camera using the preview stripes and having a look at the camera image at “1:1” zoom. If the camera resolution is too low, reduce the resolution of the calibration pattern.
4. Proceed with data capturing as usual. The required stripe patterns will be captured in addition to the dot pattern.

5. Generate 3d will now also create dense pointclouds for each projection channel.
6. In order to use the data use in Creator or MapperPM. Here you can cleanup the pointcloud, mesh the surface or even fit standard screen shapes. See chapter *Pointcloud Conversion* *Pointcloud Conversion* for further details.
7. The extracted shapes can than be used as screen in Creator for simpler recalibration, and as a Mapping in MapperPM for projection. The data can also be exported for further preparation in external modeling software.

CHAPTER SEVENTEEN

ABOUT ALIGN

After a projection system is calibrated once, it usually does not stay perfect over its whole lifetime. A thermal drift, drift induced by a motion platform, a loose optic, a lamp exchange or a projector exchange might noticeably change the resulting projection. To get a perfect image again the system would need a new calibration. Doing normal calibrations all the time might be too time consuming, especially when the screen shape is not perfect and needs to be captured stereoscopic using multiple camera positions, or a big mockup stands in the projection system after initial calibration which might be difficult or impossible to remove for recalibrations.

Assuming the screen shape is not changing and some permanent, stable reference points are available, recalibrations usually can be automized, and by reusing data from an initial calibration requiring less camera positions than during initial calibration.

Align allows to re-align drifts in already calibrated, fixed installed projection systems, using digital cameras and a high degree of automation (support for multiple fixed installed cameras or a camera on rotation unit). Align generates new data that is the basis for Mapper2d/Mapper3d to calculate updated warping and blending information.

Align keeps the initial calibration data (created with Creator) untouched so that the *Mapper2D/3D* could always switch back to the initial calibration data. It makes also use of the initial calibration data to extrapolate uncaptured areas on the projection surface, which might be obstructed by a mockup during recalibration.

In normal operation mode Align has an interface focused on running recalibration, hiding options only needed during setup. This makes the user interface more clean and avoids breaking an alignment configuration by accident.

Align needs to capture test-patterns on the projectors. For that purpose it needs:

1. A testpattern generation program running on display computers attached to the projectors (PatternGenerator
2. network connection to display computers to communicate with the testpattern generation program
3. a calibrated camera attached to the computer, where Align is running on

The following chapters describe the UI components of Align and the basic workflow of doing re-alignements.

CHAPTER

EIGHTEEN

STARTUP PARAMETERS

Align can be started with a project file as parameter. And the automiation pipeline can be run automatically.

There is also a commandline version of **Align**, called **AlignC**, intended for batch scripting. Both executables support the same options and arguments.

```
Align [options] project
AlignC [options] project
```

Options:

Option	Description
-?, -h, –help	Displays help on commandline options.
-v, –version	Displays version information.
-r, –run	Run automization pipeline on startup.
-s, –simulation	Run in simulation mode
-u, –noui	Don’t start with user interface.

Arguments:

Argument	Description
project	Path to projects configuration xml that should be loaded on startup.

CHAPTER

NINETEEN

CREATING AN ALIGN PROJECT

An align project is meant to be used for recalibrating a fixed installed system multiple times in an easy and fail-save as possible way.

The Align program shows a reduced GUI focusing on recalibrating the system with a few clicks.

The align tries to use as less as possible cameras/positions by basing the recalibration on an initial calibration, that had captured the screen geometry and initial projection placement. Thus, an align project is tied to a distinct site/projection-system and should not be copied between multiple sites.

Align keeps the initial calibration data (created with Creator) untouched so that the *Mapper2D/3D* could always switch back to the initial calibration data.

19.1 Conversion using new camera positions

The align project is created from a normal creator project by exchanging cameras and defining new camera positions using the following steps:

1. Do a normal calibration of a system using Creator, and verify the results.
2. Open Align program
3. Activate service mode using `Help/Service Mode...`
4. Generate an align project for your initial creator calibration using and follow the wizzard, that allows to select the original project and a new set of cameras. The modified project is automatically opened in align.
5. Setup camera positions for the new camera set, like it is done in the normal creator.

When everything is setup and automated, the alignment can be run through by just hitting the play button in the toolbar.

After leaving the service mode the position configuration can no more be changed.

19.2 Reusing initial camera positions

Sometimes the initial calibration with creator might have been done using fixed installed cameras, that will be used for Align as well. In that case the Creator project including its used cameras and positions can be transferred to an Align-project directly from Creators file menu.

1. Load the project in Creator
2. use `File/Transfer Creator Project to Align`
3. Save and close project
4. Open project in Align

CHAPTER

TWENTY

RUNNING AN ALIGN PROJECT

The following chapter describes an autoalignment process and discusses possible issues.

20.1 General preparations

1. Clean up the space in the projection area. Remove all obstacles in front of the projectors, laser markers and cameras. Remove cover from camera optics.
2. Turn off all lights and make sure, that nobody enters the area during picture taking.
3. Turn on the control pc, the visualization computers, the projectors and the cameras.
4. Leave the projectors running for at least 30 minutes.
5. Switch all eventually existing warping-hardware and warping-software into bypass mode. The image from the visualization computers must be shown native, without geometry correction or blending applied.
6. Start the PatternGenerator software on all Igs (Program menu or `c:\domeprojection\PatternGenerator\PatternGenerator.exe`). All Channels will display a domeprojection logo.

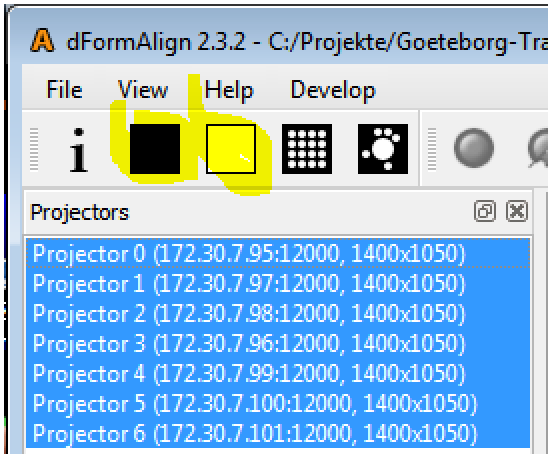
20.2 Starting the process

There are two ways to do the alignment, depending on the integration. The process is either full automated or semi-automatic. Both variants are described below.

20.2.1 Full Automated Alignment

This type of calibration is typically used, for systems with multiple fixed installed cameras or with one camera on a motorized mount.

1. Start the Align program on the control pc. The corresponding project should automatically be loaded. If it is not loaded, use `File/Load Project...`.
2. Check connection to visualization computers and if there is still any warpunit or warpsoftware active: Select all projectors (click into projector list and press `CTRL-a`) and press the black/white preview buttons to test the connection. You have to check if the blending is still visible in the white preview.
3. Connect to the cameras using the camera button. You have to see a live preview of one camera. If not, check the connection with the camera driver software, and try to connect again.
4. Start alignment with the run pipeline button. A progress bar appears and patterns are displayed on the projection. When the process is finished a message window will appear.



5. Save the project and open it in Mapper2D/3D for checking results and exporting data.

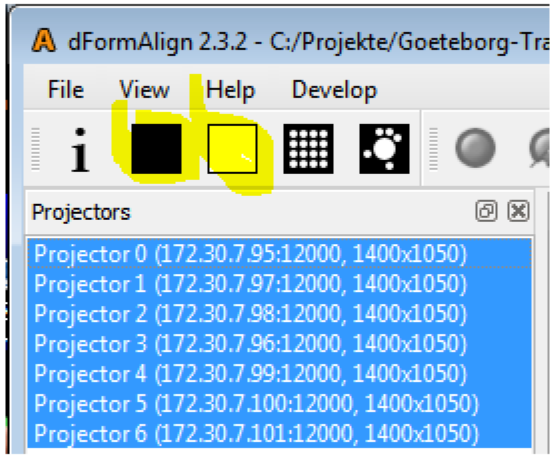
20.2.2 Semi automatic Alignment

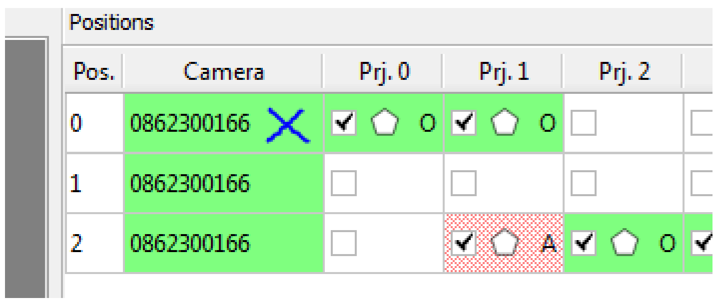
This type of calibration is typically used, when only one camera without motorized tripod head is available, but multiple camera positions/orientations are needed to capture the whole projection system.

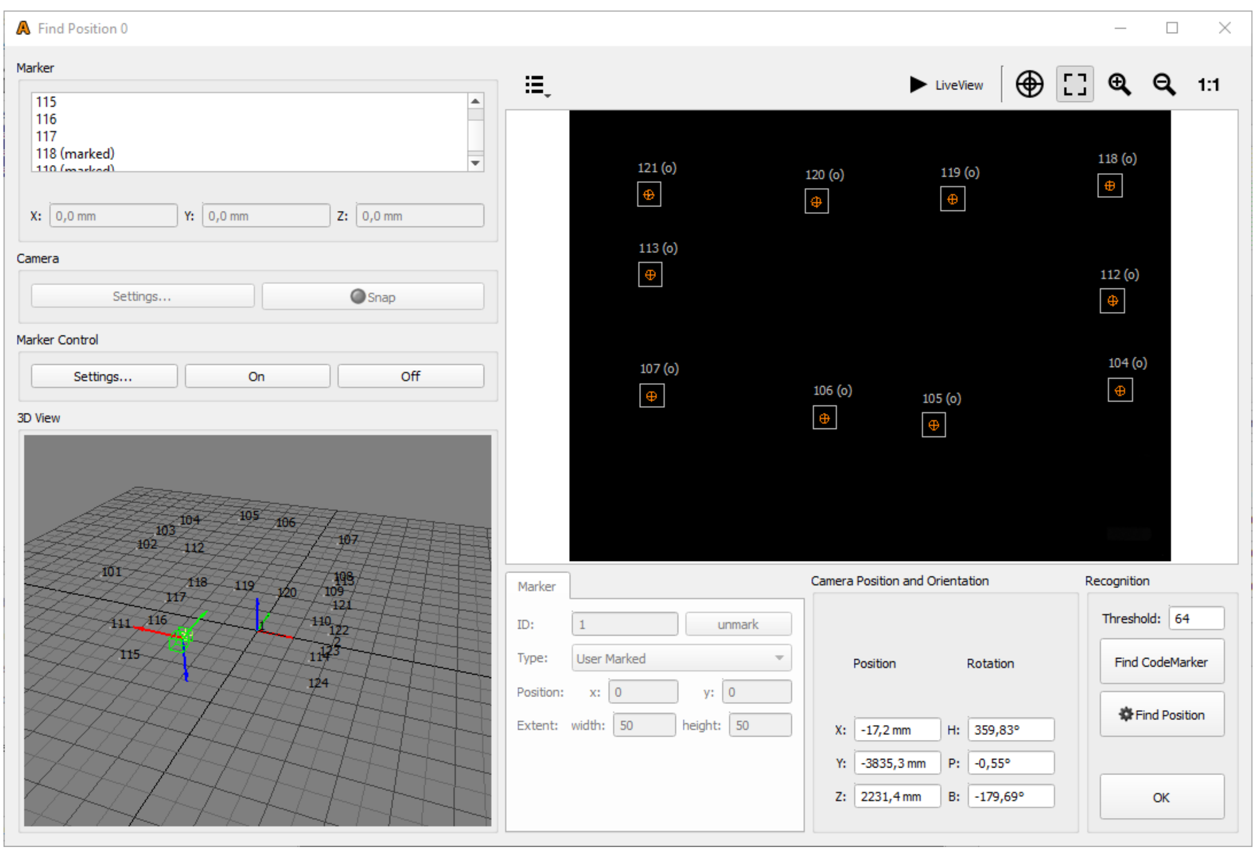
1. Start the Align program on the control pc. The corresponding project should automatically be loaded. If it is not loaded, use `File/Load Project...`.
2. Check connection to visualization computers and if there is still any warpunit or warpsoftware active: Select all projectors (click into projector list and press `CTRL-a`) and press the black/white preview buttons to test the connection. You have to check if the blending is still visible in the white preview.
3. Connect to the cameras using the camera button. You have to see a live preview of one camera. If not, check the connection with the camera driver software, and try to connect again.
4. Move the camera to the position that should be captured. The camera positions are typically predefined on site. There are either, multiple mounts where the camera can be attached or a tripod needs to be rotated to defined angles.
5. Check and calculate the camera position of a position, that should be captured. Double click on the camera column of corresponding position.

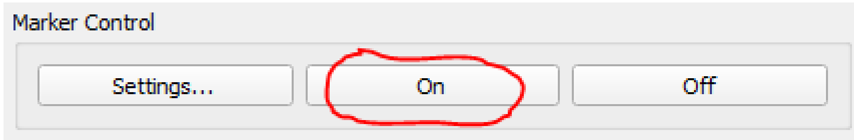
   The Find Position window will open up.
6. Turn on the position markers (lasers) with the Marker Control On button.
7. Then take a picture with the Snap button so you can see the laser markers and the expected positions.

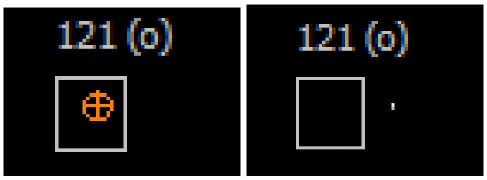
   If the white dots (laser markers) are inside the blue rectangles the camera position is good. The camera position is bad if they are outside or on the blue lines.


dFormAlign 2.3.2 - C:/Projekte/Goeteborg-Tra
File
View
Help
Develop
Projectors
Projector 0 (172.30.7.95:12000, 1400x1050)
Projector 1 (172.30.7.97:12000, 1400x1050)
Projector 2 (172.30.7.98:12000, 1400x1050)
Projector 3 (172.30.7.96:12000, 1400x1050)
Projector 4 (172.30.7.99:12000, 1400x1050)
Projector 5 (172.30.7.100:12000, 1400x1050)
Projector 6 (172.30.7.101:12000, 1400x1050)


Positions
Pos.
Camera
Prj. 0
Prj. 1
Prj. 2
0
0862300166
1
0862300166
2
0862300166


Find Position 0
Marker
115
116
117
118 (marked)
X: 0,0 mm
Y: 0,0 mm
Z: 0,0 mm
Camera
Settings...
Snap
Marker Control
Settings...
On
Off
3D View
LiveView
1:1
121 (o)
120 (o)
119 (o)
118 (o)
113 (o)
112 (o)
107 (o)
106 (o)
105 (o)
104 (o)
Marker
ID: 1
unmark
Type: User Marked
Position: x: 0 y: 0
Extent: width: 50 height: 50
Camera Position and Orientation
Position
Rotation
X: -17,2 mm
H: 359,83°
Y: -3835,3 mm
P: -0,55°
Z: 2231,4 mm
B: -179,69°
Recognition
Threshold: 64
Find CodeMarker
Find Position
OK





From left to right: good position, bad position

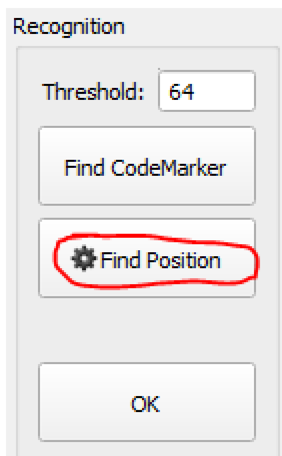
8. Fix bad camera positioning (markers outside blue rectangles) by doing one or both of the following:

   1. If the camera positioning/orientation is completely done by hand, check positioning of the tripod, and try to adjust the tripod head (typically a gear head with seperate precise controlls for heading, pitch bank)

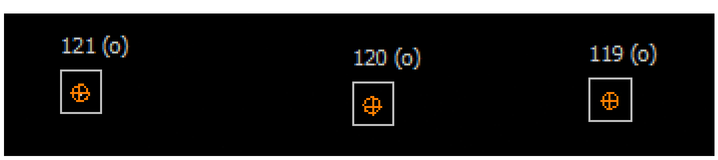
   2. If the camera is attached to fixed mounts or the camera orientation can not controlled so detailed, that all markers lie in the blue rectangles, move the white rectangles, so they fit the markers.

      To do so, just drag the rectangle with the mouse in the camera image to match the expected position.

9. If all markers where correct or you have moved all markers to the new position, press Find Position.



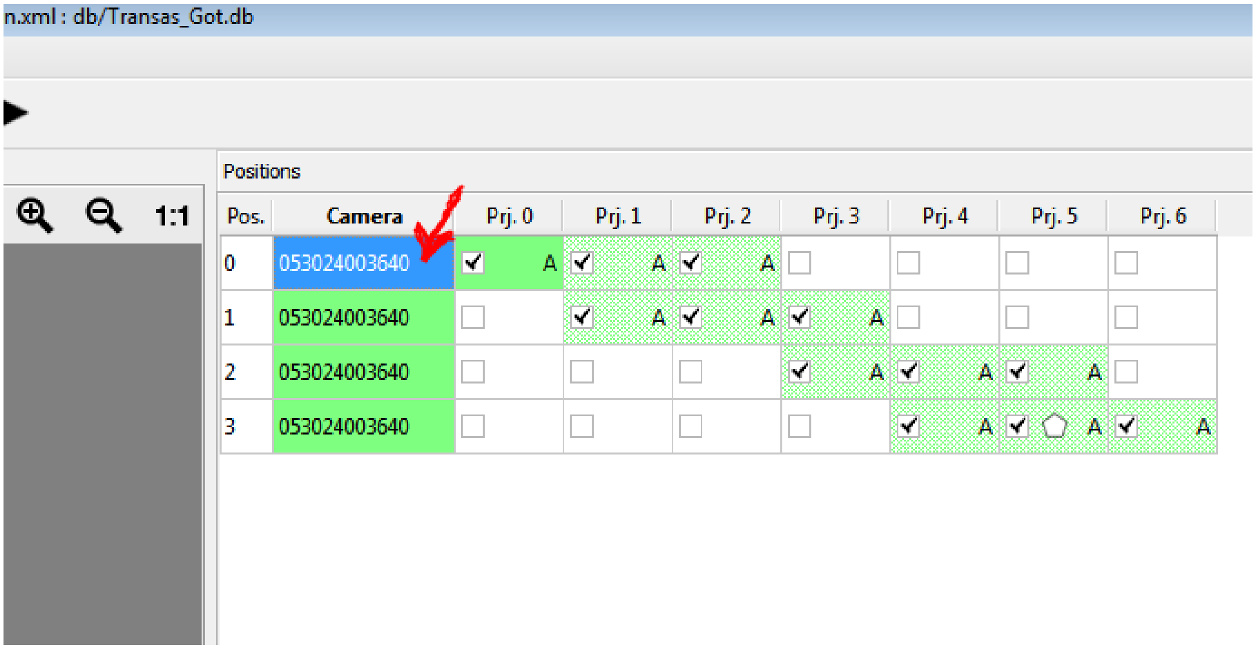
10. This will take new images and calculate the camera position. If the settings where correct you'll get orange circles with a cross inside for all markers.



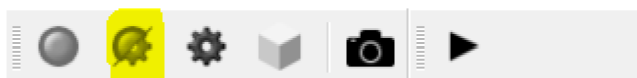
11. If you get this result, close the pos finder window with ok. If not, redo from step 5.

12. Select the position with the mouse (click on pos. or Camera column).

Note: It should become highlighted as well as the projectors in the projector dock. If not, click on another position and then on the position you want to measure.



13. Start alignment for this position with Take Images and Analyze button. A progress bar appears and patterns are displayed on the projection.



14. If all selected projectors for a position are marked green (as in the image from step 12). The capturing of the current position is finished.
15. Repeat steps 4 – 14 until all positions in the project are captured.
16. Calculate the alignment results with Generate 3D button. The autocalibration run is now finished.
17. Save the project and open it in Mapper2D/3D for checking results and exporting data.

20.3 Troubleshooting

20.3.1 Dotpattern detection

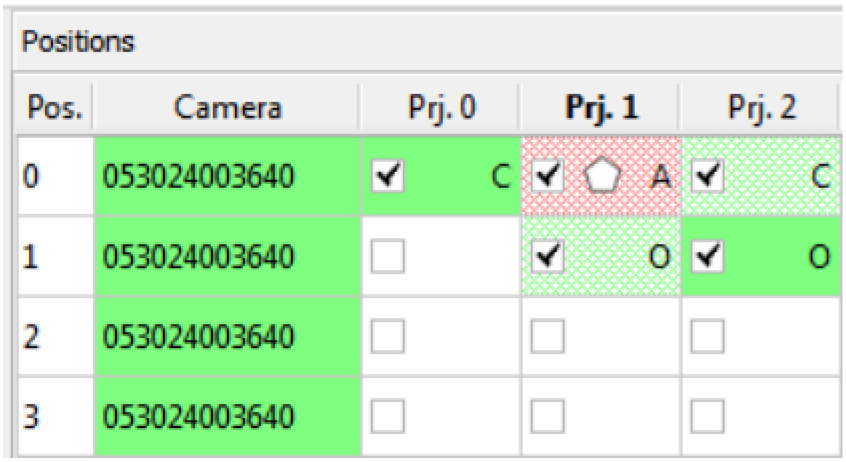
There are several potential reasons for dotpatterns not correctly or only partly detected.

Some common reasons are:

1. Warping or blending inside projectors or warp units is still switched on during calibration. This results in dots partly invisible due to blending and dots projected on different places, due to activated warping. Solution: Turn off warping and blending, then do a new calibration run.
2. Temporary objects or light in the room during calibration (flash-lights, room lights, people or others). Solution: remove these objects or lights and repeat the calibration run.
3. Brightness of projectors has changed, resulting in much darker or brighter images taken. Solution: adjust recognition parameters or camera shutter speed and repeat the calibration run.

4. Network communication problems may result in many points (usually rectangular blocks) are missing. Check your network setup, stop potentially interfering software and repeat the calibration run.

The positions table in Align gives a quick overview of the measurement results, and where potential problems have occurred. The quality of the measurements is visualized as colors in the positions table (green, yellow, red). Individual colors are shown in the position table for each measured projector on each camera position.



green:
the same amount of dots where detected as where projected.

yellow:
a few dots less than projected where detected

red:
many points where not detected or more points where detected than projected

This color coding is based only on comparing the number of detected and the number of projected dots. There is still a chance, that some points where detected at the wrong place if a cell is colored green (same amount of points detected as projected). This can usually happen if reflective materials or projector lenses are visible to the camera.

More detailed information can be shown by double-clicking on one of these table cells. An additional window opens showing the captured camera images and the recognition results.

- All orange crosses (these mark recognized points) must be placed in the center of the gray circles.
- All circles should have an orange cross inside.
- The pattern should

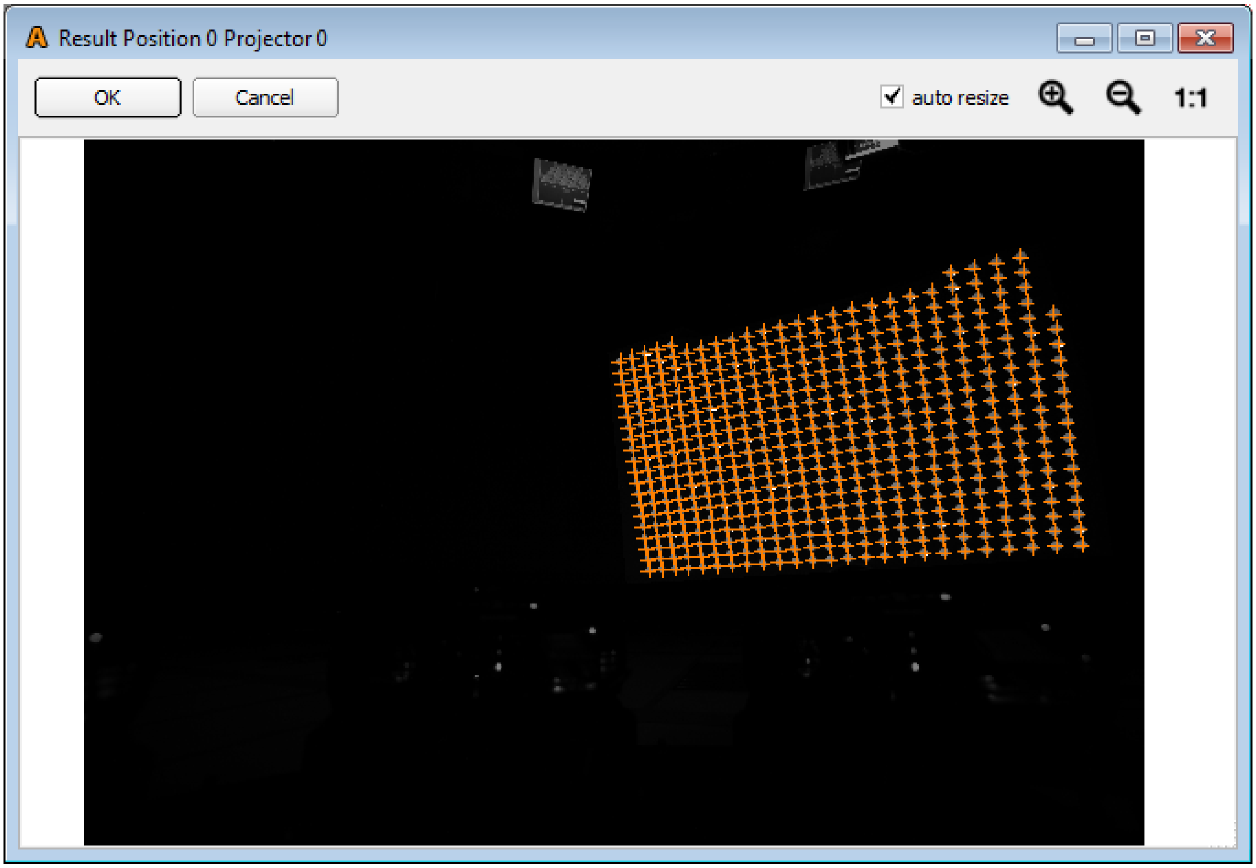
A detailed view (use the magnifying tools) looks like:

External objects (lights, people in the room or else) which disturbed the process should be visible here. Remove those objects and repeat the alignment process.

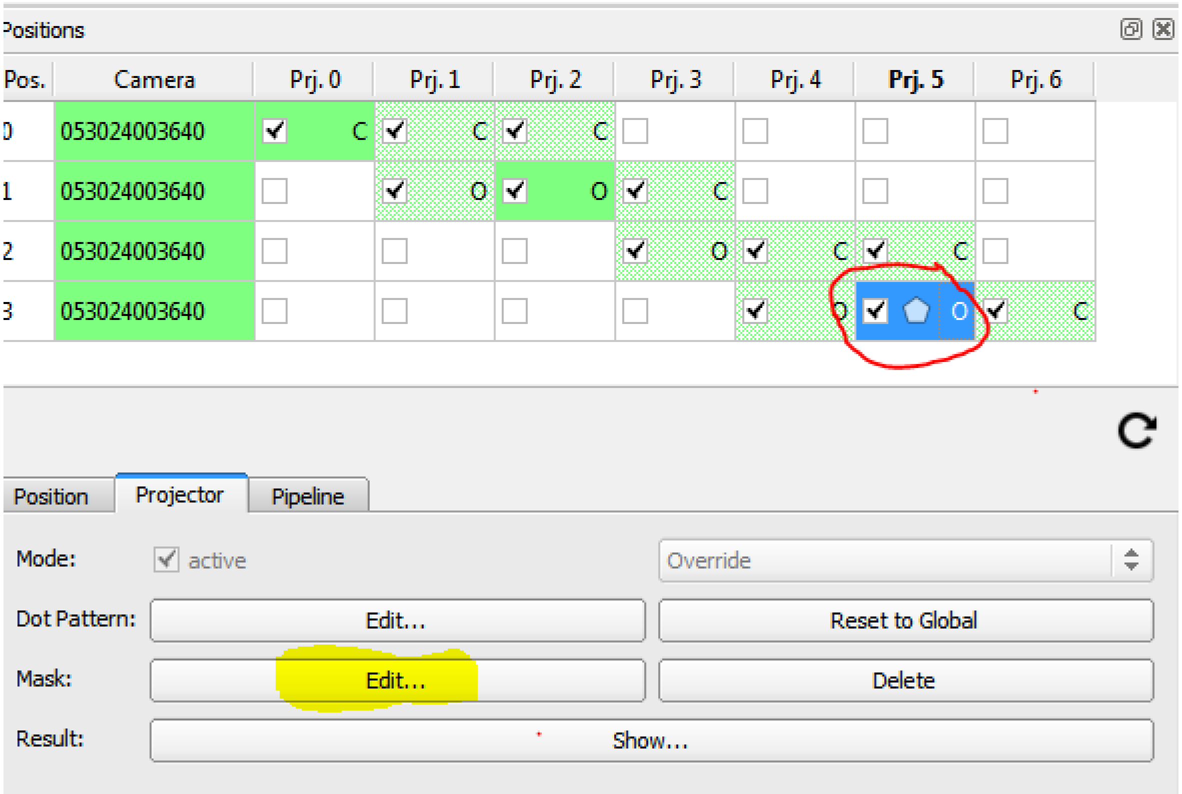
If there are permanent obstacles or disturbing lights in the picture these should be removed with a custom mask. Usually such objects are already masked out during the setup of an align project. Projector 5 in position 3 is an example, where such a mask is applied. To show this editor, select the projector and press the Mask: edit button.

This will pop up the following window:

Here the area which is considered for the image processing can be adjusted. For details on using the Mask Editor, refer to chapter *Mask Editor*.


Result Position 0 Projector 0
OK
Cancel
auto resize
1:1


auto resize
1:1

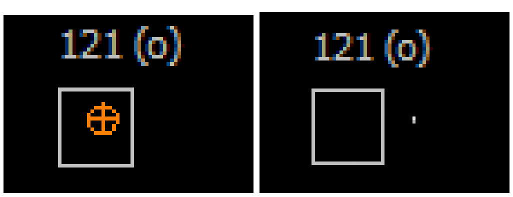


20.3.2 Camera position detection

If the camera position cannot be detected, this is shown in the camera column of the positions table. The table cell of corresponding position is transparent, indicating that the camera position was not found.

The Find Position dialog reveals details of the position finding process. This dialog can be opened either by double clicking on the corresponding cell in the positions table or by selecting the corresponding cell and then clicking the "Find Position..." button in the Position tab below the table.

In the visible camera image check if the reference markers are in their corresponding region of interest.

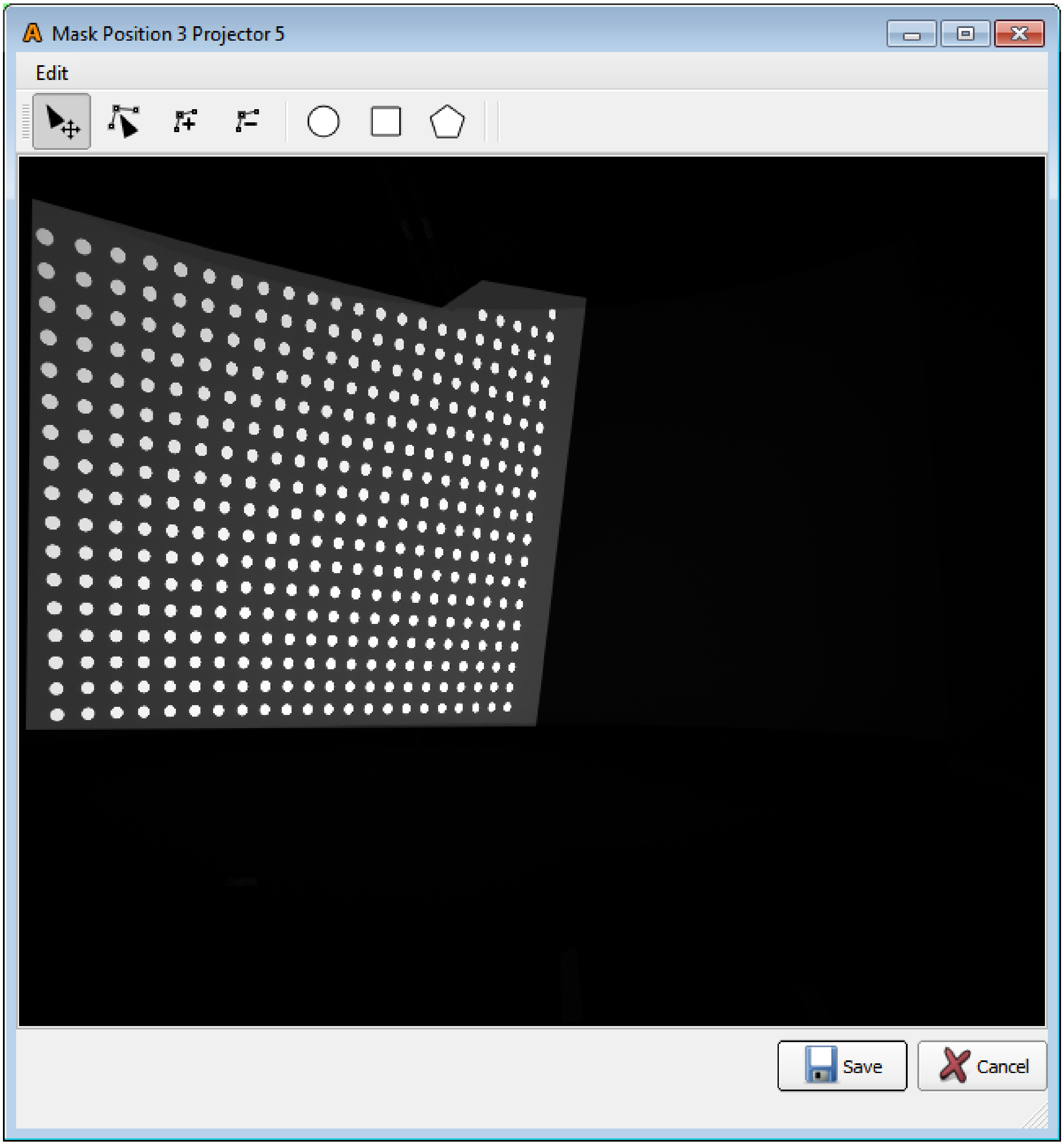


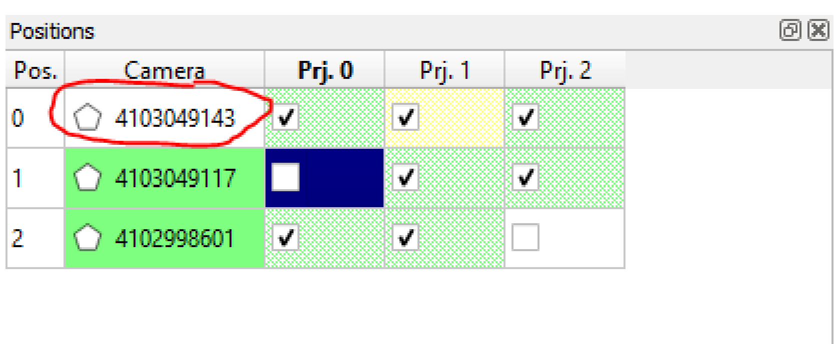
From left to right: good position, bad position

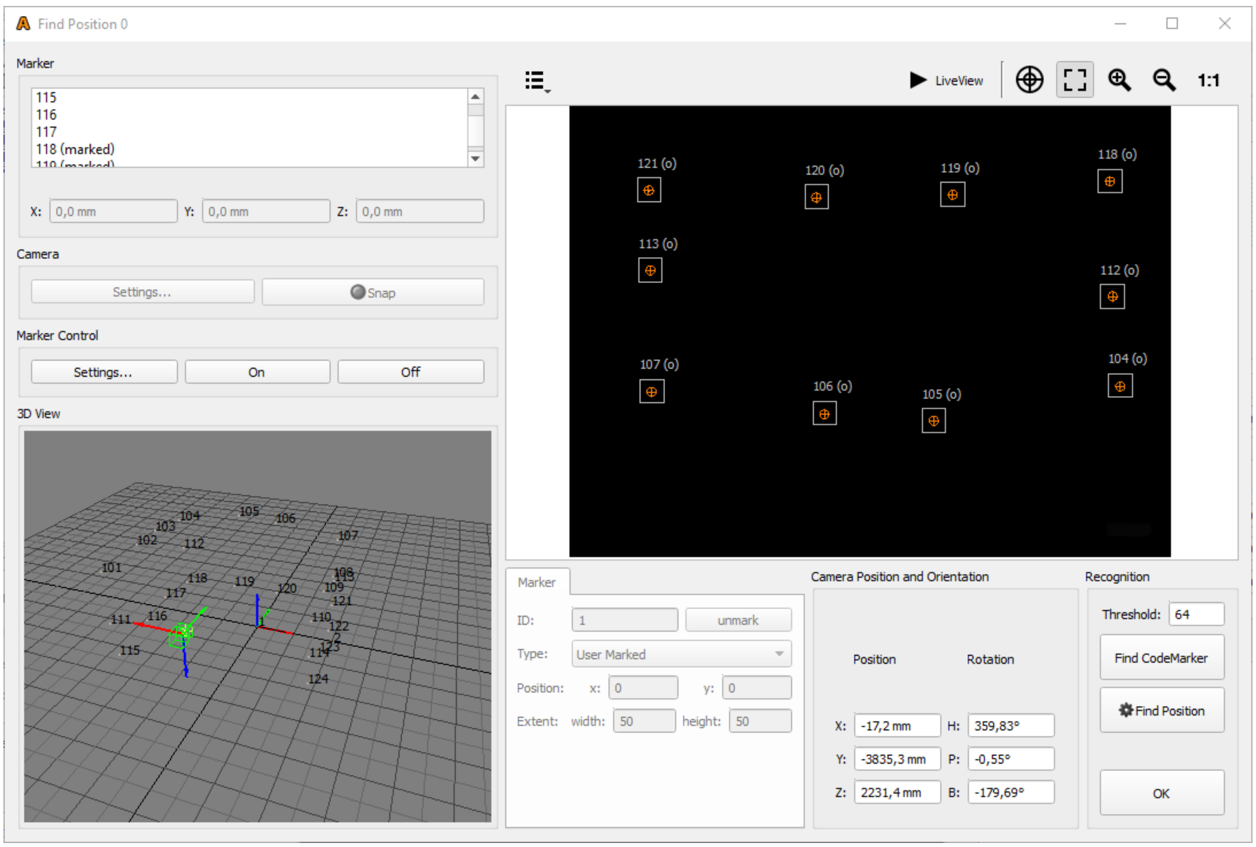
If the markers are all far off their region of interest, the camera probably has moved significantly, and should be moved back. In order to do so, turn on the markers and the live view. Than move/rotate the camera, until the markers are in the corresponding region of interest again, or at least very close.

If the region of interest, are just a bit off, the camera has rotated only slightly. In that case the region of interest can be moved over the corresponding marker again, by drag and drop.

If the camera has moved/rotated you should also check if the dotpatterns shown for that position, still all fit into the camera image. If they don't fit anymore, either the camera position/orientation should be adjusted, or shown dotpatterns must be adjusted.

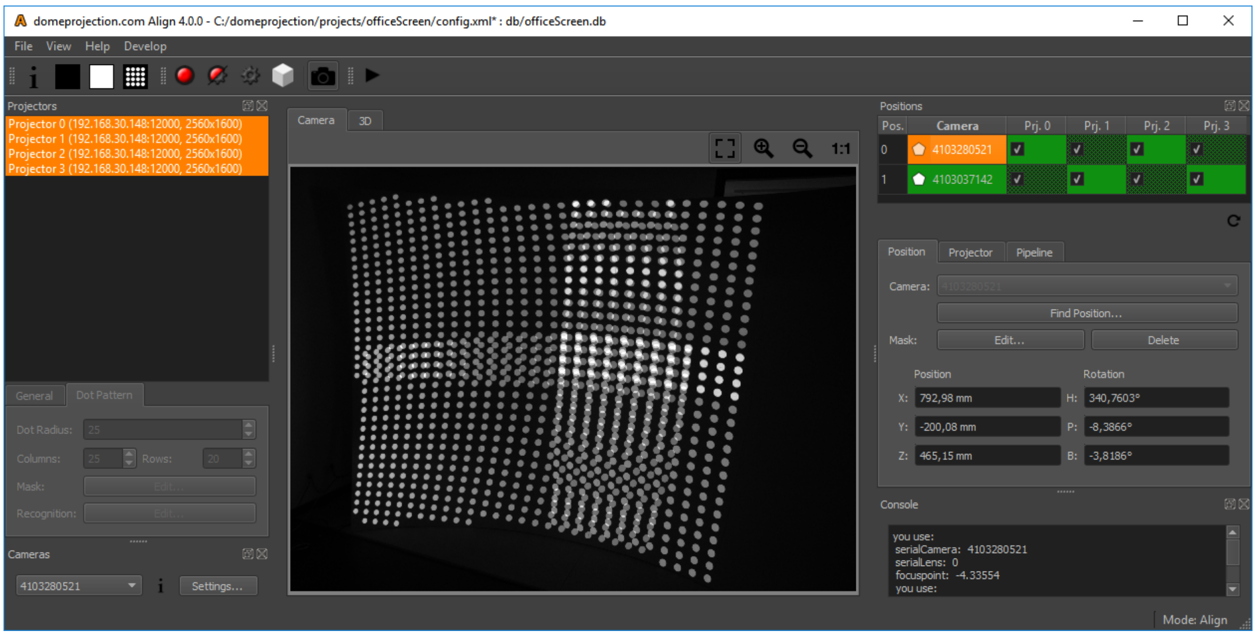

Mask Position 3 Projector 5
Edit
Save
Cancel


Positions
Pos.
Camera
Prj. 0
Prj. 1
Prj. 2
0
4103049143
1
4103049117
2
4102998601


Find Position 0
Marker
115
116
117
118 (marked)
X: 0,0 mm
Y: 0,0 mm
Z: 0,0 mm
Camera
Settings...
Snap
Marker Control
Settings...
On
Off
3D View
LiveView
1:1
121 (o)
120 (o)
119 (o)
118 (o)
113 (o)
112 (o)
107 (o)
106 (o)
105 (o)
104 (o)
Marker
ID: 1
unmark
Type: User Marked
Position: x: 0 y: 0
Extent: width: 50 height: 50
Camera Position and Orientation
Position
Rotation
X: -17,2 mm
H: 359,83°
Y: -3835,3 mm
P: -0,55°
Z: 2231,4 mm
B: -179,69°
Recognition
Threshold: 64
Find CodeMarker
Find Position
OK

CHAPTER TWENTYONE

MAINWINDOW OVERVIEW



Align has a fully configurable workspace. Figure *1 <#fig:Align* shows the default configuration with the typical widgets open.

Menus

File Menu
Load and save projects (Additional options available in Service mode).

Tools Menu
Additional tools and advanced operations on loaded project. (only available in Service mode)

View Menu
Workspace and theme management.

Help Menu
Help, Support and Program information.

Toolbar
The toolbar provides quick access to several preview and capture actions. For details see sections *Previews Toolbar*, *Capture Toolbar* and *Pipeline Toolbar*.

Hardware
On the left are docks for all the components involved in the project listed.

Projectors
The projectors dock widget shows a list of all projectors in the current project and allows to edit projector related settings.

Cameras
Each project has at least one camera. In the cameras dock widget the cameras of a project can be viewed and their settings adjusted.

Camera View/*3D View*
In the center of the window is a camera-view and 3d-view available between which the user can switch.

Positions
On the right side is the configuration of the calibration process visible.

All dock widgets can be arranged, stacked, opened and closed by user. The workspace layout is saved persistently.

It is also possible to revert to the default workspace using `View/Default Workspace`.

All available dock widgets can be found in the menu. They are described in the following sections.

The theme can be switched in `View/Theme`. An application restart is needed for a theme switch to take effect.

For using the maximum workspace on the desktop, a full screen mode can be enabled in `View/Toggle Fullscreen Mode`.

21.1 Previews Toolbar

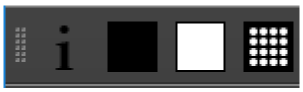


Fig. 1: Preview Toolbar

Identify
show info on selected projectors

Projector dark
make selected projectors black

Projector light
make selected projectors white, others black

Project Dot Pattern
show dot pattern on selected projectors

21.2 Capture Toolbar

Fig. 2: Capture Toolbar

Take Images
Take test-image sequences with selected camera for selected projectors, without further image analysis. During capturing process, neither cameras nor projectors should be moved.

Take Images and Analyze
Take test-image sequences with selected camera for selected projectors, and analyze images. During capturing process, neither cameras nor projectors should be moved.

Analyze Images
Analyze images for selected position and projectors. This can be used to analyze previously taken images again after change of recognition parameters or masks. It is much faster than taking images again, and no attached cameras are required.

Calculate Align
Reconstruct projection geometry by analyzing all images taken for projectors, camera positions and screen geometry information.

Toggle Camera Connection
Enable/Disable camera connection. New images can only be taken, if camera connection is active

21.3 Pipeline Toolbar

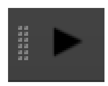


Fig. 3: Pipeline Toolbar

Run Pipeline
Starts the full realignment process. Take and process images for all camera positions and projectors.

21.4 Camera View

The camera view shows a live stream from currently active camera.

If the camera is turned off, switch it on using (see section *Capture Toolbar*).

Navigation
The view can be dragged with the left mouse button.

Scaling
The camera image is typically fit into the window. Additional scaling options are available at the top right corner of Camera View.

21.5 3D View

Visualization of currently selected Screen-type, reference points, measured geometry from selected projectors and position/orientation of selected camera position.

Several aspects of the visualization can be toggled in this views toolbar at the top edge.

Visualization Options
A drop down menu on the top left corner allows to select multiple visualization options.

Screen
Theoretical/imported screen shape

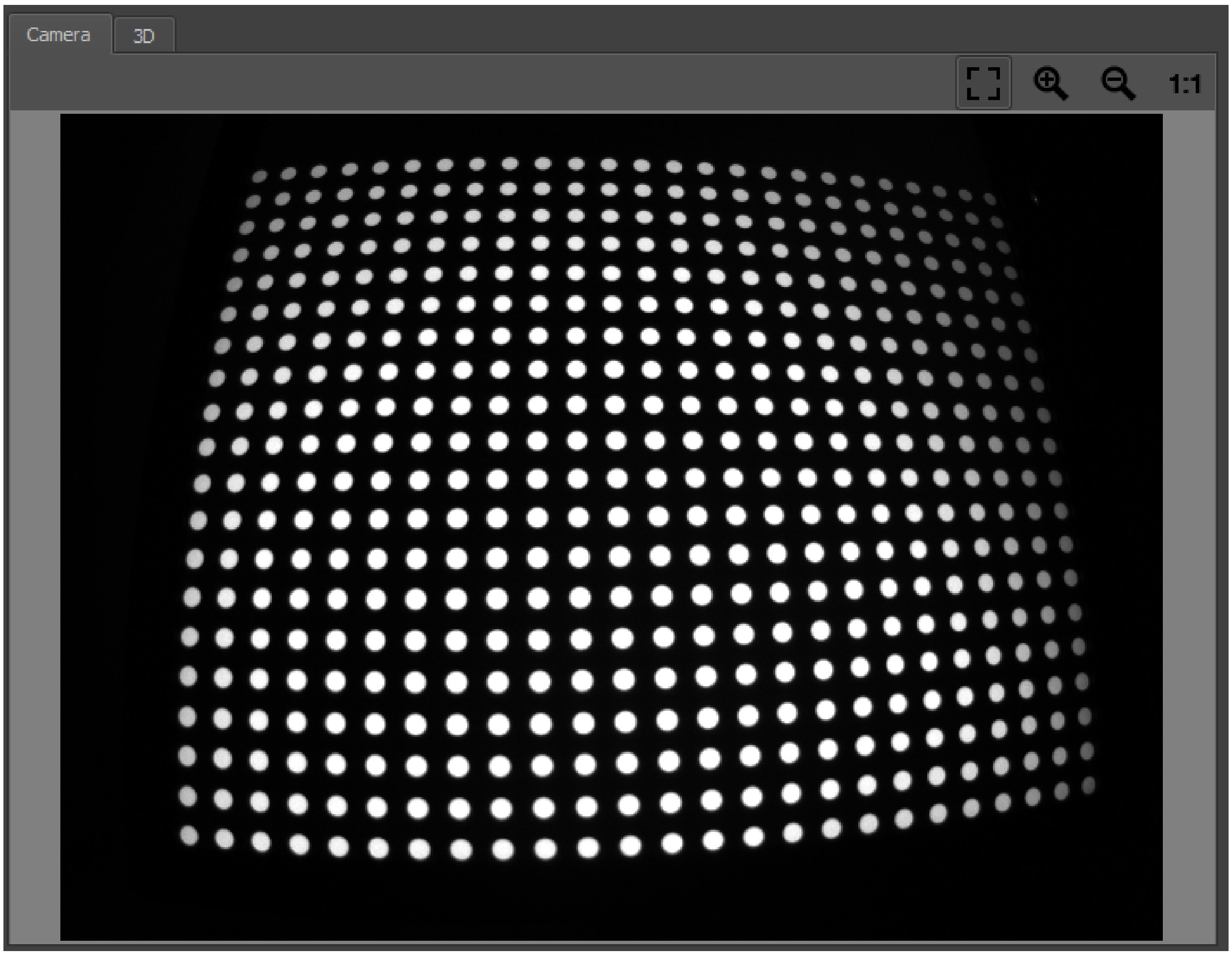


Fig. 4: Camera View

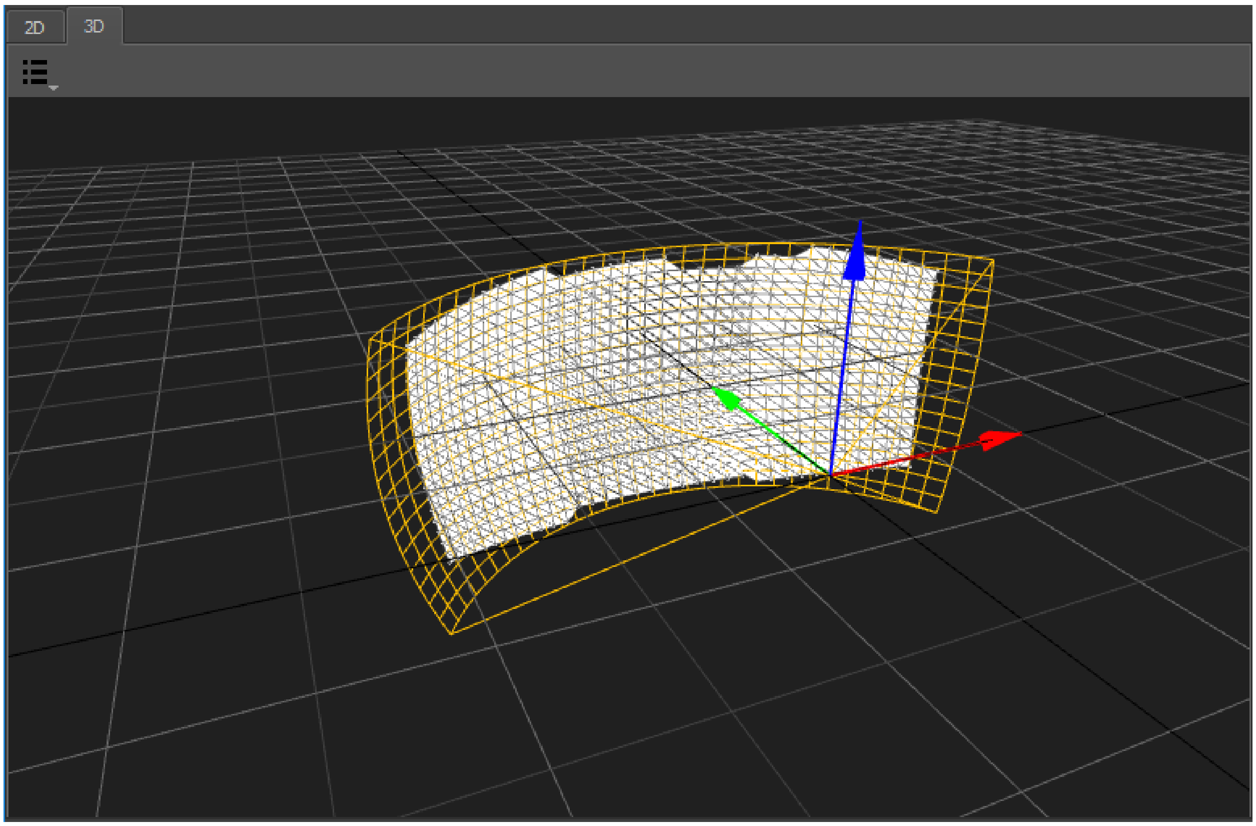


Fig. 5: 3D View

Reference Points
Imported/generated reference points

Geometry:
Generated 3d shape of initial calibration

Measured Points
Measured 3d positions of initially captured points for each projector.

Align Points
Measured 3d positions of captured points after recalibration for each projector.

Perspective
Switch to predefined orthographic views or the default perspective camera position.

Navigation
Navigate the 3d view using the mouse.

Rotate
`Left mouse-button`

Move
`Middle mouse-button`, `Alt+Shift+LMB`

Zoom
`Right mouse-button`, `Alt+Ctrl+LMB`

21.6 Projectors

Projectors reflect one projection channel each. Usually one channel is used per projector. In some setups with 4k projectors, there might be more channels in the project than actual projectors.

The projectors dock widget shows a list of all projectors in the current project and allows to edit projector related settings.

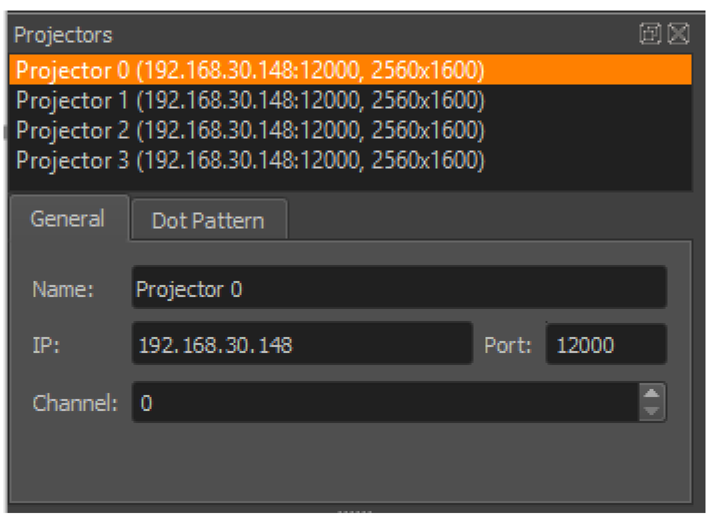


Fig. 6: Projectors

21.6.1 List

A list shows all projectors in the project. Including name, ip, port and resolution.

This widget allows multi-selection of projectors.

Several other views in the application update according to the current projector selection.

If a single projector is selected, its related settings can be edited in the editor below.

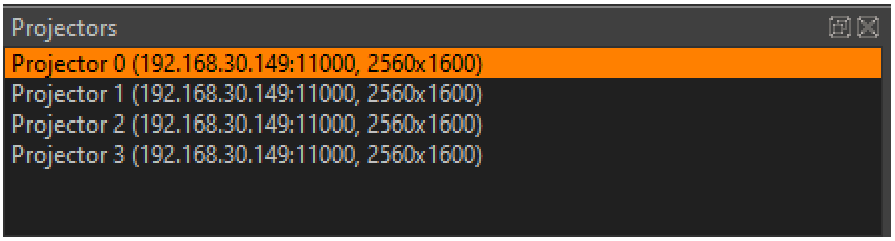


Fig. 7: Projectors list

Press `Ctrl+A` to select all projectors at once or hold `Ctrl` or `Shift` to add projectors to current selection.

21.6.2 General

Adjustable in service mode only (see section *Service Mode*)

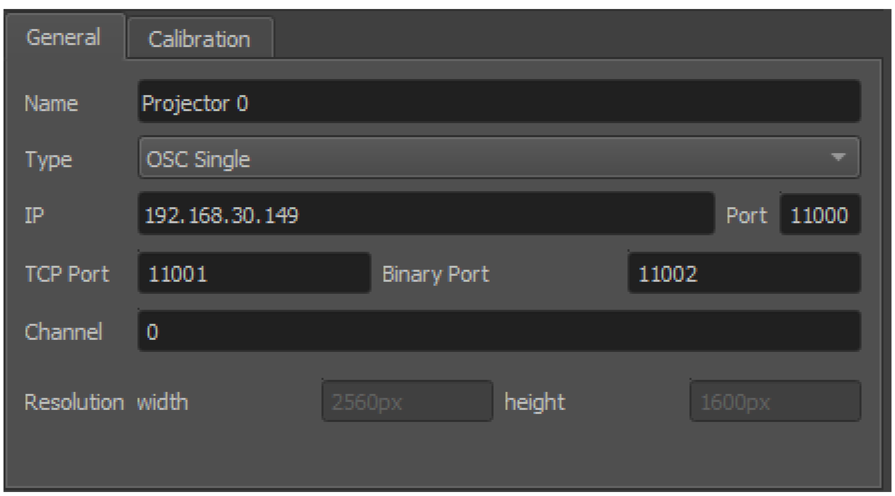


Fig. 8: General projector settings

Name
: Arbitrary string describing the projector

Type
: Interface to use for showing testpatterns.

  OSC Single
  : Default PatternGenerator based interface. Works with up to date PatternGenerator.

  OSC Multi
  : ProjectionTools channels are virtually split into multiple PatternGenerator channels. Works with standard PatternGenerator.

OSC Legacy
Can be used for very old PatternGenerator installations, or installations on limited/embedded hardware. The preview functionality is limited.

NDI
Provide testpatterns as one NDI-stream per channel. This can be used, if it is not possible to install PatternGenerator on the Mediaservers. Several Mediaservers support recieving and showing NDI-Streams. The preview functionality is limited.

Norxe Unify
Send testpatterns as image directly to Norxe Unify projectors. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Barco Pulse
Send testpatterns as image directly to Barco Pulse projectors. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Luna
Send testpatterns as image directly to domeprojection Luna warp units. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Warper4k
Send testpatterns as image directly to Westar Warper4k warp units. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

IP
network address of computer where PatternGenerator software is running on

Port
port to communicate with PatternGenerator. By default 12000. If multiple PatternGenerator run on one computer different ports need to be used.

Channel
channel number, only used for PatternGenerator virtual where one *PatternGenerator:* instance shows patterns for multiple projectors

Width and height
Have to be the same as the physical projector resolution used in the projection and displayed here for reference only (not editable).

21.6.3 Dot Pattern Settings

During the alignment process a special test-pattern is shown on each projector, and captured by cameras.

The basic settings of the dot pattern (Dot radius, columns and rows) are not editable in Align. These settings were already defined during the autoalignment setup.

There is still the possibility to deactivate distinct dots of the pattern in a separate editor.

Dot Radius
Radius of projected dots in pixels. Might need to be changed depending on how big the points are seen in the camera image.

Columns/Rows
Number of dot columns and rows.

Mask Edit
Allows to edit the Dot Pattern (see DotPattern Editor section *Dot Pattern Editor*).

Recognition Edit
Allows to edit and test recognition parameters in an editor with visual feedback (see section *Recognition Settings*).

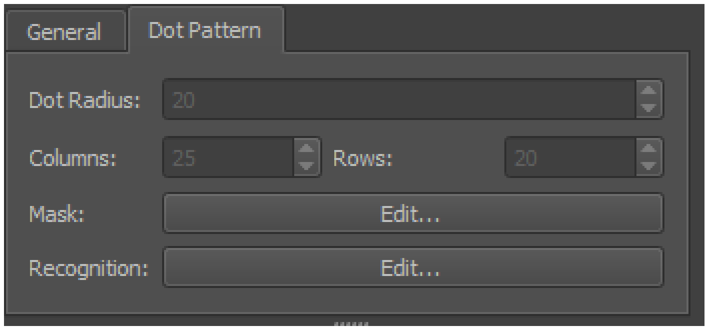


Fig. 9: Dot Pattern

21.6.4 Recognition Settings

The test-patterns captured by cameras need to be analyzed. This recognition process consists of several steps:

1. Capture multiple images:
   - Black-image (points off)
   - all dots image
   - multiple images with just part of the dots projected (this step is left out during recognition parameters setup and testing)
2. Calculate difference image between points image (points projected) and black-image (no points projected)
3. Generate binary (black/white) image using a defined binarisation threshold (pixels darker than the threshold become black, brighter pixels become white
4. Detect outlines of white image areas
5. Remove white areas in the image that are too big or too small and are probably not dots.
6. Detect point centers from outlines
7. Detect point id by analyzing sequence of dot pattern images (this step is left out during recognition parameters setup and testing)

The recognition settings editor allows to edit and test recognition parameters with visual feedback.

Threshold
The binarisation threshold controls the generation of the binary image from the difference image of black-image and points image. Pixels darker than the threshold become black, brighter pixels become white. This value should be setup in a way so that each point is clearly visible as a seperate white dot in the "Binary Image". If the value is too small points might start to merge into one big white area. If the value is too high, points start to vanish.

Radius min/max
The minimum and maximum radius of circles in camera image in pixels. Only circles within this range are detected. The camera image contains an overlay in the bottom right corner, visualizing the current radius min/max setting.

Test Parameters
Take images with camera, analyze and show results. The Editor allows to show several images from the recognition process:

Black Image
First image taken with camera. Should contain no dots.

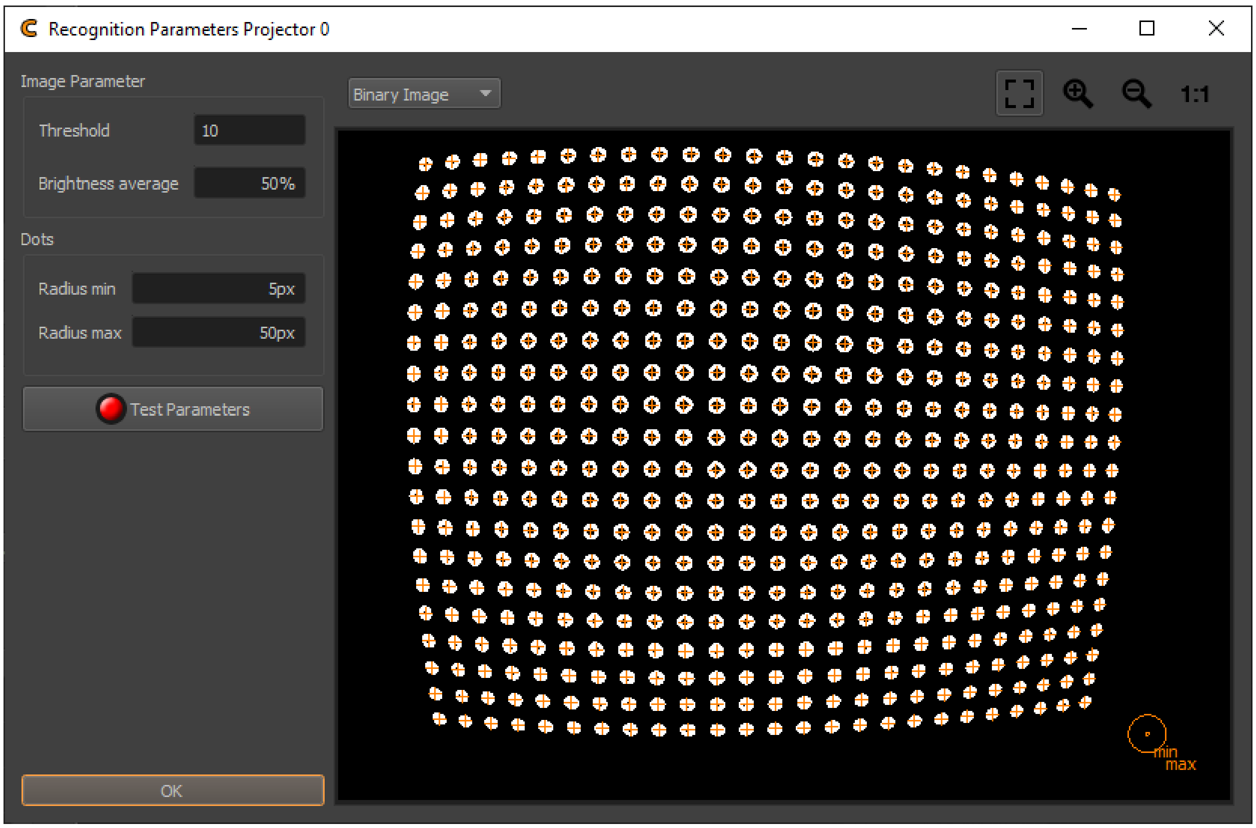


Fig. 10: Recognition Parameters Projector

White Image
Second image taken with camera. Should contain dots.

Average Image
Average of Black and White Image

Binary Image
Black/White Image. Dots should be full white, rest should be black, otherwise check threshold and camera parameters.

Contour Image
Shows contours around each dot. Each dot should have exactly one closed contour.

Orange crosses are drawn on every detected point center.

21.7 Cameras

Each project has at least one camera. In the cameras dock widget the cameras of a project can be viewed and their settings adjusted.

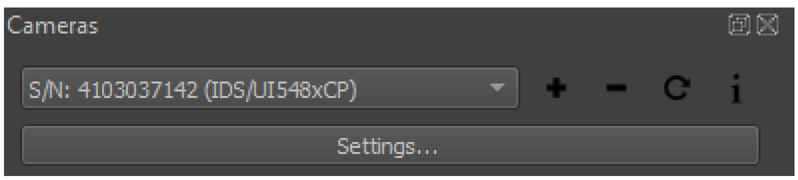


Fig. 11: Cameras dock

Combobox
Shows currently selected Camera.

i
Shows general information about camera type and lens.

Settings
Allows to adjust camera parameters in a separate Editor.

21.7.1 Camera Settings

The Camera Settings dialog allows to adjust camera settings, mainly to adjust the brightness of captured images.

The editable camera parameters are depending on the camera type. Some typical parameters are:

Camera shutter
The time the shutter is open to take one image. Higher values result in brighter images

Camera gain/iso
Gain of camera signal, high values result in grainy images. Low values preferred.

Camera aperture
adjust the lens opening. Higher values reduce the lens opening and result in darker images.

Start Automatic Parametrisation
Analyses the camera image brightness and sets an appropriate shutter, gain and iso. This is an iterative process continuously updating the values while activated. Press the button again to stop analysis and keep the current settings.

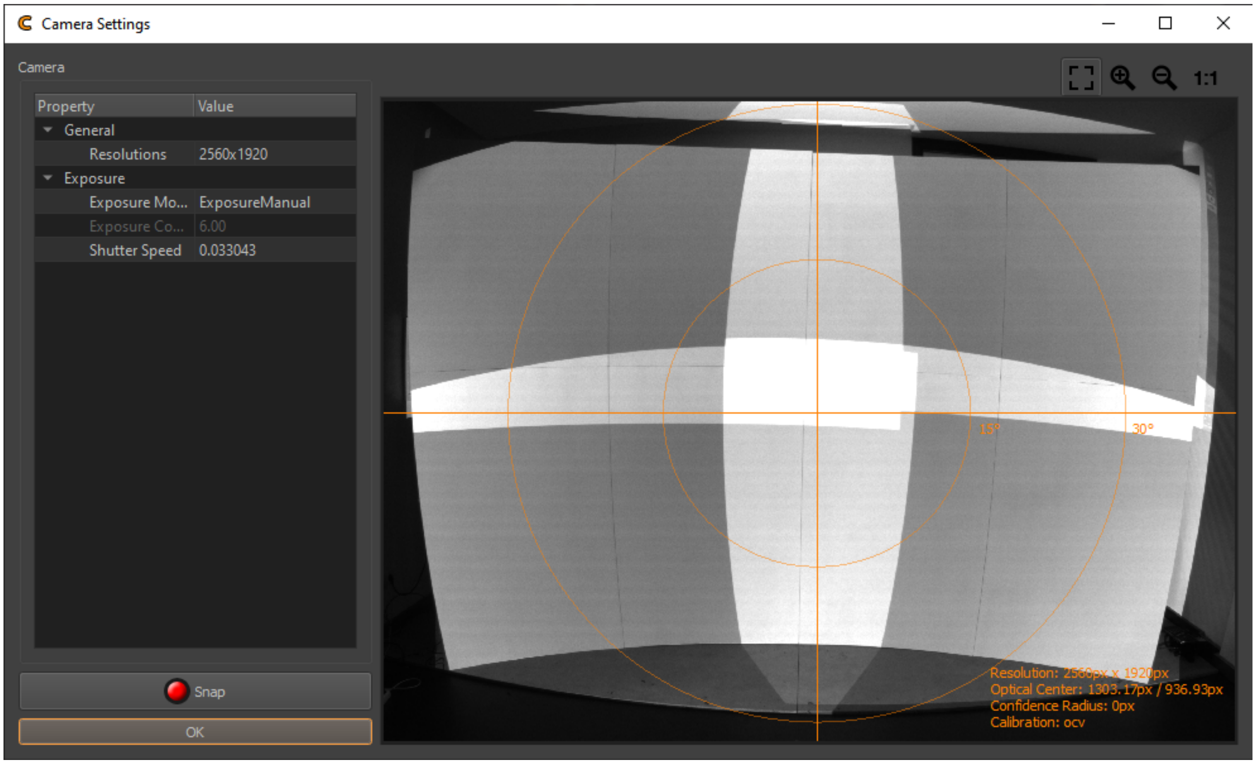


Fig. 12: Camera Settings

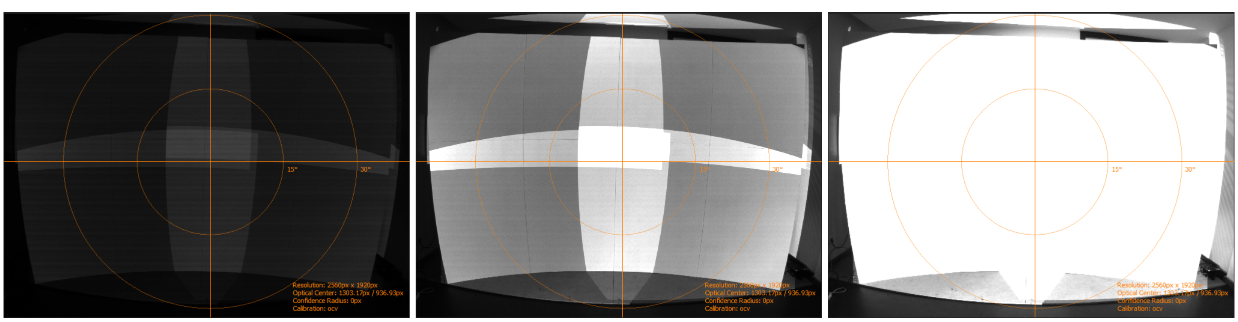
Snap

Capture a new camera image using current settings.

Visualization

An overlay on the camera image visualizes the field of view and the principal point. Additional informations about camera resolution and calibration are show on the bottom right corner.

The camera parameters should be set such that the projection is clearly visible but not too bright.



Comparison of camera settings: too dark / good / too bright

21.8 Positions

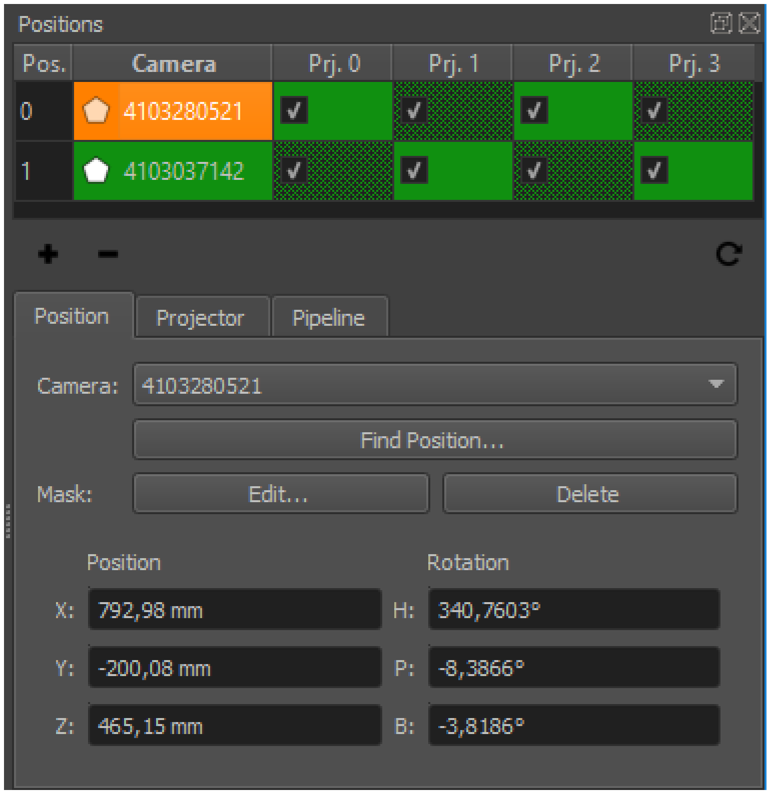


Fig. 13: Positions Editor

The realignment process typically involves image capturing from multiple positions. There might be individual cameras at each position or there is just one camera that is moved/rotated around to all the predefined positions.

The positions editor gives an overview of all these positions, which camera is used for each position, which projectors are captured from each position, how capturing data from multiple positions should be merged, calibration result and several more.

The positions editor also allows do adjust camera position related parameters.

21.8.1 Positions Table

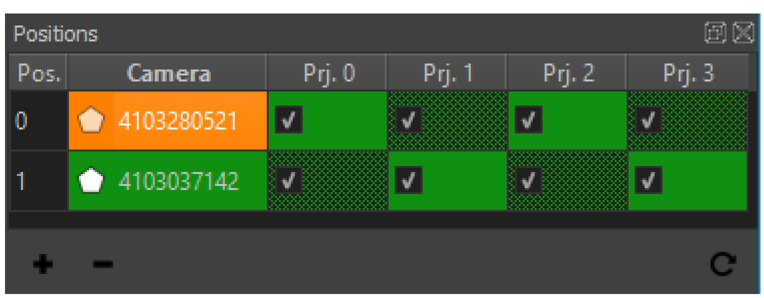


Fig. 14: Positions Table

Cell Color
Quality estimate of measurement result based on comparing the number of detected and the number of projected dots.

Green
The same amount of dots where detected as where projected.

Yellow-Red
When less than 100% of the projected points where detected, the color gradually changes from yellow (99% detected) over orange to red (0% detected).

Red
No points, or more than projected points where detected.

Cell Fillpattern
Dithered if dot pattern where overridden, solid otherwise.

Polygon Icon
Shown if a mask is defined.

Checkmark
A cell is checked, if a projector is activated for calibration on a distinct position.

Update Position List
refresh positions table

Doubleclick Camera or Position
open PosFinder for camera position

Doubleclick Projector
Open calibration result for projector. (see section *Result View*)

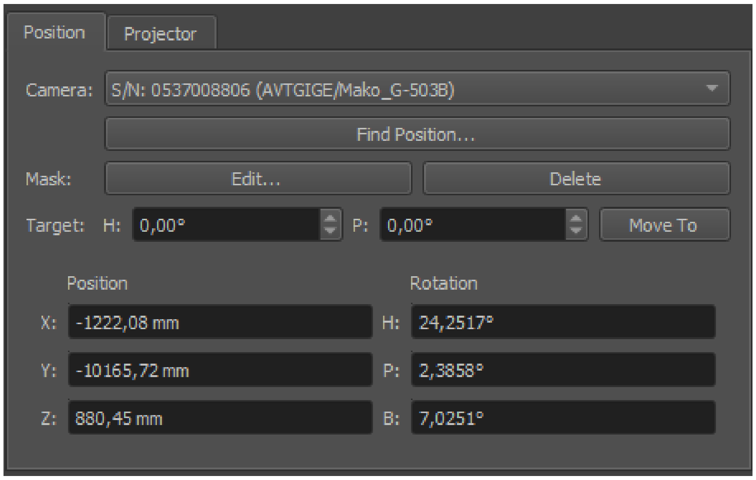
Context Menu
Quick access to camera/projector related editors.

Add Position
add new position with currently selected camera and projectors. (service mode only)

Remove Position
user defines exact position of marker/feature in image. No image analysis is done for this marker. (service mode only)

Update Position List
refresh positions table

21.8.2 Position Tab



Camera
Select the camera that should be used on this position. (service mode)

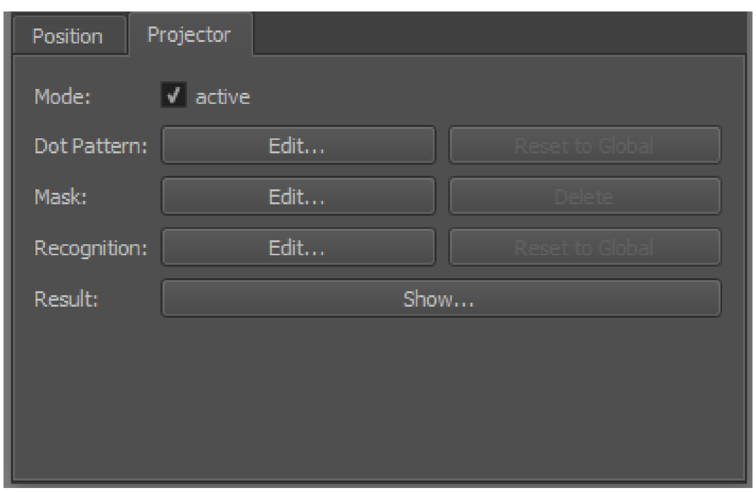
Mask Edit
Edit a mask that is applied to the camera image to avoid false point recognitions, e.g. reflective surfaces or flashing projector lenses. It can be combined with projector masks. (see section *Mask Editor*)

Mask Delete
Delete mask and use complete camera image for detection.

Find Position
Find camera position and orientation using Position Finder (see chapter *Position Finder*).

Position/Rotation
Camera Position and Orientation on this position.

21.8.3 Projector Tab



Active
Set if selected projector on selected position should be active for calibration.

Dot Pattern Edit
Override dot pattern for current projector on current position. (see section *Dot Pattern Editor*)

Dot Pattern Reset to global
Remove dot pattern override and use global dot pattern settings for current position.

Mask Edit
Edit a mask that is applied to the camera image to avoid false point recognitions, e.g. reflective surfaces or flashing projector lenses. It can be combined with position mask. (see section *Mask Editor*)

Mask Delete
Delete mask and use complete camera image for detection.

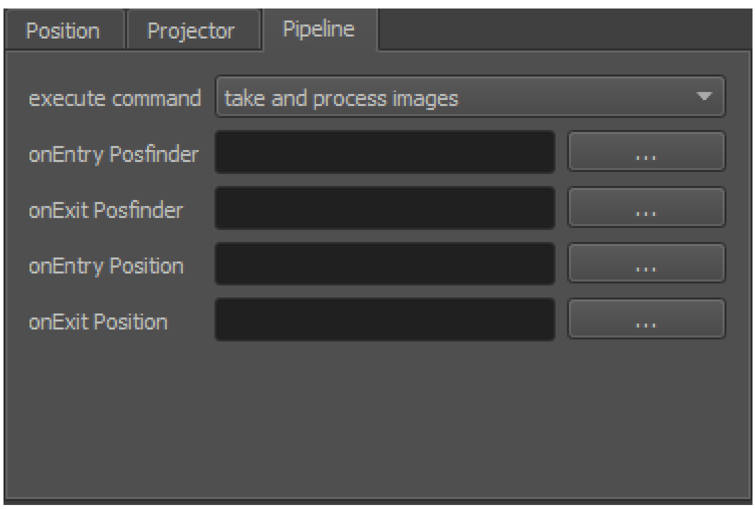
Recognition
Allows to override recognition settings for current projector on current position.

Recognition Reset to Global
Removes the override.

Show Result
Shows a result image where recognized points are marked with a cross and row/column number (see section *Result View*). If errors in the order are visible or less than 85% of points where recognized the camera parameters, recognition-parameters and masks should be checked and image taking or/and image analysis must be repeated.

21.8.4 Pipeline Tab

These settings are adjustable in service mode only.



Execute command
Control how images are captured and analyzed

take and process images
Regular image capture and analyzing. (Default)

fast take and process images
Take full dot pattern first, and check if it has moved. If it has not moved use old graycode images for processing, otherwise capture the complete image sequence again.

take images
Capture images without analysis.

process images
Analyze previously captured images.

onEntry/onExit Posfinder
Optional scripts that are run before and after position finding is run. Each camera position has its own scripts. It can be used for example to control a rotation unit with camera mounted on top.

onEntry/onExit Position
Optional scripts that are run before and after all the dot patterns of one position are captured. Each camera position has its own scripts. It can be used for example to control a matrix switch.

21.9 Collect Support Data

Calibration projects can get quite big, since all the captured camera images are kept for later use. While this is good to analyse and optimize the calibration offline this might be too much data to transfer over Internet.

`Help/Collect Support File...` allows to pack relevant project data in an archive that can still be opened in Creator but has not the massive data masses produced during image taking. It is typically requested from *domeprojection.com* for support.

CHAPTER

TWENTYTWO

SERVICE MODE

In order to avoid accidental reconfiguration of an alignment project, several settings are hidden during normal operation.

The service mode must be enabled to change and setup an alignment project.

The service mode gives access to:

1. Change Projector general connection settings
2. Creating new align projects from Creator projects
3. Adding and removing Camera positions
4. Exchanging cameras in an existing project
5. Configuring alignment process and automization
6. General project settings

22.1 Project Settings

Only available in Service mode. Use `Help/Service Mode...` to access Project settings in File menu.

22.1.1 General

Projection Delay
: Allows to adjust the delay between showing testpatterns and taking images with the camera. Increasing this value might solve issues, with images taken too soon, but slows down the capturing process.

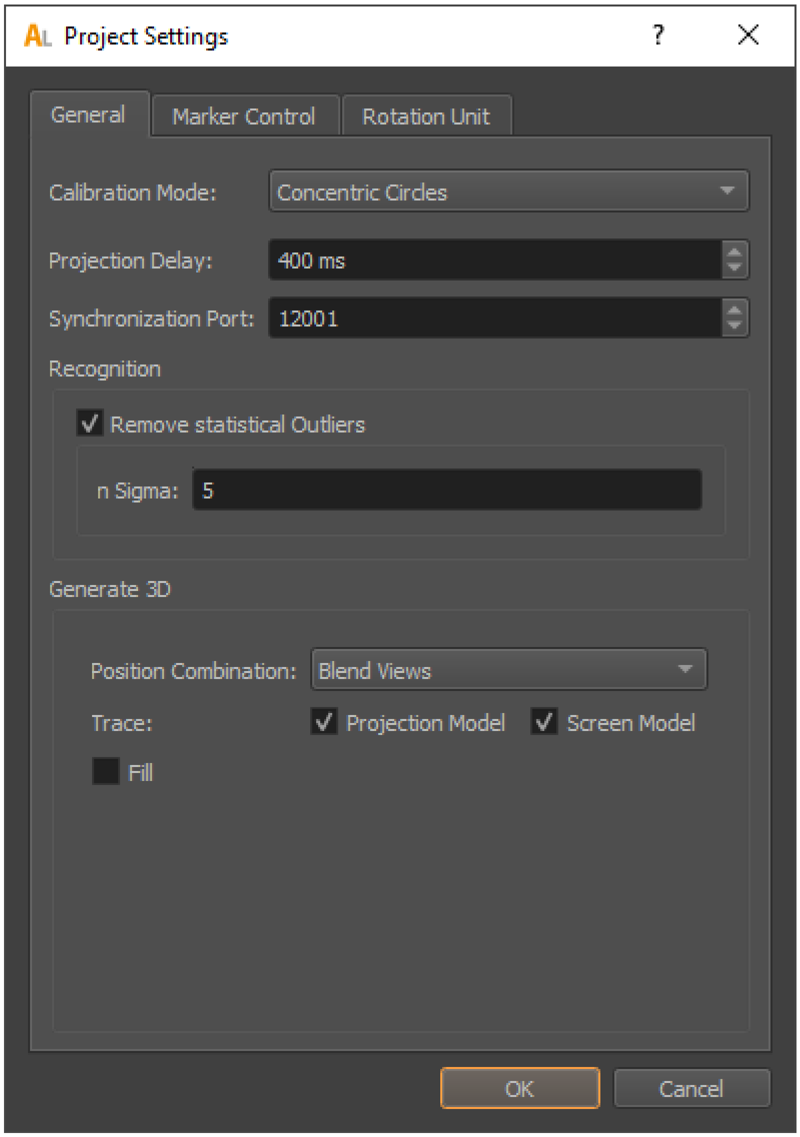
Synchronization Port
: This defines the UDP port for PatternGenerator feed back. It is used to sync the camera system to the Pattern-Generator draw loop (/bufferSwap). Has to be the same as configured in PatternGenerator.

Recognition
: Global recognition parameters used for all channels and camera positions.

    Remove statistical Outliers
    : Removes points, that are significant more distant to their neighbors than the average distance between neighboring points in the camera image. (Statistical Outlier Removal)

        n Sigma
        : Points with distance to neigbours n-times standard deviation larger than average distance are removed.

Generate 3D
: When all testpatterns are captured, a 3d model of the projection will be generated. There are different strategies


Project Settings
General
Marker Control
Rotation Unit
Calibration Mode:
Concentric Circles
Projection Delay:
400 ms
Synchronization Port:
12001
Recognition
Remove statistical Outliers
n Sigma:
5
Generate 3D
Position Combination:
Blend Views
Trace:
Projection Model
Screen Model
Fill
OK
Cancel

possible which have their pros and cons depending on calibration situation. The strategy and its settings can be adjusted here.

Position Combination
Select how calibration patterns seen from multiple camera positions are combined.

First/Last Occurance
Take the first or last capture of a dot.

Average
Equally weight multiple captures of a dot to generate an average.

Best Incidence Angle
Use only the capture with the best viewing angle (camera looking as orthogonal as possible on the screen surface).

Blend Views / Incidence Angle
Dynamically weight multiple captures by regarding how central they where in the camera image and how orthogonal the camera was looking on the screen surface. (Default)

Projection Model
Trace projection surface captured from initial calibration.

Screen Model
Trace screen model.

Fill
Fill parts that are missing during align with captured data from initial calibration.

22.1.2 Marker Control

Creator and Align can directly control active markers. These markers can be automatically detected by position finder (see section *Position Finder*)

`Project Settings.../Marker Control` allows to adjust the communication settings.

Type
Type of marker control

None
Marker control disabled.

Manual
Request user to turn markers on and off.

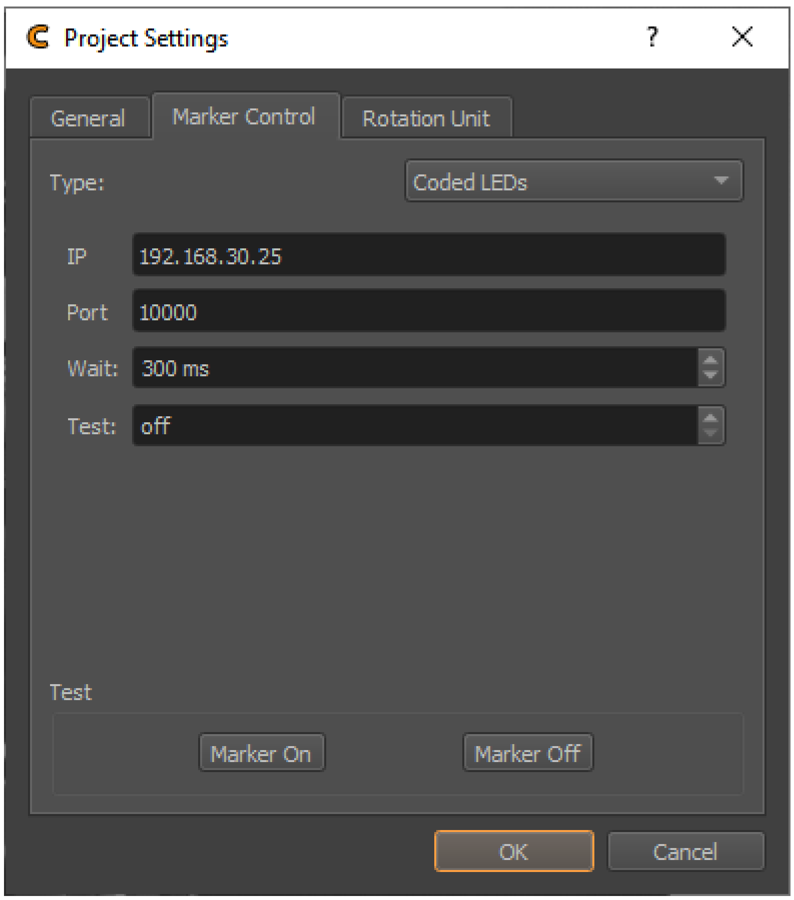
Script
Generic batch script to integrate custom automizations.

Markers On/Off
Select the batch script that turns the markers on/off.

Wait
Often it takes some time until the markers are actually switched, after the batch script returned. The delay can be adjusted here.

Aviosys
Network controlled power plug.

User / Password
Login required for this power plug. Initialized with factory defaults.


Project Settings
?
General
Marker Control
Rotation Unit
Type:
Coded LEDs
IP
192.168.30.25
Port
10000
Wait:
300 ms
Test:
off
Test
Marker On
Marker Off
OK
Cancel

IP
Network address of power plug.

Port
Communication port used on power plug. Initialized with default port.

Wait
Often it takes some time until the markers are actually switched. The delay can be adjusted here.

Netio
Network controlled power plug.

User / Password
Login required for this power plug. Initialized with factory defaults.

IP
Network address of power plug.

Port
Communication port used on power plug. Initialized with default port.

Wait
Often it takes some time until the markers are actually switched. The delay can be adjusted here.

Plugs 1/2/3/4
The netio support multiple power plugs. Select which plugs should be switched.

Coded LEDs
Micro controller enabled LEDs supporting to control and identify each individual LED.

IP
Network address of power plug.

Port
Communication port used on power plug. Initialized with default port.

Wait
Delay between setting the LEDs and capturing images.

Test
Enable individual LEDs for testing purpose, and identification.

URL
General interface for Network controlled power plugs.

Markers On/Off
Select the URLs that turn the power plug on/off. Example on/off URLs for an Aviosys:

```
http://admin:12345678@192.168.0.5/Set.cmd?CMD=SetPower+P60=1
http://admin:12345678@192.168.0.5/Set.cmd?CMD=SetPower+P60=0
```

Wait
Often it takes some time until the markers are actually switched. The delay can be adjusted here.

3D Disto
Leica 3D Disto. This measurement device with integrated laser pointer can be used to point at reference points of the project automatically. This works by finding its position relative to the project coordinate system and then pointing at the known 3d positions of reference markers in the project.

Connect
Establish connection to 3D Disto software. Make sure 3D Disto software is running on the local machine and connection to 3D Disto established.

Raw Rotation
Allows to rotate the 3D Disto in its native coordinate system.

Transform
Defines the corrent position and rotation of the 3D Disto relative to Creators coordinate system. Use for estimating the transform based on an axis or three points.

Wait
Waiting time between pointing at a reference point and taking images.

TCP
General interface for any type of TCP/IP controlled devices.

IP
Network address of marker control device.

Port
Communication port of device.

Marker On/Off
Network message to send for switching the markers on or off.

Wait
Often it takes some time until the markers are actually switched. The delay can be adjusted here.

Add Endline
Add endline control sequence to the message (\r\n) in case this is needed.

Test Marker On/Off
Turn active markers on and off using current automization settings.

22.1.3 Rotation Unit

Creator and Align support cameras mounted on a motorized rotation unit, which is a common alternative to fisheye cameras and multiple perspective cameras for capturing screens with a large field of view.

For example, one perspective camera mounted on a rotation unit could cover a full 360 degrees cylindrical screen.

`Project Settings.../Rotation Unit` allows to setup and test communication with an installed rotation unit.

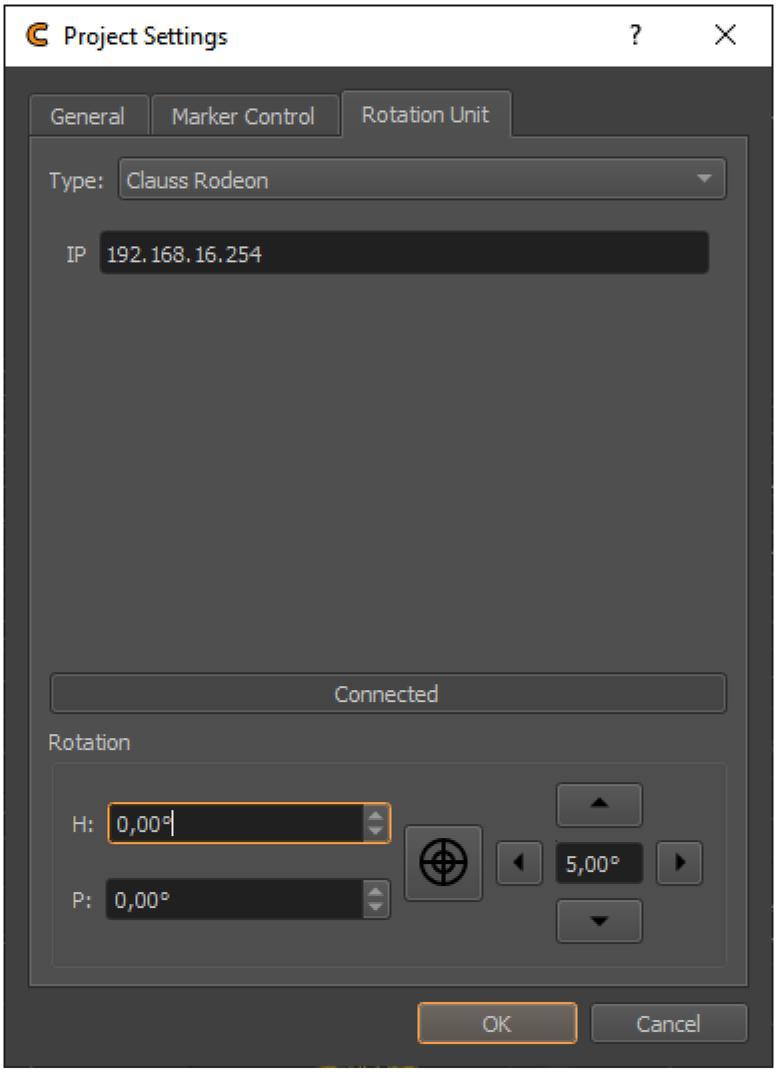
Type
Type of rotation unit.

None
No rotation unit available.

Clauss Rodeon
Motorized rotation unit from Clauss, controllable over network.

Connect
Connect to currently selected rotation unit. Allowing to test rotation.

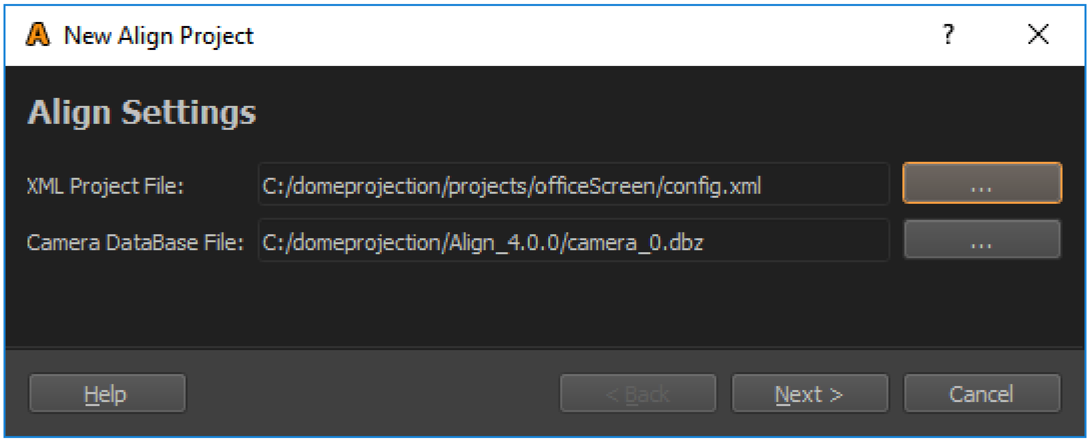
Rotation
Rotation control for currently selected rotation unit. This is for testing only. For setting permanent orientations use `Positions Editor/Position/Target` heading and pitch angles.


Project Settings
?
General
Marker Control
Rotation Unit
Type:
Clauss Rodeon
IP
192.168.16.254
Connected
Rotation
H:
0,00°
P:
0,00°
5,00°
OK
Cancel

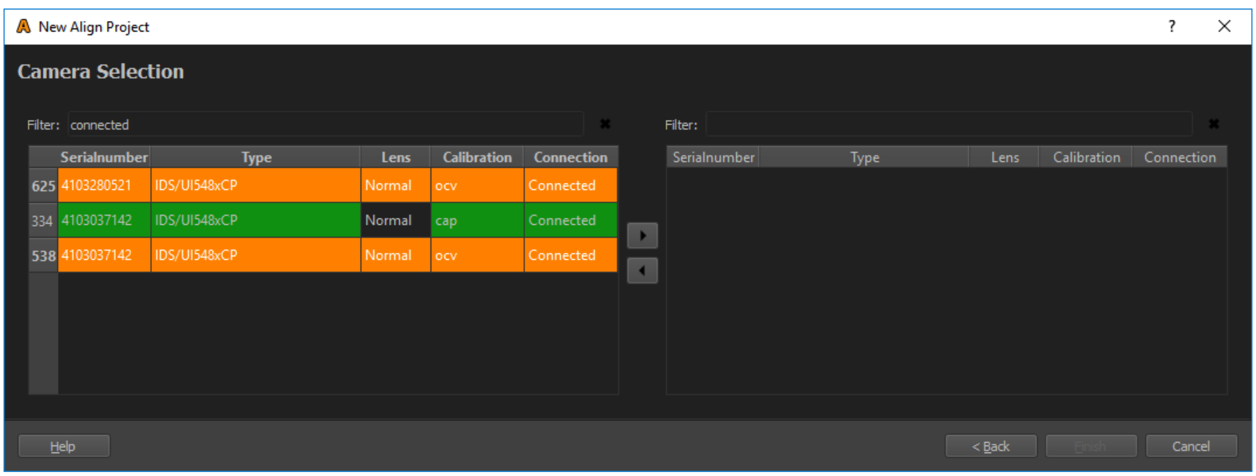
22.2 Build Align Project Wizard

Converts a calibration project for use in Align program.

Allows to select the original project and a new set of cameras from a given camera database. After conversion, the modified project is automatically opened in align and camera positions can be defined.



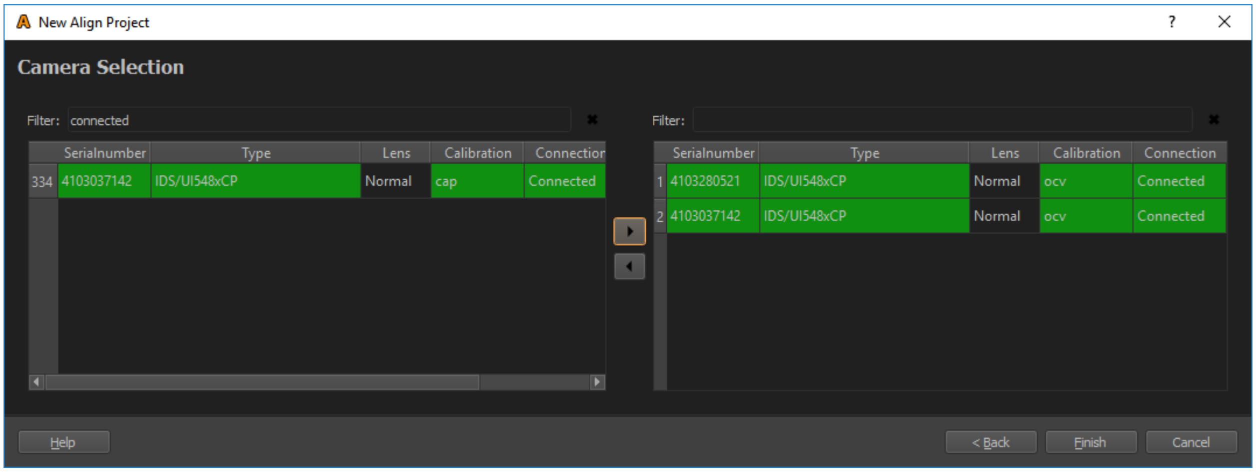
Select the project to be converted and the camera Database containing the align cameras calibration data.



Select cameras in the left list that should be used in the align project. The list can be filtered for connected cameras, by enetring "connected" in the filter.

Add the selected cameras to the project using the right-arrow button.

The project can now be converted using the "Finish" button. After that, the align program automatically opens the new project automatically.



22.3 Configure automatic Align

Configure automatic Align automatically selects projectors and adjusts dot patterns for camera positions.

It uses current camera position, orientation and opening angle information combined with initial calibration data, to predict, which projectors and which part of the dot pattern will be seen from that camera position.

Usage:

1. Add positions for each camera in Positions table and detect their position using Position Finder.
2. Than use Configure automatic Align.

CHAPTER

TWENTYTHREE

ABOUT MAPPER2D

The Mapper2d allows to define and preview content mapping on a screen.

The Mapper2d bases its calculations on measurements of the projectionsystem. The measurements are done with Creator or Align.

It can export the resulting correction data for several presentation systems, warping software and warping hardware.

CHAPTER TWENTYFOUR

MAIN WINDOW OVERVIEW

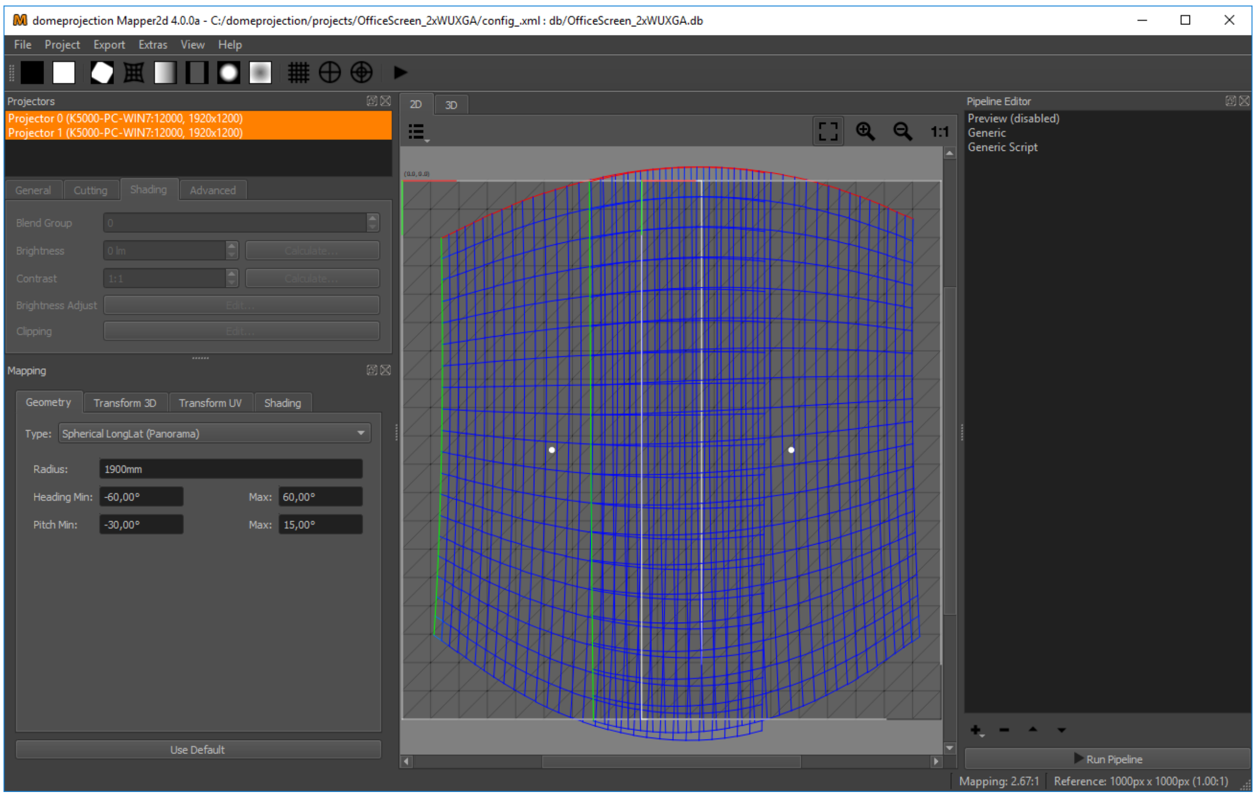


Fig. 1: Mapper2d main window

Mapper2d has a fully configurable workspace. Above figure shows the default configuration with the typical widgets open.

Menus

File Menu
Load and save projects. Adjust global project settings.

Export Menu
Export calibration data from current project using available exporters. Please refer to section *Exporters* for a list of all available exporters.

Export settings used here are non-persistent. This is useful for experimenting with different settings, without changing a previously defined autoalignment work-flow for instance. Section *Pipeline Editor* describes how to save persistent export settings using the Pipeline Editor.

Extras Menu
Additional tools and advanced operations on loaded project.

View Menu
Workspace and theme management.

Help Menu
Help, Support and Program information.

Toolbar
The toolbar provides quick access to several previews (see *Preview Toolbar*) and an automization run.

Docks
Here a list of the most important docks, also shown in the screen shot.

Projector List
The projectors dock widget shows a list of all projectors in the current project and allows to edit projector related settings.

Mapping
2D mapping of the projection, used for applying clipping, fadeout and calculating blending.

Pipeline Editor
On the right side in the Pipeline Editor exporters can be configured with persistent settings to run multiple times.

Central Views
In the center of the window are multiple views available between which the user can switch.

2D View
Shows the 2d warping between screen mapping and selected projection channels.

3D View
Shows projection surface, mapping and virtual cameras in a 3d view.

Statusbar
Gives information about aspect ratio of currently setup mapping.

All dock widgets can be arranged, stacked, opened and closed by user. The workspace layout is saved persistently.

It is also possible to revert to the default workspace using `View/Default Workspace`.

All available dock widgets can be found in the menu. They are described in the following sections.

The theme can be switched in `View/Theme`. An application restart is needed for a theme switch to take effect.

For using the maximum workspace on the desktop, a full screen mode can be enabled in `View/Toggle Fullscreen Mode`.

24.1 Projector List

There are different kinds of information stored for each projector. All projector related values are managed by the tabs below the projector list, which apply to the selected projectors.

The list shows the given Projector name, its IP address with port, the resolution and if an alignment is available (aligned).

The projector list is multi-selection enabled. Only selected projectors are shown in the 2d- and 3d-view. Press `Ctrl-A` to select all projectors at once or hold `Ctrl-` or `Shift-`key to add projectors to current selection.

Projector settings can be edited when a single projector is selected, otherwise the projector settings placed below the projector list are grayed out.

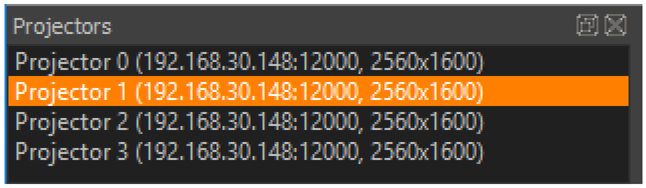


Fig. 2: Projector List

24.1.1 General Settings

The general settings, reflect the physical setup. Usually all data here is filled out in advance through the calibration setup. Changes here should only be done when the physical setup has changed (for example due to network reconfiguration, computer replacement, or rewiring)

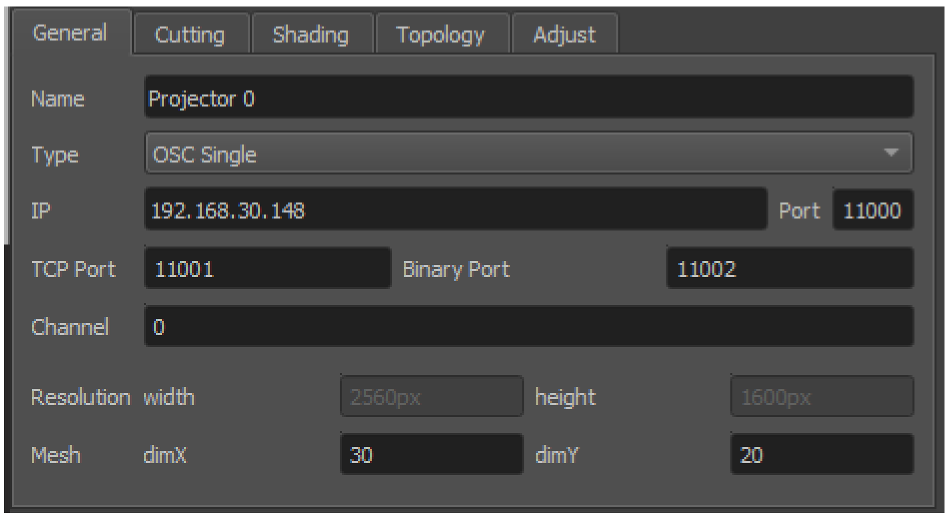


Fig. 3: General Settings

Name
: Human readable string describing the projector.

Type
: Interface to use for showing testpatterns.

  OSC Single
  : Default PatternGenerator based interface. Works with up to date PatternGenerator.

  OSC Multi
  : ProjectionTools channels are virtually split into multiple PatternGenerator channels. Works with standard PatternGenerator.

  OSC Legacy
  : Can be used for very old PatternGenerator installations, or installations on limited/embedded hardware. The preview functionality is limited.

  NDI
  : Provide testpatterns as one NDI-stream per channel. This can be used, if it is not possible to install Pattern-Generator on the Mediaservers. Several Mediaservers support recieving and showing NDI-Streams. The preview functionality is limited.

Norxe Unify
Send testpatterns as image directly to Norxe Unify projectors. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Barco Pulse
Send testpatterns as image directly to Barco Pulse projectors. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Luna
Send testpatterns as image directly to domeprojection Luna warp units. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Warper4k
Send testpatterns as image directly to Westar Warper4k warp units. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

IP
Network address of computer where PatternGenerator software is running on. Hostnames are supported as well.

Port
Networkport to communicate with PatternGenerator. By default 11000

Channel
The Channel is used to address a projector if more than one is connected to a single PC

Width and height
Have to be the same as the physical projector resolution used in the projection and displayed here for reference only (not editable).

dim X and dim Y
Attribute, defining the resolution of the warping grid. Larger values may gain better results but some constraints apply. There are hard limits depending on the warping unit. Bigger values are increasing the calculation time of many operations significantly, especially

24.1.2 Cutting

Cutting rectangles are auto generated by default. This way, they are automatically placed where the mapping of the projector is in the texture with some scale-factor (defined in project settings) increasing its size and auto rotated to best fit.

The auto generation can be disabled to allow user defined cutting rectangles (e.g. when they are already predetermined by projection design and content production). Another reason for disabling auto generation is when the cutting rectangles should no more change, e.g. when using pre-split video.

Cutting rectangles can also be placed in a regular grid with defined relative overlaps using:

`Menu/Extras/Layout Cutting Rectangles`

Auto Generate
Enable/Disable automatic generation and update of cutting rectangle. When disabled cutting rectangle settings can be edited by hand.

Position X Y
Position of cutting rectangle center as normalized coordinate in texture space

Extent W H
normalized width and height of cutting rectangle

Rotation
Orientation of cutting rectangle as degrees clock-wise

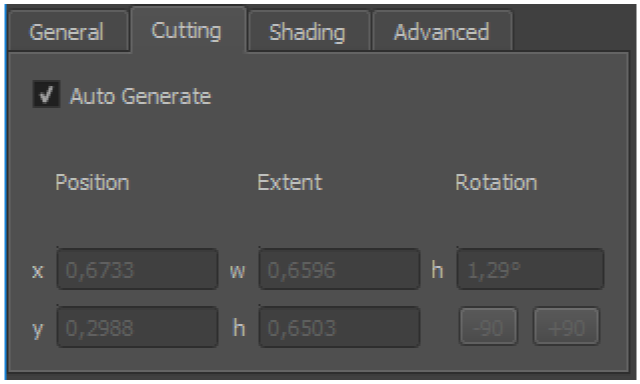


Fig. 4: Cutting settings

-90 / +90

Quickly spin cutting rectangle in 90 degree steps.

Spin cutting rectangles can be used to quickly fix auto generated cutting rectangles, whose orientation does not match the orientation of the projector mesh. For some warp units it is important that the cutting rectangle is aligned correctly, since the amount of warping that can be applied on these units is limited.

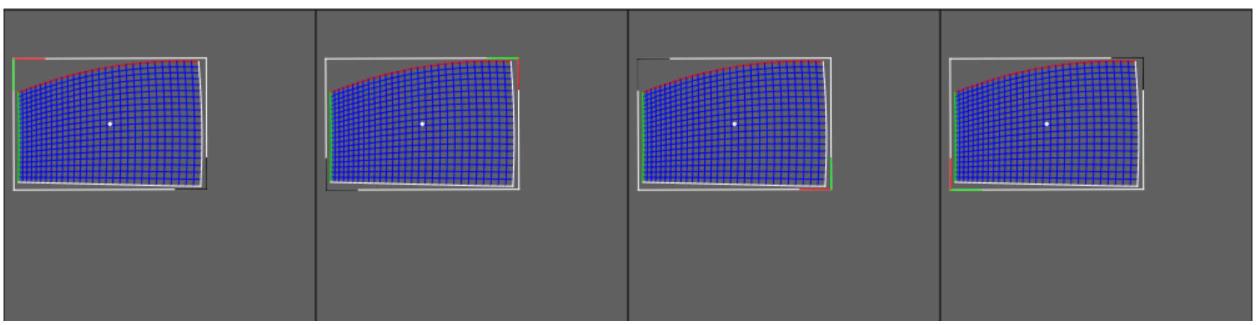


Fig. 5: Cutting spin multiple times

24.1.3 Shading

The Shading panel expose blending properties which can be different for each projector. There are other values as well, which apply to the whole setup and are adjusted in different places.

Blend Group

In order to increase light intensity, sometimes two projectors are used to project on the same area of the screen. This is a so called "tandem" or "stacked" projection. Since blending is typically calculated between all overlapping projectors, the brightness of the tandem projection pair would be reduced to the brightness of one projector canceling out the initial intention of the tandem projection. The proper use of Blend Groups helps in this case.

Blending is calculated between projectors of same blend group only. Use different blend groups for different layers of projection or projectors between which no blending should be calculated. The blend group element assigns a projector to a blend group. The default blend group is 0.

Brightness

Brightness of projector in lumen. Used for uniformity correction calculations.

Brightness Calculate

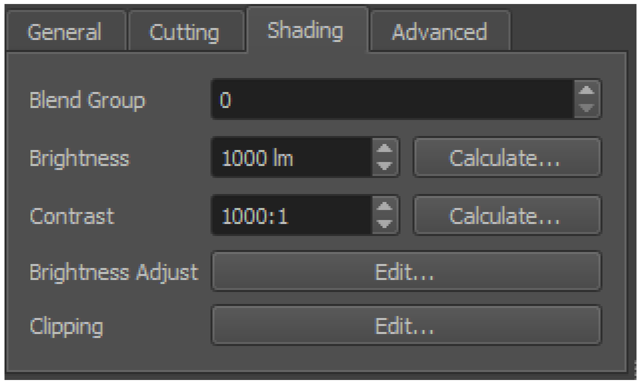


Fig. 6: Shading settings

Allows to calculate projector brightness from measured brightness of projected image center and a given screen-gain. Shows a small white rectangle on the selected projector center for taking a measurement right away.

Contrast
Contrast of projector, used for advanced black level correction calculations.

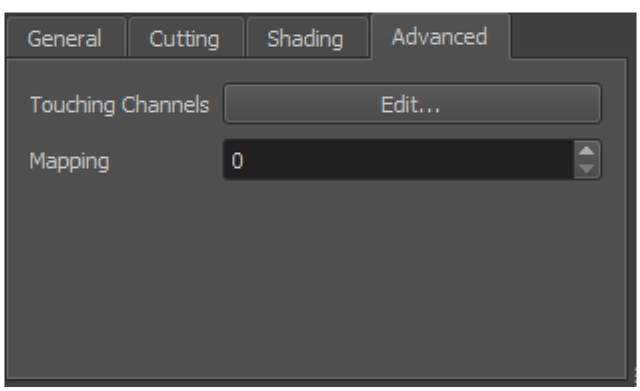
Contrast Calculate
Allows to calculate projector contrast from black and white measured at center of projected image. Shows a black image and a small white image in projector center for taking measurements.

Brightness Adjust
When global automatic uniformity correction is disabled, it allows to edit custom uniformity correction for a projector. See section *Uniformity Correction Editor* for details.

Clipping
Allows to clip parts of the current projector. The clipped parts will be covered by neighboring projectors if present. It is usually used, if projectors are partly shadowed by obstacles.

24.1.4 Topology

Relation between channels.



Touching Channels
Define the neighboring channels for high resolution projectors (see section *Touching Channels*).

Mapping
When a project has multiple mappings defined, this setting is available and allows to assign a channel to a mapping (see section *Multiple Mappings*).

24.1.5 Adjust

Allows to do additional, manual adjustment of geometry and color uniformity.

Shading

Adjust brightness and color up to pixel level.

Brightness Adjust

When global automatic uniformity correction is disabled, it allows to edit custom uniformity correction for a projector. See section *Uniformity Correction Editor* for details.

Clipping

Allows to clip parts of the current projector. The clipped parts will be covered by neighboring projectors if present. It is usually used, if projectors are partly shadowed by obstacles.

WhitePoint

Allows to adjust the color uniformity of a projector. This correction is combined with the standard uniformity correction of a projector.

Please be aware, that color uniformity correction is not compatible with all systems.

Init Preview

Uploads blending information to the PatternGenerator, so that an interactive preview can be shown while editing the whitepoint color uniformity.

Reset Preview

Puts PatternGenerator in a clean state again, compatible with standard previews.

Edit

Opens an Uniformity Correction Editor (see section *Uniformity Correction Editor*), with color editing enabled.

Blanking

If a projector has poor projection quality at the edges or corners, these areas can be removed using the blanking option. Adjust the amount of blanking for left, right, top, bottom edge and preview the results using the “Preview Cutting”. This feature does not change the resulting warping. The blanking is encoded in the exported blending as black areas.

Black Level Correction

Control appearance of projection when dark/black content is projected.

Uniformity

Allows to change the color of the software black level correction. This is sometimes necessary, if the native black of a projector has a different color than the lower gray levels. It is suggested to turn “Advanced BLC” off in project settings and set a relative high “Black Level”, in order to have a good starting point.

It is also possible to adjust multiple projectors at once by selecting the relevant projectors in the projector list and using `Extras/BLC Tweak Initialize...` followed by `Extras/Tweak Black Level Correction...`.

Note: Please be aware, that colored black level correction is not compatible with all systems.

Init Preview

Prepares the PatternGenerator to show an interactive preview while editing the black level color uniformity.

Reset Preview

Puts PatternGenerator in a clean state again, compatible with standard previews.

Edit
Opens an Uniformity Correction Editor (see section *Uniformity Correction Editor*), with color editing enabled.

Override Chip Oversize
Overrides the globally set Chip Oversize per projector (see section *Shading*).

Geometry
Allows to slightly adjust the warping. It is rarely used to handle errors or unusual setups, which are not covered by standard attributes. Please note, these parameters affect the calculations directly and may have unexpected side effects. The adjustment values will shift the calculated warping by factor*value. Its main use is like shifting a projector manually.

Note: Those properties should be used to adjust the projection manually instead of modifying it on the output device, because changes here will be exported after each autoalignment process.

24.2 2D View

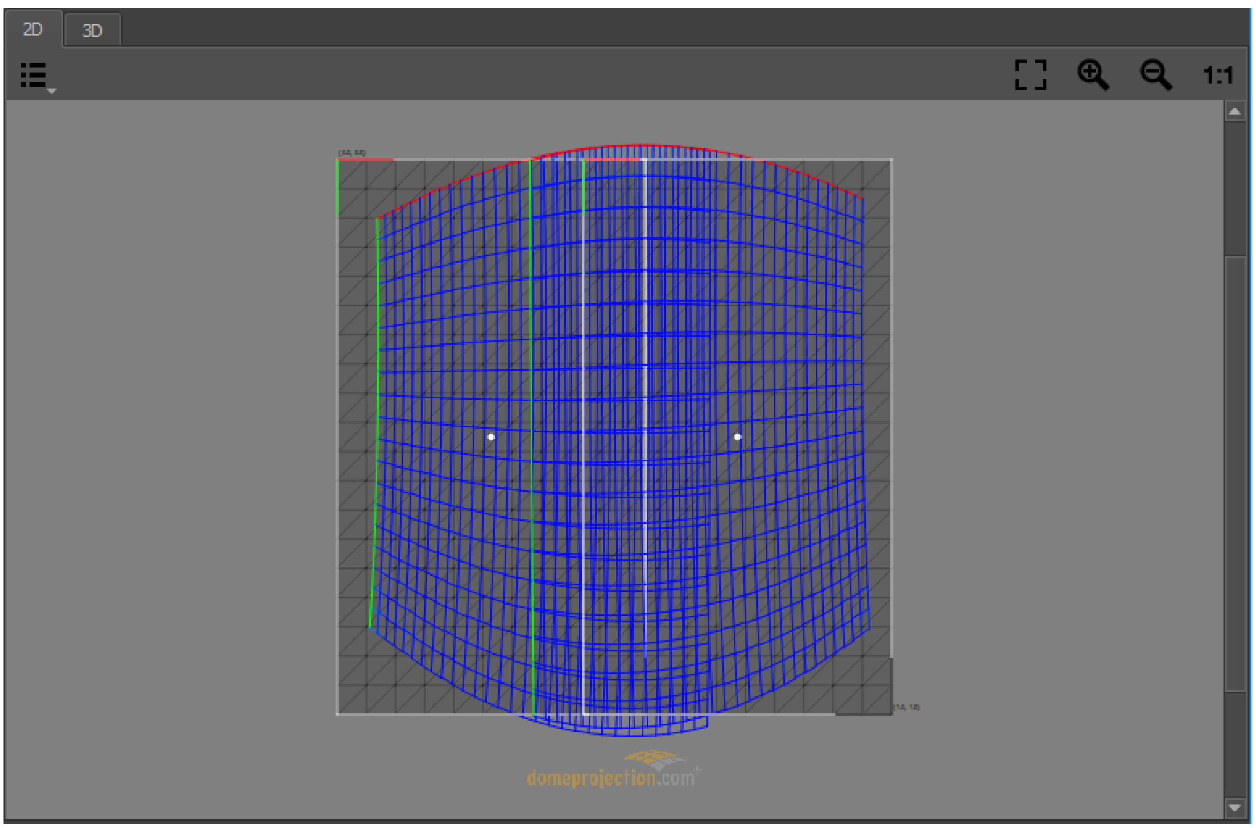


Fig. 7: 2D View

The 2D View Shows the texture space, a normalized space ranging from (0,0) top-left to (1,1) bottom-right.

Selected projectors are shown in this view as a mesh. The mesh represents the region of the texture used for the corresponding projector. The red and green edge represent the top and left edge of the projector. The mesh is also colored depending on the estimated quality of the calibration. The quality gradient ranges from blue (very good) over green and yellow to red (bad).

Visualization Options
A drop down menu on the top left corner allows to selet multiple visualization options.

Cutting Rectangles
The cutting rectangle of the selected projector is shown. The red/green lines mark the top left corner of the cutting rectangle. The black lines mark the bottom right corner. A white dot marks the center of the cutting rectangle.

Reference Image
The projects reference image set in project settings can be shown as background. It can be set in global project settings, see section *General* for details.

Fadeout
In addition a visualization of the fadeout can be activated. The fadeout start and stop edge is marked by a white and black line. The fadeout can be adjusted in mapping settings, see section *Shading* for further informations.

UV-Layout
A semi-transparent grid visualizing the area covered by the current mapping. This area is influenced by current mappings uv transform. Especially interesting for “Reference Mesh” mapping. See section *Mapping* for further information about mappings.

Navigation
The view can be dragged with the left mouse button.

Scaling
Several scaling options are available at the top right corner of 2D View.

24.3 3D View

Shows the measured screen and mapping visualization in 3d space. Several aspects of the visualization can be toggled in this views toolbar at the top edge.

Visualization Options
A drop down menu on the top left corner allows to select multiple visualization options.

Mapping
Represents the current Mapping-settings. It shows the screen-shape and iconic projection-rays at the corners of the screen. In addition the projection of the measured points onto the screen are visualized.

Projection
The measured projection can be visualized in three different ways:

Measured Points
3d-position of measured points.

Measured Mesh
Triangulation of measured points. If a reference-image is set, the image will be shown as texture on the geometry.

Full Mesh
Based on current Measurements, the full projector is reconstructed (unmeasured parts as well). If a reference-image is set, the image will be shown as texture on the geometry.

Perspective
Switch to predefined orthographic views or the default perspective camera position.

Navigation
Navigate the 3d view using the mouse.

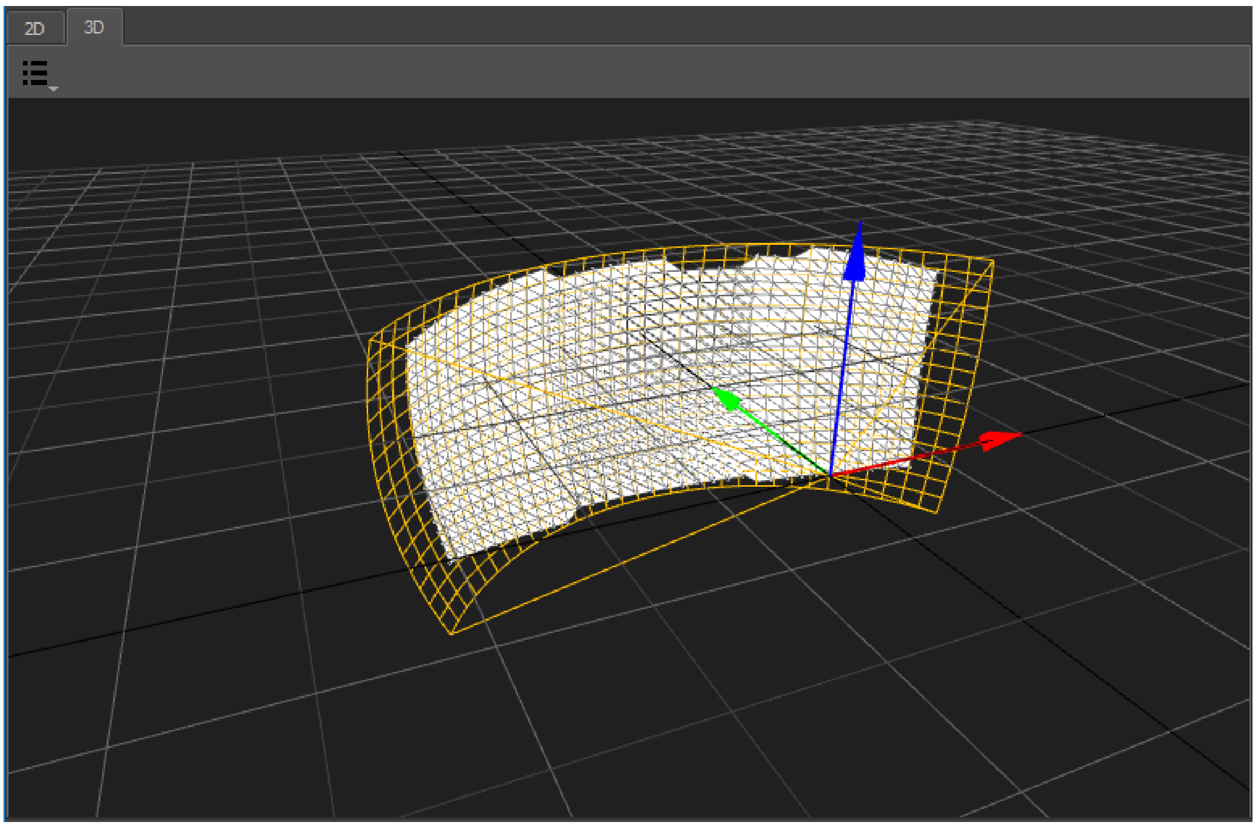


Fig. 8: 3D View

Rotate
    `Left mouse-button`

Move
    `Middle mouse-button`, `Alt+Shift+LMB`

Zoom
    `Right mouse-button`, `Alt+Ctrl+LMB`

24.4 Project Settings

The project settings allow to adjust global settings for a project. The project settings can be found in the `Project/ Project Settings...`

24.4.1 General

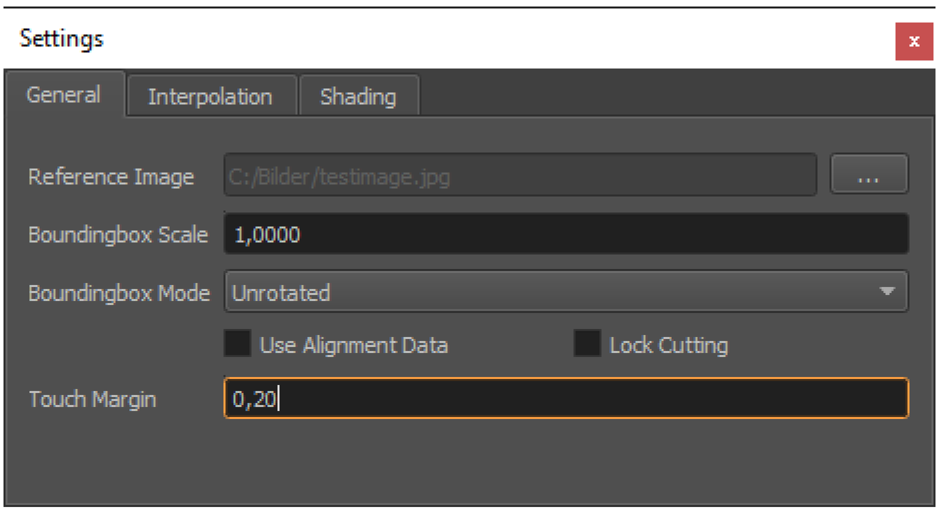


Fig. 9: General Settings

Reference Image
    An image that will be shown in background of 2d view. Resolution and Aspect-ratio of this image is also shown in the statusbar. So its aspect ratio can be compared with the aspect-ratio of the current mapping-settings.

Boundingbox Scale
    The auto generated cutting rectangles touch the warping mesh by default (scale 1.0). A save area can be added by increasing this value. Typically used when the project will be recalibrated and presplit content is used where the cutting-rectangles must be fixed, other wise the presplit content would have to be recreated.

Boundingbox Mode
    Select if cutting rectangles should be unrotated or rotated. Several exports require the cutting to be unrotated, which is the default.

Use alignment Data
    Used in auto-alignment setups with Align. It switches between the original calibration and the data from recalibration (alignment data)

Lock Cutting
Avoids accidentally changing cutting-rectangles in projects using presplit content. Cutting-rectangles should be fixed after presplit content is cutted, since it will not fit any more when cutting rectangles are changed.

Touch Margin
Allows to globally adjust touch margin for touching channels. See section *Touching Channels* for further information about high resolution projectors with multiple inputs and touching channels.

24.4.2 Interpolation

Captured calibration data is usually incomplete and captured only for a finite number of points. For exporting correction data, Mappers need to interpolate and extrapolate this data for each pixel of a projector and maybe even beyond. Many mathematical strategies exist for that purpose, all with individual strengths and weaknesses.

For some projects, depending on screen and mapping type, it might be necessary to switch to another interpolation type than the default. This can be done in the global `Settings/Interpolation` tab.

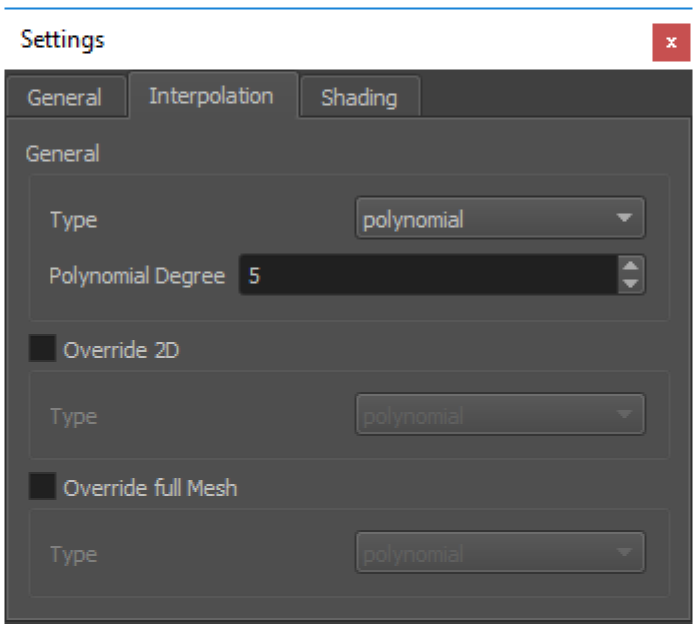


Fig. 10: Interpolation Settings

Interpolations are used for different purposes in the project.

General
For all purposes, if not overridden.

Override 2D
Optional override for interpolations between 2d mapping and projectors (influences the grids seen in 2D view).

Override full Mesh
Optional override for generating full meshes in 3d (influences full mesh visualization in 3D View and some advanced exporters)

Two interpolation types are available.

Polynomial (Default)
Gives good generalization of general shape of warping with good exact extrapolation near measured data. Has the tendency to fold and generate wrong results far away from measured data. Has a *degree* parameter to adjust

the complexity of warping. Lower values give better extrapolation results, but less fitting to details and strong curvatures.

Spline
Gives better results for strong warpings and tight radii, or even sharp corners on screen. Generally captures details better, but has less generalization. More relaxed far distance extrapolation. Takes considerable more time to calculate!

24.4.3 Shading

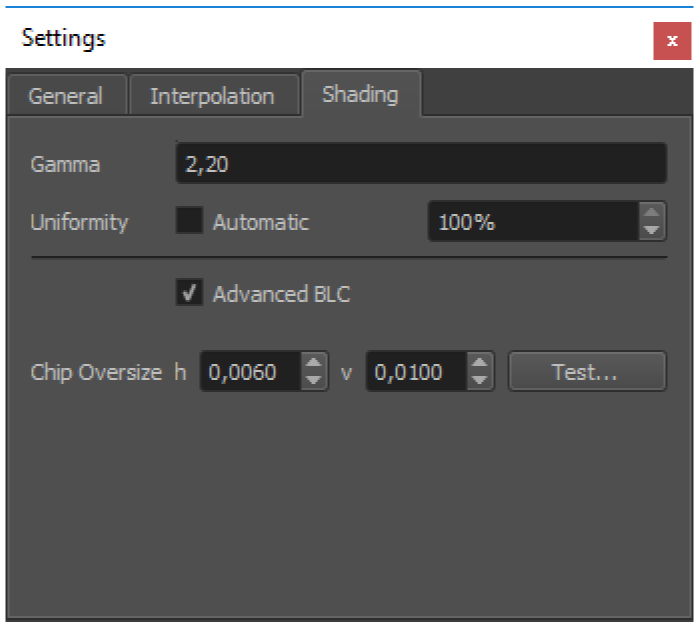


Fig. 11: Global shading settings

The shading-tab of the project-settings dialog allows to set several global parameters that influence blending and black-level-adjust calculations.

Gamma
Gamma of the projectors. Too high values will result in overexposed blending regions, a value that is too low will result in underexposed blending regions.

Uniformity
Enable automatic global uniformity calculation. Allows to adjust the degree of correction. 100% meaning full uniform brightness as the darkest point in the projection. 50% meaning brightness is reduced for all areas brighter than the medium brightness.

Advanced BLC
Automatic overlap calculation and regarding uniformity information for black level correction calculations. Brightness and contrast settings for each individual projector are used.

Max Overlap
Maximum number of projectors overlapping at any point. Typical is 2 for a linear setup of projectors in one row or 4 for a grid of projectors with multiple lines and rows. (Non Advanced BLC only)

Black level
Projectors typically produce no perfect black. They expose still some light to the screen when the input signal is full black. Black Level describes the amount of light the projector exposes for black images. The corresponding preview can be used to help adjusting this value. (Non Advanced BLC only)

Chip Oversize
Projectors typically expose light to a larger area than the area of addressable pixels. These surrounding parts must be taken into account for black-level calculation. When they are not regarded, the edges of the overlapping areas will become apparently brighter than the adjacent areas.

H/V
Horizontal/vertical oversize. Normalized values relative to channel width/height.

Fade
Compensate for smooth black level spillover typically seen on LCOS projectors. Off by default.

Test
Project dark triangles on each projector, supposed to line up with the borders of overlapping projectors. The preview regards global chip oversize, as well as potential overrides per channel. If there is a gap between triangles and overlapping projector decrease the chip oversize. If triangles are drawn partly on top of overlapping projectors increase chip oversize.

24.5 Preview Toolbar

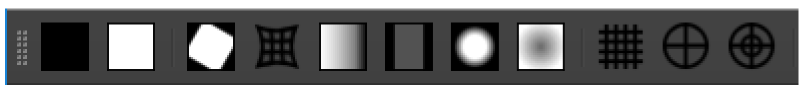


Fig. 12: Preview Toolbar

Several quick previews can be shown on physical screen, to assist during setup of blending, fadeout, ramps, mapping and easy camera.

The most often used previews have a button in the *Preview Toolbar*. Simply press a preview-button to show or update the corresponding preview.

Under some additional previews can be found.

Please note, that many preview images are results of simplified calculations and therefore not perfect. To judge the quality of a calibration a more time consuming preview export or an export into the real imaging system is needed.

Note: For the preview to work a PatternGenerator must be properly installed and running on each display computer. The warping is handled dynamically by PatternGenerator. Eventually installed warp units should not apply any blending or warping during the preview.

Black
make all projectors black

White
make all projectors full white

Cutting
Visualize, which parts of projectors will be used for projection. Due to intersection of physically projected area and cutting rectangles, this area can be smaller than the actual projector.

Warping
Visualize the resulting warping grid based on current virtual camera settings.

Shading
rough shading preview (resolution is depending on projects mesh resolution settings)

Black Level
rough black level adjust preview (resolution is depending on projects mesh resolution settings)

Fadeout
rough preview of current fadeout settings (without blending)

Uniformity
preview of current uniformity correction without blending applied

Rectangular grid
project a rectangular grid using current mapping settings (typically used with Perspective, Planar, Cylindrical or Spherical LongLat mapping)

Polar Grid Half Dome
project a circular grid using current mapping settings (typically used for spherical polar mapping)

Polar Grid Full Dome
project a circular grid using current mapping settings, projects twice as much rings as Half Dome grid. (typically used for spherical polar mapping)

Outlines
Renders all expected outlines using the calibrated system except for selected projectors. Selected projectors have their current real outline rendered and are filled gray. This can be used to put single projectors easily in their correct position after maintenance and before recalibration. Usage:

1. Select Projector, that has moved.
2. Preview Outlines.
3. Adjust physical projector position, orientation, zoom and shift until it fits its rendered outlines as close as possible.
4. Re-Align the system to get perfect continuous geometry again.

24.6 Statusbar

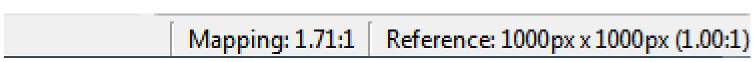


Fig. 13: Mapper2d Status Bar

The statusbar at the bottom of the mainwindow shows multiple status informations.

On the **left side** it shows **event** based information.

In the **second section** it shows the **aspect ratio** resulting **from current mapping** settings. The basic mapping settings (min, max values and radius etc. of screen geometry are taken into account). Settings in Transform3d and Transform UV are not taken into account.

In the **last section** it shows the **resolution and aspect-ratio** of the current **reference** image.

CHAPTER

TWENTYFIVE

EXTRAS

Here additional functionality not yet discussed in other parts of the manual are described. These additional functionalities are usually found in the .

25.1 Cut Image

Cut Image is used to cut sub-regions from an image using the current cutting-rectangle. These images can be used as presplit content on the different IGs and warped by warping software/hardware.

25.2 Warp Image

Warp Image is used to create preview images for each projector. The warping can be shown, if those images are displayed full-screen on the clients. Select first a source image, which will be used and then the target directory, where the results are stored.

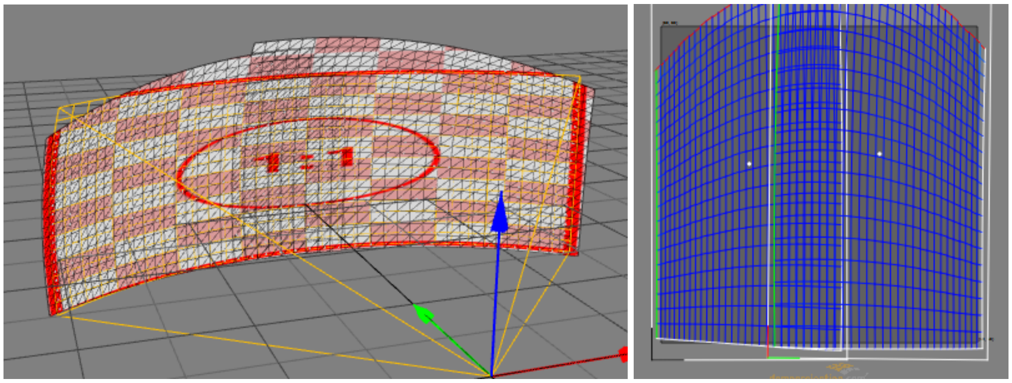
25.3 Transform Image

Transform Image currently supports conversion of cube maps into polar images. Additional transformations might be added in future.

25.4 Compensate Screen Aspect Ratio

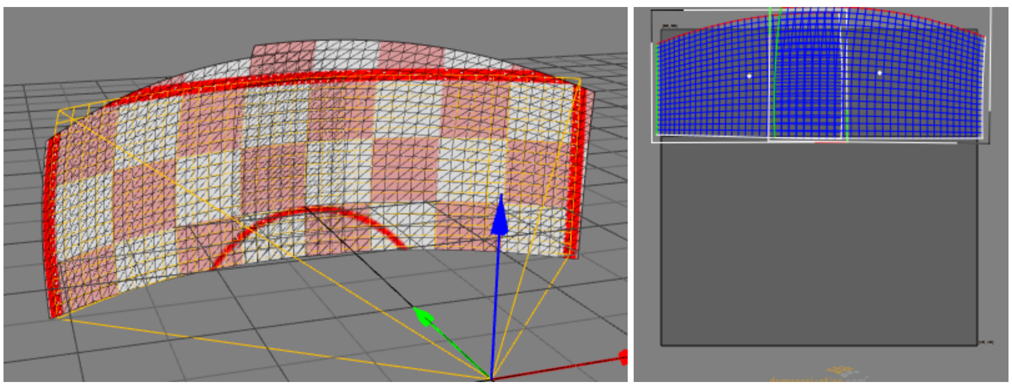
Projection screens are usually not square. They can have rather extreme aspect ratios. Often this is not a problem, since the content is designed for the given screen aspect ratio, and the complete content is just stretched over the screen.

Some playout systems have no idea about of the screen aspect ratio or how the content need to be stretched. They need to get this information from Mappers export, especially the cutting rectangles. In a standard mapper setup the cutting rectangles fill a normalized space, disregarding any screen aspect.



Stretched image on screen and corresponding uv-coordinates before aspect correction.

Compensate Screen Aspect Ratio takes the current screen aspect ratio into account and produces texture coordinates and cutting rectangles that appear unstretched.



Straight image on screen and corresponding uv-coordinates after spect correction.

The aspect ratio can be changed from the default.

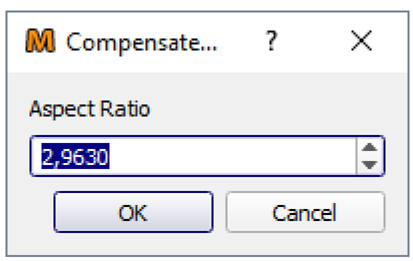


Fig. 1: Compensate Screen Aspect Ratio settings

CHAPTER

TWENTYSIX

ABOUT MAPPER3D

The Mapper3d program is used for managing all aspects of a 3d calibration and for exporting the results to the corresponding warp units.

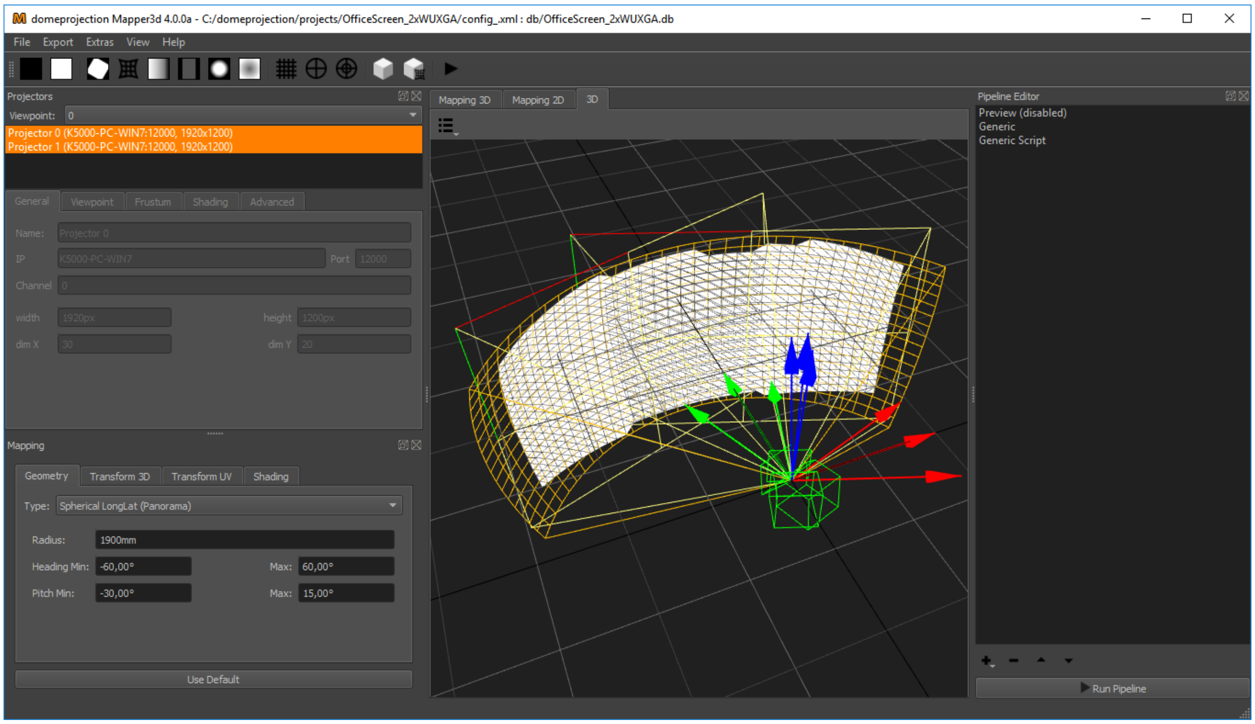
Based on any available calibration the following options are available:

- access to many parameters of the projection setup, like IP addresses, image resolution and projector resolution
- displaying test data on the screens using the PatternGenerator program installed on the image generator machines
- managing view port settings like viewer position or projection area
- changing and applying all aspects of blending and image operations
- exporting the result data for different warp units/software or image generators

CHAPTER

TWENTYSEVEN

MAIN WINDOW OVERVIEW



Mapper3d has a fully configurable workspace. Figure above shows the default configuration with the typical widgets open.

Menus

File Menu
Load and save projects. Adjust global project settings.

Export Menu
Export calibration data from current project using available exporters. Please refer to section *Exporters* for a list of all available exporters.

Export settings used here are non-persistent. This is useful for experimenting with different settings, without changing a previously defined autoalignment work-flow for instance. Section *Pipeline Editor* describes how to save persistent export settings using the Pipeline Editor.

Extras Menu
Additional tools and advanced operations on loaded project.

View Menu
Workspace and theme management.

Help Menu
Help, Support and Program information.

Toolbar
The toolbar provides quick access to several previews (see *Preview Toolbar*) and an automization run.

Docks
Here a list of the most important docks, also shown in the screen shot.

Projector List
The projectors dock widget shows a list of all projectors in the current project and allows to edit projector related settings.

Mapping
2D mapping of the projection, used for applying clipping, fadeout and calculating blending.

Pipeline Editor
On the right side in the Pipeline Editor exporters can be configured with persistent settings to run multiple times.

Central Views
In the center of the window are multiple views available between which the user can switch.

Mapping 3D
Shows the warping between virtual camera and selected projection channel.

Mapping 2D
Shows the 2d warping between screen mapping and selected projection channels.

3D
Shows projection surface, mapping and virtual cameras in a 3d view.

All dock widgets can be arranged, stacked, opened and closed by user. The workspace layout is saved persistently.

It is also possible to revert to the default workspace using `View/Default Workspace`.

All available dock widgets can be found in the menu. They are described in the following sections.

The theme can be switched in `View/Theme`. An application restart is needed for a theme switch to take effect.

For using the maximum workspace on the desktop, a full screen mode can be enabled in `View/Toggle Fullscreen Mode`.

27.1 Projector List

There are different kinds of information stored for each projector. All values are managed by the tabs below the projector list, which apply to the selected projectors.

The list shows the given Projector name, its IP address with port, the resolution and if an alignment is available (aligned).

The projector list is multi-selection enabled. Only selected projectors are shown in the 2d- and 3d-view. Press `Ctrl-A` to select all projectors at once or hold `Ctrl-` or `Shift-`key to add projectors to current selection.

By selecting any projector inside, all fields in the settings tabs are updated and all previous modifications to it are applied.

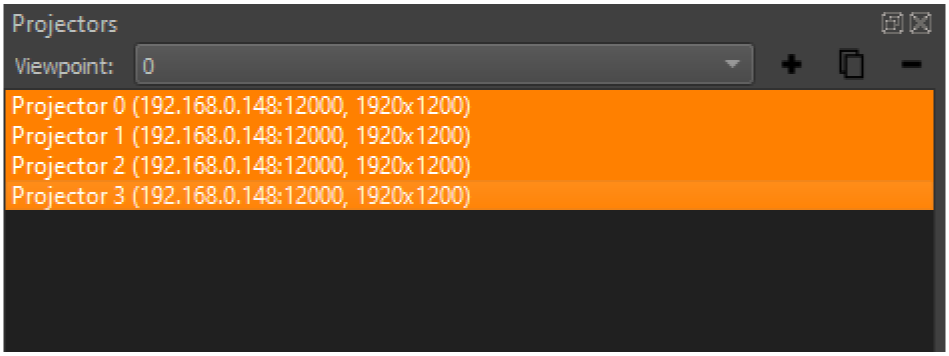


Fig. 1: Projector List

27.1.1 Viewpoint

The viewpoint pull down menu is used to manage different sets of projector view settings. Its main use is to switch safely and quickly between different eye-points, like pilot's positions in a simulator. Switching between viewpoint groups does not modify the resulting projection immediately, you have to export the project again (most commonly through running the exporter pipeline again).

Selection
: If multiple viewpoints are defined in the project, select the current viewpoint for editing.

Add Viewpoint
: Add a new mapping to the project.

Duplicate Viewpoint
: Duplicate the currently selected viewpoint.

Remove Viewpoint
: Remove the currently selected viewpoint. This is only possible when more than one viewpoint is present in the project.

See *Viewpoint* for details about viewpoints and how to setup.

27.1.2 General settings

First there are the general settings, which reflect the physical setup. Usually all data here is filled out in advance through the calibration process and its setup.

Name
: Human readable string describing the projector.

Type
: Interface to use for showing testpatterns.

  OSC Single
  : Default PatternGenerator based interface. Works with up to date PatternGenerator.

  OSC Multi
  : ProjectionTools channels are virtually split into multiple PatternGenerator channels. Works with standard PatternGenerator.

  OSC Legacy
  : Can be used for very old PatternGenerator installations, or installations on limited/embedded hardware. The preview functionality is limited.

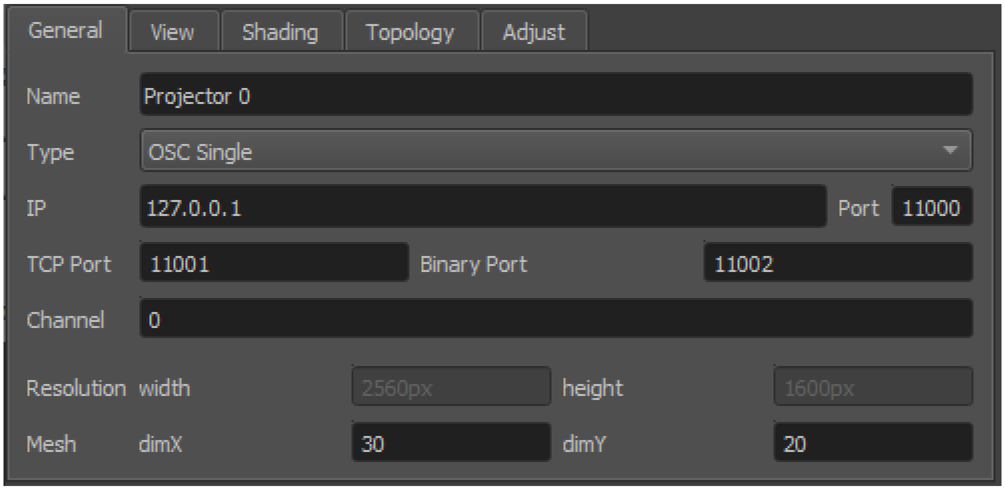


Fig. 2: general projector settings

NDI
Provide testpatterns as one NDI-stream per channel. This can be used, if it is not possible to install PatternGenerator on the Mediaservers. Several Mediaservers support recieving and showing NDI-Streams. The preview functionality is limited.

Norxe Unify
Send testpatterns as image directly to Norxe Unify projectors. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Barco Pulse
Send testpatterns as image directly to Barco Pulse projectors. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Luna
Send testpatterns as image directly to domeprojection Luna warp units. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Warper4k
Send testpatterns as image directly to Westar Warper4k warp units. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

IP
Network address of the computer where the PatternGenerator software is running on. Hostnames are supported as well.

Port
Networkport to communicate with PatternGenerator. By default 11000.

Channel
The Channel is used to address a projector - if more than one is connected to a single PC.

Width and height
Have to be the same as the physical projector resolution used in the projection and displayed here for reference only (not editable).

dim X and dim Y
Attribute, defining the resolution of the warping grid. Larger values may gain better results but some constraints apply. There are hard limits depending on the warping unit. Bigger values are increasing the calculation time of many operations significantly, especially blend map calculation.

27.1.3 View settings

The view settings define the output warping depending on a calibration. All properties of the virtual projection camera are managed here. All changes are displayed in the graphical views (Warping, 3D).

Note: The changes are displayed only after pressing the Enter key or change of the input focus, since all modifications to view settings lead to a time consuming recalculation.

The transform group defines the relative position (eye-point) and orientation of the virtual camera per channel.

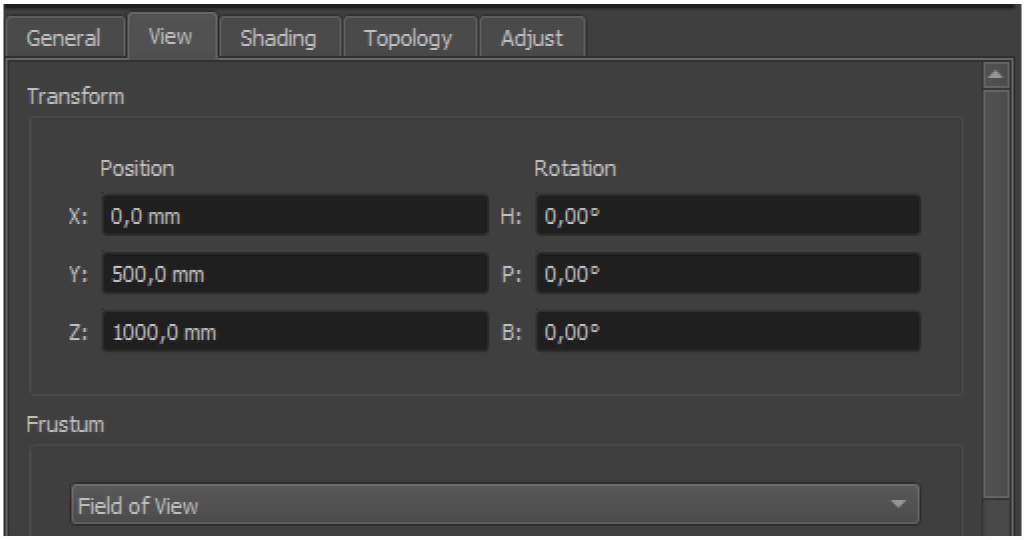


Fig. 3: Viewpoint settins

Position (x,y,z)
The position relative to the center of the systems point of origin. Values entered in millimeter.

Rotation (heading, pitch, bank):
Each virtual camera can be rotated around the defined eyepoint. Note that no setting for all cameras is available, they are usually rotated in different directions. The rotation order is:

1. heading
2. pitch
3. bank

The viewing frustum is setup in the frustum group. There are three different methods for entering/viewing the data. They can be selected with the pull down menu (currently displaying Field of View) and change the input dialogue.

Input Method
Select method for viewing/entering frustum data. Changes input fields below accordingly. Options are:

Field of View
enter the value in degree for the horizontal (HFOV) and vertical (VFOV) field of view. Shift the projection by fractions of 100 with h shift and v shift.

Zoom
enter aspect ratio, zoom, h shift and v shift as fractions of 100.

Separate Angles
enter the four (top, bottom, left, right) opening angles in degree relative to the middle point.

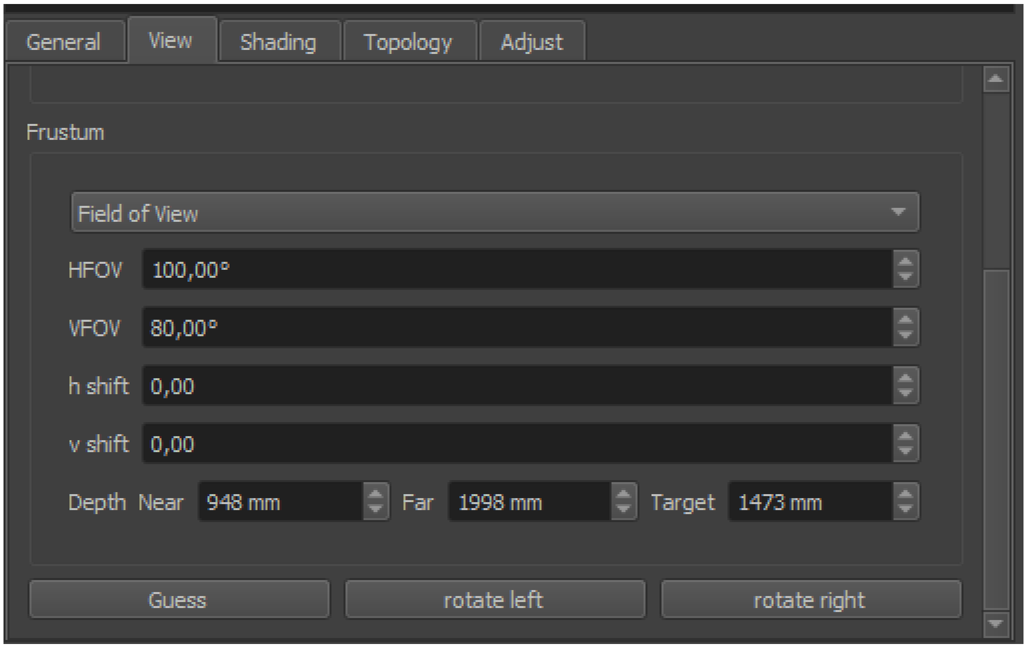


Fig. 4: Frustum settings

Depth (near, far, target)
Adjust the depths range and target distance. The target depth is used for generating target rectangles for advanced 3d export (see section *Export Generic Advanced 3D*).

Guess
The Guess button can be used to calculate the frustum and viewpoint orientation, based on the measured data. It will open a dialog with further options. For details see section *Viewpoint*.

Rotate left/right
Rotate (spins) the frustum in corresponding direction while keeping current frustum shape (switching between portrait and landscape).

27.1.4 Shading settings

The Shading panel expose blending properties which can be different for each projector. There are other values as well, which apply to the whole setup and are adjusted in different places.

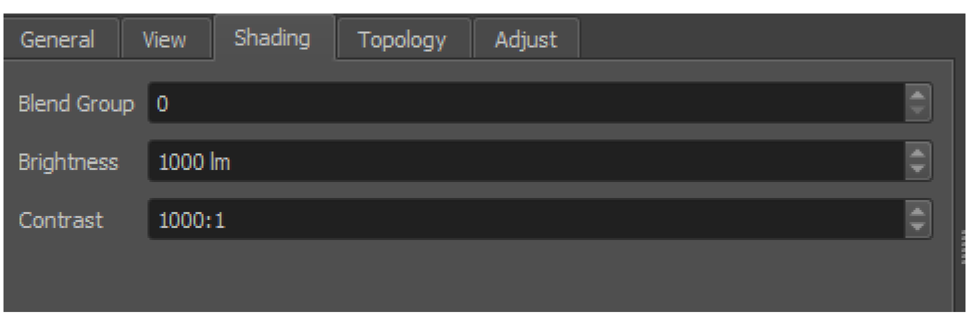


Fig. 5: Shading settings

Blend Group

In order to increase light intensity, sometimes two projectors are used to project on the same area of the screen. This is a so called “tandem” or “stacked” projection. Since blending is typically calculated between all overlapping projectors, the brightness of the tandem projection pair would be reduced to the brightness of one projector canceling out the initial intention of the tandem projection. The proper use of Blend Groups helps in this case.

Blending is calculated between projectors of same blend group only. Use different blend groups for different layers of projection or projectors between which no blending should be calculated. The blend group element assigns a projector to a blend group. The default blend group is 0.

Brightness
Brightness of projector in lumen. Used for uniformity correction calculations.

Brightness Calculate
Allows to calculate projector brightness from measured brightness of projected image center and a given screen-gain. Shows a small white rectangle on the selected projector center for taking a measurement right away.

Contrast
Contrast of projector, used for advanced black level correction calculations.

Contrast Calcutate
Allows to calculate projector contrast from black and white measured at center of projected image. Shows a black image and a small white image in projector center for taking measurements.

Override Chip Oversize
Allows to override the global chip oversize values. This might be used, when there are different projector types in a projection system. Chip oversize is important for Black Level Correction calculations, see section *Black Level Correction* for more information about Black Level Correction.

27.1.5 Topology

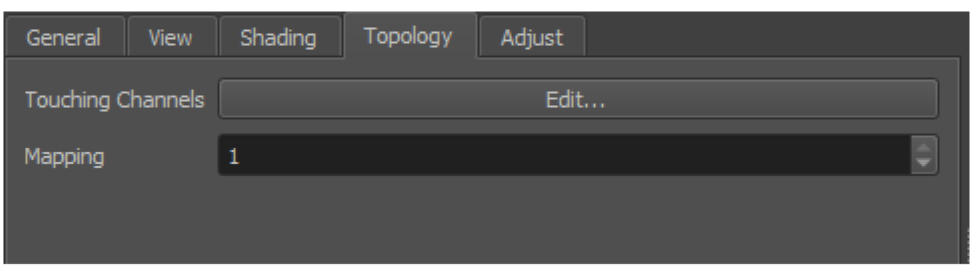


Fig. 6: Shading settings

Touching Channels
Define the neighboring channels for high resolution projectors (See section *Touching Channels*).

Mapping
Select the mapping used for that channel.

27.1.6 Adjust

Allows to do additional, manual adjustment of geometry and color uniformity.

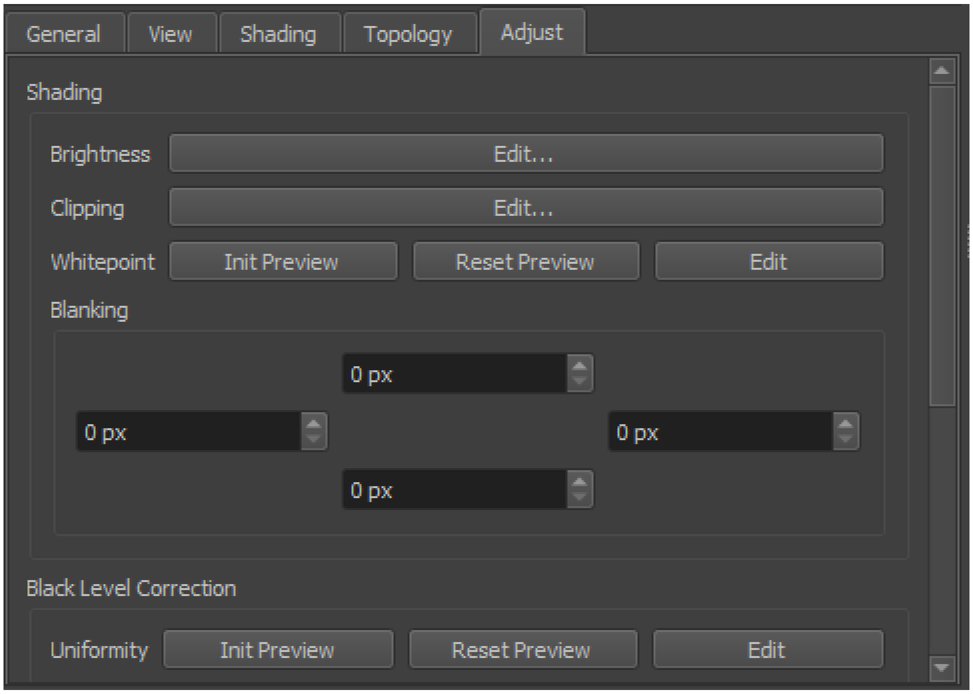


Fig. 7: Adjust settings

Shading
Adjust brightness and color up to pixel level.

Brightness Adjust
When global automatic uniformity correction is disabled, it allows to edit custom uniformity correction for a projector. See section *Uniformity Correction Editor* for details.

Clipping
Allows to clip parts of the current projector. The clipped parts will be covered by neighboring projectors if present. It is usually used, if projectors are partly shadowed by obstacles.

WhitePoint
Allows to adjust the color uniformity of a projector. This correction is combined with the standard uniformity correction of a projector.

Please be aware, that color uniformity correction is not compatible with all systems.

Init Preview:
Uploads blending information to the PatternGenerator, so that an interactive preview can be shown while editing the whitepoint color uniformity.

Reset Preview:
Puts PatternGenerator in a clean state again, compatible with standard previews.

Edit:
Opens an Uniformity Correction Editor (see section *Uniformity Correction Editor*), with color editing enabled.

Blanking
If a projector has poor projection quality at the edges or corners, these areas can be removed using the

blanking option. Adjust the amount of blanking for left, right, top, bottom edge and preview the results using the "Preview Cutting". This feature does not change the resulting warping. The blanking is encoded in the exported blending as black areas.

Black Level Correction

Control appearance of projection when dark/black content ins projected.

Uniformity

Allows to change the color of the software black level correction. This is sometimes necessary, if the native black of a projector has a different color than the lower gray levels. It is suggested to turn "Advanced BLC" off in project settings and set a relative high "Black Level", in order to have a good starting point.

It is also possible to adjust multiple projectors at once by selecting the relevant projectors in the projector list and using `Extras/BLC Tweak Initialize...` followed by `Extras/Tweak Black Level Correction...`.

Note: Please be aware, that colored black level correction is not compatible with all systems.

Init Preview

Prepares the PatternGenerator to show an interactive preview while editing the black level color uniformity.

Reset Preview

Puts PatternGenerator in a clean state again, compatible with standard previews.

Edit

Opens an Uniformity Correction Editor (see section *Uniformity Correction Editor*), with color editing enabled.

Override Chip Oversize

Overrides the globally set Chip Oversize per projector (see section *Shading*).

Geometry

Allows to slightly adjust the warping. It is rarely used to handle errors or unusual setups, which are not covered by standard attributes. Please note, these parameters affect the calculations directly and may have unexpected side effects. The adjustment values will shift the calculated warping by factor*value. Its main use is like shifting a projector manually

Note: Those properties should be used to adjust the projection manually instead of modifying it on the output device, because changes here will be exported after each autoalignment process.

27.2 Global settings

There are some properties that apply to the whole projection system. They can be modified in the settings tabs.

27.2.1 General settings

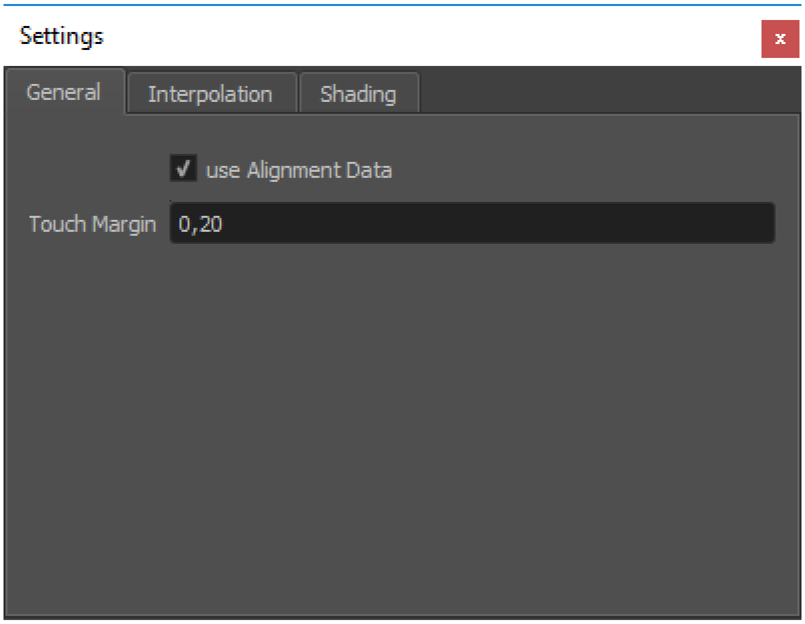


Fig. 8: General settings

Use Alignment Data
The most important element is the selector for Alignment data. If true, all further calculations are based on the data from the last auto align process instead of the initial calibration. The button is unavailable as long as there is not alignment data for all projectors stored in the database.

Touch Margin
Allows to globally adjust touch margin for touching channels. See section *Touching Channels* for further information about high resolution projectors with multiple inputs and touching channels.

27.2.2 Interpolation

Captured calibration data is usually incomplete and captured only for a finite number of points. For exporting correction data, Mappers need to interpolate and extrapolate this data for each pixel of a projector and maybe even beyond. Many mathematical strategies exist for that purpose, all with individual strengths and weaknesses.

For some projects, depending on screen and mapping type, it might be necessary to switch to another interpolation type than the default. This can be done in the global `Settings/Interpolation` tab.

Interpolations are used for different purposes in the project.

General
For all purposes, if not overridden.

Override 2D
Optional override for interpolations between 2d mapping and projectors (influences the grids seen in 2D view).

Override full Mesh
Optional override for generating full meshes in 3d (influences full mesh visualization in 3D View and some advanced exporters)

Two interpolation types are available.

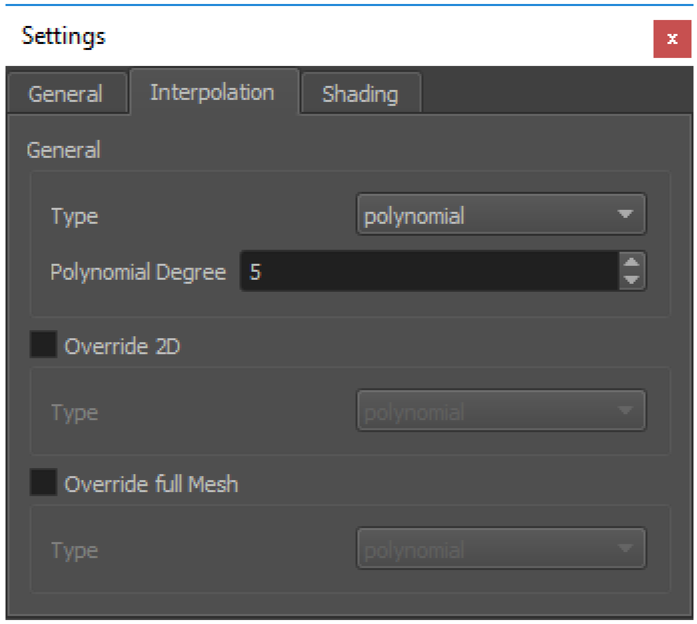


Fig. 9: Interpolation settings

Polynomial (Default)
Gives good generalization of general shape of warping with good exact extrapolation near measured data. Has the tendency to fold and generate wrong results far away from measured data. Has a *degree* parameter to adjust the complexity of warping. Lower values give better extrapolation results, but less fitting to details and strong curvatures.

Spline
Gives better results for strong warpings and tight radii, or even sharp corners on screen. Generally captures details better, but has less generalization. More relaxed far distance extrapolation. Takes considerable more time to calculate!

27.2.3 Shading

The shading-tab of the project-settings dialog allows to set several global parameters that influence blending and black-level-adjust calculations.

Gamma
Gamma of the projectors. Too high values will result in overexposed blending regions, a value that is too low will result in underexposed blending regions.

Uniformity
Enable automatic global uniformity calculation. Allows to adjust the degree of correction. 100% meaning full uniform brightness as the darkest point in the projection. 50% meaning brightness is reduced for all areas brighter than the medium brightness.

Advanced BLC
Automatic overlap calculation and regarding uniformity information for black level correction calculations. Brightness and contrast settings for each individual projector are used.

Max Overlap
Maximum number of projectors overlapping at any point. Typical is 2 for a linear setup of projectors in one row or 4 for a grid of projectors with multiple lines and rows. (Non Advanced BLC only)

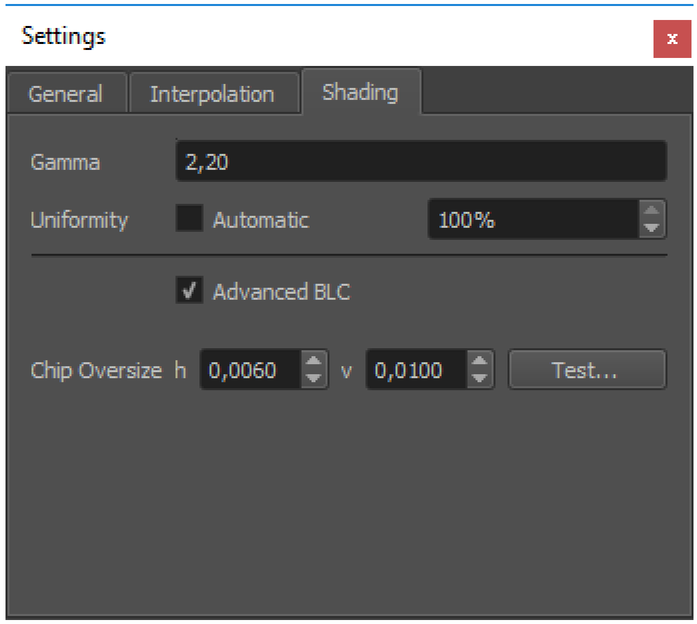


Fig. 10: Global shading settings

Black level
Projectors typically produce no perfect black. They expose still some light to the screen when the input signal is full black. Black Level describes the amount of light the projector exposes for black images. The corresponding preview can be used to help adjusting this value. (Non Advanced BLC only)

Chip Oversize
Projectors typically expose light to a larger area than the area of addressable pixels. These surrounding parts must be taken into account for black-level calculation. When they are not regarded, the edges of the overlapping areas will become apparently brighter than the adjacent areas.

H/V
Horizontal/vertical oversize. Normalized values relative to channel width/height.

Fade
Compensate for smooth black level spillover typically seen on LCOS projectors. Off by default.

Test
Project dark triangles on each projector, supposed to line up with the borders of overlapping projectors. The preview regards global chip oversize, as well as potential overrides per channel. If there is a gap between triangles and overlapping projector decrease the chip oversize. If triangles are drawn partly on top of overlapping projectors increase chip oversize.

27.3 Mapping 3D view

The Mapping 3D view shows how 3D content rendered with virtual cameras is warped for each channel. The warping is represented as a distorted mesh in normalized projector chip coordinates ranging from (0,0) top-left to (1,1) bottom-right.

The red and green edge represent the top and left edge of the projector. The mesh is also colored depending on the estimated quality of the calibration. The quality gradient ranges from blue (very good) over green and yellow to red (bad).

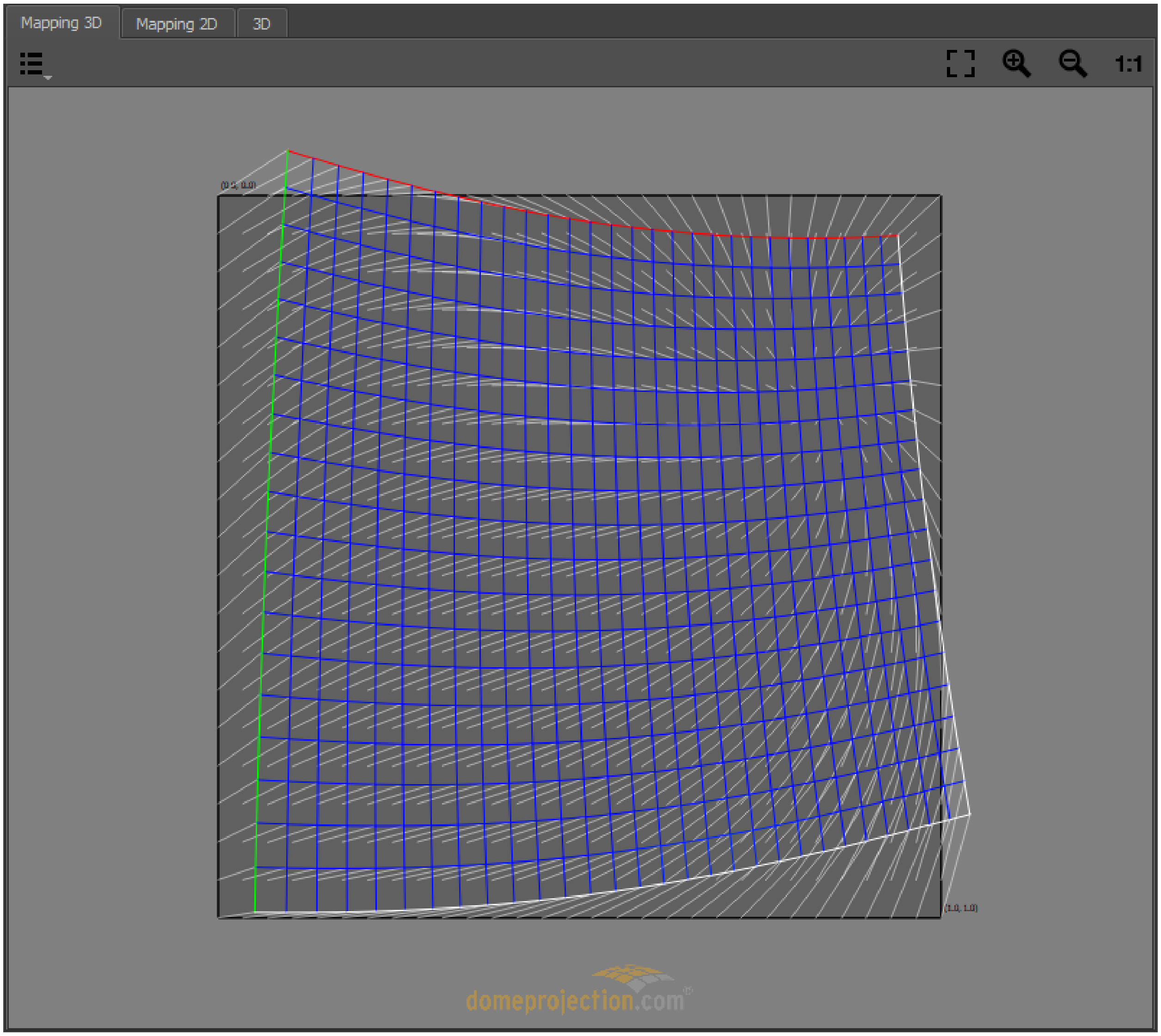


Fig. 11: Mapping 3D view

Visualization Options
A drop down menu on the top left corner allows to select multiple visualization options.

Show Source
Shows the source grid.

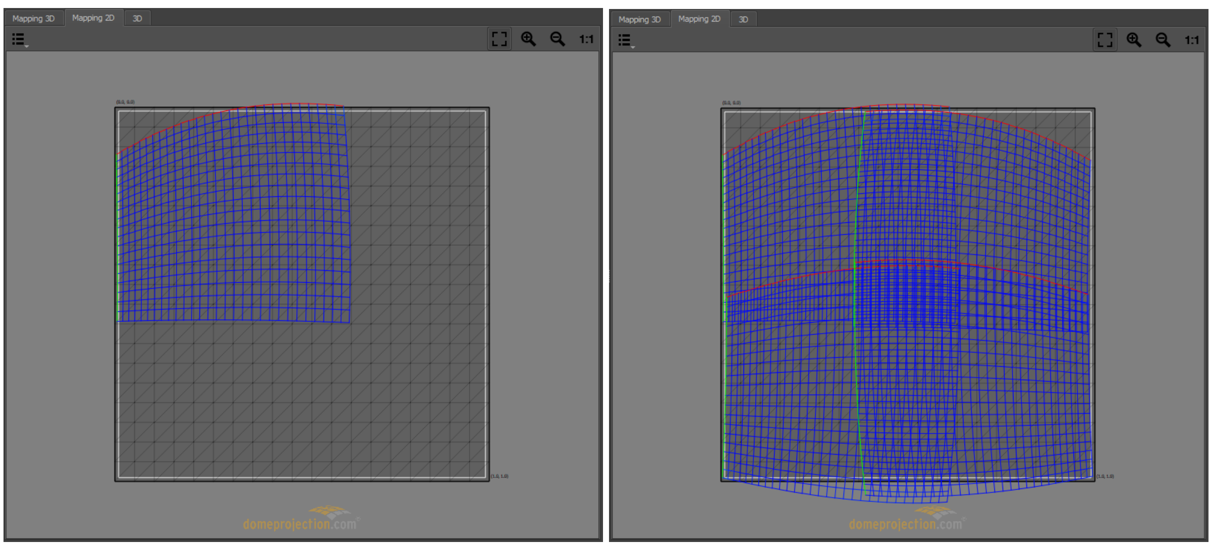
Show Target
Shows the warped grid.

Show Vector
Visualizes the warping offset for each warping point, rendered as a white connection line between corresponding source and target coordinates.

Navigation
The view can be dragged with the left mouse button.

Scaling
Several scaling options are available at the top right corner of 2D View.

27.4 Mapping 2D view



Mapping2d view with one projector (left) or all projectors (right) selected

The Mapping 2D View Shows the texture space, a normalized space ranging from (0,0) top-left to (1,1) bottom-right. It defines how 2d content is mapped onto the screen. This mapping is used for fadeout, clipping and blending calculations.

Selected projectors are shown in this view as a mesh. The mesh represents the region of the texture used for the corresponding projector. The red and green edge represent the top and left edge of the projector. The mesh is also colored depending on the estimated quality of the calibration. The quality gradient ranges from blue (very good) over green and yellow to red (bad).

Visualization Options
A drop down menu on the top left corner allows to select multiple visualization options.

Fadeout
In addition a visualization of the fadeout can be activated. The fadeout start and stop edge is marked by a white and black line. The fadeout can be adjusted in mapping settings, see section *Shading* for further informations.

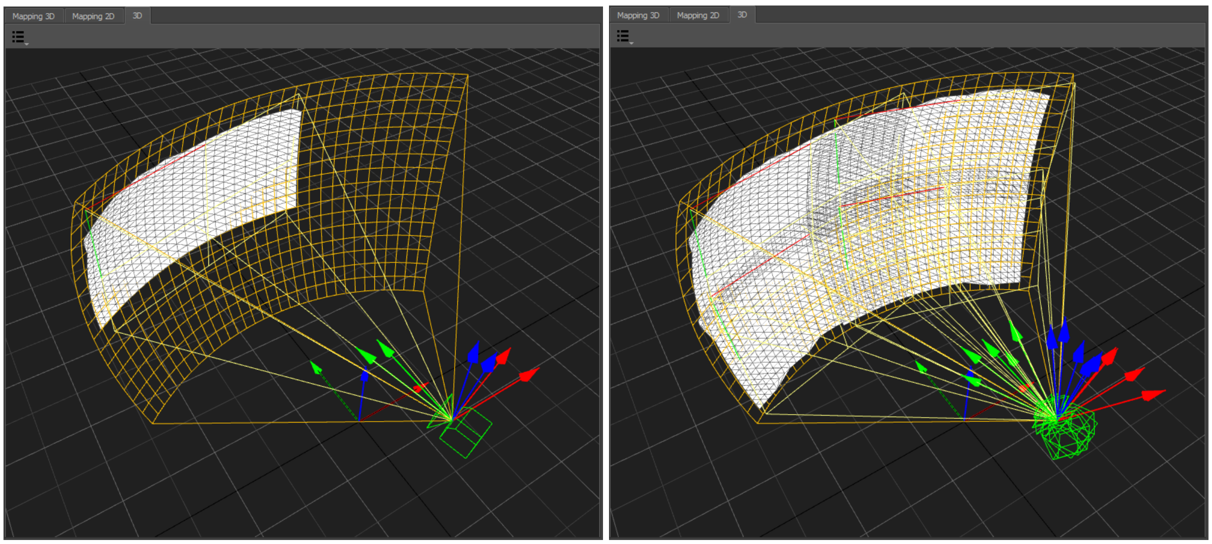
UV-Layout
A semi-transparent grid visualizing the area covered by the current mapping. This area is influenced by current mappings uv transform. Especially interesting for “Reference Mesh” mapping. See section *Mapping* for further information about mappings.

Navigation
The view can be dragged with the left mouse button.

Scaling
Several scaling options are available at the top right corner of 2D View.

27.5 3D view

The 3d view window shows the measured screen, mapping visualization and current virtual cammeras in 3d space.



3D view displaying one projector (left) or all projectors (right)

The current selection of projectors, camera position and reference points is regarded. Unselected elements are dimmed or hidden.

Viszalization Options
A drop down menu on the top left corner allows to select multiple visualization options.

Mapping
Represents the current Mapping-settings. It shows the screen-shape and iconic projection-rays at the corners of the screen. In addition the projection of the measured points onto the screen are visualized.

Virtual Cameras
shows a representation of currently setup virtual cameras. The camera frustum is rendered regarding cameras frustum settings and target distance.

Projection
The measured projection can be visualized in three different ways:

Measured Points
3d-position of measured points.

Measured Mesh
Triangulation of measured points.

Full Mesh
Based on current Measurements, the full projector is reconstructed (unmeasured parts as well).

Perspective
Switch to predefined orthographic views or the default perspective camera position.

Navigation
Navigate the 3d view using the mouse.

Rotate
`Left mouse-button`

Move
`Middle mouse-button`, `Alt+Shift+LMB`

Zoom
`Right mouse-button`, `Alt+Ctrl+LMB`

27.6 Preview Toolbar

Several quick previews can be shown on physical screen, to assist during setup of blending, fadeout, ramps, mapping and easy camera.

The most often used previews have a button in the *Preview Toolbar*. Simply press a preview-button to show or update the corresponding preview.

Under some additional previews can be found.

Please note, that many preview images are results of simplified calculations and therefore not perfect. To judge the quality of a calibration a more time consuming preview export or an export into the real imaging system is needed.

Note: For the preview to work a PatternGenerator must be properly installed and running on each display computer. The warping is handled dynamically by PatternGenerator. If installed, warp units should not apply any blending or warping during the preview. Only exception is Preview 3D unwarped, this preview mimics a simple 3d engine where the rest of the correction needs to be done on an external warping solution.

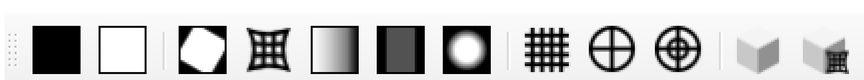


Fig. 12: Preview Toolbar

Black
make all projectors black

White
make all projectors full white

Cutting
Visualize, which parts of projectors will be used for projection. Due to intersection of physically projected area and virtual camera frustum, this area can be smaller than the actual projector. Also projector blanking settings can further reduce the area actually projected on.

Warping
Visualize the resulting warping grid based on current virtual camera settings.

Shading
rough shading preview (resolution is depending on projects mesh resolution settings)

Black Level
rough black level adjust preview (resolution is depending on projects mesh resolution settings)

Fadeout
rough preview of current fadeout settings (without blending)

Uniformity
preview of current uniformity correction without blending applied

Rectangular grid
project a rectangular grid using current mapping settings (typically used with Perspective, Planar, Cylindrical or Spherical LongLat mapping)

Polar Grid Half Dome
project a circular grid using current mapping settings (typically used for spherical polar mapping)

Polar Grid Full Dome
project a circular grid using current mapping settings, projects twice as much rings as Half Dome grid. (typically used for spherical polar mapping)

Outlines
Renders all expected outlines using the calibrated system except for selected projectors. Selected projectors have their current real outline rendered and are filled gray. This can be used to put single projectors easily in their correct position after maintenance and before recalibration. Usage:

1. Select Projector, that has moved.
2. Preview Outlines.
3. Adjust physical projector position, orientation, zoom and shift until it fits its rendered outlines as close as possible.
4. Re-Align the system to get perfect continuous geometry again.

Preview 3D
Render a simple cube map using currently setup virtual cameras. This preview is not warped. Warping on external warping solution must be activated.

Preview 3D warped
Render a simple cube map using currently setup virtual cameras. This preview is already warped. Warping on external warping solution must be deactivated.

Live Warping
Opens an interactive 3D-Preview, where the viewpoint can be modified on the fly. This can be used to check quality and image cut-off for dynamic view-dependent warping.

CHAPTER

TWENTYEIGHT

VIEWPOINT

After a calibration, a basic project for the Mapper3d is created. While the screen points are all calculated and the screen is set up, the viewpoint still has to be adjusted.

A viewpoint contains view informations (camera positions, offsets and frustum settings) for each projection channel which are later used in 3D engines to render a part of the 3d scene for each individual channel.

28.1 Configure a viewpoint

In the beginning all cameras are placed at the origin and have no orientation. In order to get a correct perspective these cameras / views need to be placed in the designed eyepoint, the position where the viewers head will be placed in the projection system. To cover the complete screen the rotation offsets and frustum settings of each view need to be adjusted to point at and cover the corresponding projection channel.

To change the viewpoint, switch into the 3d view and select all projectors in the projectors list. This allows to adjust the view for all projectors at once and the changes can be seen in the 3d view.

First adjust the view position using `Projectors/View/Transform/Position`, according to the physical setup.

After the position is adjusted, the orientation and frustum settings of cameras can be setup automatically using `Projectors/View/Guess` or `Extras/Guess Frusti...`. According to selected options this will update camera orientations and their field of view to look through their corresponding projection area.

Usually this gives already a valid camera setting. But further finetuning is still possible by manually overriding all the camera parameters (see section *View settings*). For example most hardware warp units can't rotate the image by 180 degrees. In this case the bank value needs to be adjusted to reduce the required warping.

The used field of view is also of interest for the final effective resolution of the projection system.

28.2 Guess Frusti

Automatically generate frustum settings for currently selected viewpoint.

Orientation
: Updates viewpoint orientation(rotation), when enabled

Direction
: Two options are available for adjusting views heading and pitch:

  Surface Normal
  : Adjusts heading and pitch, so that view points perpendicular to surface.

  Point at Center
  : Adjusts heading and pitch, so that view points at center of projection channel.

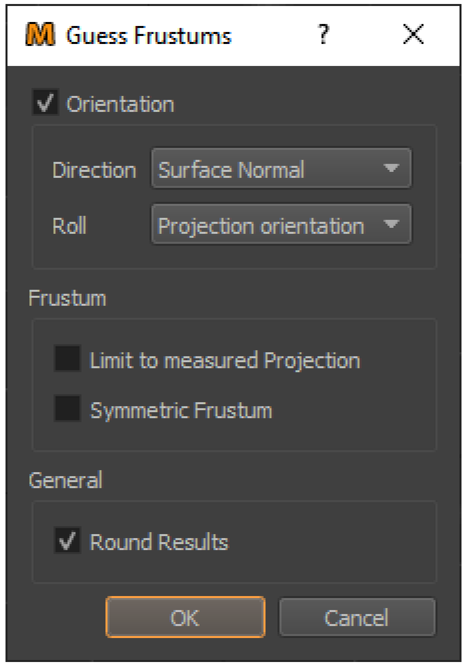


Fig. 1: Guess Frusti Dialog

Roll

Two options are available for adjusting views roll(bank).

Unrotated

Keep a roll of 0°.

Projection Orientation

Adjusts roll(bank), to be aligned with projection.

Limit to measured Projection

Sometimes projectors can go far beyond screen borders. This setting allows to keep the frustum small, encompassing only the measured area of a projector.

Symmetric Frustum

Some 3D-Engines have restrictions, for the frustum. This setting allows to enforce a symmetric frustum.

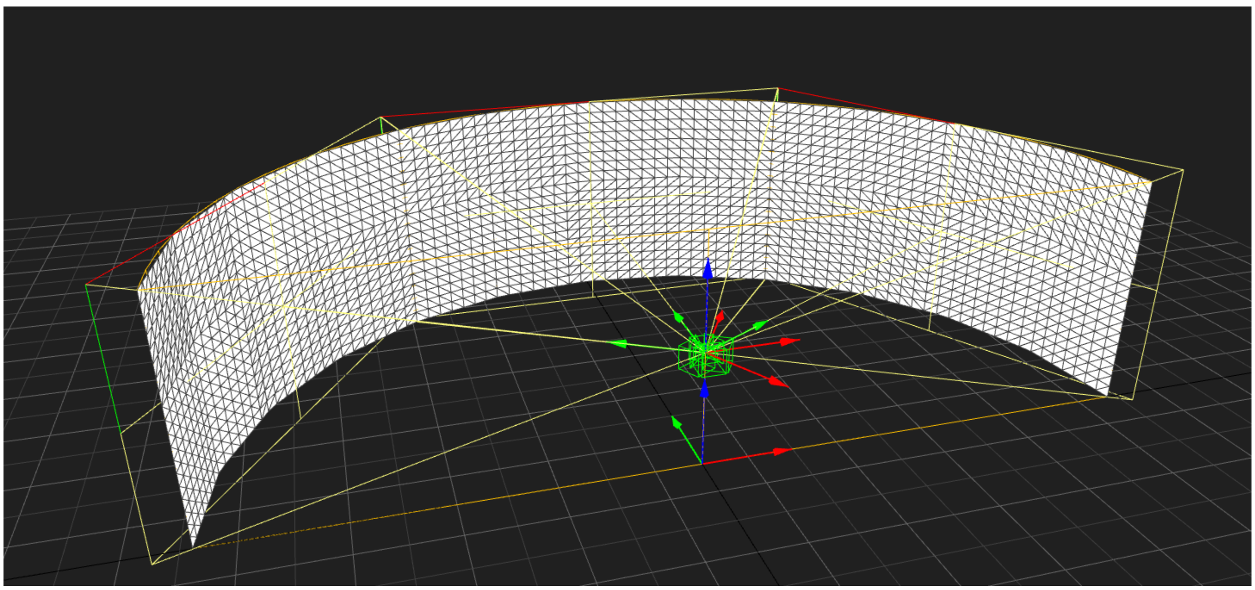
Round Results

Generate more easy to read and manually transfer values, by rounding to integer numbers.

CHAPTER

TWENTYNINE

GENERATE LED WALL



Use `Menu/File/New LED Wall project...` to create a new project for a LED wall. This allows to prepare exports for LED Walls with known Design without prior calibration in *Creator*.

29.1 Dialog Settings

Project name
: Name for the new project.

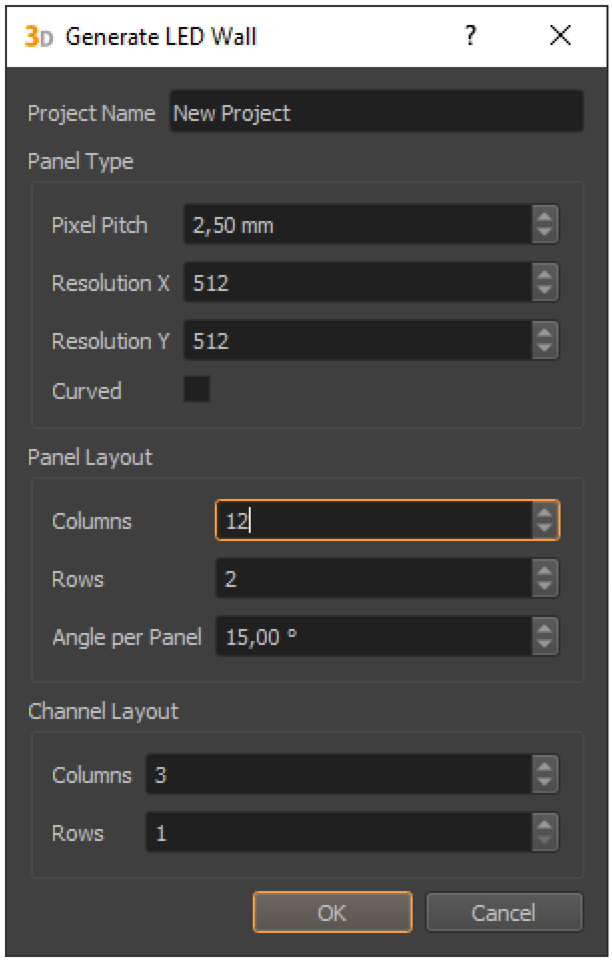
Panel Type

Pixel pitch
: Distance of two neighboring pixels.

Resolution x/y
: Horizontal and Vertical resolution.

Curved
: Enable for panels that are curved. Curvature will be automatically calculated to conform with Panel Layout settings. Disabled by default.

Panel Layout


Generate LED Wall
Project Name
New Project
Panel Type
Pixel Pitch
2,50 mm
Resolution X
512
Resolution Y
512
Curved
Panel Layout
Columns
12
Rows
2
Angle per Panel
15,00 °
Channel Layout
Columns
3
Rows
1
OK
Cancel

Columns/Rows
The number of panels columns and rows used

Angle per Panel
The curvature of the LED Wall defined as angle per Panel.

Channel Layout

Columns/Rows
The number of (correction-)channels the wall is split into. Resolution of each channel is calculated from LED Wall resolution.

CHAPTER

THIRTY

ABOUT MAPPERPM

The MapperPM program is used for managing all aspects of a projection mapping calibration and for exporting the results to the corresponding media server.

Based on any available calibration the following options are available:

- calculating projector positions, orientations and frustum settings
- calculating blending
- calculating lens distortion
- displaying test data on the mapped object using the PatternGenerator program installed on the image generator machines
- exporting the correction data for different media servers or warp units/software

CHAPTER

THIRTYONE

BASIC WORKFLOW

The MapperPM takes previously captured calibration data and creates correction data for the projection mapping use-case. In that case the geometry projected on is typically discontinuous with complex uv-mapping.

The correction data created consists of:

1. projector positions, orientations and frusti
2. blending
3. lens distortions

The following chapters will explain how to calibrate a projection mapping system for the simplest case, in which the full 3d geometry including mapping of the object to project on is known in advance.

It is assumed that the reader has basic knowledge of capturing data with ProjectionTools Creator.

31.1 Requirements

A 3d model of the object to project on, including uv-mapping must be available during the calibration.

31.2 Capture Calibration Data

The Creator is used to capture the calibration data, using some settings to optimize the process for projection mapping.

1. Create a new project. Set screen type to custom and import the designed 3d model.
2. For meshes with low density a reference point will automatically generated for each vertex. If the screen model was too complex, markers need to be imported separately or manually added on the mesh surface using the `Points/Add` menu.
3. Disable triangulate, since you want to ensure the calibration data lies perfect in the surface of the ideal 3d model, which avoids double imaging later, due to discrepancies of real and designed mapping object
4. Capture calibration data as usual with one or multiple camera positions
5. Store project

31.3 Preparing export in MapperPM

1. Load previously created project in MapperPM.
2. Hit `Mapping/Use Default` to use the 3d-object imported into creator as screen as well for mapping content.
3. In the 3D-View the object to project on and the projectors should be visible in plausible relative positioning. By default MapperPM is updating projector positions automatically.
4. Switch `Settings/Interpolation/General/Type` to spline, since for projectionmapping usually only a small part of each projector is captured and the generated warping needs to be extrapolated quite far and need to contain high frequent details.
5. Hit `Preview Toolbar/Preview 3d warped` to project a quick preview of a checkerboard without blending.
6. A high quality preview including blending can be shown, by adding a 3d preview to the Pipeline Editor.
7. Add one of the available exporters to the Pipeline Editor and export for the media server or 3D-Engine in use.

CHAPTER THIRTYTWO

MAIN WINDOW OVERVIEW

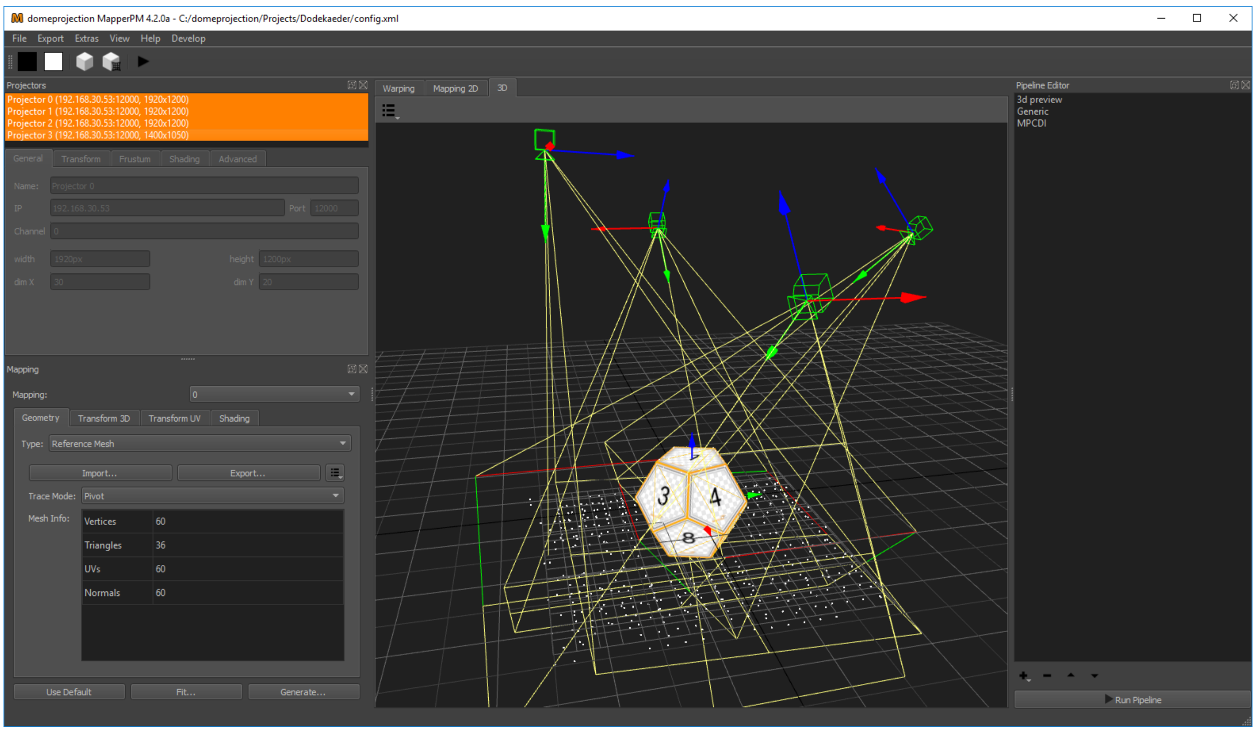


Fig. 1: MapperPM main window

MapperPM has a fully configurable workspace. Above figure shows the default configuration with the typical widgets open.

Menus

File Menu

Load and save projects.

Export Menu

Export calibration data from current project using available exporters. Please refer to section *Exporters* for a list of all available exporters.

Export settings used here are non-persistent. This is useful for experimenting with different settings, without changing a previously defined autoalignment work-flow for instance. Section *Pipeline Editor* describes how to save persistent export settings using the Pipeline Editor.

Extras Menu

Additional tools and advanced operations on loaded project.

View Menu
Workspace and theme management.

Help Menu
Help, Support and Program information.

Toolbar
The toolbar provides quick access to several previews and an automization run.

Docks
Here a list of the most important docks, also shown in the screen shot.

Projectors
The projectors dock widget shows a list of all projectors in the current project and allows to edit projector related settings. (see section *Projector List*)

Mapping
Defines how image content should be mapped to the 3d object used to put content on the mapped object. By default it is a uv-mapped reference object. It is also possible to apply additional fadout and clipping. (see section *Mapping*)

Pipeline
On the right side in the Pipeline Editor exporters can be configured with persistent settings to run multiple times. (see section *Pipeline Editor*)

Central Views
In the center of the window are multiple views available between which the user can switch.

Warping
Shows the warping between ideal and real projector of the currently selected channel.

Mapping 2D
Shows uv-layout of currently selected Mapping, which is used to put 2d content on the mapped object and to define fadeout and clipping.

3D
Shows projection surface, mapping and projectors in a 3d view.

All dock widgets can be arranged, stacked, opened and closed by user. The workspace layout is saved persistently.

It is also possible to revert to the default workspace using `View/Default Workspace`.

All available dock widgets can be found in the menu. They are described in the following sections.

The theme can be switched in `View/Theme`. An application restart is needed for a theme switch to take effect.

For using the maximum workspace on the desktop, a full screen mode can be enabled using View `Menu/Toggle Fullscreen Mode`.

32.1 Projector List

There are different kinds of information stored for each projector. All values are managed by the tabs below the projector list, which apply to the selected projectors.

The list shows the given Projector name, its IP address with port, the resolution and if an alignment is available (aligned).

The projector list is multi-selection enabled. Only selected projectors are shown in the 2d- and 3d-view. Press `Ctrl-A` to select all projectors at once or hold `Ctrl`- or `Shift`-key to add projectors to current selection.

Projector settings can be edited when a single projector is selected, otherwise the projector settings placed below the projector list are grayed out.

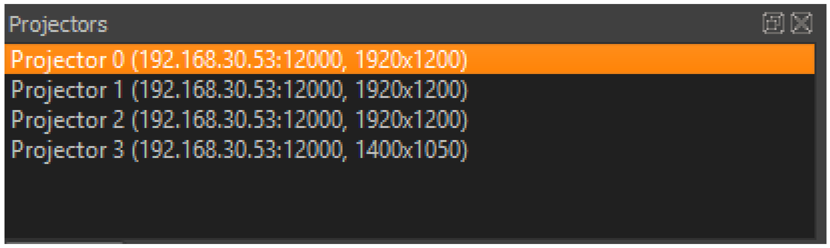


Fig. 2: Projector list

32.1.1 General settings

First there are the general settings, which reflect the physical setup. Usually all data here is filled out in advance through the calibration process and its setup.

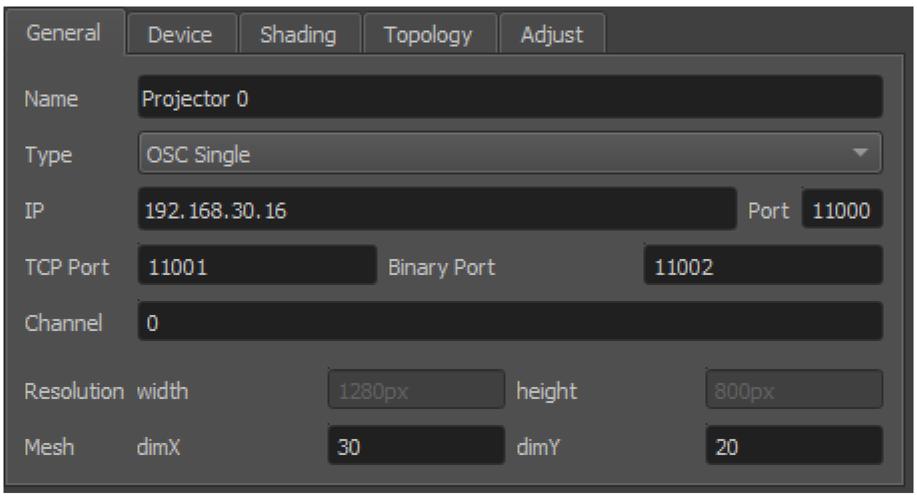


Fig. 3: General projector settings

Name
: Human readable string describing the projector.

Type
: Interface to use for showing testpatterns.

  OSC Single
  : Default PatternGenerator based interface. Works with up to date PatternGenerator.

  OSC Multi
  : ProjectionTools channels are virtually split into multiple PatternGenerator channels. Works with standard PatternGenerator.

  OSC Legacy
  : Can be used for very old PatternGenerator installations, or installations on limited/embedded hardware. The preview functionality is limited.

  NDI
  : Provide testpatterns as one NDI-stream per channel. This can be used, if it is not possible to install Pattern-Generator on the Mediaservers. Several Mediaservers support recieving and showing NDI-Streams. The preview functionality is limited.

Norxe Unify
Send testpatterns as image directly to Norxe Unify projectors. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Barco Pulse
Send testpatterns as image directly to Barco Pulse projectors. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Luna
Send testpatterns as image directly to domeprojection Luna warp units. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

Warper4k
Send testpatterns as image directly to Westar Warper4k warp units. This allows calibration without access to IGs.The preview functionality is limited, and not interactive.

IP
Network address of the computer where the PatternGenerator software is running on. Hostnames are supported as well.

Port
Networkport to communicate with PatternGenerator. By default 12000.

Channel
The Channel is used to address a projector - if more than one is connected to a single PC.

Width and height
Have to be the same as the physical projector resolution used in the projection and displayed here for reference only (not editable).

dim X and dim Y
Attribute, defining the resolution of the warping grid. Larger values may gain better results but some constraints apply. There are hard limits depending on the warping unit. Bigger values are increasing the calculation time of many operations significantly, especially blend map calculation.

32.1.2 Transform and frustum settings

The transform and frustum settings define the physical position, orientation and projection frustum of each projector. These settings are generated automatically by default. When disabling `Settings/General/Update Projector Positions` these settings can be adjusted manually.

The transform tab defines the position and orientation of the projector.

Position (x,y,z)
The position relative to the center of the systems point of origin. Values entered in millimeter.

Rotation (heading, pitch, bank)
Each projector can be rotated. The rotation order is:

1. heading
2. pitch
3. bank

The projection frustum is setup in the frustum tab. There are three different methods for entering/viewing the data. The method can be selected with the drop down menu (currently displaying Field of View).

Input Method
Select method for viewing/entering frustum data. Changes input fields below accordingly. Options are:

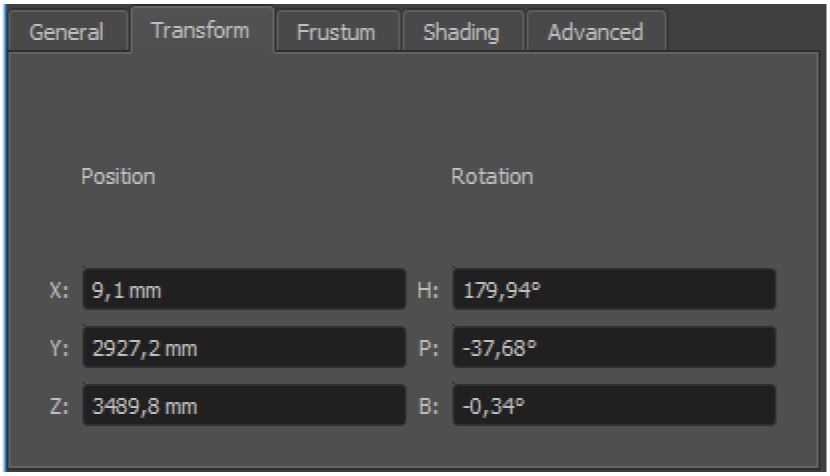


Fig. 4: Transform

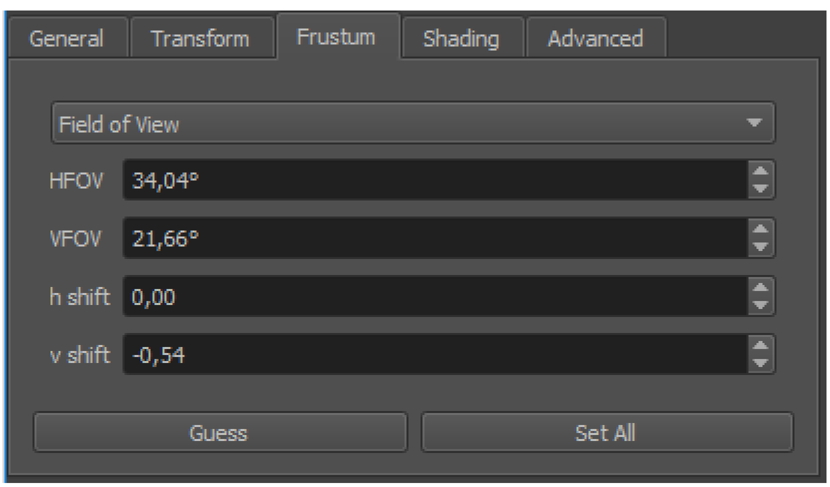


Fig. 5: Frustum

Field of View
enter the value in degree for the horizontal (HFOV) and vertical (VFOV) field of view. Shift the projection by fractions of 100 with h shift and v shift.

Zoom
enter aspect ratio, zoom, h shift and v shift as fractions of 100.

Separate Angles
enter the four (top, bottom, left, right) opening angles in degree relative to the middle point.

Guess
The Guess button can be used to calculate the frustum and viewpoint orientation for the selected projector, based on the measured data. It is optionally possible to fix the current frustum and only update position and orientation of the projector. This makes calculation more stable when only limited depth information is available (projection on a flat area).

Set All
Uses the current frustum for all projectors.

32.1.3 Shading settings

The Shading panel expose blending properties which can be different for each projector. There are other values as well, which apply to the whole setup and are adjusted in different places.

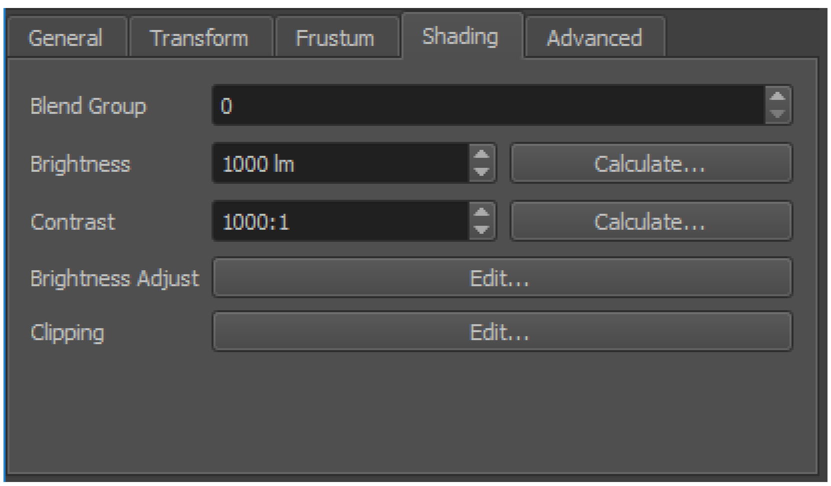


Fig. 6: Shading settings

Blend Group
In order to increase light intensity, sometimes two projectors are used to project on the same area of the screen. This is a so called “tandem” or “stacked” projection. Since blending is typically calculated between all overlapping projectors, the brightness of the tandem projection pair would be reduced to the brightness of one projector canceling out the initial intention of the tandem projection. The proper use of Blend Groups helps in this case.

Blending is calculated between projectors of same blend group only. Use different blend groups for different layers of projection or projectors between which no blending should be calculated. The blend group element assigns a projector to a blend group. The default blend group is 0.

Brightness
Brightness of projector in lumen. Used for uniformity correction calculations.

Brightness Calculate
Allows to calculate projector brightness from measured brightness of projected image center and a given screen-gain. Shows a small white rectangle on the selected projector center for taking a measurement right away.

Contrast
Contrast of projector, used for advanced black level correction calculations.

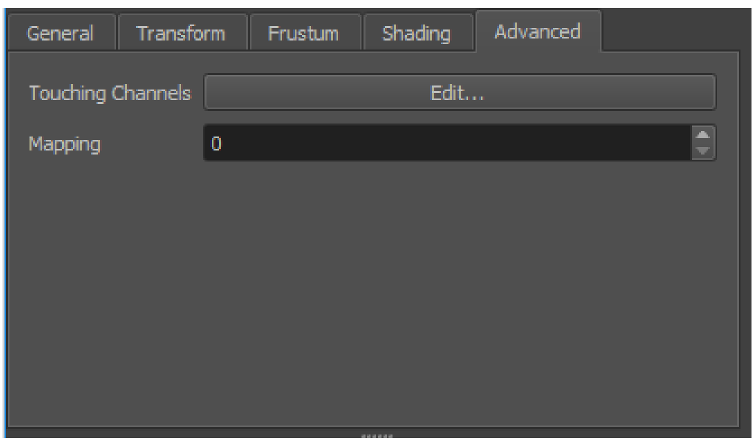
Contrast Calcutate
Allows to calculate projector contrast from black and white measured at center of projected image. Shows a black image and a small white image in projector center for taking measurements.

Brightness Adjust
When global automatic uniformity correction is disabled, it allows to edit custom uniformity correction for a projector. See section *Uniformity Correction Editor* for details.

Clipping
Allows to clip parts of the current projector. The clipped parts will be covered by neighboring projectors if present. It is usually used, if projectors are partly shadowed by obstacles.

32.1.4 Advanced projector settings

Additional not so common settings can be adjusted here.



Touches
Define the neighboring channels for high resolution projectors (See section *Touching Channels*).

32.2 Global settings

There are some properties that apply to the whole projection system. They can be modified in the settings tabs.

32.2.1 General settings

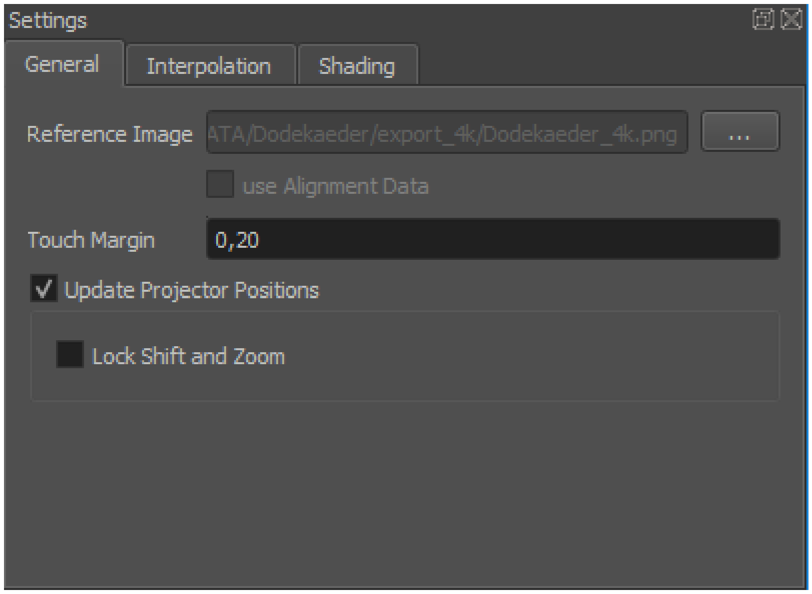


Fig. 7: General settings

Reference Image
An image that will be shown in background of 2d view and on mappings in 3d view.

Use Alignment Data
If true, all further calculations are based on the data from the last auto align process instead of the initial calibration. The button is unavailable as long as there is not alignment data for all projectors stored in the database.

Touch Margin
Allows to globally adjust touch margin for touching channels. See section *Touching Channels* for further information about high resolution projectors with multiple inputs and touching channels.

Update projector Positions
When enabled, projector positions, orientations and frustum settings are updated when ever calibration data has changed. (Enabled by default)

Lock Shift and Zoom
When enabled, only projector positions and rotations are updated. This makes calculations more stable when only limited depth information is available (projection on a flat area). (disabled by default)

32.2.2 Interpolation

Captured calibration data is usually incomplete and captured only for a finite number of points. For exporting correction data, Mappers need to interpolate and extrapolate this data for each pixel of a projector and maybe even beyond. Many mathematical strategies exist for that purpose, all with individual strengths and weaknesses.

For some projects, depending on screen and mapping type, it might be necessary to switch to another interpolation type than the default. This can be done in the global `Settings/Interpolation` tab.

Interpolations are used for different purposes in the project.

General
For all purposes, if not overridden.

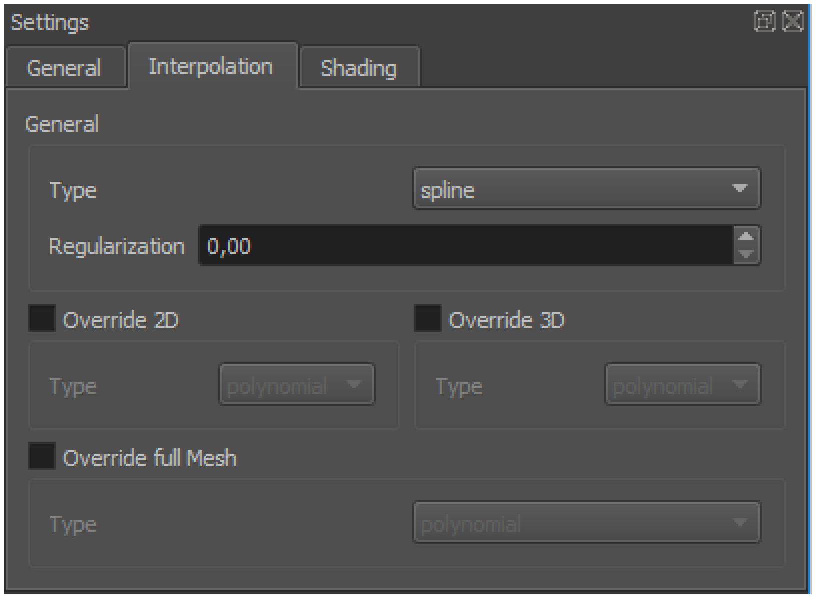


Fig. 8: Interpolation Settings

Override 2D
Optional override for interpolations between 2d mapping and projectors (influences the grids seen in 2D view).

Override full Mesh
Optional override for generating full meshes in 3d (influences full mesh visualization in 3D View and some advanced exporters)

Two interpolation types are available.

Polynomial (Default)
Gives good generalization of general shape of warping with good exact extrapolation near measured data. Has the tendency to fold and generate wrong results far away from measured data. Has a *degree* parameter to adjust the complexity of warping. Lower values give better extrapolation results, but less fitting to details and strong curvatures.

Spline
Gives better results for strong warpings and tight radii, or even sharp corners on screen. Generally captures details better, but has less generalization. More relaxed far distance extrapolation. Takes considerable more time to calculate!

32.2.3 Shading

The shading-tab of the project-settings dialog allows to set several global parameters that influence blending and black-level-adjust calculations.

Gamma
Gamma of the projectors. Too high values will result in overexposed blending regions, a value that is too low will result in underexposed blending regions.

Uniformity
Enable automatic global uniformity calculation. Allows to adjust the degree of correction. 100% meaning full uniform brightness as the darkest point in the projection. 50% meaning brightness is reduced for all areas brighter than the medium brightness.

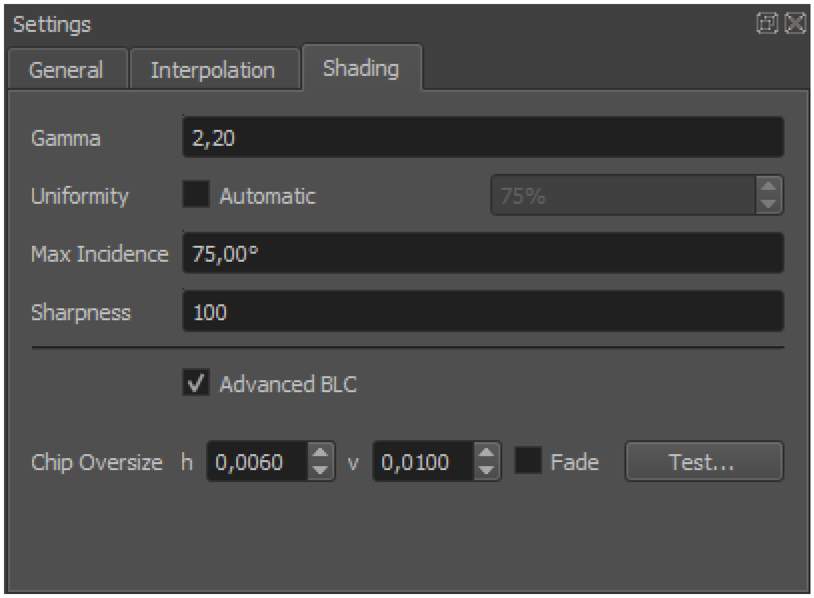


Fig. 9: Global shading settings

Max Incidence
Defines the maximum incidence angle up to which a projector is used for projection on a certain area on the projection surface. This avoids too flat projections where image of projector is weak and pixels are extremely stretched.

Sharpness
Allows to gradually select between wide/smooth blending zones and hard narrow transitions between projectors. 1: smooth 100: hard.

Smooth (1)
Usually good for smooth organic shapes.

Hard (100)
Usually good for polygonal objects, where projectors are projecting from quite different angles, and effectively each projector is covering one or several facets on its own.

Advanced BLC
Automatic overlap calculation and regarding uniformity information for black level correction calculations. Brightness and contrast settings for each individual projetor are used.

Max Overlap
Maximum number of projectors overlapping at any point. Typical is 2 for a linear setup of projectors in one row or 4 for a grid of projectors with multiple lines and rows. (Non Advanced BLC only)

Black level
Projectors typically produce no perfect black. They expose still some light to the screen when the input signal is full black. Black Level describes the amount of light the projector exposes for black images. The corresponding preview can be used to help adjusting this value. (Non Advanced BLC only)

Chip Oversize
Projectors typically expose light to a larger area than the area of addressable pixels. These surrounding parts must be taken into account for black-level calculation. When they are not regarded, the edges of the overlapping areas will become apparently brighter than the adjacent areas.

H/V
Horizontal/vertical oversize. Normalized values relative to channel width/height.

Fade
Compensate for smooth black level spillover typically seen on LCOS projectors. Off by default.

Test
Project dark triangles on each projector, supposed to line up with the borders of overlapping projectors. The preview regards global chip oversize, as well as potential overrides per channel. If there is a gap between triangles and overlapping projector decrease the chip oversize. If triangles are drawn partly on top of overlapping projectors increase chip oversize.

32.3 Warping view

The Warping view shows how 3D content rendered with virtual cameras is warped for each channel. The warping is represented as a distorted mesh in normalized projector chip coordinates ranging from (0,0) top-left to (1,1) bottom-right.

The red and green edge represent the top and left edge of the projector. The mesh is also colored depending on the estimated quality of the calibration. The quality gradient ranges from blue (very good) over green and yellow to red (bad).

Visualization Options
A drop down menu on the top left corner allows to select multiple visualization options.

Show Source
Shows the source grid.

Show Target
Shows the warped grid.

Show Vector
Visualizes the warping offset for each warping point, rendered as a white connection line between corresponding source and target coordinates.

Navigation
The view can be dragged with the left mouse button.

Scaling
Several scaling options are available at the top right corner of 2D View.

32.4 Mapping 2D view

The Mapping 2D View Shows the texture space, a normalized space ranging from (0,0) top-left to (1,1) bottom-right. It defines how 2d content is mapped onto the screen. This mapping is also used to define fadeout and clipping.

Selected projectors are shown in this view as a mesh. The mesh represents the region of the texture used for the corresponding projector. The red and green edge represent the top and left edge of the projector. The mesh is also colored depending on the estimated quality of the calibration. The quality gradient ranges from blue (very good) over green and yellow to red (bad).

Visualization Options
A drop down menu on the top left corner allows to select multiple visualization options.

Fadeout
In addition a visualization of the fadeout can be activated. The fadeout start and stop edge is marked by a white and black line. The fadeout can be adjusted in mapping settings, see section *Shading* for further informations.

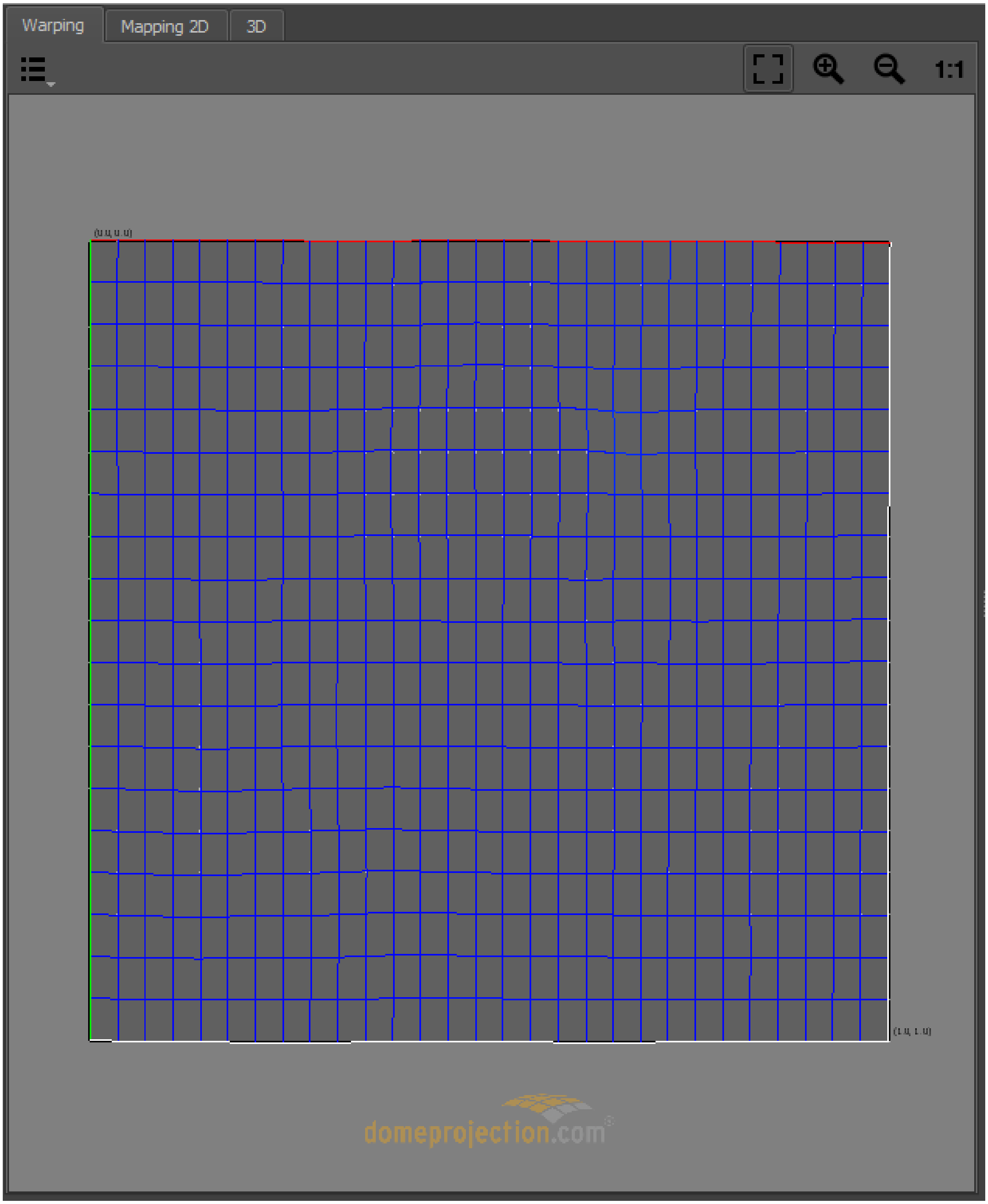


Fig. 10: Warping view

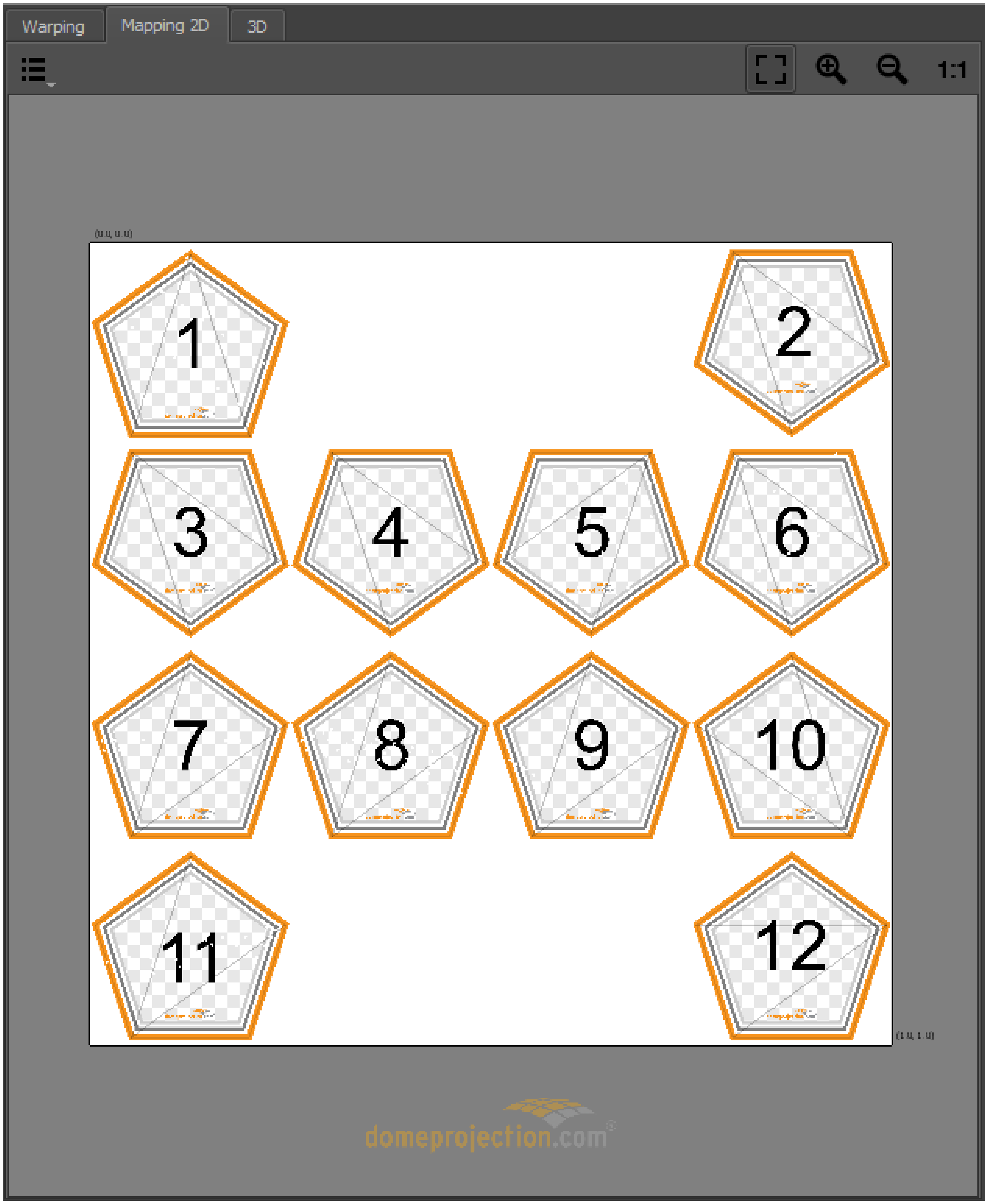


Fig. 11: Mapping 2d view

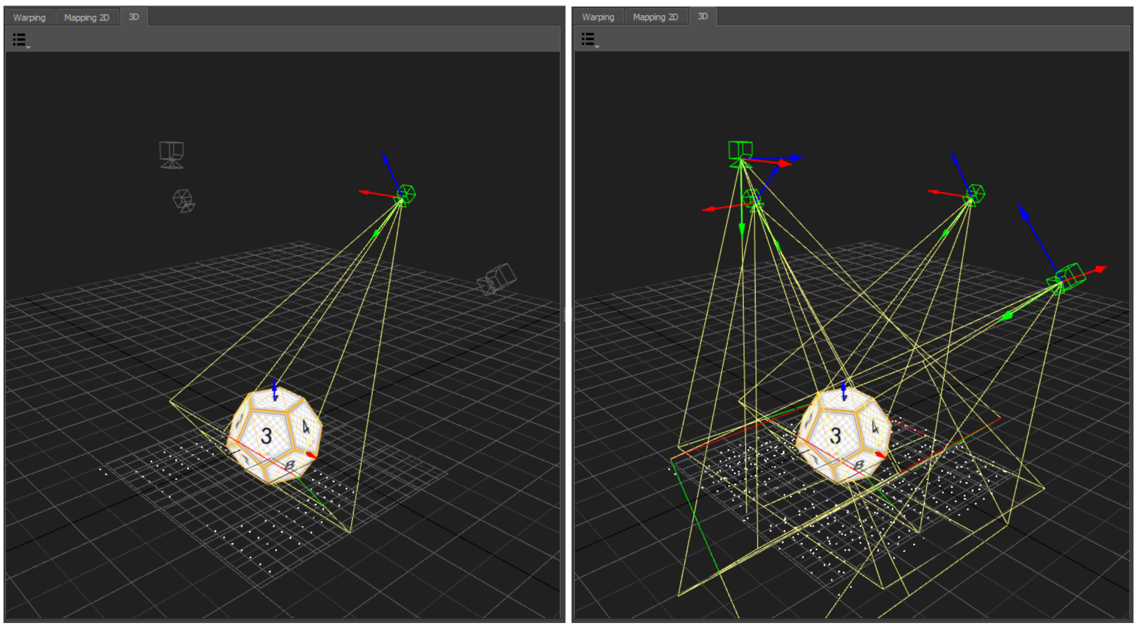
UV-Layout
A semi-transparent grid visualizing the area covered by the current mapping. This area is influenced by current mappings uv transform. Especially interesting for "Reference Mesh" mapping. See section *Mapping* for further information about mappings.

Navigation
The view can be dragged with the left mouse button.

Scaling
Several scaling options are available at the top right corner of 2D View.

32.5 3D view

The 3d view window shows the measured screen, mapping visualization and currently selected projectors in 3d space.



3d view displaying one projector (left) or all projectors (right)

The current selection of projectors, and mappings is regarded. Unselected elements are dimmed or hidden.

Viszalization Options
A drop down menu on the top left corner allows to select multiple visualization options.

Mapping
Represents the current Mapping-settings. It shows the screen-shape and iconic projection-rays at the corners of the screen. In addition the projection of the measured points onto the screen are visualized.

Virtual Cameras
shows a representation of currently setup virtual cameras. The camera frustum is rendered regarding cameras frustum settings and target distance.

Projection
The measured projection can be visualized in three different ways:

Measured Points
3d-position of measured points.

Measured Mesh
Triangulation of measured points.

Traced Mesh
Mesh traced from calculated projector position onto 3d scene.

Perspective
Switch to predefined orthographic views or the default perspective camera position.

Navigation
Navigate the 3d view using the mouse.

Rotate
`Left mouse-button`

Move
`Middle mouse-button`, `Alt+Shift+LMB`

Zoom
`Right mouse-button`, `Alt+Ctrl+LMB`

32.6 Preview Toolbar

Several quick previews can be shown on physical screen, to assist during setup of blending, fadeout, ramps, mapping and easy camera.

The most often used previews have a button in the *Preview Toolbar*. Simply press a preview-button to show or update the corresponding preview.

Under `Extras/Preview` some additional previews can be found.

Note: Please note, that many preview images are results of simplified calculations and therefore not perfect. To judge the quality of a calibration a more time consuming preview export or an export into the real imaging system is needed.

Note: For the preview to work a PatternGenerator must be properly installed and running on each display computer. The warping is handled dynamically by PatternGenerator. If installed, warp units should not apply any blending or warping during the preview. Only exception is Preview 3D unwarped, this preview mimics a simple 3d engine where the rest of the correction needs to be done on an external warping solution.

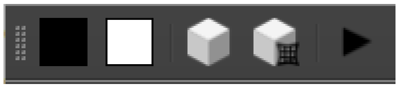


Fig. 12: Preview Toolbar

Black
make all projectors black

White
make all projectors full white

Preview 3D
Render a simple cube map using currently setup virtual cameras. This preview is not warped. Warping on external warping solution must be activated.

Preview 3D warped

Render a simple cube map using currently setup virtual cameras. This preview is already warped. Warping on external warping solution must be deactivated.

CHAPTER

THIRTYTHREE

ABOUT PATTERNGENERATOR

The PatternGenerator program is used to display test patterns during a calibration, alignment and for displaying result data. All projected areas have to be covered by PatternGenerator output for calibration/alignment.

CHAPTER

THIRTYFOUR

INSTALLATION

34.1 Windows

Use the ProjectionTools windows installer in IG-Mode to install the application on all computers, used for projection (image generators). It can optionally put in autostart to run it automatically with windows.

34.2 Linux

To obtain a linux compatible version, contact domeprojection.com with informations about the distribution used.

Linux versions have been successfully tested on Ubuntu 18.04 LTS and newer versions. It is designed to run on various Linux distributions. Compatibility has also been verified on other widely used distributions such as Debian, Fedora, and CentOS.

CHAPTER

THIRTYFIVE

OPERATION

When installed with autostart option, PatternGenerator might already be running, and the system tray icon is visible. Otherwise, start PatternGenerator from the start menu.

After PatternGenerator startup a logo and some system information will be shown on each configured display. If no window is present, use the system tray icon to open the main window (single click on the icon, or choose show from the system tray menu).

When PatternGenerator is started for the first time, it might not show up on the desired display channels yet.

Open the settings either using the `c` key or using the system tray menu.

Then select an appropriate Channel Layout type. In most cases one of the automatic modes (Main Display, Secondary Displays, All Displays) should be fine, but there is also a custom mode for full control over the display configuration.

In order to check the settings, the `d` key can be pressed to display the viewport layout. Each physical projector image should show a white border with size and channel information to visualize the displays. Press the `d` key again to turn off the debug overlay.

The PatternGenerator should now be ready to use.

CHAPTER

THIRTYSIX

STARTUP PARAMETERS

```
PatternGenerator [options] dataPath
```

Options:

Option	Description
-?, -h, –help	Displays help on commandline options.
-v, –version	Displays version information.
-s, –silent	Start minimized.
-f, –fullscreen	Start on main display.
-m, –multi	Sart on all displays.
-o, –other	Start on secondary displays.

Arguments:

Argument	Description
dataPath	Path containing configuration data.

CHAPTER

THIRTYSEVEN

KEYBOARD SHORTCUTS

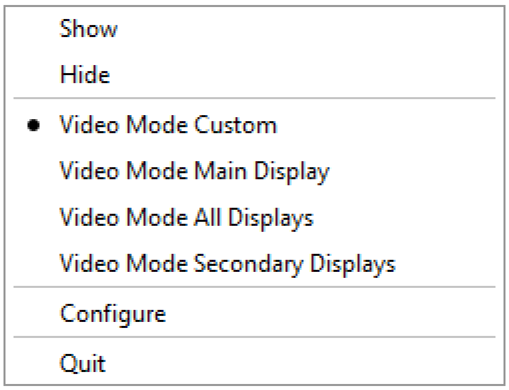
Key	Description
H	Toggle on screen help
I	Show general setup information
C	open viewport configuration dialog
D	Toggle viewport layout
S	Save current viewport layout
ESC	Minimize PatternGenerator
Q	Quit PatternGenerator

CHAPTER

THIRTYEIGHT

SYSTEM TRAY

When PatternGenerator is running, a system tray icon is visible. This allows to open/hide PatternGenerator, open the settings dialog, and quit the application.



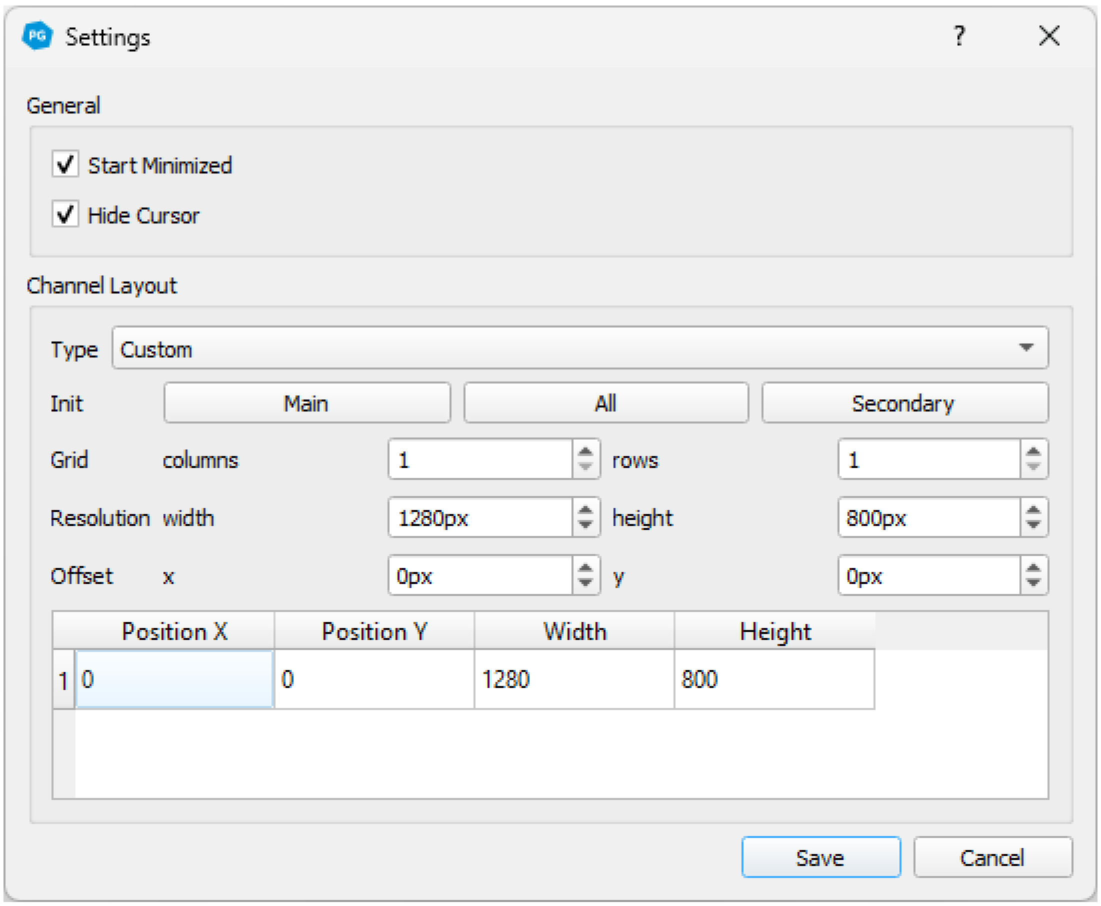
Show / Hide:
Show or hide the PatternGenerator window.

Video Mode:
Switch between different video modes, resulting in different *Channel Layout*.

Configure:
Open the settings dialog.

SETTINGS

The setting dialog can be opened either using the `c` key or using the system tray menu.



39.1 General

Start Minimized:
If checked, the PatternGenerator will start minimized to the system tray.

Hide Cursor:
If checked, the cursor will be hidden inside the PatternGenerator window.

39.2 Channel Layout

The PatternGenerator can be started in different modes, which can be set through its settings dialog, systemtray menu and commandline options.

Type:
The type of display layout to use. The following options are available:

- **All Displays**
  The PatternGenerator will start, covering the whole windows desktop. There will be a virtual screen for each device. This is useful if more than one projector is connected to a PC and all projectors are visible to windows as separate displays
- **Secondary Displays**
  The PatternGenerator is started on all visible screens except the primary monitor. There will be a virtual screen for each device. This is useful if using a Laptop (especially with high dpi devices) has projectors attached or the display computer has not only projectors but a monitor connected as well.
- **Main Display**
  The PatternGenerator is started using full-screen mode on the primary device. The resolution is equal to the screen.
- **Custom**
  Create custom configurations in case automatic display detection is not sufficient. For example when the display splits are invisible to windows due to the use of nvidia mosaic or matrox triple heads. This mode is also helpful if configuration should stay fixed and not be determined on startup, even if windows desktop arrangement changes.

  Init:
  Initialize the custom grid based on detected displays on the desktop. This is similar to the automatic modes, but executed just once and allows for further adjustments.

  Grid:
  Adjust how many columns and rows of channels should be generated in a regular grid.

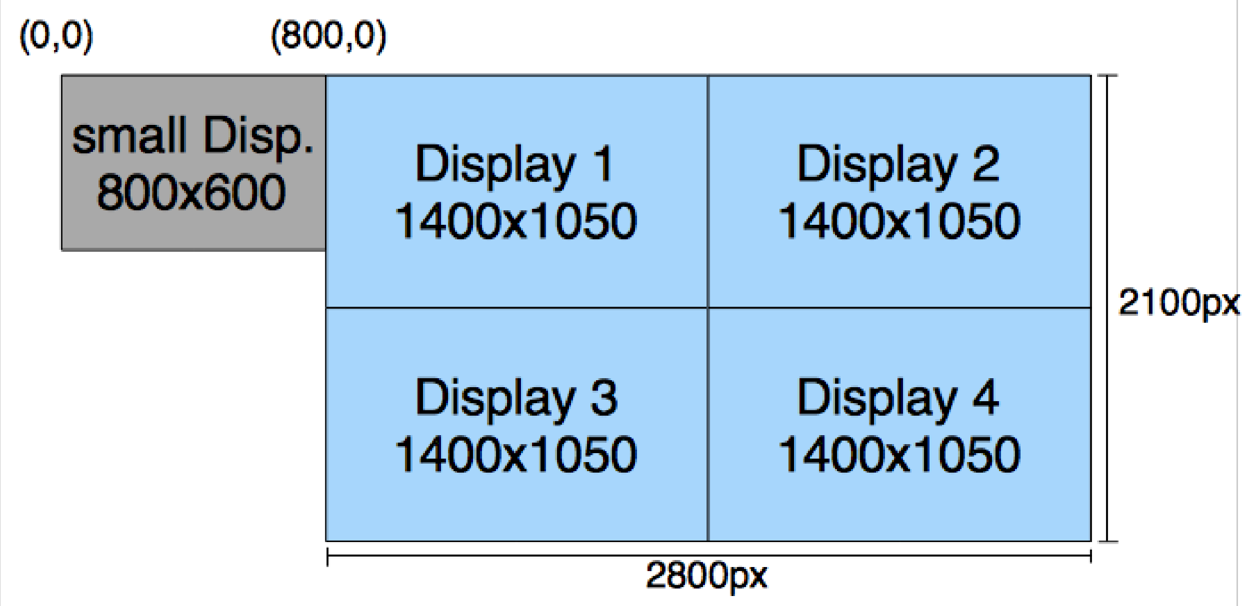
  Resolution:
  Set the resolution for each channel in the grid.

  Offset:
  Apply a global offset to all channels. For example when the grid of channels should start beside the main display.

  Table:
  Full control over position and resolution of each channel.

39.3 Example

This example has one main display that is not part of the projection and 4 projectors with a resolution of 1400x1050 each, that are set up as a grid.



When all displays are visible to windows, the automatic mode **Secondary Displays** can be used.

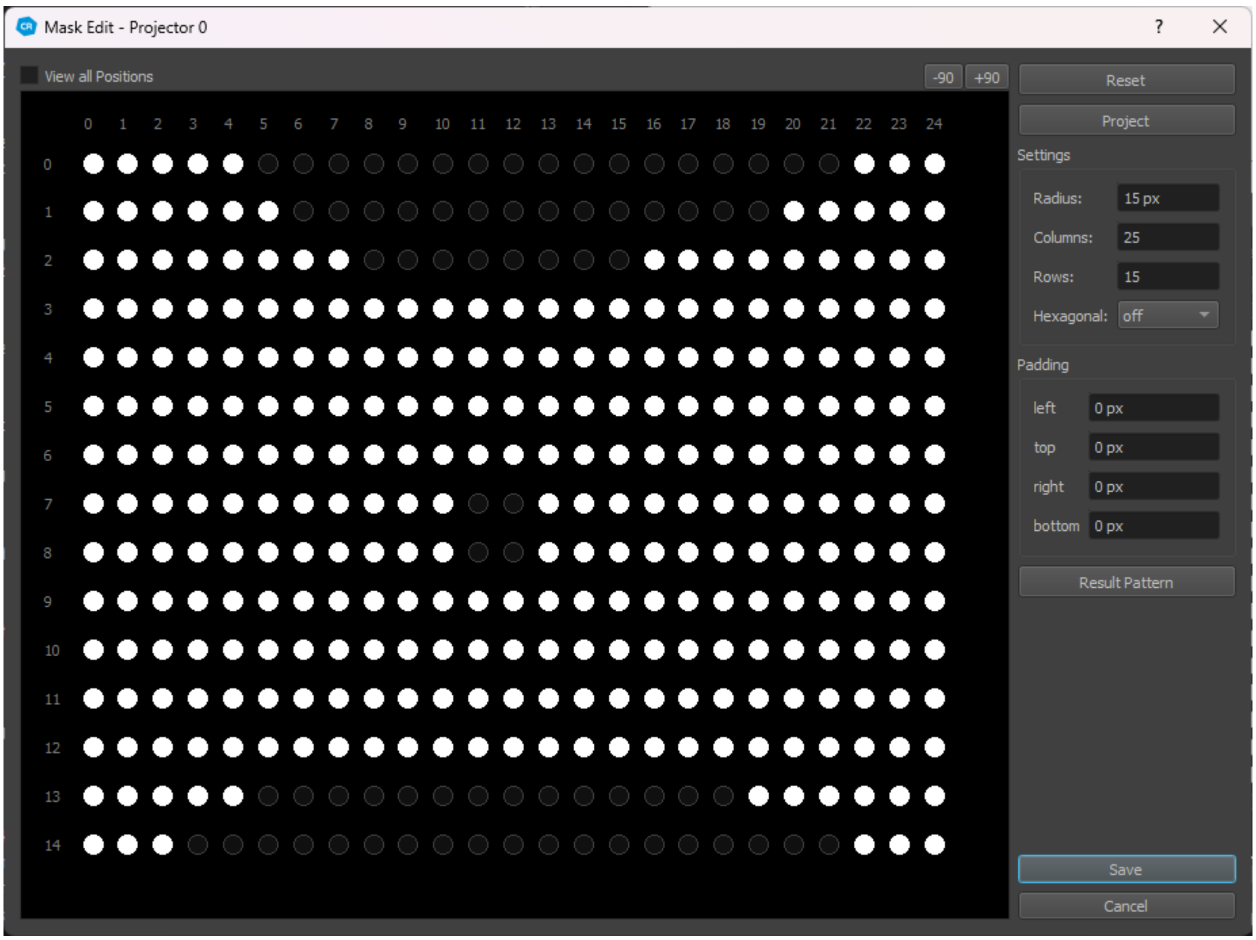
If the projector channels are merged into one large virtual display, the custom mode can be used to set up the grid manually.

Settings:

- Type: Custom
- Grid Columns: 2
- Grid Rows: 2
- Resolution width: 1400
- Resolution height: 1050
- Offset x: 800
- Offset y: 0

CHAPTER FORTY

DOT PATTERN EDITOR



The Dot Pattern editor allows to reduce the projected points for a projector. This is often needed if points are projected beyond screen or only visible by half.

The more dots are displayed the better is the result of calibration. But all points in the mask must be visible by the selected camera.

To remove dots drag over the points by pressed left mousebutton, for adding points drag with pressed right mousebutton or hold alt-key. After modifying the dot mask press Save to save the mask.

In order to get more close to the screen edge, or if projectors have some parts at the edge where they can not produce a clean image, a padding setting can be used to fine adjust the dot pattern placement.

The adjustments made in this dialog are shown live on the physical projector, giving immediate feedback of the result.

Remove Points:
To remove dots, click o the points or drag over the points with left mousebutton.

Add Points:
For adding points drag with pressed right mousebutton or hold alt-key.

Reset:
Reset the dot pattern mask by enabling all dots again. Or if a dot pattern for a distinct camera position is edited, the mask will be reseted to the global projector mask.

Project:
Show/update the current dot pattern on projector.

Global Settings:
If a global dot pattern mask is edited the following settings are also available.

Radius:
radius of dots in pixels. Might need to be changed depending on how big the points are seen by camera.

Columns/Rows:
number of dot columns/rows

Hexagonal:
Arrange dots in a hexagonal, more dense packed pattern. This often leads to better data at the edges of the screen.

The hexagonal pattern can be oriented horizontal or vertical.

Padding:
Inset of points on left/right/top/bottom edge of projector

Result Pattern:
Adjust the dot pattern to the currently detected dots. When the Dot Pattern Editor is opened on a projector on a distinct position, the dots detected on this position are used. When the global Dot Pattern Editor is used, all captures from all camera positions for the current projector are considered.

View all Positions:
Visualizes additional information as dot border color. The following screenshot has the projector masked completely on current position for better visibility of dot borders.

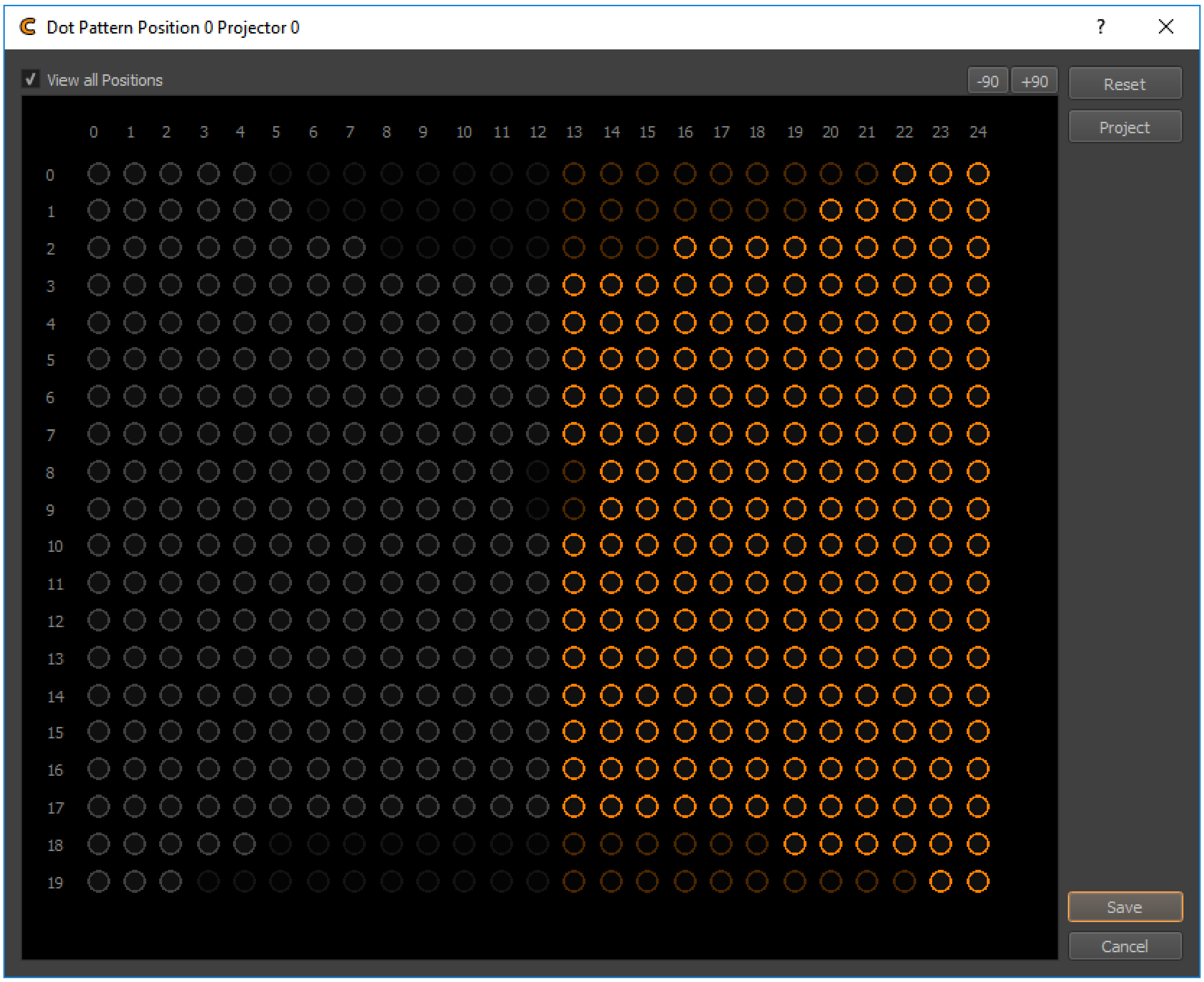
Dark:
masked globally

Bright:
not masked globally

Orange:
used on other positions

Gray:
not used on other positions.

Rotate +-90:
Visually rotates the dot pattern in the editor, for more convenient editing of dot patterns for projectors in portrait mode, or other strange orientations.


Dot Pattern Position 0 Projector 0
?
View all Positions
-90
+90
Reset
Project
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Save
Cancel

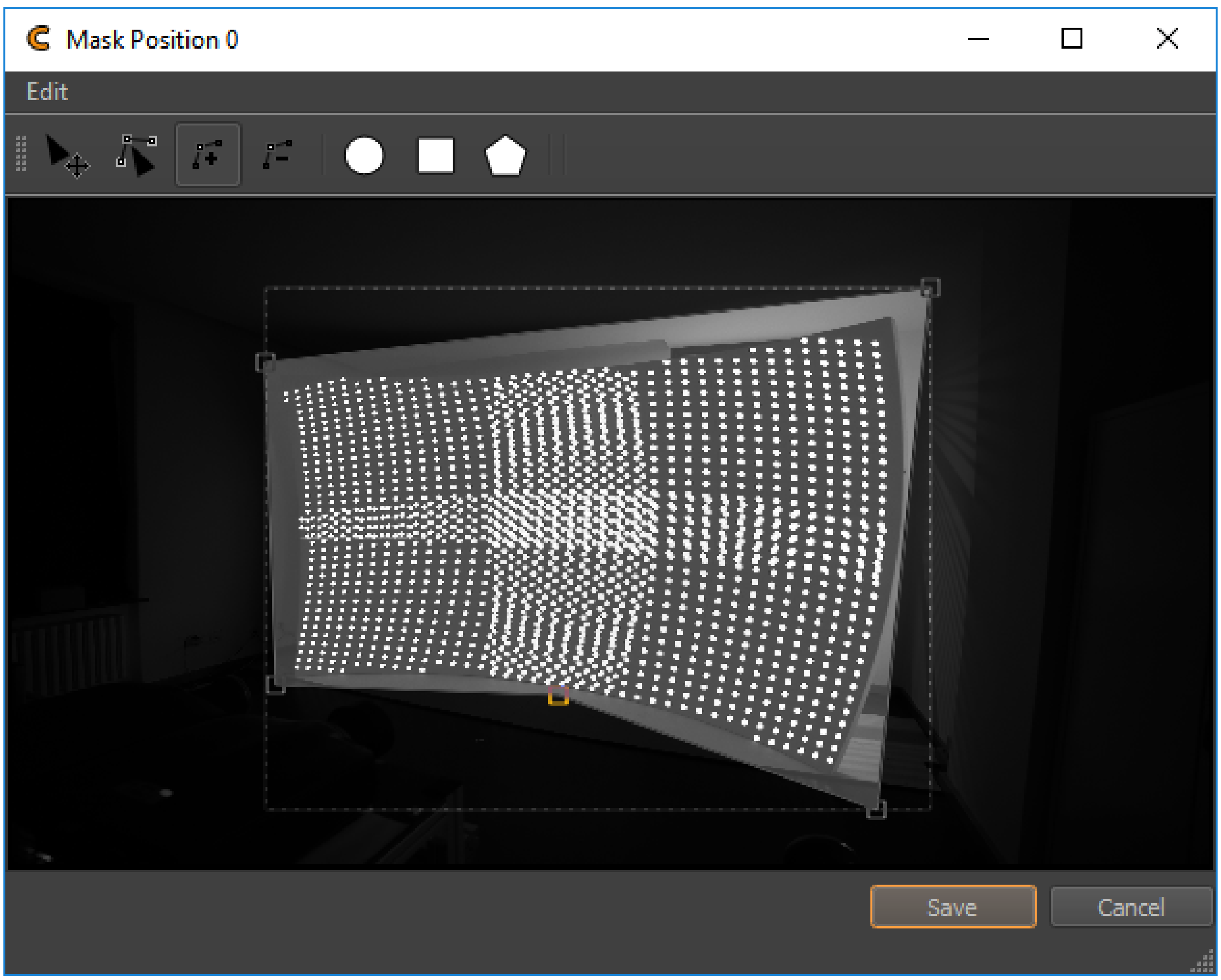
CHAPTER

FORTYONE

MASK EDITOR

Sometimes reflections, blinking lights or monitors that are not part af the actual projection are falsely detected as part of the projection and thus negatively influence the calibration result. Masking areas in the camera image containing such disturbances avoids their false detection.

The Mask Editor allow to create vector based masks for captured camera images. It shows a camera image and allows to paint on top to mask regions.



The masking is defined through the color of the background and the color of the shapes. Black areas are masked out. By default the background is white and created shapes are black, so that the created shapes cut out parts from the projection.

The fastest way to mask the outer parts of a camera image, is to outline the area that should be kept, using a white polygonal shape on a black background.

1. Activate .
2. Set the corners of the polygon by clicking on the image. You now have a black polygon on a white background, which would mask out its contents.
3. Use (Ctrl-I) to have a white polygon on black background. Now the outer part will be removed from recognition.
4. Accept the changes by pressing the Save button.

Add Shapes:
Using the toolbar, new shapes can be placed. Click the circle, rectangle, or polygon to place the corresponding form on the drawing canvas.

Add Circle (C):
Click on the image to create new circles.

Add Rectangle (R):
Click on the image to create new rectangles.

Add Polygon (P):
Set the corners of the polygon by clicking on the image.

Delete Selected Items (Del):
Selected Shapes can be deleted by pressing the "del"-key or through the menu item .

Clear Scene (Ctrl-N):
The complete scene can be cleared to white through the menu item .

Edit Items (V) :

Left-Mouse-Button:
Select and move shapes on the canvas

Middle-Mouse-Button:
Stretch circles and rectangles

Right-Mouse-Button:
Proportional scale of circles and rectangles

Edit Polygons:
When a polygonal shape is selected, additional editing options are available:

Edit Points (A):
Select and drag polygon vertices to adjust their position. (Arrow-Keys) can be used as well for moving. (,) and (.) select previous or next adjacent vertex.

Add Points (+):
Click on any polygon edge to add a vertex. While mouse is still pressed, position of currently added vertex can be corrected.

Remove Points (-):
Click on vertices to remove them.

Invert Scene (Ctrl-I):
The complete masking can be inverted using

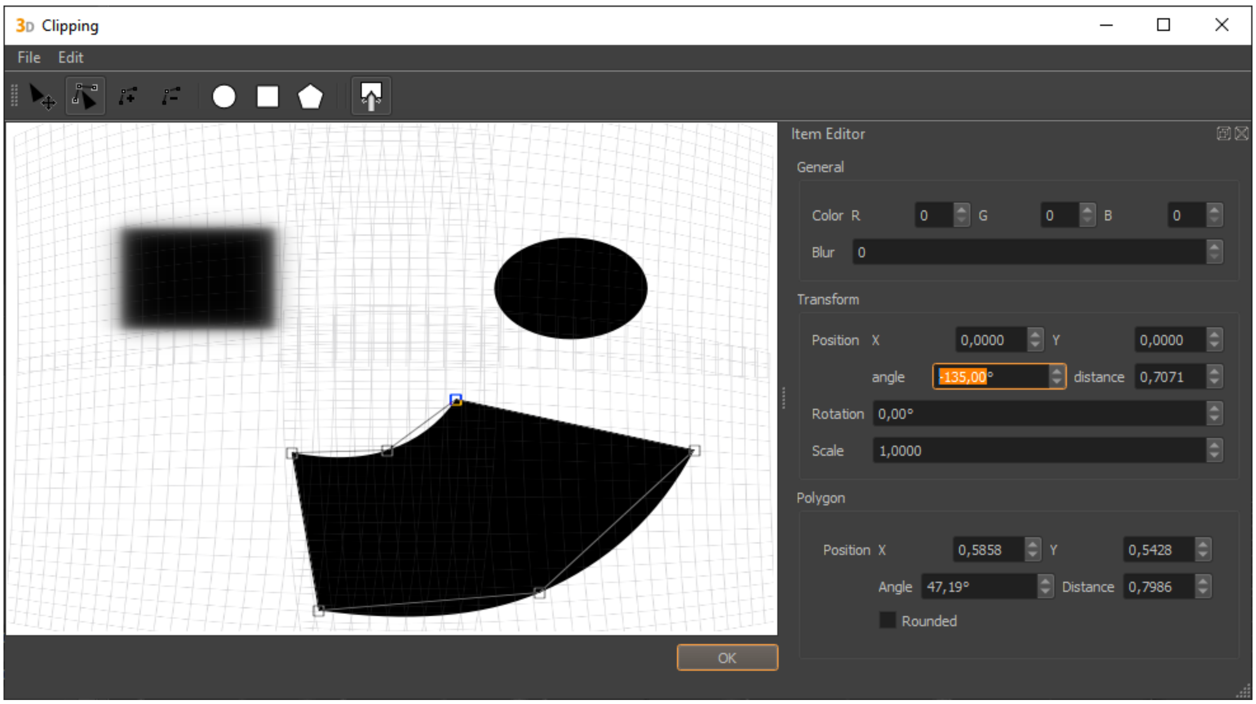
Set Item Color…:
The color of currently selected shapes can be changed using .

Set Item Background Color…:
The background color can be changed using .

CHAPTER

FORTYTWO

CLIPPING EDITOR



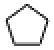
The Clipping Editor is used for vector based drawing of clipping images. The data is stored resolution independent and can be exported in varying resolutions. It supports a live-preview on the actual projection using the PatternGenerator.

42.1 Create and delete Shapes

Add Shapes:
Using the toolbar, new shapes can be placed. Click the circle, rectangle, or polygon to place the corresponding form on the drawing canvas.

Add Circle `C`
Click on the image to create new circles.

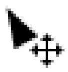
Add Rectangle `R`
Click on the image to create new rectangles.

Add Polygon  **P**
    Set the corners of the polygon by clicking on the image.

Delete Selected Items `Delete`
    Selected Shapes can be deleted by pressing the ”del”-key or through the menu item .

Clear Scene (Ctrl-N)
    The complete scene can be cleared to white through the menu item .

42.2 Edit Shapes

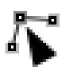
Edit Items  **V**

`Left-Mouse-Button`
    Select and move shapes on the canvas

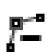
`Middle-Mouse-Button`
    Stretch circles and rectangles

`Right-Mouse-Button`
    Proportional scale of circles and rectangles

Edit Polygons
    When a polygonal shape is selected, additional editing options are available:

Edit Points  **A**
    Select and drag polygon vertices to adjust their position. (Arrow-Keys) can be used as well for moving. **,** and **.** select previous or next adjacent vertex.

Add Points  **+**
    Click on any polygon edge to add a vertex. While mouse is still pressed, position of currently added vertex can be corrected.

Remove Points  **-**
    Click on vertices to remove them.

42.3 Colors

The clipping is defined through the color of the background and the color of the shapes. Black areas are clipped out from the projection. By default the background is white and created shapes are black, so that the created shapes cut out parts from the projection.

Invert Scene `Ctrl-I`

The complete clipping can be inverted using

Set Item Color…

The color of currently selected shapes can be changed using

Set Item Background Color…

The background color can be changed using

42.4 Blur

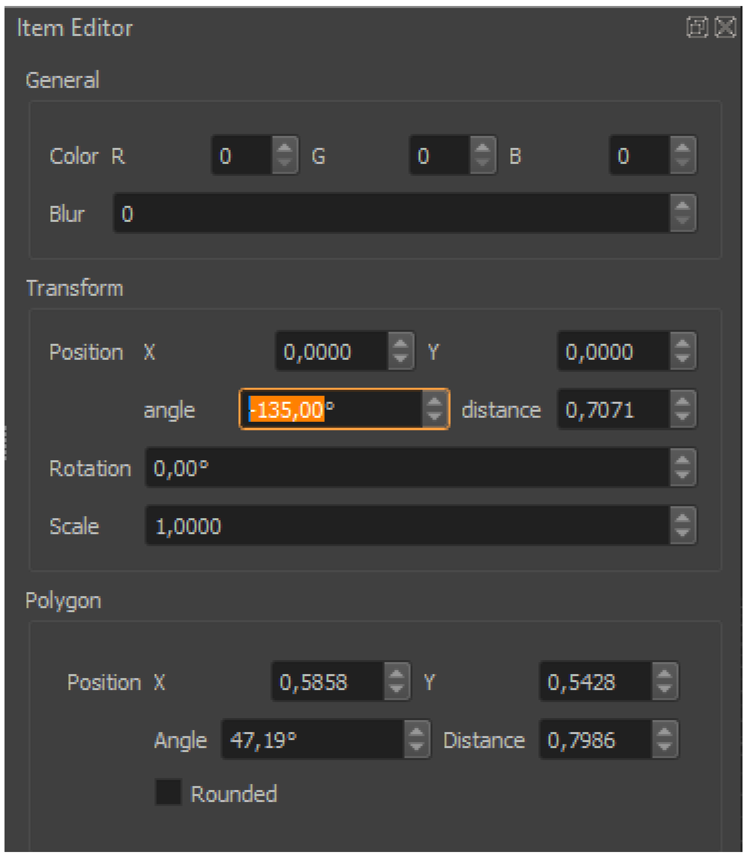
Shapes can be blurred, to get soft edges in the clipping export.

Set Item Blur…:
The blur of currently selected shapes can be changed using `Menu > Edit > Set Item Blur...`

Note: The effect of blur is currently not shown in the live-preview on the real screen.

42.5 Item Editor

The Item Editor allows to precisely adjust all aspects of the clipping items through numerical input fields.



General
General settings. Adjustable for all shapes.

Color
Defined as R G B components (range 0-255)

Blur
range 0-99; 0 = off

Transform
Transform (adjustable for all shapes): the position of an item can be adjusted numerical in two variants.

Position X/Y
Item position as Cartesian coordinate x and y (the canvas ranges from 0,0 top left to 1,1 bottom right corner; 0.5,0.5 is the center of the canvas)

Position angle/distance
Item position as polar coordinate angle (counter clockwise) and distance (from canvas center)

Rotation
Item rotation in degrees, clockwise.

Scale
Item scale

Shape Type specific
The third section contains specific parameters depending on the current shape type (rectangle, circle or polygon).

Width / Height
Width and height of rectangle or ellipse items.

X/Y
Vertex position as Cartesian coordinate x and y relative to item origin.

Angle/distance
Vertex position as polar coordinate angle (counter clockwise) and distance (from item origin).

Rounded
Allows to select between sharp corner or smooth curve passing through a vertex.

42.6 Load and Save

The clipping data is stored along with the Mapper3d project file. But there is an option to explicitly store the clipping data in an extra xml-file (export) and load clipping data from such a file. This way you can transfer clippings from one project to an other, or make backups of different versions of your clipping.

42.7 Export Image

The clippingEditor allows to export images in an arbitrary resolution.

This allows you to manipulate the clipping-image in any image manipulation software. You can use your manipulated image for clipping in Mapper2d and Mapper3d (see section *Shading*).

42.8 Live Preview

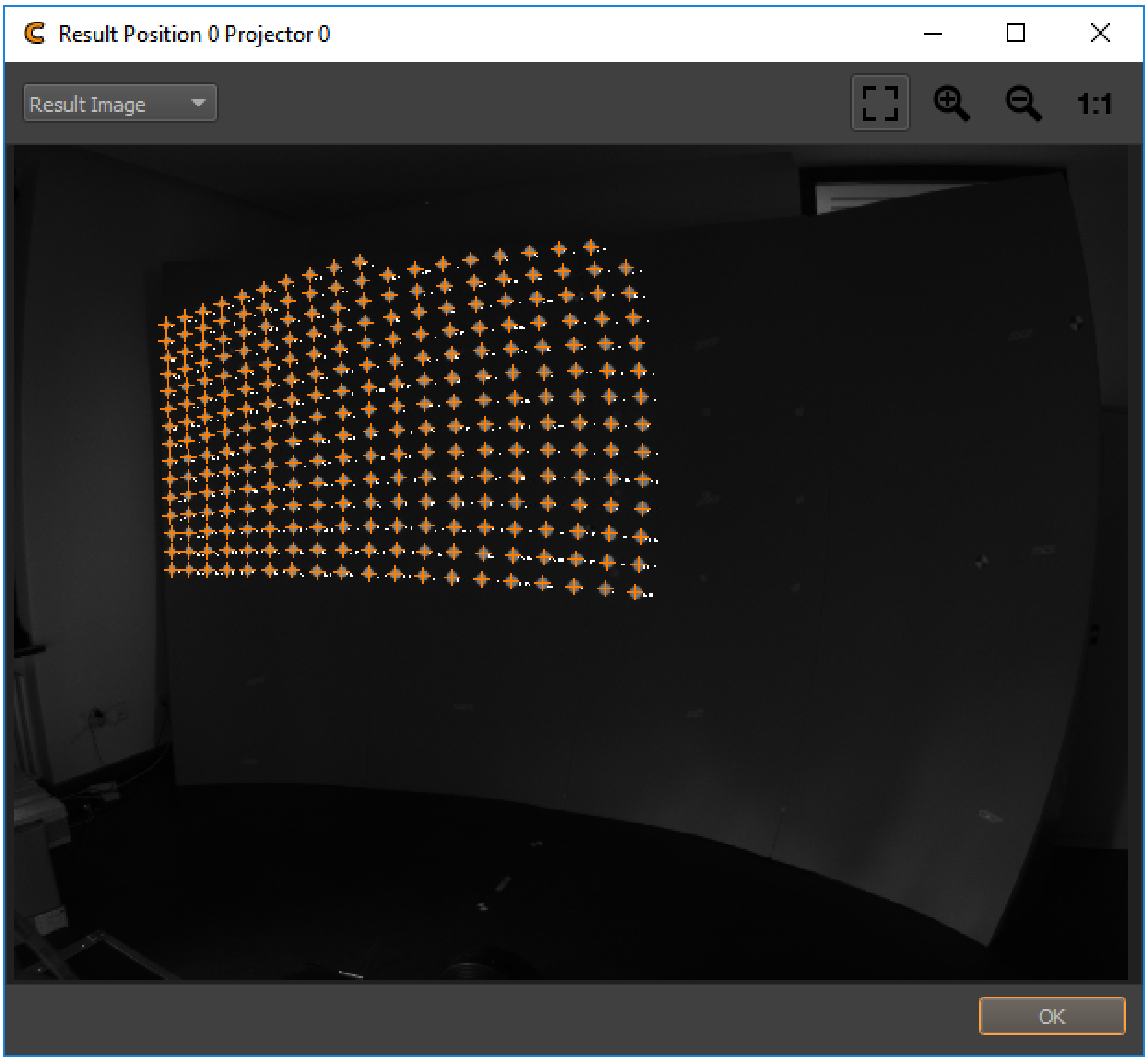
Started from Mapper, Clipping Editor supports a live-preview on the real projection using the *PatternGenerator*. Live-preview can be toggled using Clipping Editors main-toolbar.

CHAPTER

FORTYTHREE

RESULT VIEW

Shows a detailed result of dot pattern recognition and allows to find obstacles disturbing lights or reflections that might have negatively influenced the calibration.



Layer Selection:

Select between multiple images showing different stages of the detection process.

Black Image:
First image taken with camera. Should contain no dots.

White Image:
Second image taken with camera. Should contain dots.

Average Image:
Average of Black and White Image

Binary Image:
Black/White Image. Dots should be full white, rest should be black, otherwise check threshold and camera parameters.

Contour Image:
Shows contours around each dot. Each dot should have exactly one closed contour. If contours are shown, but orange crosses missing. Check dot radius min/max setting in Recognition Settings (see section *Recognition Settings*)

Result Image:
Shows column and row number in each detected dot.

Zoom Options:
Select between different zoom levels and automatic fitting using toolbuttons on top right.

Navigation:
If zommed in, the image can be moved around with left mouse button.

Ideally each projected point should have an orange cross in the middle, showing that it was successfully recognized. Otherwise some of the following artifacts might be visible:

Undetected Points:
If several points are not detected, this might be due to an obstacle (remove and recapture images) or too poor light conditions (check camera settings and recognition threshold).

False detected points:
No orange crosses should be found outside of the actual projection area. These might be false detections induced by disturbing lights or reflections. Turn off the disturbing lights or use a position or projector mask to block detection in these areas of the camera image (see section *Mask Editor*).

Half Dots:
Dots that are only partly visible usually have a wrong center detected. These should not not be used for calibration. Remove these dots using the dot pattern editor (see section *Dot Pattern Editor*)

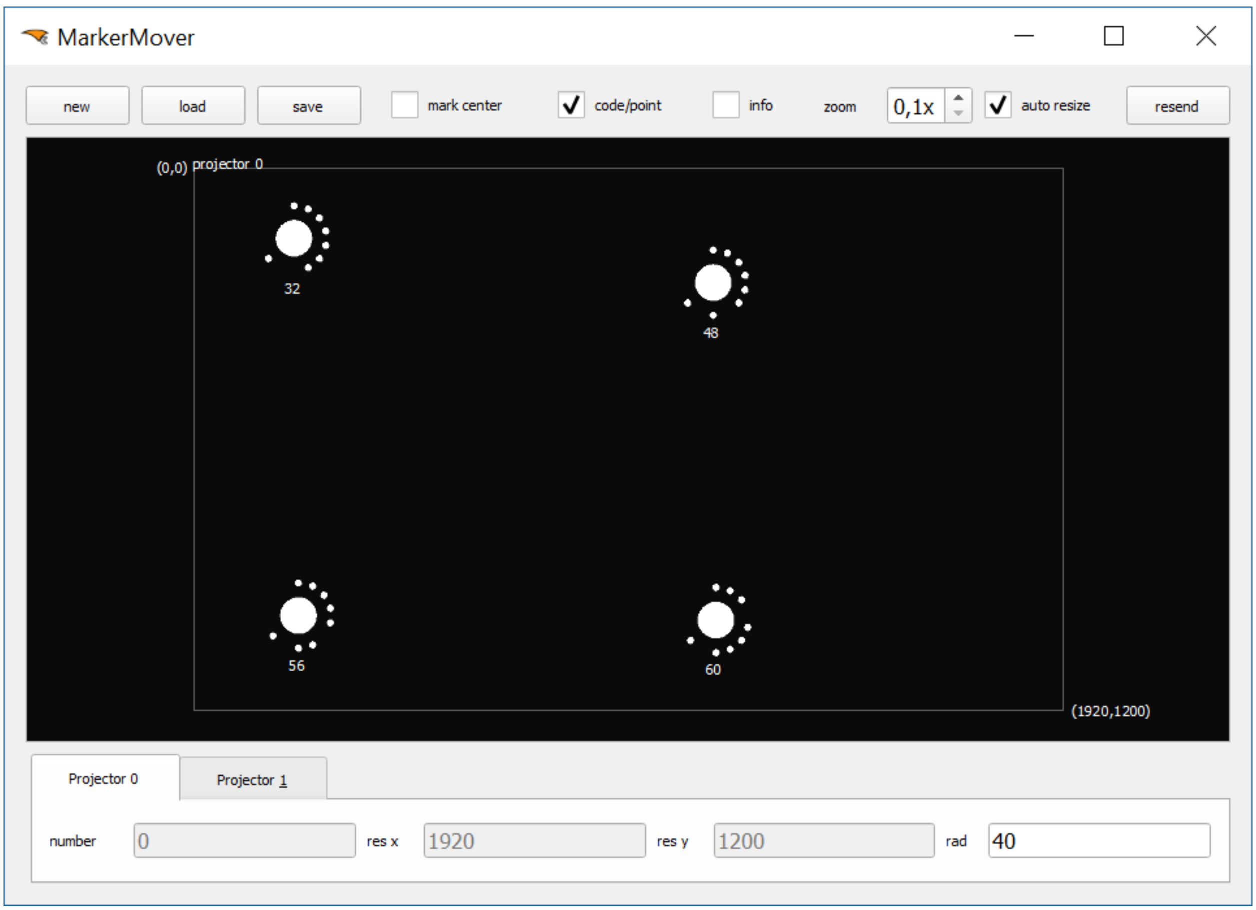
CHAPTER

FORTYFOUR

MARKER MOVER

Using the Marker Mover you can display unique markers on the screen which can be recognized by image processing algorithms. They are used for measuring the screen. Since those markers have to be perfectly visible (no obstacles behind, no overlapping) and evenly distributed across the projection we provide this tool to interactively edit their positions.

The Marker Mover is available through “” in Creator.



All UI elements are described in the follwing reference section

new:
: creates a new project, you can set the number and properties of the projectors and markers

load:
: load a saved project

save:
save a project into the creator internal data structures. Two files are generated in the subfolder code:

- codemarker_all.txt contains the data for the Creator
- codemarker.txt contains the data in a format readable by the MarkerMover

mark center:
display a cross in the middle of a marker. Use this if you want to measure the marker position with the Leica Disto 3D

code/point:
switch between two render modes. Code displays a recognizable marker with id number (for image processing) and point shows only a point with the index number (better for measuring with Leica Disto 3D).

info:
highlight current projector and projection boundaries on the projection. Useful for changing the marker positions.

zoom:
change the size of the preview

auto resize:
fit the preview to the window

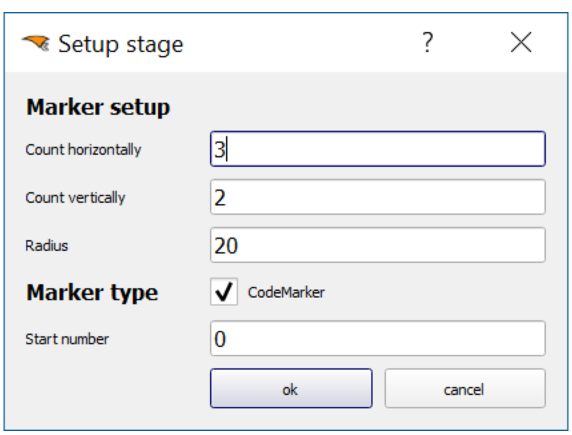
resend:
send all data to the PatternGenerator software at once. Use this if you want to manually update the projection.

Main Window:
you can move all markers with the mouse (hold left mouse button). All changes are previewed life on the projection.

Projector panel:
displays projector properties

- number: id number of projector
- res x: width of projection screen
- ip: res y: height of projection screen
- rad: radius of the markers (adjustable).

44.1 The new menu dialog



A new MarkerMover setup is created using this dialog.

Count horizontally and vertically:
how many markers are distributed on the projection (HxV)

Radius:
radius of the markers (can be adjusted later if they appear too small or large on the projection)

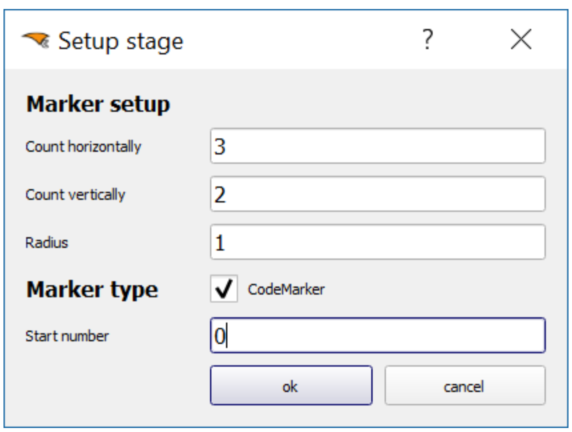
Marker type:
change the marker type (as in main window code/point)

Start number:
use this to change the index number of the first marker. Useful for starting a measurement with the Leica Disto 3D.

The "New" dialog is openend with usually correct defaults for the currently active project.

44.2 Usage

- The marker mover can be used to temporary place markers on screen using PatternGenerator. These markers can be measured (e.g with a Leica Disto3D) and then used as reference markers in the Position Finder.
- Be aware that these markers should only be used temporary. When the projectors are moved after points 3d positions where measured, camera positions can no more be calculated correctly. When projectors have moved, markers must be measured again!
- Use the "New" button to create a new set of markers. The following image shows a typical setting for measurement with a Leica Disto 3D. Note that "CodeMarker" is disabled and "Start Number" is set to 3. This makes mapping of data exported from Disto 3D easier to map to projected points after importing the data into Position Finder.

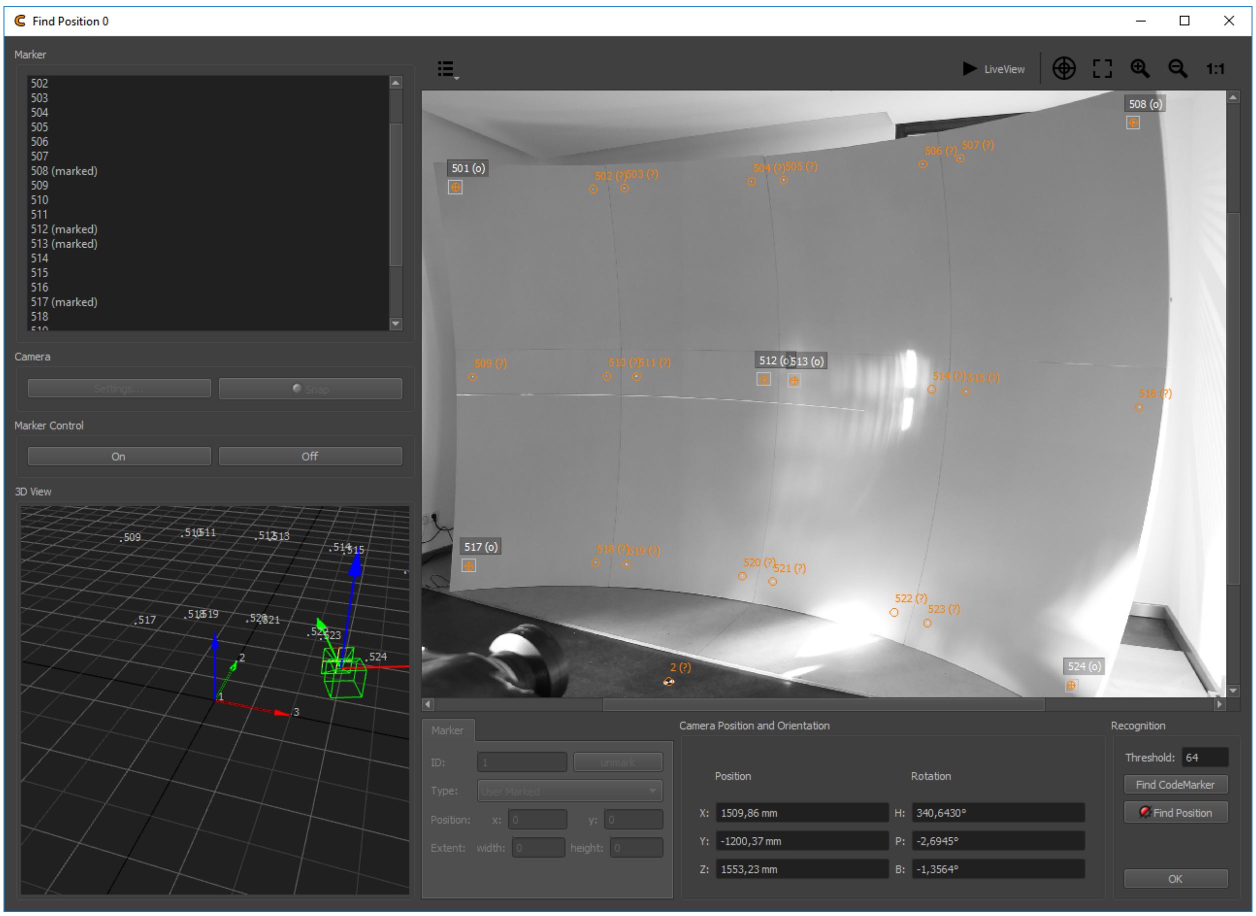


Markes can be moved by dragging in the central widget. A live preview is shown on connected PatternGenerators.

CHAPTER FORTYFIVE

POSITION FINDER

The Position Finder is used to calculate camera position and orientation based on markers seen by camera. The exact world position of these markers needs to be known (see section *Reference Points*). The PosFinder allows to, prepare marker detection and finally calculate camera position and orientation.



Marker List

Shows a list of all available markers. The selected marker is highlighted in 3d view.

Marker List Context Menu:

A context menu allows to manipulate marker selection and manipulate multiple selected markers at once.

Select marked:

Select all makers, that are marked in current positions camera image.

Set Type…:
Change type for all selected markers.

Set Extent…:
Change region of interest extent for all selected markers.

Unmark:
Remove all selected markers from current camera image.

Center on measured point:
Center region of interest for selected markers on currently recognized marker center.

Center on reprojected point:
Center region of interest for selected markers on their reprojection.

Marker Settings:
Recognition settings for currently selected marker.

ID:
Current Marker identification number.

Delete:
Remove marker from current camera image.

Type:
Different marker recognition algorithms can be selected. See section *Supported Marker Types* for details.

Position x/y:
Position of marker/region of interest in pixels in camera image

Extent width/height:
Size of region of interest in pixels

Camera Settings:
Adjust camera parameters for find position.

Camera Snap:
Take a new camera image.

Marker Control on/off:
Turn active markers on and off. (requires correctly setup remote control in project settings)

3D View:
Visualizes markers as point cloud and detected camera position/orientation. Rotate, move and zoom with left, middle and right mouse-button.

Camera Image View
Used to place markers/region of interests in the camera image.

It shows region of interests, marker type and id. After position finding ran, the detected marker center is marked with an orange cross and reprojection of markers 3d position is marked as orange circle.

If the shown image is loaded from disk, a time-stamp is shown in bottom right corner of the image.

Visualization Options:
Allows to toggle different overlays.

LiveView:
toggle between live image and captured image from camera (live image might have lower resolution, and might disregard camera settings)

Navigation Options:
Allow to center currently selected marker and to zoom the camera image.

Camera Position and Orientation
Shows the found camera position and orientation. Can be overridden by hand.

The camera position/orientation can be overridden by hand, e.g. for initial rough positioning the camera and using the marker reprojection in the camera image to assign markers more easily.

Recognition:

Threshold:
Binarisation threshold

Find Code Marker:
Activate to search for code marker in complete camera image.

Find Coded LEDs:
Activate to search for coded LEDs in complete camera image. Only available when coded LEDs control is setup in the current project.

Find Coded Laser:
Activate to search for coded Laser in complete camera image. Only available when 3D Disto control is setup in the current project.

Find Position Button:
Take images and calculate camera position based on markers found in image.

45.1 Usage

1. Turn markers on if you have active markers ().
2. Update the camera image by pressing
3. If the markers are difficult to see, check and snap a new image.
4. Select at least six markers in the marker list and mark them in the camera image by double-click. The markers are user marked by default (no image detection involved see section *Supported Marker Types*) but this can be changed later.
5. Hit "Find Position". You have an initial camera position, and potential other markers are overlayed in the camera image.

When the calibration was successful, Camera position and orientation should be updated (see position/orientation textboxes and 3d view). Also the recognized markers and assumed marker positions in image based on projection of 3d markers are visualized in camera image. The recalibration of this camera position is done and the PosFinder can be closed.

If problems occur, e.g not enough markers detected or camera position implausible, check recognition parameters threshold and thresh avg. Than hit "Find Position" again.

For getting a more precise camera position, you can add more markers, optimize the marker positions or use automatic marker detection.

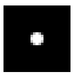
1. Activate additional proposed marker positions directly in the camera image by dragging them.
2. The position of activated markers can be modified by dragging them in the camera image.
3. The type of activated markers can be changed to run image detection, by selecting all active markers int the marker list and using and then to switch their type.
4. Hit "Find Position" again. You have a refined camera position.

45.2 Supported Marker Types

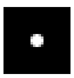
The Find Position dialog supports a wide range of marker types. Several are detected automatically but even visual features without special detection can be manually marked by user.

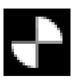
Here a list of all supported marker detections and their usage.

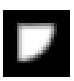
 **User Marked**
User defines exact position of marker/feature in image. No image analysis is done. Can be used for any visible feature. Needs to be manually updated each time the camera moves.

 **Hotspot**
Used for small active markers that can be turned on and off automatically. Can be used in medium bright environments, since two images are taken for comparison (marker on and marker off). The weighted center of a bright spot will be searched within given region of interest.

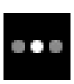
Scripts for enabling and disabling lightsource must be setup, otherwise recognition will fail!

 **Ellipse**
Can be used for larger circular active markers, or passive markers. Search for a bright elliptical pattern in area of interest.

 **Checkerboard Marker**
Passive checkerboard marker will be searched within region of interest.

 **Screen Corner**
Screen corner will be searched within region of interest. Assumes a bright screen in front of dark background or a bright screen surrounded by black frame.

 **CodeMarker**
Searches for coded markers in given region of interest. Each of these markers is visually different so they can be identified and distinguished automatically. These markers can also be found automatically in the whole camera image (activate).

 **Coded LED Marker**
Searches for coded LED markers in given region of interest. Each of these markers is turned on and off in an unique pattern so they can be identified and distinguished automatically. These markers can also be found automatically in the whole camera image (activate). This option is only available, when Coded LEDs are activated in .

Disto3D Marker
Searches for coded laser markers in given region of interest. These can be generated using a Disto3D, which must be selected as type in `Project Settings/Marker Control`.

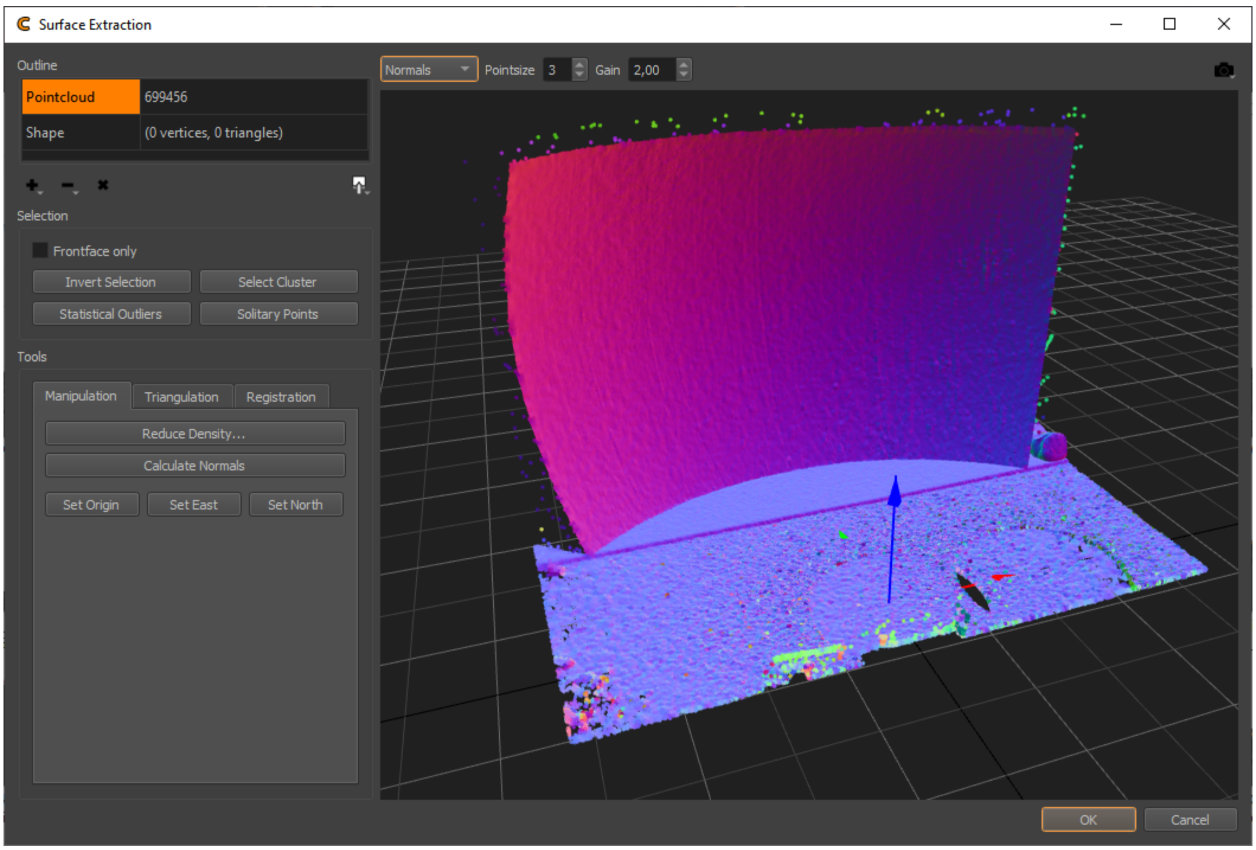
Template Marker
When selecting this type of marker, the template must be initialized using `Capture`. After initialization, the template will be searched in the given region of interest.

CHAPTER FORTYSIX

POINTCLOUD CONVERSION

The Pointcloud conversion dialog allows extraction of, and fitting of shapes on, pointcloud data. These shapes might be used for export and optimization of the calibration process.

Pointcloud data might be imported from scanning devices like *Leica Nova Multistation*, *Leica BLK360*, imported from general pointcloud files or generated with ProjectionTools *High Resolution Scanning* capabilities.



46.1 User Interface

Outline:
Allows to select between pointcloud and extracted/fit shape for editing.

Add:
Add points from several different sources, such as PCL, PTS, PLY, XYZ, TXT, *Leica 3D DISTO*, *Leica Nova Multistation*, *Leica BLK360*

Delete:
Delete currently selected points / triangles. Holding the button opens a popup menu allowing to delete unselected points as an alternative.

Delete All:
Delete all points/triangles from currently selected item.

Export:
Export points/triangles in different formats, such as PCL, PTS, XYZ, TXT, OBJ.

Selection:
Adjust selection and selection behavior.

Frontface only:
When selecting in the 3d view, select only elements with normals facing towards camera.

Invert Selection:
The Invert selection command will change the current selection such that everything previously unselected will now be selected and vice versa.

Select Cluster:
Attempts to extend the current selection to include all elements belonging to the same continuous and smooth surface.

Statistical Outliers:
Selects statistical outliers, based on a given neighbor count and deviation threshold. This effectively selects points in areas that are less dense than the average.

Solitary Points:
Allows to select points with less than n neighbors in a given radius.

Tools:
Contains tools for pointcloud manipulation, triangulation and registration.

Manipulation:
Pointcloud manipulation

Reduce Density:
Reduce pointcloud density, based on target average distance between points.

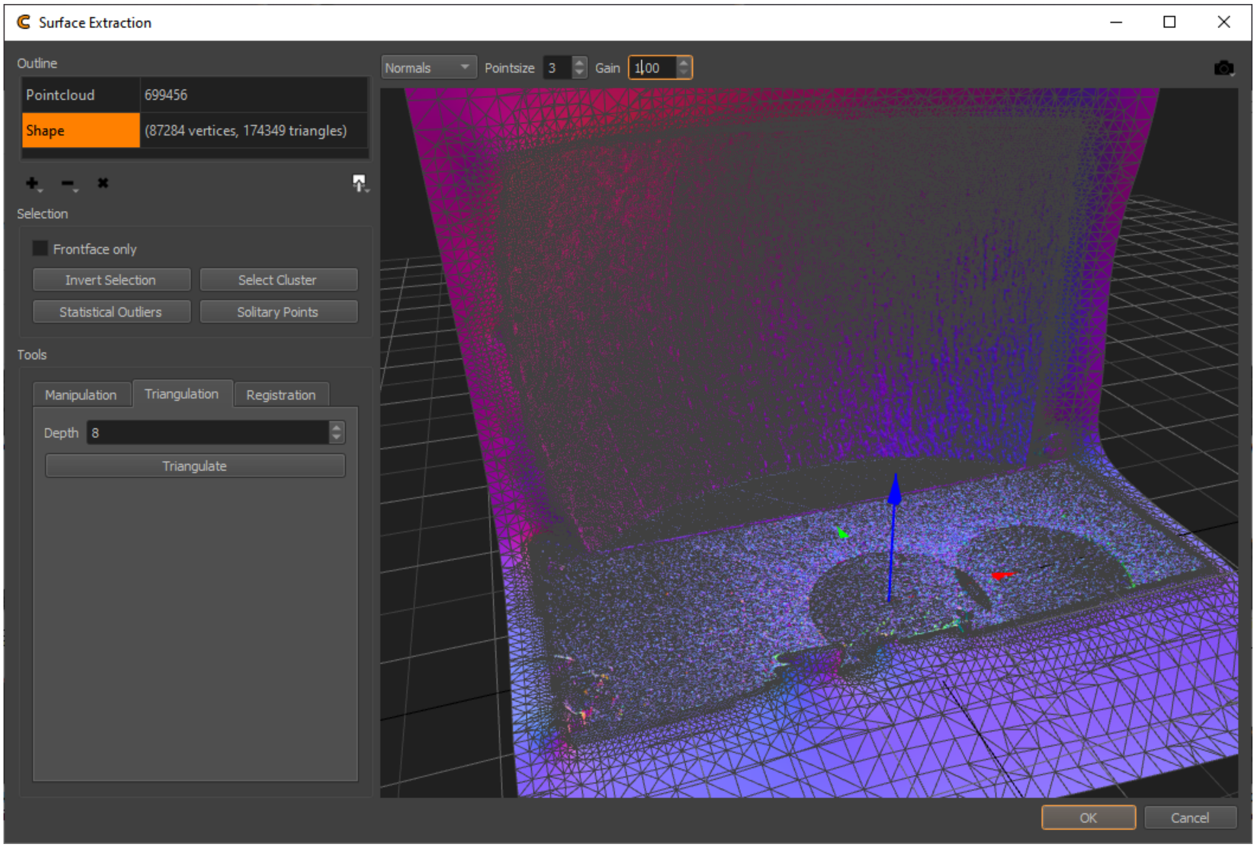
Calculate Normals:
Calculates point normals, assuming a sensor position of (0, 0, 800).

Set Origin:
Translates the pointcloud so that the currently selected point is at the world origin.

Set East:
Rotates the pointcloud about its vertical axis, so that the selected point is in east (x) direction. The height of the point is ignored.

Set North:
Rotates the pointcloud about its vertical axis, so that the selected point is in north (y) direction. The height of the point is ignored.

Triangulation:
Surface extraction



Depth:
Iterations of space subdivision for surface extraction. Higher values, result in more dense meshes. Increasing the depth by one roughly quadruples the number of vertices/triangles in the resulting mesh.

Triangulate:
Starts the triangulation of currently selected points in pointcloud.

Registration:
Surface and primitive fitting.

Type:
Select shape type, that should be fit to selected points. Plane, Cylinder and Sphere are currently supported.

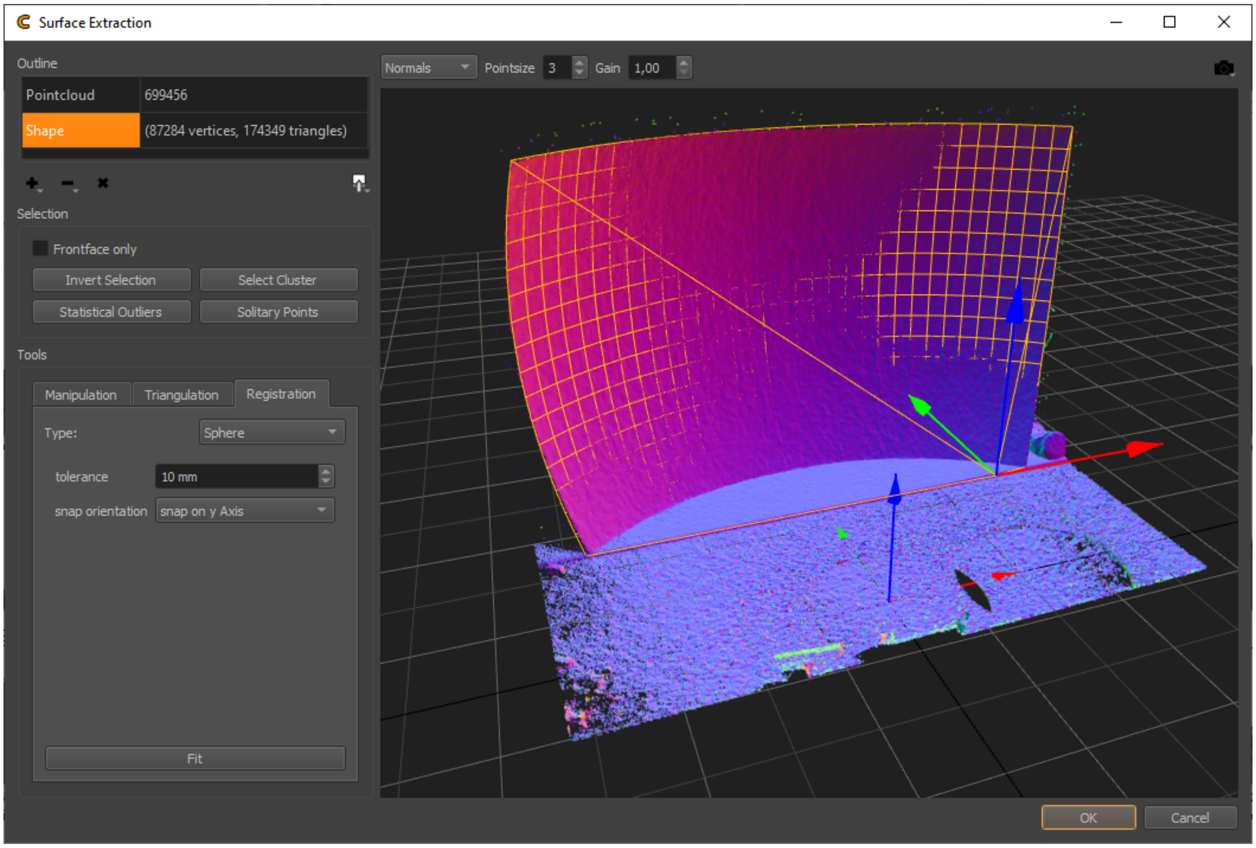
Fit:
Fit current shape type to selected points in pointcloud.

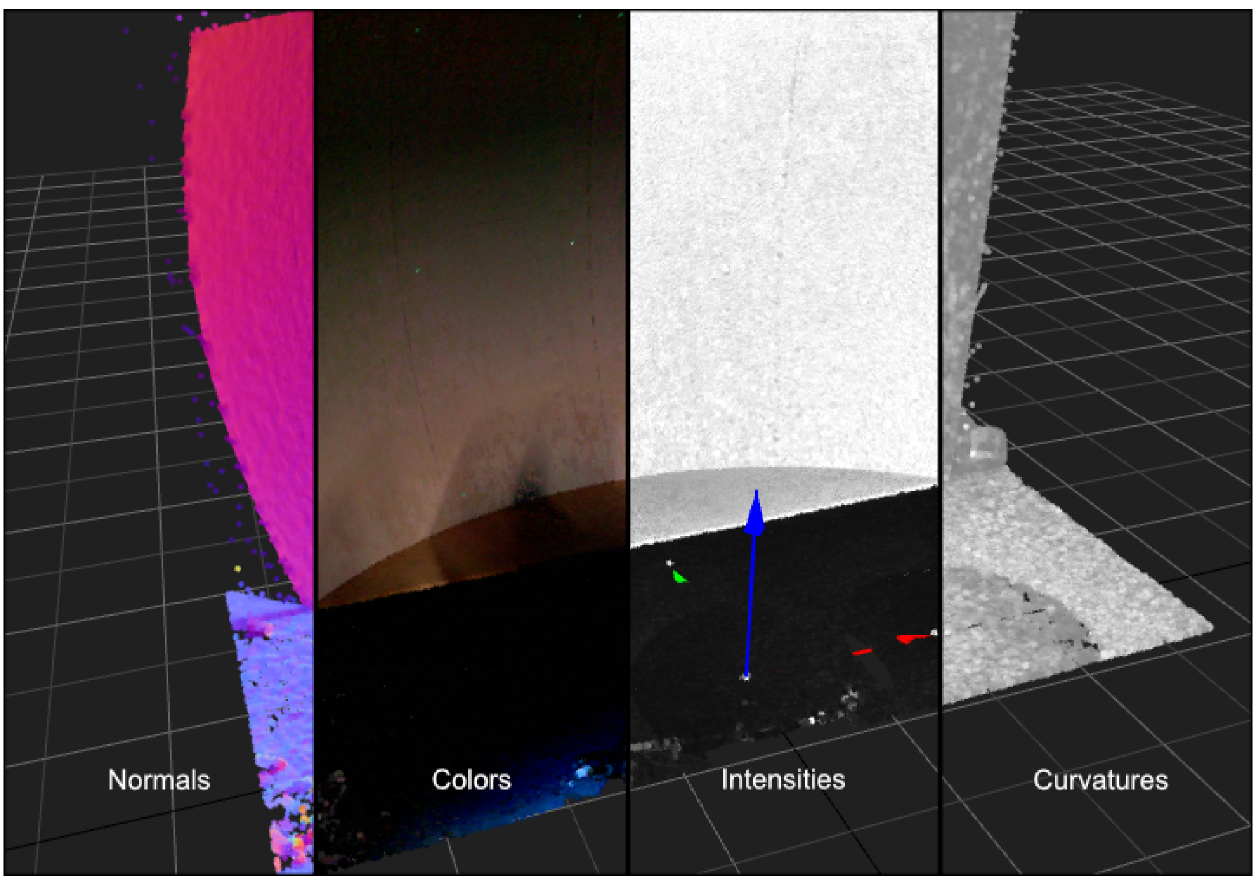
3D View Options:

Pointcloud shading:
Allows to select between alternative pointcloud data visualizations.

Normals:
Visualize the normals as colors

Colors:
Show captured color, if available


Surface Extraction
Outline
Pointcloud
699456
Shape
(87284 vertices, 174349 triangles)
Selection
Frontface only
Invert Selection
Select Cluster
Statistical Outliers
Solitary Points
Tools
Manipulation
Triangulation
Registration
Type:
Sphere
tolerance
10 mm
snap orientation
snap on y Axis
Fit
Normals
Pointsize
3
Gain
1,00
OK
Cancel


Normals
Colors
Intensities
Curvatures

Intensities:
Show captured intensities

Curvatures:
Show calculated curvatures

Pointsize:
Adjust point size of active pointclouds

Gain:
Adjust brightness of color, intensity and curvature shading

Perspective:
Adjust camera for several standard orthographic views, default perspective and origin.

3D View:

Rotation:
ALT + Left Mouse Button

Translate:
ALT + Shift + Left Mouse Button

Scale:
ALT + CTRL + Left Mouse Button or Scroll-wheel

Selection:
Single click to select single points. Hold and drag for rectangle selection. Hold CTRL to remove from selection. Hold Shift to add to selection. Hold CTRL + Shift to intersect with previous selection.

46.2 Workflow

Preparation:

Import:
Import pointcloud data from one of the many supported sources. In some cases pointcloud data might already be pre-loaded and processed, e.g. when the conversion dialog is opened from Creator after a high-res scan was done.

Cleanup:
Cleanup the pointcloud data. This involves removal of parts out of parts out of scope and noise. Selecting and deleting points manually as well as various filters can be used for that process (see selection group-box).

Orientation:
Bring the data into an useful coordinate system, using the "Set Origin" and "Set East/North" functionality.

Tip: Multiple pointclouds in the same coordinate system can be loaded consecutive. This can be used to stitch multiple incomplete pointclouds together.

Preprocess:
Calculate normals, when not yet generated. Several imports from scanning devices generate the normals automatically on import. When importing a general pointcloud, manual normal estimation might be needed (Use).

Backup (Optional):
Saving the cleaned up pointcloud for later use is often a good idea. When using , a pointcloud including available normal, color, intensity and curvature information is saved, which can be loaded later retaining all the data.

Extraction:

Reference Points:
Select individual points of the cloud (usually based on color), which can later be used as reference points, e.g. for the position finding process of cameras.

Registration:
Fit a standard shape (sphere, cylinder, plane) to pointcloud selection. The results can only be used directly in ProjectionTools, after closing the dialog. There is no export available.

Triangulation:
Generate a mesh surface with adjustable detail, for currently selected pointcloud. Optionally remove parts of the generated mesh, e.g. too far extrapolated parts.

Use/export:

Use:
When accepting and closing the dialog, the extracted data will be used in ProjectionTools based on the context where the dialog was opened.

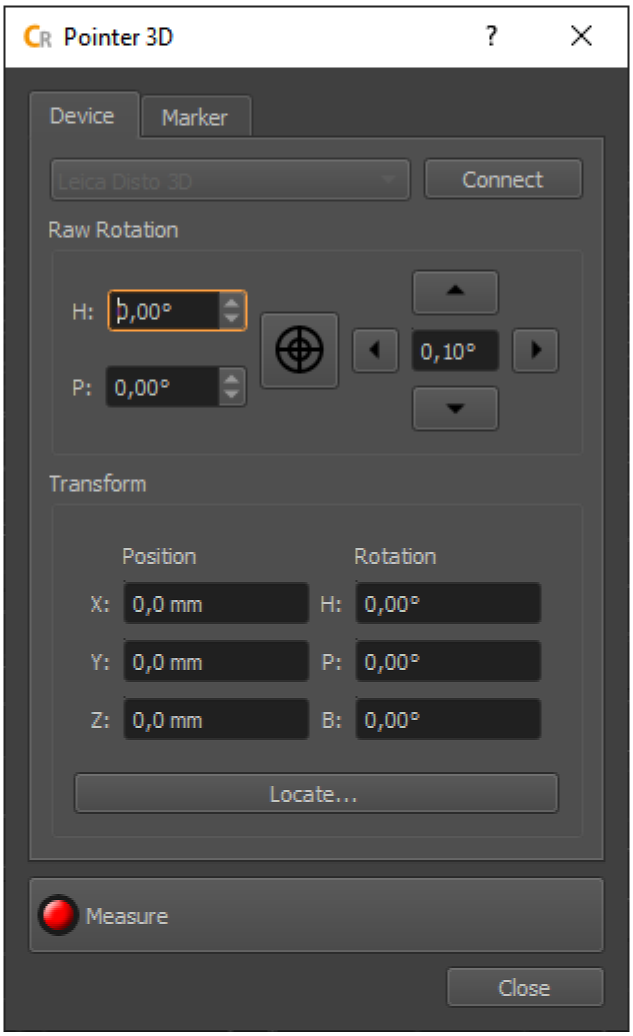
Export:
When multiple, data was extracted, use exports to store the data for later import and use. For example a list of selected points could be saved as “Points TXT” for later use as reference points and an extracted mesh could be exported as “Mesh OBJ” for later use as reference mesh. These exports could also be used for further cleanup or enhancements in third party software, e.g. uv-unwrapping for using a mesh a custom mapping in Mapper2D.

CHAPTER

FORTYSEVEN

POINTER 3D

The Pointer 3D dialog allows to use a Leica 3D Disto as a remote-controlled pointing and measure device.



Features:

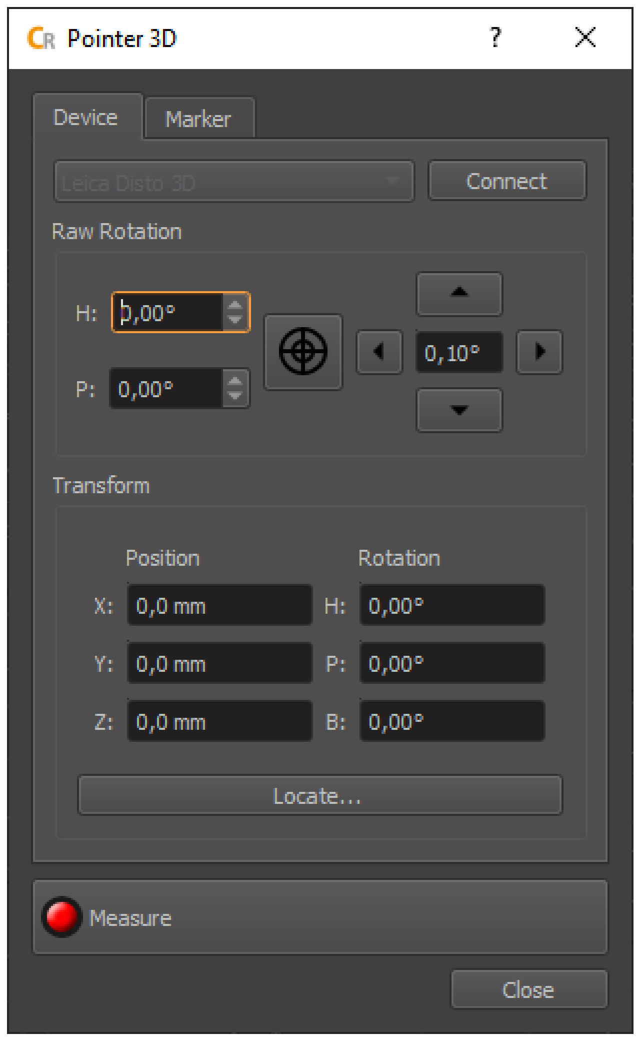
- Measurements can be taken and directly imported without the need to copy and convert files.
- Reference points with known 3d positions, can be marked easily.

47.1 Usage

1. Install and run Leica 3D Disto software available from Leica.
2. Connect to 3D Disto with Leica 3D Disto software. Keep the software running.
3. Connect Pointer 3D using .
4. Determine current Disto 3D position and orientation using
5. Start measuring using or pointing at reference marker by double-click on entry in

47.2 Controls

Device:
General setup



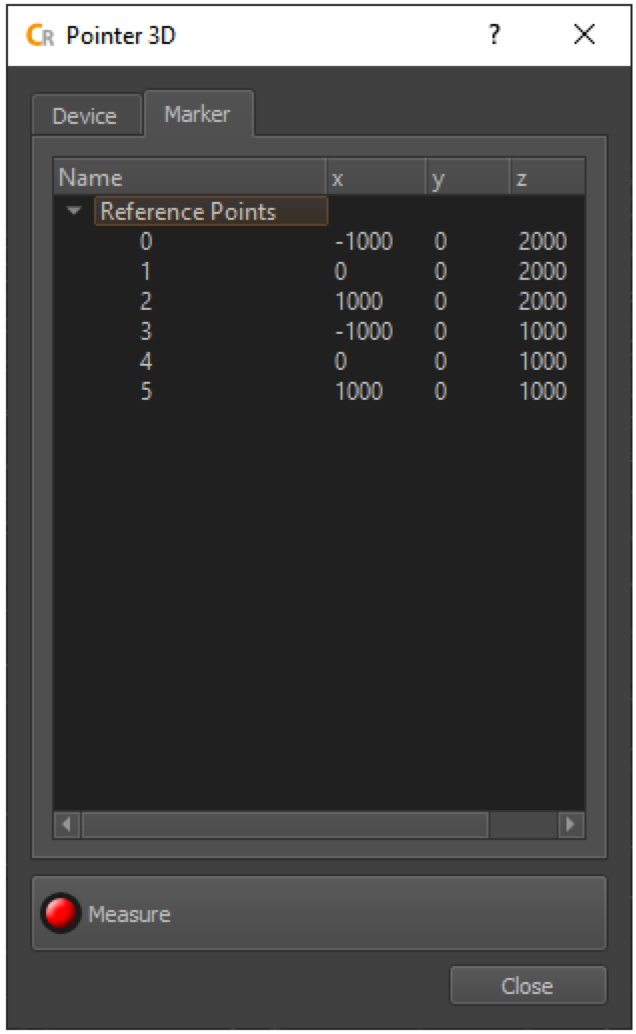
Connect:
Establish connection to 3D Disto software. Make sure 3D Disto software is running on the local machine and connection to 3D Disto established.

Raw Rotation:
Allows to rotate the 3D Disto in its native coordinate system.

Transform:
Defines the current position and rotation of the 3D Disto relative to Creators coordinate system. Use for estimating the transform based on an axis or three points.

Measure:
Take a measurement and add measured point to marker list.

Marker:
List of known reference points.



Marker list:
Double click on an entry to point at with the 3D Disto.

Measure:
Take a measurement and add it to the marker list.

CHAPTER

FORTYEIGHT

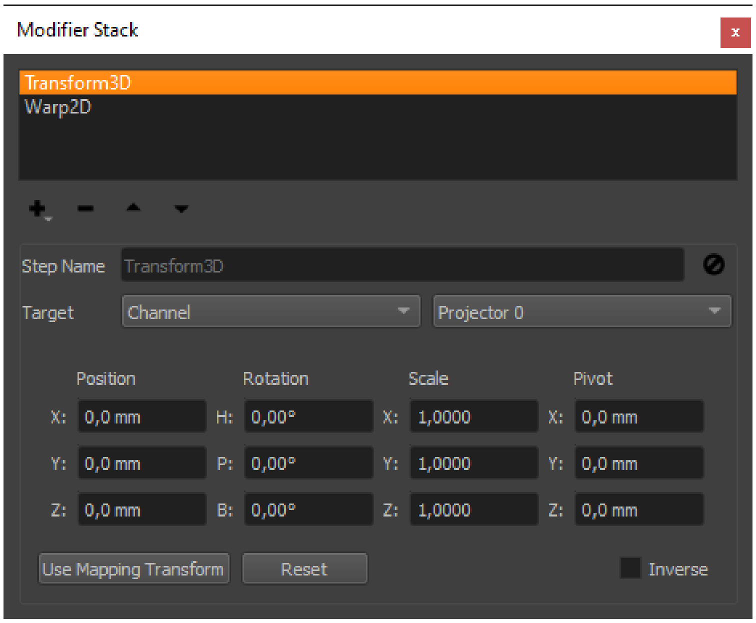
MODIFIER STACK

The modifier stack allows to manipulate geometric data with multiple modifiers in a non-destructive manner. The execution order of modifiers is from top to bottom.

In the global context of ProjectionTools Mapper it manipulates the calibration data generated by Creator on the fly.

This allows for multiple use cases, for example:

- Adjusting the global coordinate system.
- Correct for distortion of Mylar in collimated systems.
- Mapping a realtime rendered 360 degree panorama on a flat wall.



+:
: add a new modifier

-:
: remove selected modifier

up arrow:
: move selected modifier up

down arrow:
: move selected modifier down

Step Name:
Each modifier can have a custom name.

Disable Button:
Disable the selected modifier step (enabled by default).

Target:
Each step can be applied to all channels (default), limited to a single channel or limited all channels on one mapping.

Several modifiers are available. Their usage and purpose is described in the following sections.

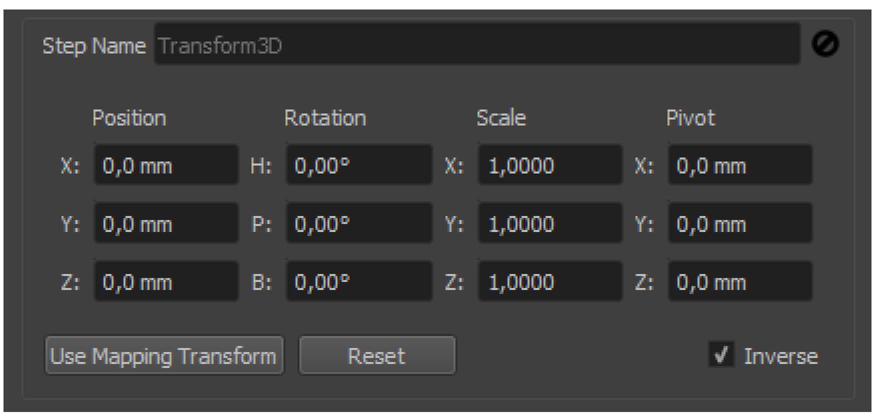
48.1 Transform3D Modifier

This modifier applies an affine transformation to geometry.

The transformation can be inverted as well. This is the default. It allows to remove a certain transformation, or make a certain position/orientation the new reference coordinate system.

It can be used for:

- Removing an unwanted translation/rotation of the calibration data.
- Making the designed eyepoint, the cockpit or any other coordinate system that is used by 3d engine the reference coordinate system. This way viewpoint offsets can be setup and exported in the same coordinate system, as the 3d engine is using.



Position, Rotation, Scale, Pivot:
adjust the transformation that should be applied or removed

Use Mapping Transform:
Copy transform from currently setup mapping.

Reset:
Set transform to identity again.

Inverse:
Apply inverse transformation (remove transformation). Activated by default.

48.2 Warp2D Modifier

Allows to project geometry on a given surface (mapping) and warp along that surface.

It can be used for:

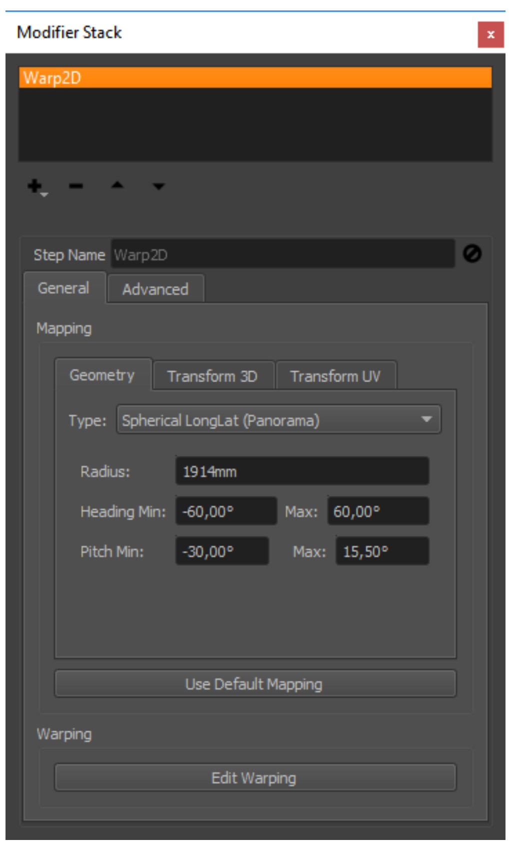
- Let rectangular content follow irregular screen outlines.
- Adjusting the projection on the BPS (Back Projection Screen) in a collimated system according to a reference slide-projector.
- Adjusting the projection on the BPS in a collimated system to compensate the distortion of the Mylar.

48.2.1 Mapping

Before starting to work on the actual warping, the mapping should be setup correctly.

The Mapping group in the general tab allows to define this mapping, the surface where the geometry is projected on and warped along.

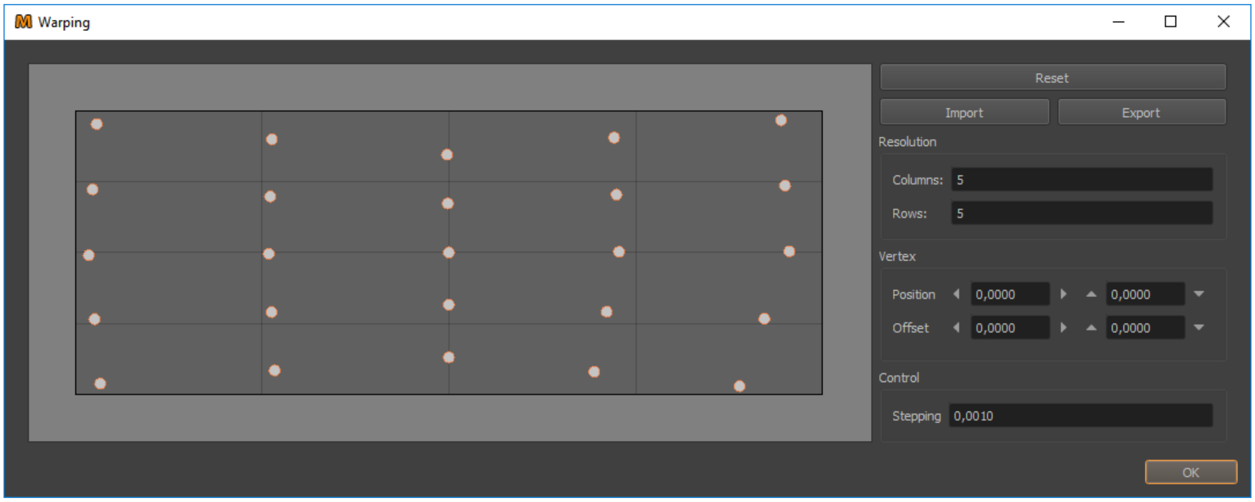
It has the same controls as the global mapping settings in Mapper, and usually the same settings should be used here, which can be done by pressing the button.



48.2.2 Warping

The warping editor can be opened using .

Beside the 2d view on the left side, where warping grid points can be dragged to adjust the warping, additional controls are available on the right side.



Manipulate Warping:
Click on individual grid points to select them and move them by dragging the mouse.

Multiple points can be selected at once and moved simultaneously. For multi-selection hold Ctrl-Key or use rubber-band selection (drag out a rectangular area, where each point inside will be selected).

Reset:
Resets the warping to zero. Current number of columns and rows is maintained.

Import:
Allows to import warping in different formats.

Export:
Allows to export current warping in different formats. These files can be imported again using the import functionality.

Resolution Columns/Rows:
Allows to adjust the warping grid resolution. When the resolution is changed, the new grid points are interpolated using the current warping grid.

Vertex Position/Offset:
Here the position and offset of selected grid points (vertices) can be viewed and edited numerically.

Control Stepping:
Adjusts the step size for gridpoint manipulation. It is used in the numerical inputs, as well as for keyboard shortcuts and move buttons.

Hint: A live preview can be enabled, using ProjectorControl. Setup and show a grid preview in the desired resolution. It is a good idea to use a quite low resolution, e.g. 10 x 10 to speed up preview. Then activate .

48.2.3 Advanced

Inverse:
Reserved for future usage: Inverts the warping. Enabled is the default. When applied to calibration data, this means the calibration data is warped inverse so that effectively any mapping will be warped forward as defined in the warping editor.

Preview:
Allows to select between different preview modes.

Import 3D Data:
Allows to import 3d reference points to define a warping. The reference points are projected using the current mapping to generate 2d coordinates. The points for import have to meet several criteria:

- they need to be defined in the same global coordinate system that is used in the ProjectionTools project
- the complete grid needs to be defined (no missing points)
- the points need to be ordered linewise from top-left to bottom-right.

XLSX Format (exemplary excerpt):

	A	B	C	D	E	F	G	H
1	id	x	y	z	u	v	column	row
2	REF_1_0003	0,7801	323,9746	881,8202	0	0	0	0
3	REF_1_0004	6,145	633,2541	936,3937	0,05	0	1	0
4	REF_1_0005	57,8183	940,9494	982,877	0,1	0	2	0
5	REF_1_0006	165,1113	1240,3285	1025,21	0,15	0	3	0
6	REF_1_0007	313,8705	1505,2589	1061,8972	0,2	0	4	0
7	REF_1_0008	505,3089	1749,7418	1089,9704	0,25	0	5	0
8	REF_1_0009	728,087	1958,6251	1108,806	0,3	0	6	0
9	REF_1_0010	981,3939	2127,1655	1121,879	0,35	0	7	0
10	REF_1_0011	1266,3371	2253,396	1129,2564	0,4	0	8	0
11	REF_1_0012	1561,1796	2327,0752	1134,5139	0,45	0	9	0
12	REF_1_0013	1864,6552	2352,0146	1136,9244	0,5	0	10	0

CSV / TXT Format (exemplary excerpt):

```
x;y;z;u;v;c;r
0.7801;323.9746;881.8202;0;0;0;0
6.145;633.2541;936.3937;0.05;0;1;0
57.8183;940.9494;982.877;0.1;0;2;0
165.1113;1240.3285;1025.21;0.15;0;3;0
...
3318.6295;1227.1266;-659.0816;0.85;1;17;6
3392.5252;971.2722;-677.8292;0.9;1;18;6
3422.868;690.7218;-697.1232;0.95;1;19;6
3407.542;430.5957;-713.4679;1;1;20;6
```

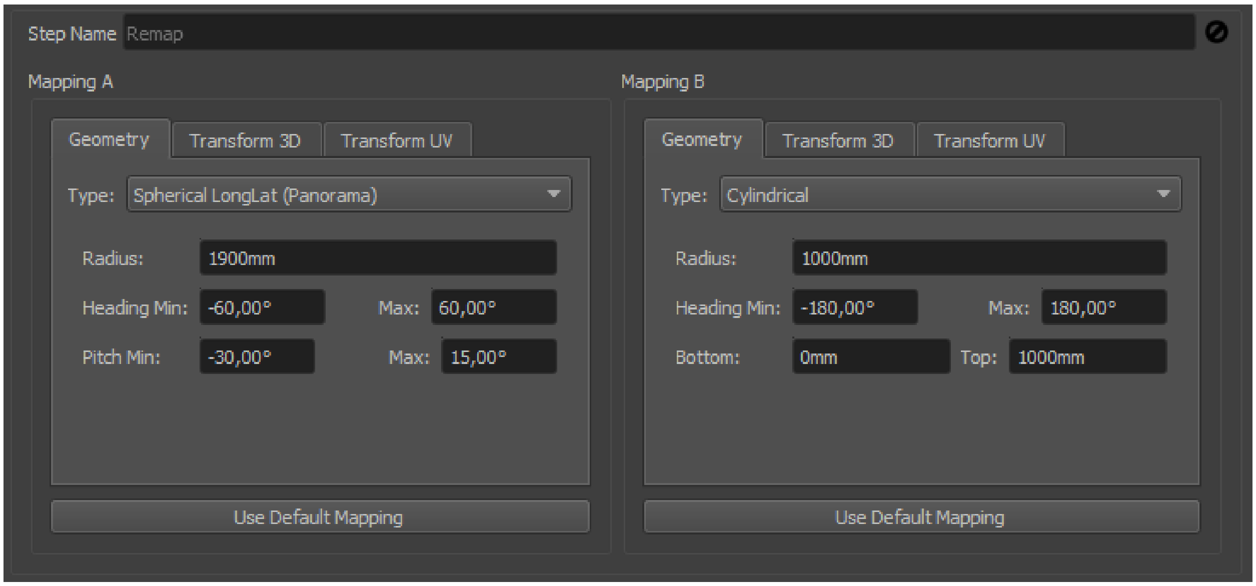
48.3 Remap Modifier

Allows to project geometry on one mapping surface and generate a new geometry along a second mapping surface.

```
geometry -> project on mapping A surface -> put on mapping B surface
```

It can be used for:

- Rough adjustment of the projection on the BPS (Back Projection Screen) in a collimated system. For that purpose geometry can be projected on one spherical long-lat mapping and put on a second spherical long-lat mapping, that only differs in Transform3D rotation and heading and pitch min/max settings. For that purpose it works well to start with both mappings having the same settings, typically the default mapping, and than manipulating the input mapping A. This results in a direct manipulation of the resulting geometry. Manipulating Mapping B would result in inverse manipulation of the resulting geometry.
- Wrapping realtime rendered content on any smooth surface with distorted perspective. For example, mapping a realtime rendered 360 degrees panorama on a flat wall, by mapping the measured screen shape from a planar screen to 360 degrees cylindrical and than defining virtual cameras looking around 360 degrees onto the cylindrical mapping.



Mapping A:
The mapping where the geometry is initially projected on. Controls are same as for standard mappings.

Mapping B:
The target mapping, to which the geometry is transferred to. Controls are same as for standard mappings.

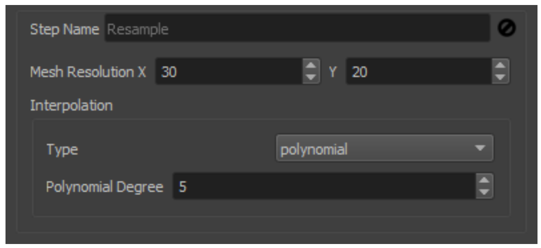
Use Default Mapping:
Copy the settings from current mapping in project.

48.4 Resample Modifier

Allows to resample geometry to a defined full grid of m x n vertices.

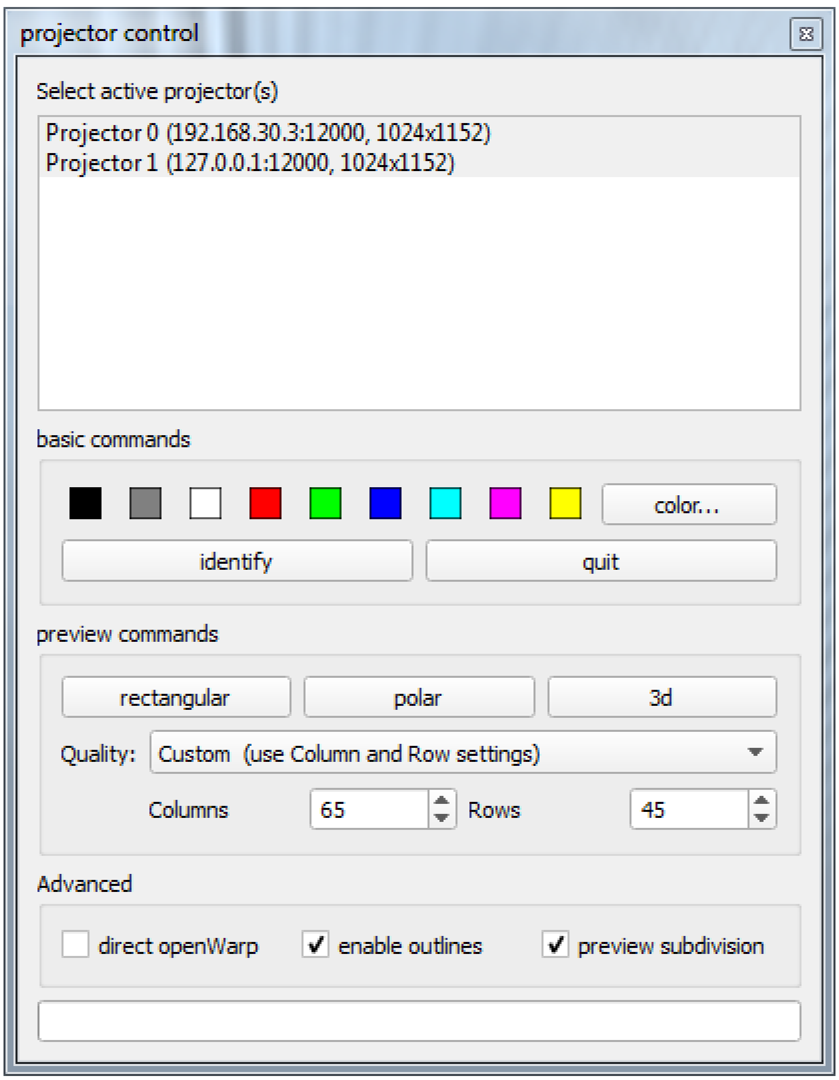
It can be used for:

- Before making complex geometry distortions or mappings it can be useful to increase the density of the initial geometry.
- Original geometry might also have large undefined areas, which might be better to be filled in 3d space before doing the final mapping.



PROJECTOR CONTROL

The projector control provides advanced previews and basic control of the PatternGenerator channels.



Color Preview:
Shows uniform test-colors on selected projectors. Quick selectors for standard colors and a color picker for custom color selections are provided in the basic commands box.

Identify:

showing channel number, resolution and setup information on selected projectors

Quit
quits selected PatternGenerator instances

Rectangular/Polar Grid:
preview of rectangular + polar grids in different resolutions (Quality: Rough, Medium, High, Custom)

3d preview:
Rendering an image corresponding to Viewport/Frustum settings per channel. This preview requires the corresponding warping/blending applied on a warp-unit seperately, in order to produce a continuous image on the projection screen.

Direct openWarp:
Lets PatternGenerator store images compatible for direct upload on openWarp units

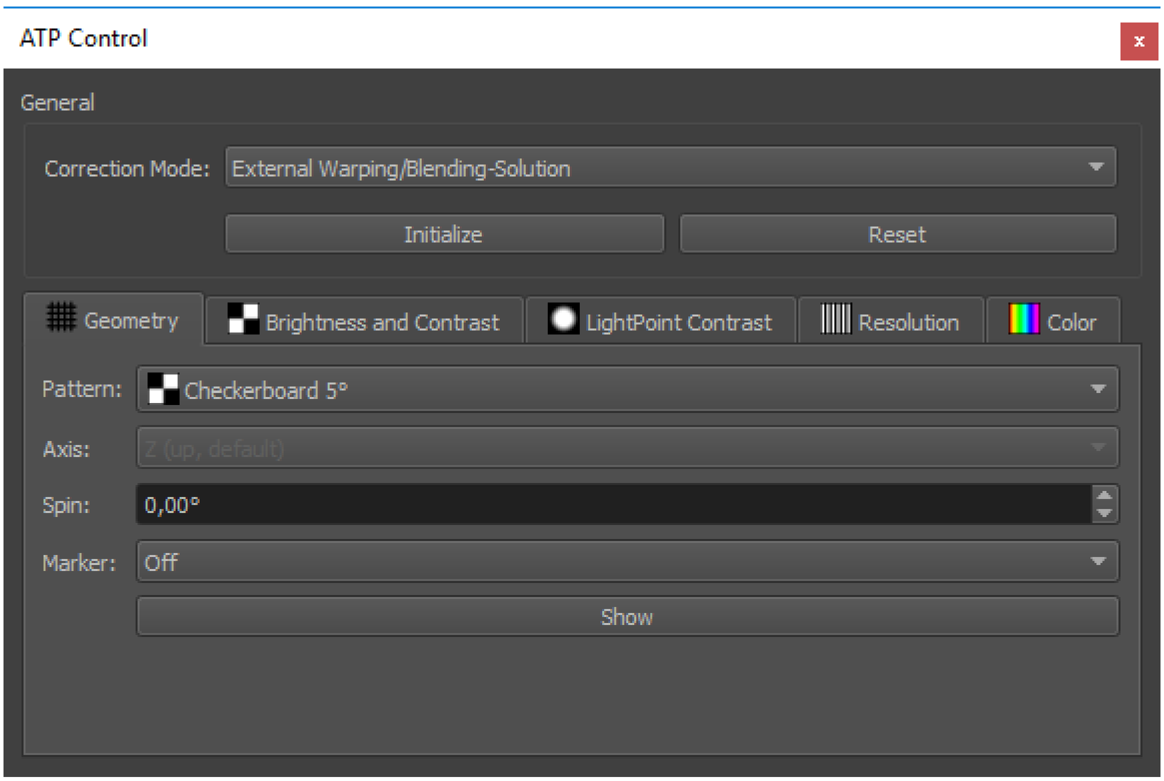
Enable Outlines:
Adds projector outlines and a dark gray background to grid previews.

Preview Subdivision:
Enables subdivision of line-segments in grid previews. This produces more smooth/accurate grids but is slower and requires PatternProjector version 2.1.1 or newer.

CHAPTER

FIFTY

ATP CONTROL



The ATP Control provides advanced test patterns usually required during Acceptance Test Procedure (ATP).

For showing the test patterns, the minimal requirement is only the *PatternGenerator*. So it comes in handy when the final 3D-Engine is not yet ready or does not provide such test patterns.

In order to come as close to the final 3D-Engine result as possible, the warping/blending solution of the visual system should be used. Only if such is not available (no warp unit, or warping driver) use the *PatternGenerator* internal Warping and Blending preview capabilities.

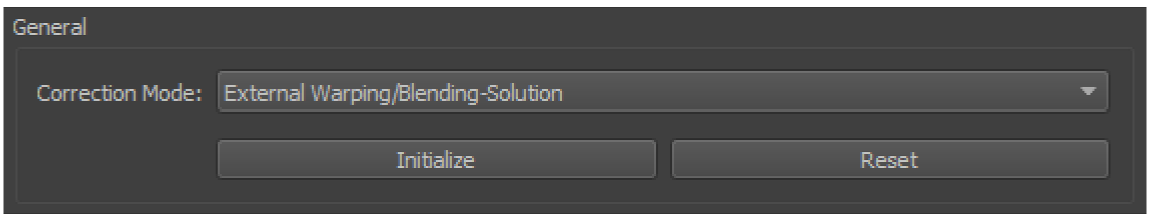
Since the test patterns are rendered independent of the finally used 3D engine it provides a good idea of the principal capabilities of the visual system but it does not fully replace a final check using the 3D engine to be used. The final 3D-Engine can differ in multiple ways. For example in effective resolution due to different filtering, or internal resolution. It can also differ in contrast and colors if additional tone-mapping is done inside of the engine.

50.1 Workflow

Some preparation needs to be done before the test pattern can bes switched quickly in *ATP Control*.

1. PatternGenerator must be running.
2. Enable potential external warping/blending solution.
3. Select according to current setup and desired preview quality.
4. Press **Initialize** - Button (System shows a simple cube map and is ready for quickly switching between ATP Test Patterns)
5. Show and switch between different test patterns.
6. Reset *PatternGenerator* when finished with ATP.

50.2 General Settings



Correction Mode:
Select how the geometry and blending correction should be handled.

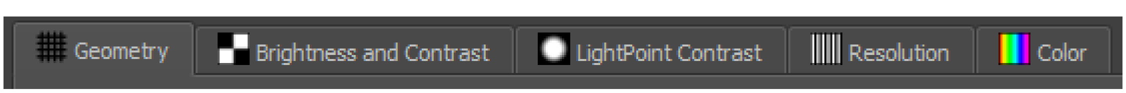
- External Warping/Blending-Solution
- PatternGenerator internal - Rough (no blending, and black-level correction)
- PatternGenerator internal - HighQuality (Advanced3D export options will be shown during next Initialization step for further options.)

Initialize:
Prepares *PatternGenerator* for showing test patterns. Shows Advanced 3D export options, when is selected.

Reset:
Switches *PatternGenerator* back to normal mode

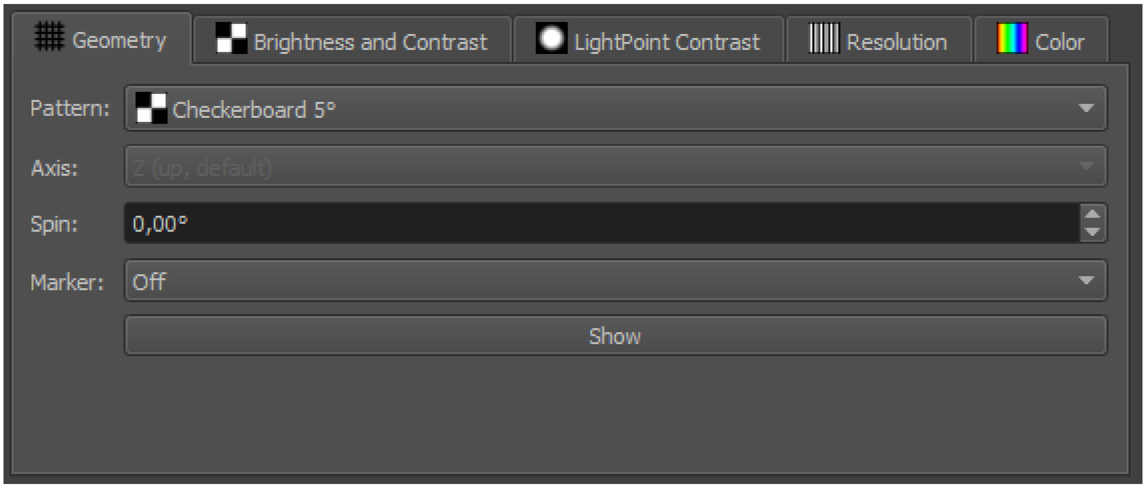
50.3 Test Patterns

After system is prepared, the actual test patterns can be shown. These are grouped according to the usual display system parameters to be tested.



50.3.1 Geometry

Shows test patterns for checking geometrical quality.



Pattern:
Selection of checkerboard and grid patterns in different resolutions.

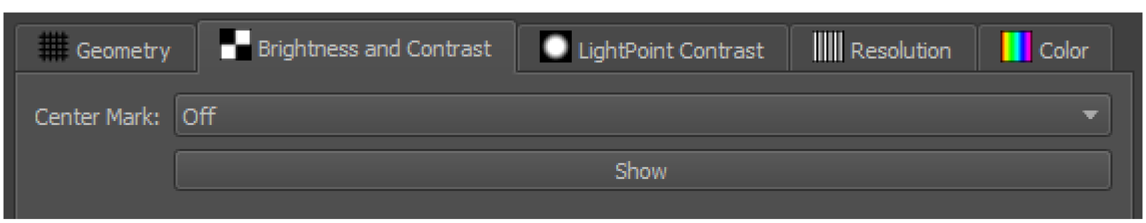
Spin:
Rotate pattern around major axis, for emphasizing potential discontinuities in warping.

Marker:
Optional enable reference marker reprojection, for checking absolute precision. Marker size can be adjusted in degrees.

Show:
Activate geometry pattern.

50.3.2 Brightness and Contrast

Shows a standard 5 degrees checkerboard grid on the whole system for measuring standard system contrast. The expected system contrast is much lower than the theoretical projector contrast, since it includes cross reflections in the system.

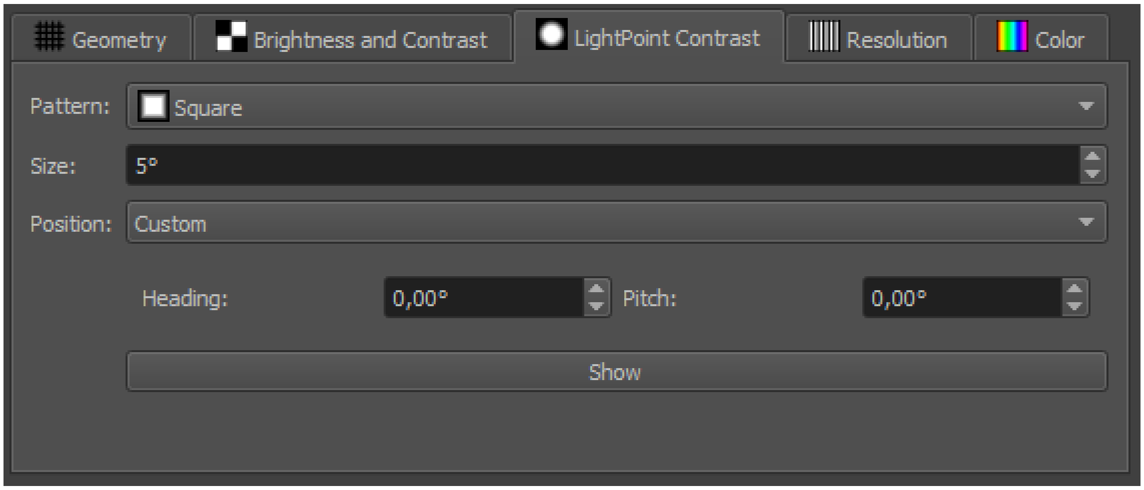


Center Mark:
Shows an additional white rectangle in the center of each projection channel.

Show:
Activate Brightness and Contrast pattern.

50.3.3 Light Point Contrast

Shows a single 5 degrees light point on black background by default. This allows to test the maximum contrast reachable in a visual system.



Pattern:
Selection of multiple light point shapes.

Size:
Size in degrees relative to current viewpoint.

Position:
Allows to switch between

- Custom (Default) single point on user defined position on screen (heading, pitch relative to current viewpoint)
- Channel Center (one point at center of each projection channel)

Show:
Activate LightPoint Contrast pattern.

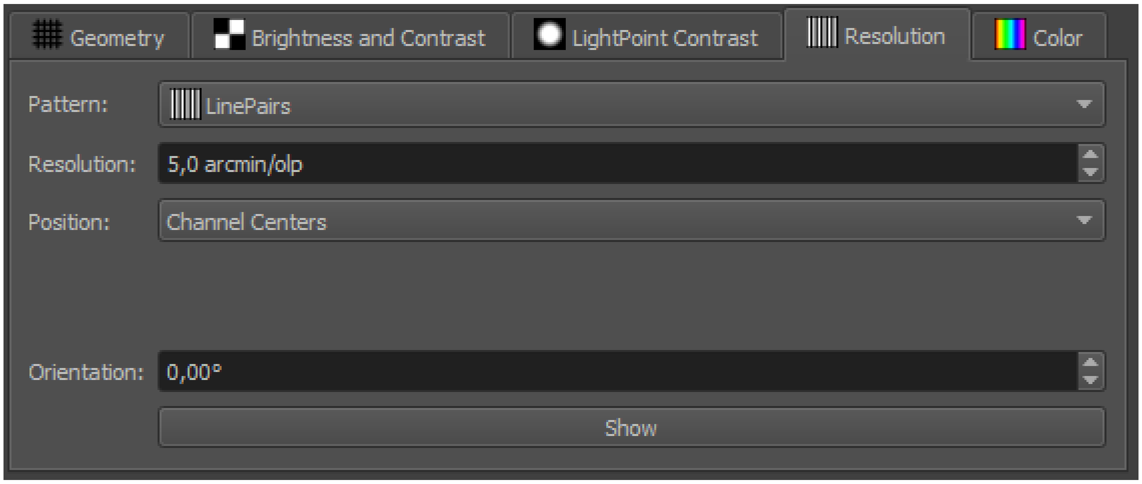
50.3.4 Resolution

Shows optical linepairs according to a given optical resolution relative to current viewpoint. When all shown lines are countable on the screen, the visual system provides given optical resolution. This is the effective resolution including degradation of resolution due to warping.

Note: A visual system passes a resolution test, when all elements in the pattern are still modulated, not necessary black/white but dark/bright. The same number of lines should be elements on the screen (viewer can step close to the screen). When a different number of elements is counted, the test is not passed for that resolution.

Resolution test patterns can be used by either showing the required system resolution and check if the pattern is still shown correctly, or by starting with a low resolution (high arcmin/olp) and than gradually increasing the projected resolution (low arcmin/olp) until elements are not modulated correctly anymore and apparently fewer elements are projected.

Pattern:
Select between multiple patterns



- LinePairs: 48 horizontal and vertical line pairs (24 per sub-segment)
- Points: 48 dots in a horizontal row

Resolution:
Optical resolution of the testpattern relative to the current viewpoint in arcmin/olp (/element). Lower values mean higher resolution.

Position:
Allows to switch between

- Channel Center (Default): (one pattern at center of each projection channel)
- Custom: single pattern on user defined position on screen (heading, pitch relative to current viewpoint)
- Pixel Perfect: Pixel perfect at center of each channel. *Warping must be turned off to work correctly!* Can be used to count pixels on screen, measure size of pattern and calculate projectors optical resolution provided on screen (disregarding rest of visual pipeline).

Orientation:
Rotates pattern around their center. Usually the effective resolution of the system increases for patterns oriented diagonal to pixel raster of projectors.

Show:
Activate Resolution pattern.

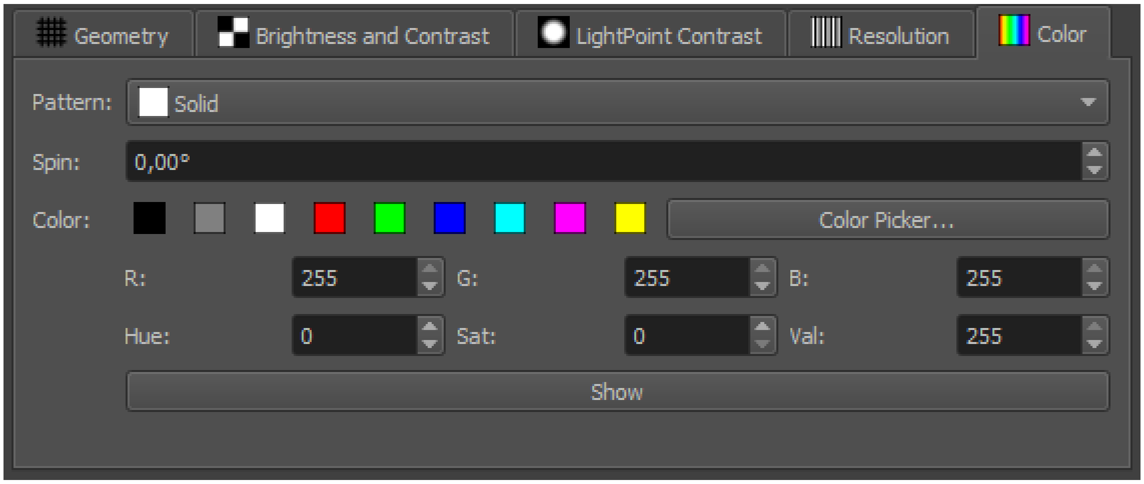
50.3.5 Color

Show uniform and optionally structured colors on the complete screen. This allows to test brightness and color uniformity for different colors.

Sometimes the uniformity changes when the base color is changed, this usually is caused by gamma or color-space problems in the projectors.

Pattern:
Select between multiple patterns

- Solid (Default): Unstructured solid color
- Gradients: can reveal breakups in the gamma curve
- Checkerboard 5 degrees: this pattern is sometimes required for uniformity measurements.



- Clouds: some random smooth cloud structure

Spin:
Rotate pattern around major axis, for moving the pattern through blendzones.

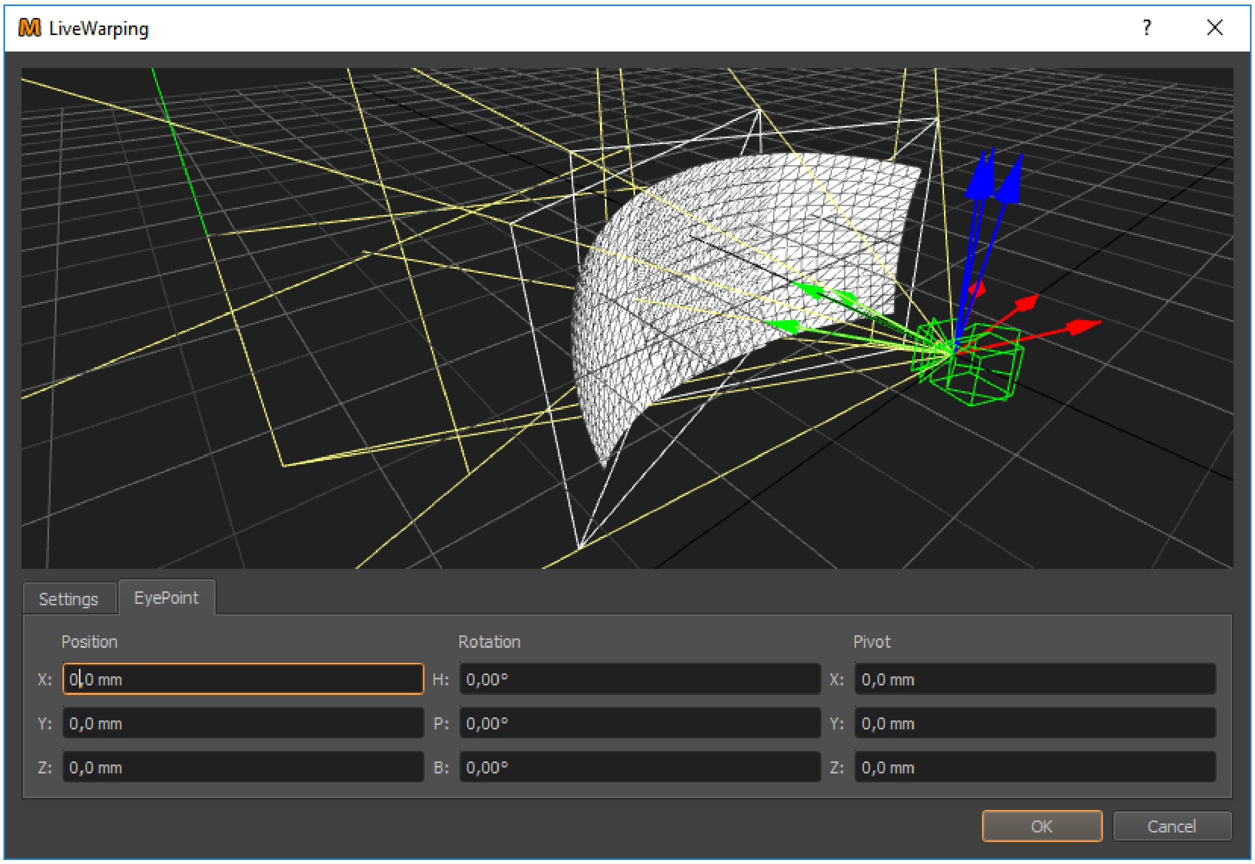
Color:
Several ways for selecting and modifying colors from presets, over color picker to live controls.

Show:
Activate Color pattern.

CHAPTER

FIFTYONE

LIVEWARPING PREVIEW



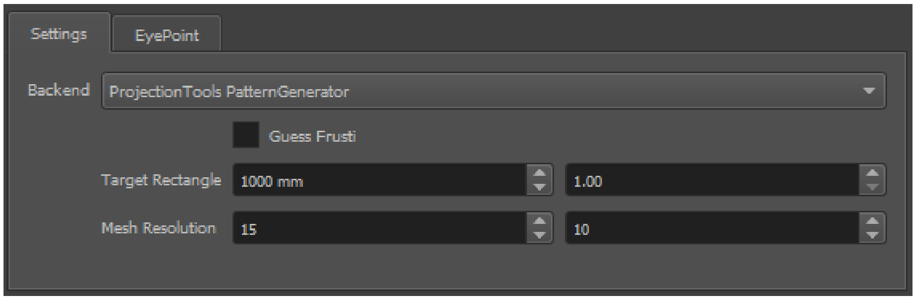
This dialog enables the possibility to check quality and image cut-off for dynamic view-dependent warping.

51.1 Settings

The settings page allows the configuration of the live warping preview.

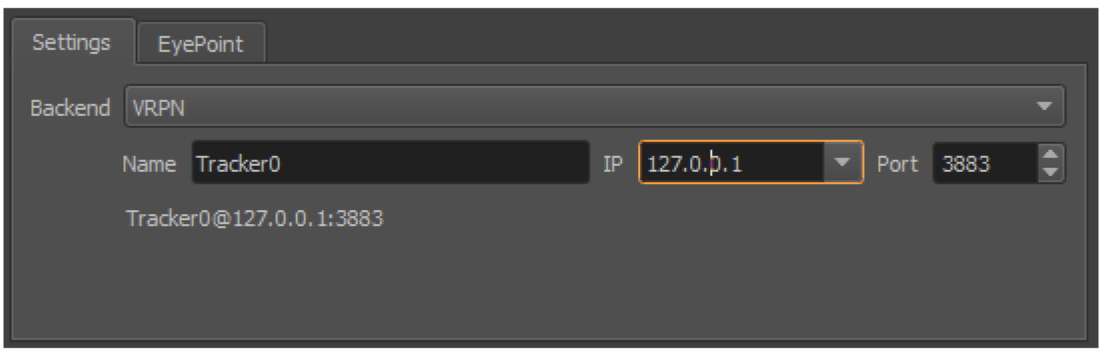
The preview can either be done on PatternGenerator (default) or positional data can be provided as VRPN server, to test behavior directly in a compatible 3D engine.

51.1.1 ProjectionTools PatternGenerator



Guess Frusti
When enabled, calculate frusti based on projection mesh instead of previously defined target rectangles.

51.1.2 VRPN



To enable the VRPN Tracker Simulator switch the Backend to VRPN. Then configure the VRPN tracker by selecting the name, IP address and port the Tracker Simulator should run on. Below the IP address drop down list you will find the identifier to be used in a VRPN client application.

51.2 EyePoint

On the EyePoint page the eye point can be moved to any arbitrary point in 3d space as well. In addition the rotation and pivot can be defined as well.

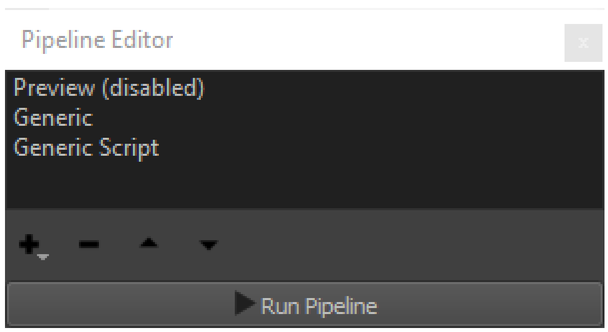
CHAPTER

FIFTYTWO

PIPELINE EDITOR

The steps needed to export data and update a system after recalibration is usually fixed after setup once. The Pipeline Editor is used to define these steps once and to rerun them easily.

The pipeline editor is used to configure one or multiple exporters and scripts with persistent settings. All steps configured in the pipeline editor can be run in the defined order by pressing the "Run Pipeline" button.



+:
    add a new step

-:
    remove selected step

up arrow:
    move selected step up

down arrow:
    move selected stop down

Run Pipeline:
    run all active steps in the pipeline in the given order (top to bottom)

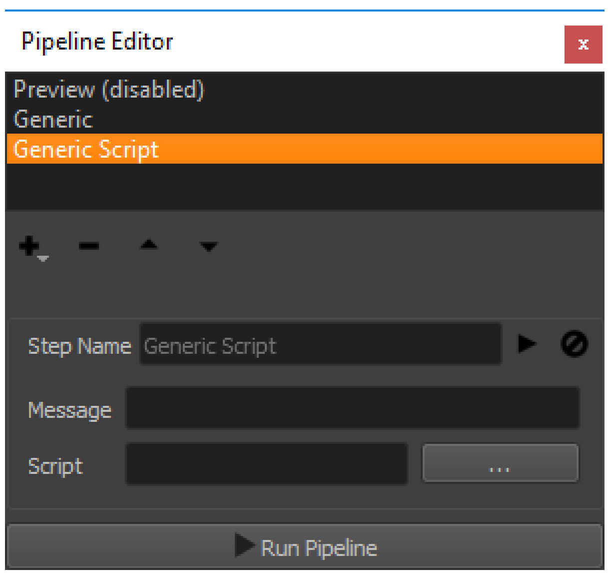
Selecting a step shows its settings.

Each step has some common settings.

Step Name:
    Give selected step a custom name.

Play Button:
    Run currently selected step.

Disable Button:
    Disable this step when running the complete pipeline.


Pipeline Editor
Preview (disabled)
Generic
Generic Script
Step Name
Generic Script
Message
Script
...
Run Pipeline

CHAPTER

FIFTYTHREE

LEICA X3/X4 WITH DST 360 ADAPTER

53.1 Prerequisites

- PC with Bluetooth
- free Leica software DISTO Transfer PC
- Leica X3/X4 with DST 360 rotation base

53.2 Connection

- Start the DISTO Transfer Software on the PC
- Turn on the Leica X3/X4
- Mount the X3/X4 device onto the DST 360 rotation base to trigger the leveling procedure
- Follow the steps on the X3/X4 display to perform the leveling procedure

53.3 Software setup

Configure the DISTO Transfer Software under `Mainwindow/Setup`

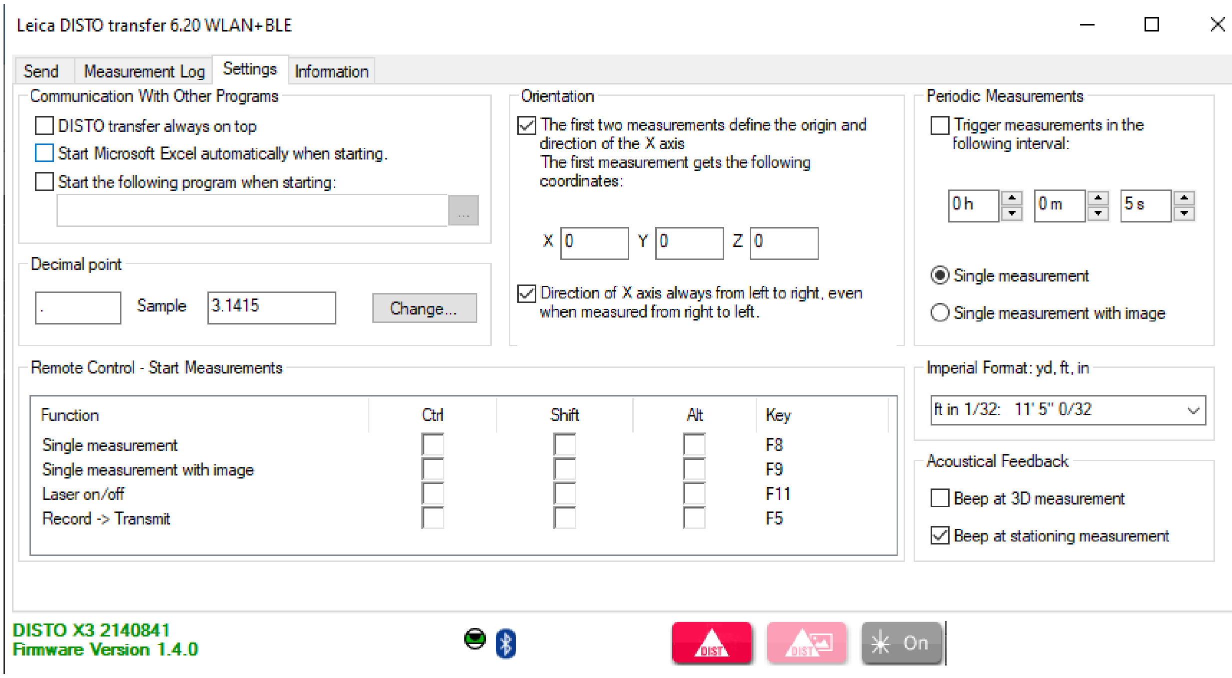
Settings

- use decimal point as divider
- use first two measurements as the definition for the origin & direction of the X axis

Send

- Select the following data format: `Position XCoord YCoord ZCoord##Return`
- Select "Send to a fixed input position"
- Open up the text editor of choice and select it as target for the DISTO data send

Fig. 1: DISTO Transfer Mainwindow



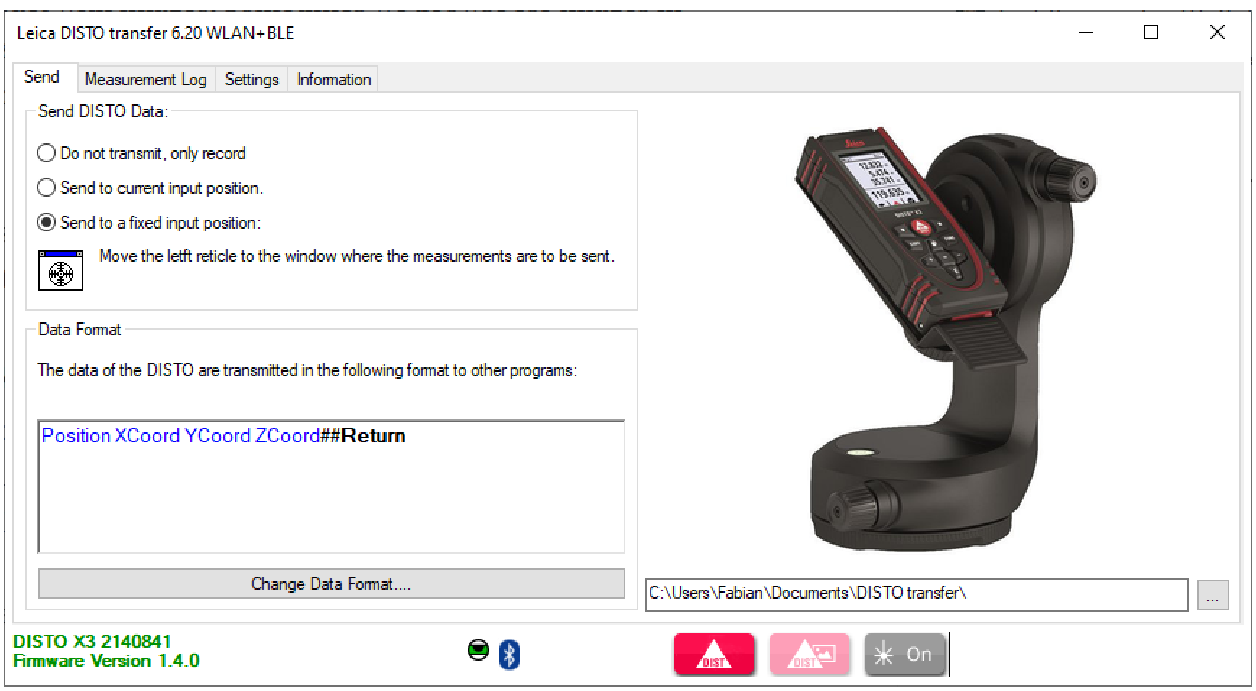


Fig. 2: Sending Data

53.4 Capturing data

1. orient the device by measuring world origin and point on X axis as the first two points
2. continue capturing all points of interest
3. measurements will be send automatically to the open text editor in the specified format
4. once done save the marker file in .txt format, which can be opened in ProjectionTools

Warning: The direct .csv point list export from DISTO Transfer is currently unusable in ProjectionTools. ISTO Transfer uses a comma as decimal point as well as delimiter for separating the entries, which hinders a useful file parsing.

CHAPTER

FIFTYFOUR

LEICA 3D DISTO

The Leica 3D Disto allows to measure 3d coordinates of reference points. The following sections describe how to capture data, that can be imported into ProjectionTools.

54.1 Preparation

There are some settings that need to be set in the 3D Disto software to make sure the export is compatible with **ProjectionTools**.

Setting	Value
Device…/Tilt Sensor…	On
Settings…/Language…	English
Settings…/Units…/Distance…	0.000 m
Settings…/Units…/Decimal separator…	1.00
Settings…/Import/Export…/Format…	East/North/Height
Settings…/Import/Export…/List Separator…	;

54.2 Measurement with Room Scan

1. Mark coordinate system with two reference points (origin and one marker along x-axis). All markers will be measured relative to this coordinate system
2. start room scan application on Disto 3D tablet
3. set reference height to 0
4. measure reference center twice (once for reference height and once for origin)
5. measure second reference point on floor for definition on x-axis
6. measure markers (when using projected points from markermover, measure them in order of numbering so it makes finding points easier later in Creator Position Finder)
7. save data
8. export data to USB stick

54.3 Measurement with 3D Disto Ver. 4.0.5.0 and up

1. Mark coordinate system with two reference points (origin and one marker along x-axis). All markers will be measured relative to this coordinate system
2. start the 3D Disto software either on PC or the Leica tablet
3. measure the first marker point, it will become the origin of the reference frame
4. the first marker point will have reference height 0 by default
5. measure the second marker point for defining the x-axis
6. measure markers (when using projected points from markermover, measure them in order of numbering so it makes finding points easyser later in Creator Position Finder)
7. save data
8. export data to USB stick or hard drive

For setting a different reference height use the option in the world view (see orange arrow in fig. *Setting the reference height in the Disto 3D software*). When activated, enter the desired height and measure a point. This point will have the chosen reference height and the height of all other measured points will be adjusted accordingly.

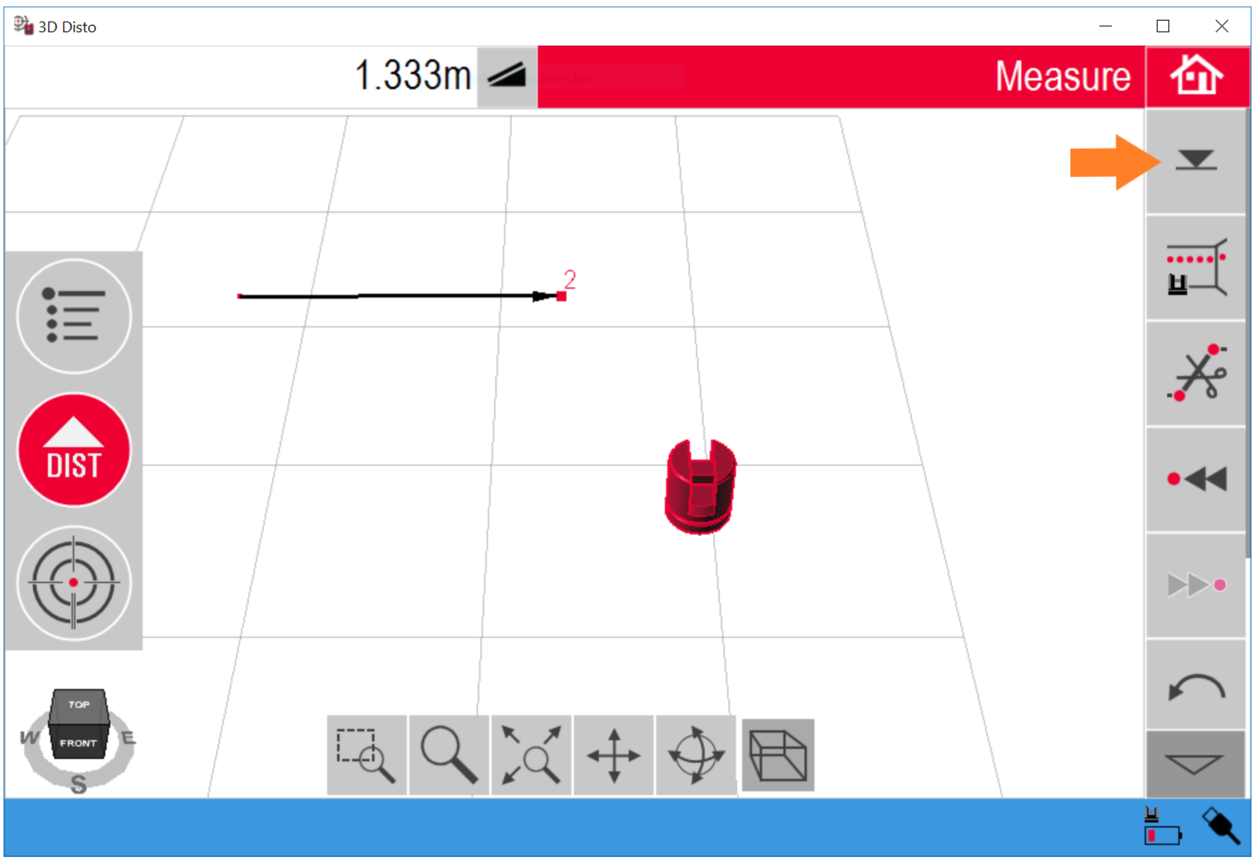


Fig. 1: Setting the reference height in the Disto 3D software

54.4 Repositioning

While usually not required, in some situations it might not be possible to measure all markers from one position. In such case it is possible to reposition the 3D Disto using the following steps.

1. Save current location using `Applications.../Location.../Secure Location` and measuring 3-5 points, that can be seen from current and next 3D Disto position. It is a good idea to mark these points visually, so they can be distinguished from each other.The 3d position of these points is measured and a snapshot is saved for each point for later reference.
2. Reposition the 3D Disto.
3. Wait until tilt check is finished.
4. Calculate the new 3D Disto position using `Applications../Location.../Relocate`.
    1. A list of thumbnails is presented, from which points must be selected and remeasured.
    2. After two measured points a check for precision follows, where the 3D Disto targets at the next Save Point. Please adjust the orientation of the 3D Disto if necessary and measure. The Disto will tell the result, if the precision is good enough.
    3. If precision is good enough, accept the result and continue measurements. If Precision is not good enough, measure more save points.

54.5 Import Data in Creator

1. Attach USB stick to computer
2. Open Reference Points dock in Creator.
3. Hold “+” button below marker list and select “Import Leica 3D Disto” to import csv data from USB stick. Points should show up in marker list and 3d view

CHAPTER

FIFTYFIVE

LEICA BLK360

Scanning with Leica BLK360 is straight forward. There are two ways of operation. Either Stand-alone or with computing device connected. Please refer to the BLK360 user manual for details about setting up the device for scanning and how to connect to it.

ProjectionTools *Pointcloud Conversion* dialog can be used to import and process data directly from the scanner or even trigger scanning with defined resolution settings, which is the preferred way of operation.

Usually a medium resolution, colored scan provides provides enough data. Higher resolution scans will significantly slow down the processing.

55.1 Limitations

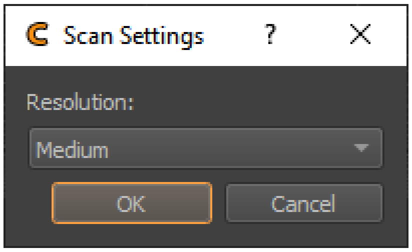
A dedicated graphics-card is required for data download and processing. If your machine has integrated graphics and a dedicated graphics card open Windows Graphics settings and make the following changes.

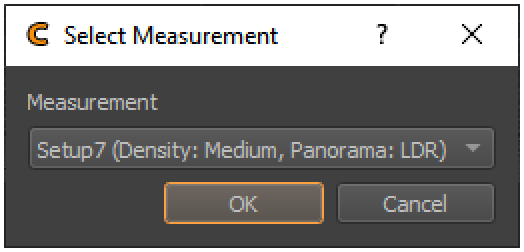
1. Turn on Hardware-accelerated GPU scheduling.
2. Under "Graphics performance preference" select "Browse" and add the "Creator.exe" file from its location on the disk. Now select the Creator from the list below and select `Options/High Performance`.

55.2 Scan and import data

Short description using ProjectionTools *Pointcloud Conversion* for scanning and download of data.

1. Press the power button to turn on the BLK360.
2. The BLK360 is starting. The ring-shaped LED is blinking yellow.
3. If the ring-shaped LED is continuous green, the BLK360 is ready for operation.
4. Connect the pc with the BLK360-35xxxxxx wireless network. The instrument specific password is printed on the label in the battery compartment.
5. Start the scanning or data download using `Pointcloud Conversion dialog/Add/Capture Scan Leica BLK360` or `Pointcloud Conversion dialog/Add/Import Scan Leica BLK360`.





6. Cleanup and process imported scan data in *Pointcloud Conversion* dialog.

55.3 Data Management

For cleaning the internal storage of the BLK360 the free BLK360 Data Manager from Leica can be used. It can also be used for adjusting scan settings.

Please be aware that the downloaded backups (*.blk) created with BLK360 Data Manager can not be read by ProjectionTools!

To keep a backup of pointcloud data for later use in ProjectionTools it is a good idea to export a .pcd file from *Pointcloud Conversion* dialog after cleanup.

CHAPTER

FIFTYSIX

LEICA NOVA MULTISTATION

The Leica Nova Multistations (MS50, MS60) are capable of 3d measuring of individual points and doing full 3d scans. The following sections describe how to capture data, that can be imported into ProjectionTools.

Heidiwidthka

56.1 Preparation

1. Press the power button to turn on the Multistation and follow instructions.
2. check distance units are set to meters using `User/System Settings/Regional Settings`
3. Create a new job on the SD-Card using `Jobs and Data/New Job`. Set Device to SD Card. Creating the job on the SD-Card is important for later transfer of data to the PC.
4. Make sure the optic is in 1. Position (Leica logo is not upside down)

56.2 Find multistation position

1. Setup position using `Go to Work/Setup`
   1. Select method "Orientate to line" and follow instructions
   2. Follow instructions
   3. use calculated device position
   4. panorama is not needed

56.3 Reposition Multistation

Sometimes multiple positions are needed to capture all required data. In such cases follow these steps after physically repositioning the Multistation.

1. Setup position using `Go to Work/Setup`
2. Select method "Resection" and follow instructions

56.4 Measure Points

1. select `Go to Work/Setup` and continue with current setup
2. measure points
3. export points as described in following chapter

56.5 Export Points

1. use `Jobs and Data/Export and copy data.../Export ASCII data` and export to SD card
2. check configuration

   Delimiter
   Comma

   1st position
   Point ID

   2nd position
   Easting

   3rd position
   Northing

   4th position
   Elevation

3. Hit ok

56.6 Scan

1. use `Go to Work/Survay+/Scanning`
2. always use zoomed out camera and measure distance to compensate camera parallax.
3. create one or multiple scan definitions. Multiple scans can be processed as one batch.
4. start scans. All defined scans will be processed.

56.7 Data transfer to PC

The SD card can be safely removed while the multistation is in the main menu or turned off. Take the SD card and read it on the pc using a card reader. The exported points list can be imported by Reference Points dock and Scans can be loaded in *Pointcloud Conversion* Dialog.

CHAPTER

FIFTYSEVEN

CANON CAMERA

57.1 Preperation

Before a Canon camera can be used with the ProjectionTools it has to be calibrated by the domeprojection team. Otherwise the calculation for the projector alignment will be incorrect.

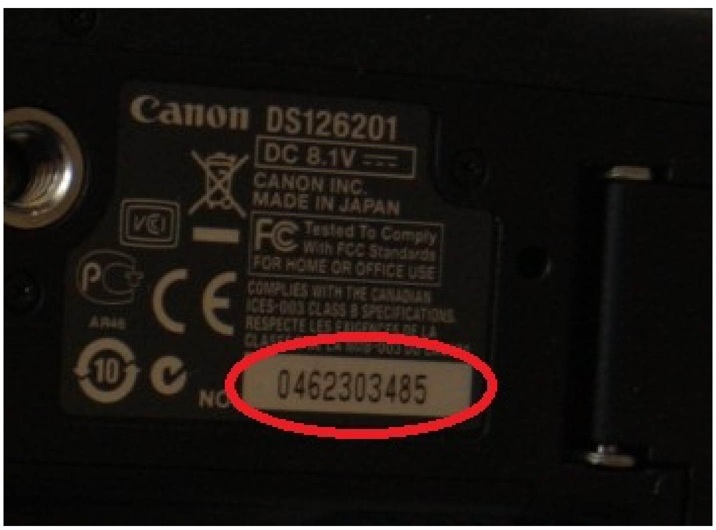
After the successful calibration, the camera will be selectable in the Creator, also the serial number of the camera will be set as the owner within the camera.

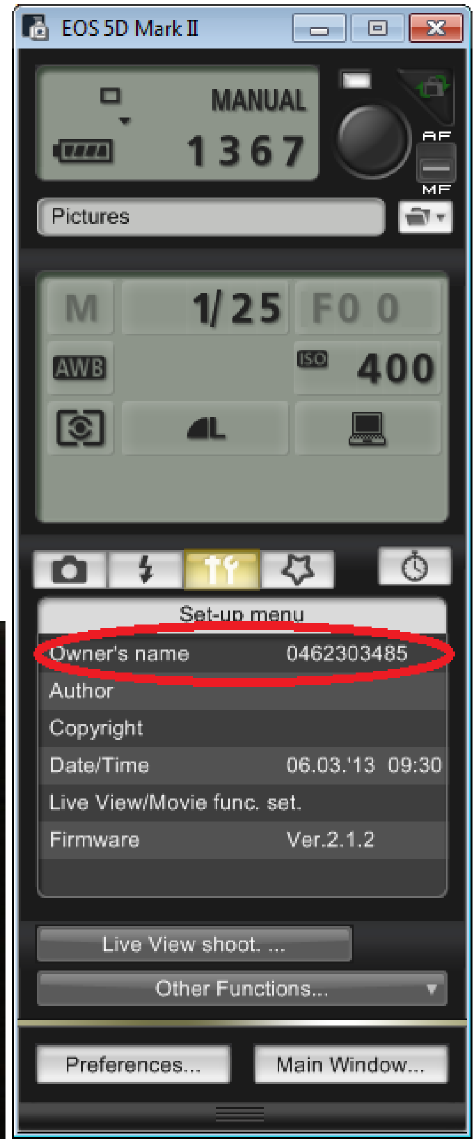
57.2 Camera Settings

To ensure a proper calculation certain camera settings have to be checked.

1. The picture mode has to be set to M for manual
2. The picture quality has to be set to L to have the full resolution
3. Turn off the Auto power off function
4. The manual focus of the lens has to be put to the mark made by the domeprojection team to ensure a good result. Auto-focus must be switched of for lenses that support auto-focus.

5. The serial number of the camera has to be set as the owner.





57.3 Potential Problems

1. The Dots are not or only partly recognized.
   - Check if picture Mode is not set to M (Manual)
   - Check ISO values and exposure time as well as recognition-parameters in Creator
2. ISO values and or exposure time can not be change within the Creator.
   - Check if picture Mode is not set to M (Manual)
3. The calculation of the camera position is wrong despite correct recognized markers.
   - Ensure that camera resolution is to L
4. The camera lost the connection to the computer
   - The auto power off function might be turned on

    - The battery could be low

5. After the calculation do the projectors not fit together
    - The manual focus might not be set to the calibrated value or auto-focus is set to automatic
    - Wrong resolution might be set within the camera
6. My camera is not selectable when creating a new project with the Creator
    - Camera was not calibrated by *domeprojection.com*
7. The camera does not get recognized by the Creator
    - check if camera is turned on
    - check if camera is connected to the computer
    - The owners name might not be set to the serial number of the camera

CHAPTER

FIFTYEIGHT

CALIBRATION TROUBLESHOOTING

58.1 Getting rid of falsely recognized dots

58.1.1 Mask camera image

It is not always possible to eliminate all sources that interfere with the picture taking process. Sometimes light sources or shiny surfaces cause the system to detect dots where there actually are none. In that case an additional mask can be applied to the camera image using `Positions/Position/Edit Mask...`.

The mask can be used to hide objects (dark mask drawn on top of light sources) or to actively mark the area to be used (bright mask drawn over the points to be recognized).

The whole scene can be inverted using the shortcut `CTRL-I` or the menu entry: `Edit/Invert Scene`. The color of single selected objects can be changed through the menu entry: `Edit/Set Item Color...`. *It is highly advised to use only the colors black (disregard objects) or white (use objects) - even if its possible to use the full color spectrum.*

The next step is to analyze the images again. Use `Capture Toolbar/Analyze Images`. By default the dots will be projected onto the screen again, but no pictures will be taken. When looking on the results again, the false hits should have been removed.

58.1.2 Mask dot pattern

In order to let Creator know how many points actually should be detected, the dot pattern can be adjusted, and dots that are beyond screen, cut off, or projecting on obstacles can be removed. So they are not projected at all, not detected and not counted when the calibration quality is calculated and shown as color and tooltip of cells in position table.

By double-clicking on a projector in the projector list a dialog is opened that allows to edit this dot pattern for the corresponding projector.

In the biggest part of this new window a dot pattern is visible. This pattern will be shown during the calculation process.

By using the mouse, dots can be deleted (click and drag) form the pattern or recreated (alt+click and drag). Using the "projecting" button the actual pattern will be projected onto the screen.

If the dots appear to be too small, or not plentiful enough the size as well as the number can be altered.

When satisfied with the result save the dot map by clicking "save" and close the dialog to continue the same process with the other projectors.

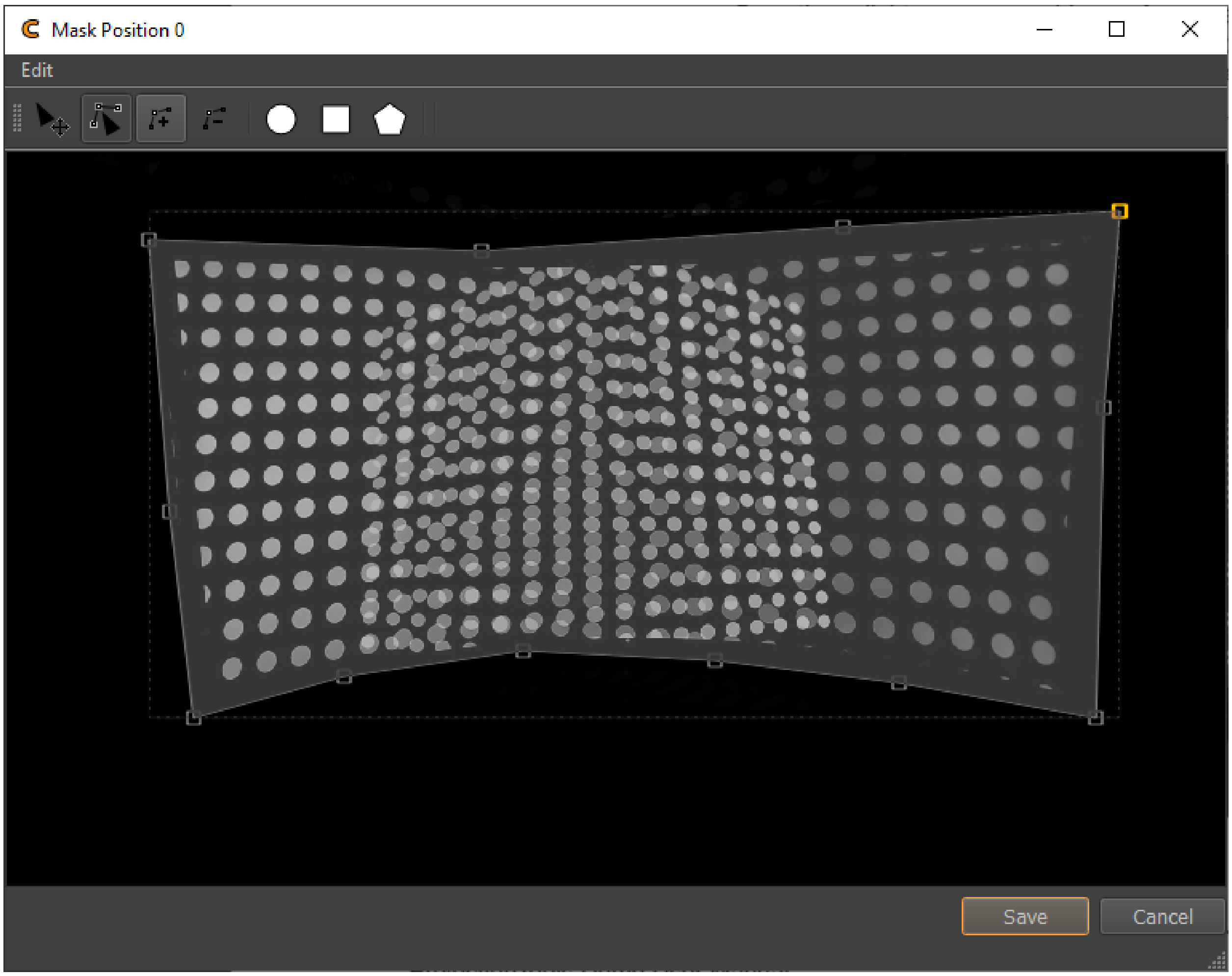


Fig. 1: Mask Edit

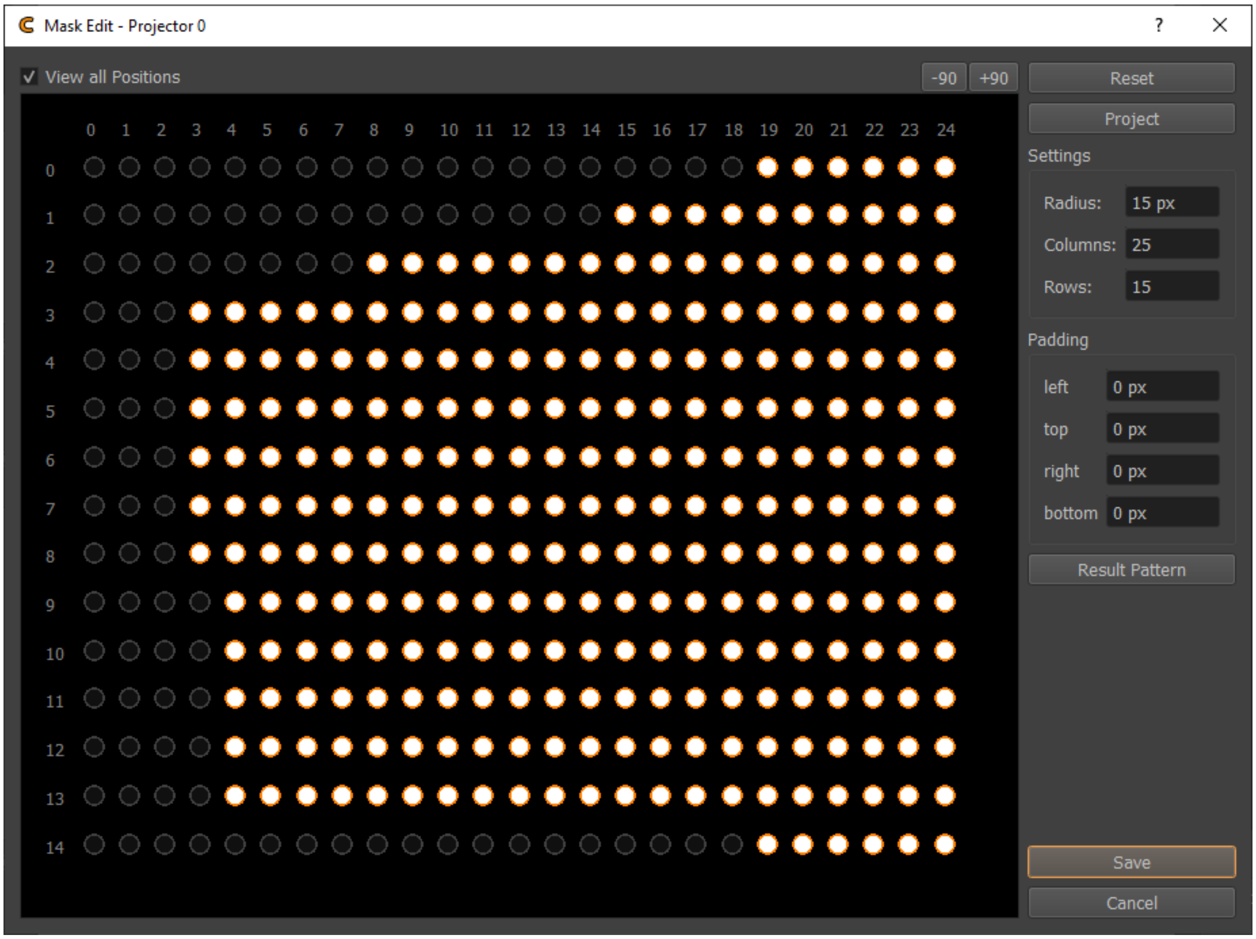


Fig. 2: Dot Pattern Editor

58.2 Fix too bright or too dark blending

When the blend zones are too bright or too dark, probably the gamma curve of the projector is not matching the assumed gamma curve in Mapper2d.

Check and adjust the gamma setting of your projector to be on gamma 2.2. If not possible, adjust `Settings/Shading/Gamma` in Mapper2d. Use preview image again to update the projection with the new gamma values applied.

Blending too dark
Gamma in Mapper2d is lower than actual projector gamma.

Blending too bright
Gamma in Mapper2d is higher than actual projector gamma.

CHAPTER

FIFTYNINE

GENERIC FAQ

59.1 CodeMeter

59.1.1 Version Updates

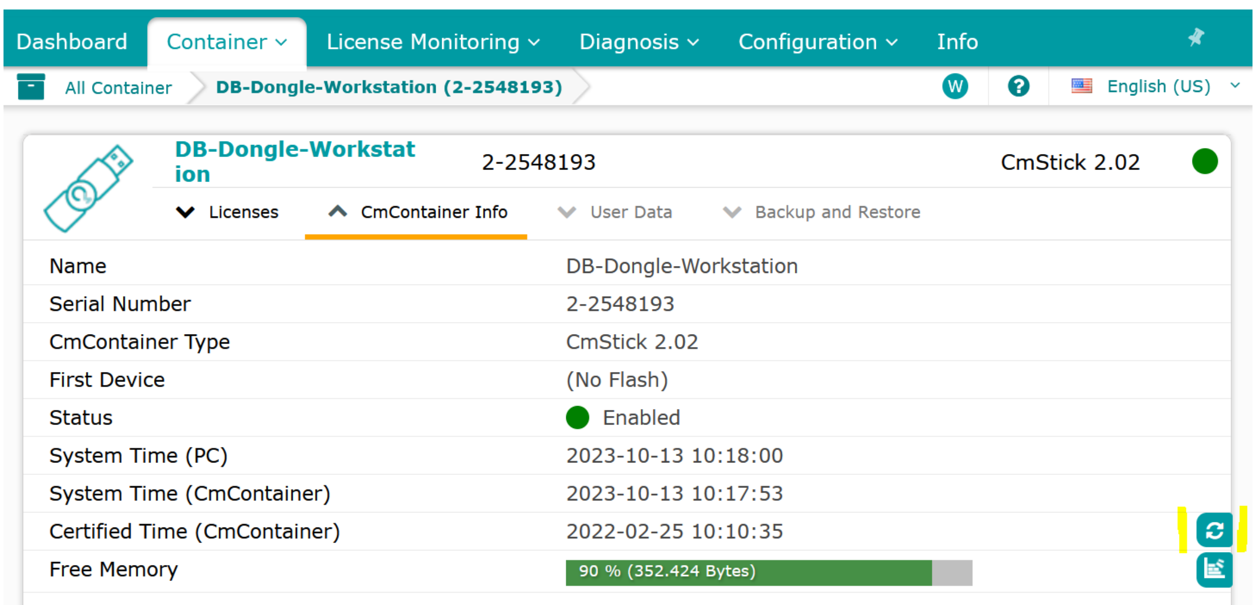
Updating the CodeMeter runtime often leads to problems. We strongly advise to uninstall previous versions of CodeMeter before installing a different version.

The current version can be obtained from the manufacturers website. Currently located at: https://www.wibu.com/support/user/user-software.html

59.1.2 Wrong Certified Time

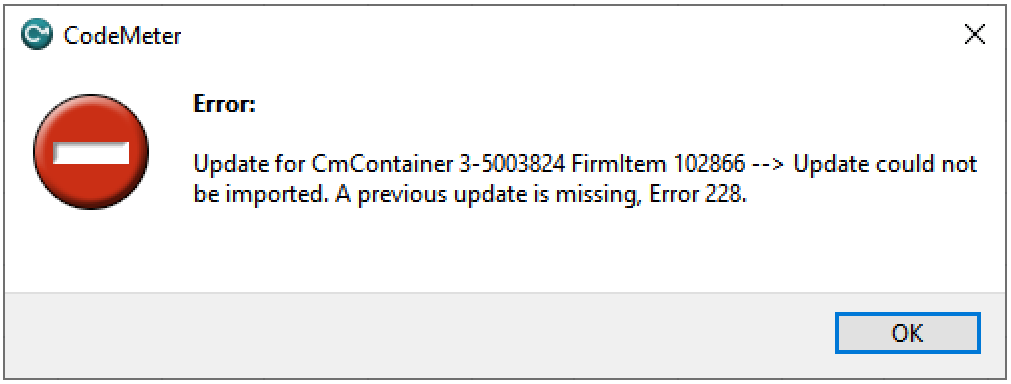
Sometimes the dongle seems to be confused about the current date and time. This can be fixed using the WebAdmin tool. Right click on the CodeMeter tray icon and select WebAdmin. Select the Container information page and inspect the three displayed times.

Usually updating the **Certified Time (CmContainer)** resolves such issues.



59.1.3 Update Error

The error message “A previous update is missing, Error 228” indicates that a previous update is missing, which makes it impossible to proceed with the current update. In this case, it is recommended to generate a new license request and send it by email to license@domeprojection.com.



59.2 GigE Camera Troubleshooting

The steps listed in this section are simplified and generalised for all GigE cameras, and may not apply exactly to yours.

59.2.1 Configuring the network adapter

- First, the camera’s drivers must be installed. Make sure to accept installation of the “filter” driver.
- It is good practise to adjust the network parameters using the following recommended adapter configuration. The Packet Size/Jumbo Frame setting is the most important.

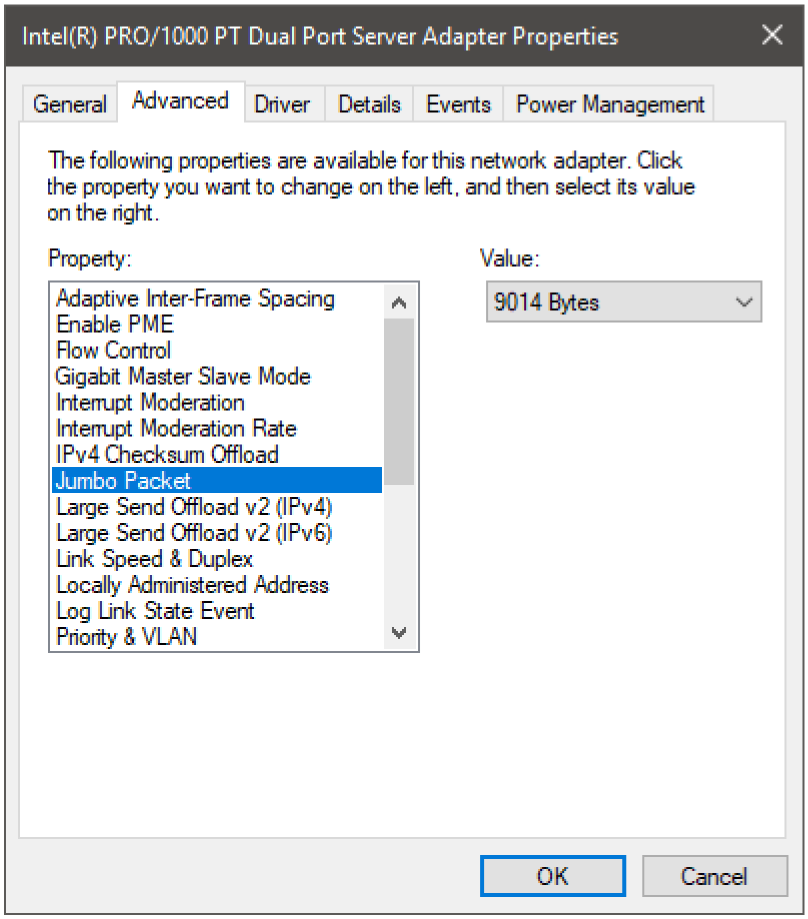
Properties	*Value*
Packet Size(MTU)/Jumbo Frame	8228 or larger
Interrupt Moderation Rate	Extreme
Transmit buffers	256 bytes
Receive buffers	Max setting available

- The Camera and PC should be on the same subnet, and the camera needs a gateway set - set it to the camera’s IP address if no gateway is known.
- If problems are experienced after these changes are made then it may be necessary to disable all network modules on the network card except IPv4 and the filter driver.

59.2.2 Information on recommended adapter configuration settings

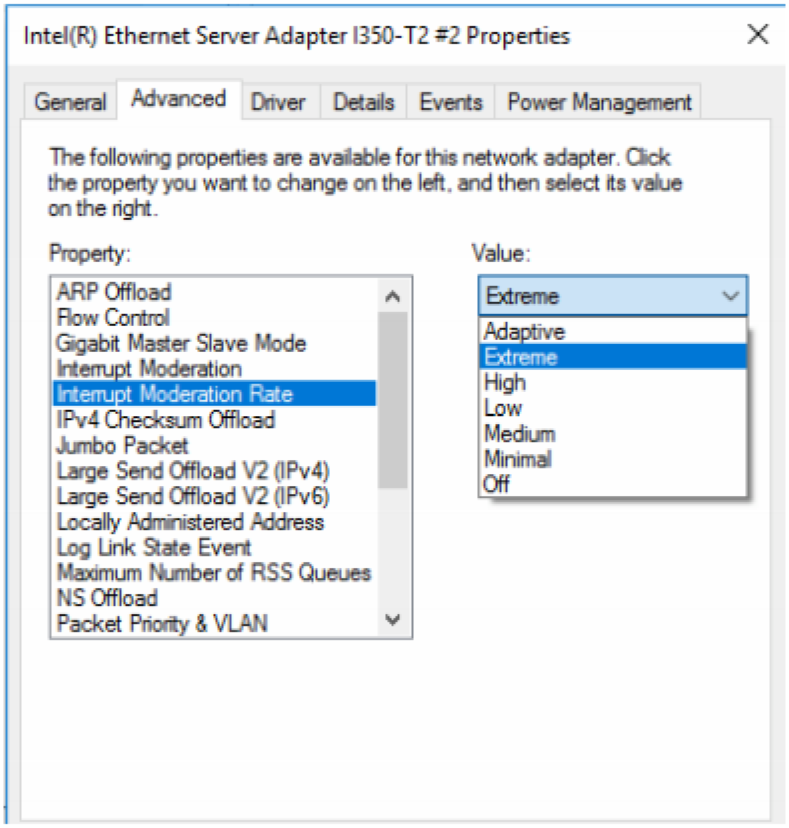
Jumbo Frames.

Make sure jumbo frame are enabled if available as this significantly reduces CPU cycles and overhead, which leads to improved performance. If you do not have 9KB jumbo frames / packets, please check your recommended network specifications.



Interrupt Moderation.

This is another way to reduce CPU usage and overhead. We recommend that in most cases and the rate be set to high or extreme where possible.



Receive Buffers and Transmit Buffers.

Setting the Receive Buffers to the highest value available can also help to reduce general overhead and is recommended. Set the Transmit Buffers to 256 bytes if possible.

59.2.3 Troubleshooting Jumbo Frame Compatibility

Not all network adapters support 9KB jumbo frames. It's best to use the highest jumbo frame KB size the network adapter supports, and use one that supports 9KB jumbo frames if possible.

Example scenario: Multiple cameras connected through a switch to an NIC.

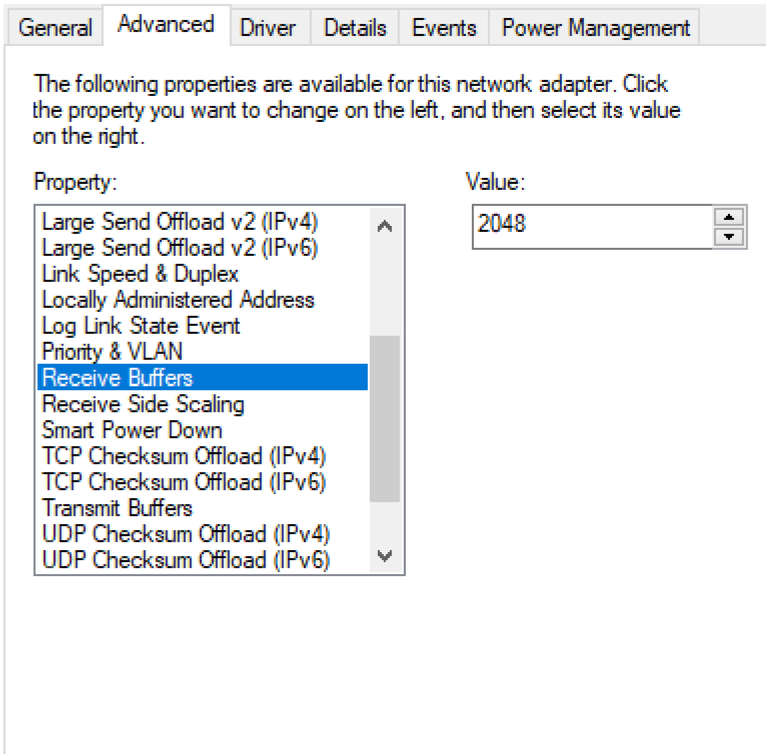
It is common for network switches to support jumbo frames, but only up to 4KB (this will be noted in its specifications). If the NIC (network adapter) is set to use 9KB, but the switch only supports 4KB, it will result in packet loss and therefore dropped frames.

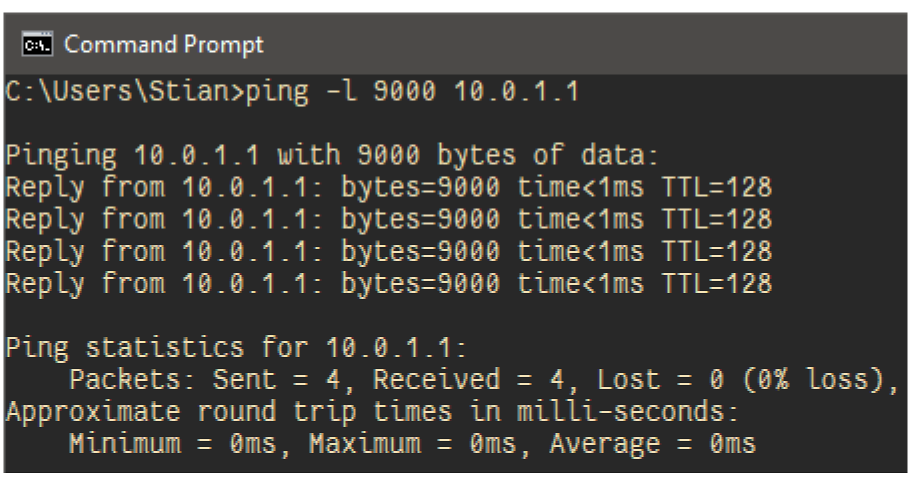
You can test the performance of a network adapter by using the command line utility.

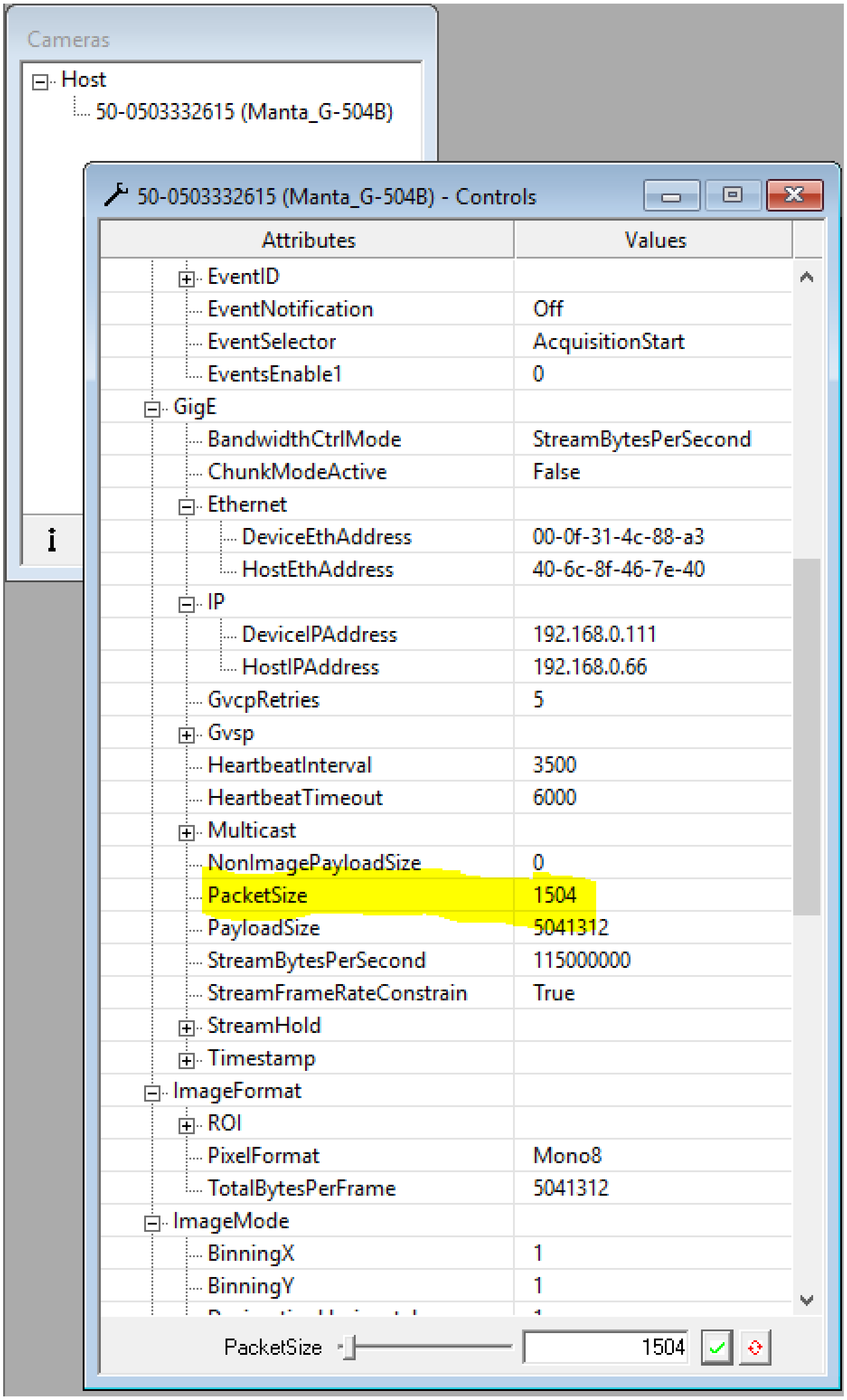
Here we're pinging the network adapter with a packet size of 9000 bytes (9KB). If the request times out it's likely it's likely that it does not support jumbo frames.

You can also check the jumbo frames packet size in the camera settings (if jumbo frames are enabled in the network adapter).

Note: the camera driver can often check whether jumbo frames are possible based on the camera and network adapter settings, but it won't be able to test the capabilities of the switch.


General
Advanced
Driver
Details
Events
Power Management
The following properties are available for this network adapter. Click the property you want to change on the left, and then select its value on the right.
Property:
Large Send Offload v2 (IPv4)
Large Send Offload v2 (IPv6)
Link Speed & Duplex
Locally Administered Address
Log Link State Event
Priority & VLAN
Receive Buffers
Receive Side Scaling
Smart Power Down
TCP Checksum Offload (IPv4)
TCP Checksum Offload (IPv6)
Transmit Buffers
UDP Checksum Offload (IPv4)
UDP Checksum Offload (IPv6)
Value:
2048


Command Prompt
C:\Users\Stian>ping -l 9000 10.0.1.1
Pinging 10.0.1.1 with 9000 bytes of data:
Reply from 10.0.1.1: bytes=9000 time<1ms TTL=128
Reply from 10.0.1.1: bytes=9000 time<1ms TTL=128
Reply from 10.0.1.1: bytes=9000 time<1ms TTL=128
Reply from 10.0.1.1: bytes=9000 time<1ms TTL=128
Ping statistics for 10.0.1.1:
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 0ms, Maximum = 0ms, Average = 0ms


Cameras
Host
50-0503332615 (Manta_G-504B)
50-0503332615 (Manta_G-504B) - Controls
Attributes
Values
EventID
EventNotification
Off
EventSelector
AcquisitionStart
EventsEnable1
0
GigE
BandwidthCtrlMode
StreamBytesPerSecond
ChunkModeActive
False
Ethernet
DeviceEthAddress
00-0f-31-4c-88-a3
HostEthAddress
40-6c-8f-46-7e-40
IP
DeviceIPAddress
192.168.0.111
HostIPAddress
192.168.0.66
GvcpRetries
5
Gvsp
HeartbeatInterval
3500
HeartbeatTimeout
6000
Multicast
NonImagePayloadSize
0
PacketSize
1504
PayloadSize
5041312
StreamBytesPerSecond
115000000
StreamFrameRateConstrain
True
StreamHold
Timestamp
ImageFormat
ROI
PixelFormat
Mono8
TotalBytesPerFrame
5041312
ImageMode
BinningX
1
BinningY
1
PacketSize
1504

Example scenario: *StatPacketsResent* message shown in viewer.

This is an indication of buffer overflow on the switch, and often will be fixed by smaller packet sizes. In Vimba Viewer for example this is achieved by decreasing the GevSCPSPacketSize. You can refer to the documentation of the viewer in order to find instructions on how to do this.

59.2.4 How to minimise dropped packets (General)

- Check the Gigabit Ethernet cable. A damaged cable often cause the host to use the 10/100Mbps speed mode.
- Use one of the NICs recommended in our hardware selection guide.
- Use the latest NIC driver from the NIC manufacturer.
- Use a dedicated LAN/NIC/Switch for the cameras. Do not share camera networks with internet, company LAN etc. If using multiple camera on a single port NIC through a switch, be sure the sum of StreamBytesPerSecond on all cameras does not exceed available bandwidth (124,000,000 Mbps).

59.2.5 How to minimise dropped packets (AVT)

- Use AVT PvAPI version 1.26 or higher with filter driver version 1.22 or higher enabled on NIC. The filter driver that is installed along with the GigE viewer and works alongside the native Ethernet apater driver to optimise CPU usage and minimise dropped packets. It is only available on Windows. It can be reinstalled from *C:/Program Files/Allied Vision Technologies/GigEViewer Allied Vision Technologies GigE Filter Installer 1.22.exe*.
- Disable the firewall if no filter driver is used.