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Projector Calibration overview

Projection Calibration is the process of calibrating your projectors to the 3D space.

The disguise software offers three different calibration methods. Each has their own benefits and drawbacks. We recommend planning which form of calibration will be used during pre-production.

To learn more about manual calibration see here.

To learn more about QuickCal see here.

To learn more about OmniCal see here.
Warning: reset all digital and optical warps inside the projector, including lens-shift, otherwise the lineup features will be interrupted.

Open the projector editor by either right-clicking the projector directly in the Stage, or by right-clicking the projector from the screens list in the Stage editor.

Familiarize yourself with the properties of a projector. After this follow the instructions explained below.

Set the correct resolution

Set the resolution of the projector to match the corresponding output head’s resolution.
Warning: If the resolution of the projector doesn’t match the real world output, you will end up with an incorrect calibration.

Add surfaces

Under the **Surfaces** tab add the projection screens that the particular projector is covering.
Warning: If you don’t add a screen to the projector the output will stay black.

Add the projector outputs to the Output Feeds

Ensure all of the Feed rectangles from the projector outputs have been added to the output heads.

Please see adding feed rectangles for information how to do this.
Place the projector correctly

Change the pos (projector position) and the throw ratio (lens value) properties so that the projector covers the required part of the screen surface. A laser measure may be required to calculate the correct position by measuring the distance from the physical projector to the video surface.

Adjust the Look at position

The Look at position of a projector defines the centre point of its corresponding output feed. When lining up a virtual projector to the physical projector it is therefore crucial to match the Look at position to its corresponding point in the real world.

Disguise has a built-in wireframe feature allowing the system to generate a line-drawing based on the 3D mesh of the projection surface. In the same output frame disguise will also output a red cross positioned in the centre of the output feed. When the wireframe test pattern is applied, disguise will output this red cross regardless of the orientation of the projector.

Consequently, if the look at position of the projector is aligned to the red cross on the physical projection surface, the virtual projector and the physical projector are orientated around the same point which is a great starting point for an accurate manual lineup.

Align the look at position of the projector

- Change the output mode to wireframe by clicking the output tab at the bottom of the projector editor.

- Return to the Stage level. Set the step value of the look at position to 0.01 to enable smoother scrolling of the look at values. To change the step value, right-click the property name and change the value in the Step value property.

- Begin aligning the look at position of the projector to the red cross by comparing the look at positions crosshair in the Stage level and the red cross being outputted from the physical projector.
Look at position of the virtual projector now matches its corresponding point on the physical video screen, in this example a wooden sculpture

**Adjust the throw Ratio**

- To zoom in on the physical video screens content, change the `throwRatio` value. This value corresponds to the lens size of the physical projector.

- If the exact lens size is known (for example a fixed lens size is being used), type it in.

- If a zoom lens is being used, set the start value to the lowest (or highest) value in the zoom range. Slowly change the value by scrolling the mouse wheel in the property field.

**Fine tune property values**

- After setting the initial lens value, try not to edit the position properties. Instead, start adjusting the `rotation` parameters if needed, in particular the x and y rotations. Aim to establish parallel lines mapping onto the video screen **globally** rather than focusing only on one part of the screen. Adjust the `step` value if needed.

- Go back and fine tune the values of the lookAt position to center the output to the physical video screen. **Remember to establish parallel lines.**

- Adjust the throw ratio to zoom in/out of the content on the video screen. Assuming that the 3D mesh is accurate to the physical video screen, the mapping should gradually fall into place.
Projector has been manually calibrated; the 3D mesh test pattern now lines up with the wooden sculpture.

If the projection surface does not match the 3D model after carrying out manual calibration the lineup may need to be fine-tuned. Please see the sub-chapter Warping outputs for more information.
Multi-Pose Projection

Calibration Overview

The QuickCal configuration includes a Multi-Pose workflow to allow for the calibration of objects that move.

Multi-Pose Projection Workflow

- place the moveable object in a particular position (the “pose”) and then perform a standard quick-calibration.

- Then rotate the object to a second position.

- Drag the existing markers to the correct positions and add new ones if necessary, until the projected image is correct and sharp.

- This process is then repeated for as many poses as are required.

Unlike in the single-pose workflow, we see the dropped calibration points rotate along with the model.

Example

Example application: a car on a rotating turntable, with encoder
In this image, is an example of a car on a motorised turntable. During configuration as the car rotates, the calibrated points gradually drift from their locations on the real model, showing that the calibration isn’t perfect across the space. Once the car is in a new pose, we simply drag the existing markers to the correct positions, and add new ones if necessary, until the projected image is correct and sharp.
Quick Calibration overview

This sub-chapter explains the process of using QuickCal to line up projectors to real world screens.

QuickCal overview

QuickCal is a user-driven process of calibrating a virtual projector's position, orientation and lens properties to match the real-world projector. QuickCal is based on reference points on given 3D meshes for a projector's target surfaces, and user-defined 2D image coordinates that are manually assigned to these 3D reference points. As long as the 3D meshes are good matches to the real-world projection surfaces, QuickCal can accurately calculate the projector parameters.

The basic process of QuickCal is relatively simple: drop reference points onto the 3D model of the projection surface, and then 'line up' by dragging each point in the projector's output raster until it hits the corresponding point on the real surface. Once you've done enough points (about 10-15 per projector) the disguise software can work out exactly where the projector is, and what lens qualities it has.

3D mesh accuracy

When calibrating projectors using QuickCal it is crucial that the 3D mesh object is modelled accurately to the physical model. The reason for this is that disguise's calibration algorithm assumes that the virtual reference points link exactly to their corresponding real-world points. The best way to generate a highly accurate 3D model is to laser scan the physical model, or to laser cut the physical model based on the same 3D file you later use in the disguise software. For building projections we recommend a mesh with a +/-5mm error margin.

Using QuickCal

To start using QuickCal, first move the virtual projector into roughly the right position and orientation, and set up its lens qualities to roughly match the real projector. You don't have to be particularly accurate in this, but when you're trying to select projectors in the visualiser for editing, it's easier when they're in roughly the right place. Then move on to creating reference points, and then line them up.
General QuickCal background information

The calibration goal is to calculate a projector's projection matrix so that it produces physically valid projections on its assigned projection surfaces in the real world (the scene). This means that the matrix does not need to be absolutely physically correct, but should be correct for at least this projection area (or rather volume). Indeed, it helps to think of the calibration as a process that works on a volume in space, rather than on 2-dimensional surfaces.

The calibration process uses as main inputs:

**3D Reference Points (in world space)**

These are usually created from vertices of the mesh/object. Note that the mesh needs to match the real object, at least in the vertices used for creating Reference Points. In d3 Reference Points are 3D objects themselves, and a certain point can be used by several Projectors.

**2D coordinates (in the projector image plane)**

These are created during line up of a Reference Point in a given Projector. In the disguise software the Projector Configuration stores a pair that links the 2D coordinate to the 3D Reference Point.

**Projection matrix**

The projection matrix is a linear transformation that represents the projector's position, orientation and internal sensor and lens properties. Note that the disguise software currently does not support correction of non-linear lens distortion in QuickCal. Lens distortion is only calculated and compensated for in OmniCal.

In the disguise software the projection matrix is applied to all 3D meshes in the Surfaces list, so they get transformed and projected on to the virtual Projector's image plane. This creates the projector's output image that is visible in the Feed Scene.
Choice of Reference Points and Order of line-ups

A Reference Point and the 2D line-up coordinate together form a correspondence point pair. Several such pairs are required for a calibration. QuickCal supports several algorithms that have different requirements on the minimum number of points (e.g. 4, 6, or more).

It doesn't matter for the calibration itself which object/mesh the Reference Points come from, as long as that 3D point exists in the real world as a recognisable feature. Object corners are usually good choices.

It is possible to use Reference Points from several objects for a single Projector.

Important requirements are:

- The real-world equivalents of the Reference Points are actually visible by the physical projector (lie inside its light cone).

- All Reference Points that are used for a projector:

  span a large enough 3D volume. Often this is referred to as "adding enough depth". The main issue is to ensure that the Reference Points do not all lie on the same (virtual) plane in 3D space.

  should evenly cover a large enough area in the Projector's image. It's a good idea to use Reference Points that get lined-up in all four corners of the projector output image.

Additionally, if you want to verify the wireframe of an object during QuickCal line-up, then the objects needs to be added to the Projector's Surfaces list.

It is worth to keep in mind that calibrating creates a working volume for a projector, using the 3D Reference Points as a helper. So the volume in which the projector "is valid in" is always limited by the extent of Reference Points you have lined up. As an example, lining up 6 points that are all in the same image corner of the projector will likely produce a calibrated matrix that doesn't work well for the rest of the image. The same goes for points that are in close proximity in the real world, i.e. the calibrated matrix will only be valid in the small volume within those points.
The order in which Reference Points are created and lined up does not affect the calculation of the projection matrix. The calibration will produce the same result no matter what points are lined up first.

However, to help the calibration work out things faster, it makes sense to line up Reference Points from extreme parts of the scene first, before adding points that are closer to each other. Otherwise there may not be a good visual output until enough points are lined up so that they cover the whole scene with enough depth.

**Short QuickCal Rules**

1. Leave the Calibration Method setting at Auto, unless you really have a good reason to force a specific algorithm. Auto will choose the best algorithm based on how many Reference Points you have, and what their 3D relationship is.

2. Don't "cheat" with your line-up coordinates unless you absolutely have to.

3. Never "cheat" until all Reference Points have been added and lined-up.

4. Line up the extreme parts of the mesh(es) and projector image first (e.g. image corners Left/Right/Top/Bottom and Close/Far in the scene). Then improve on that by adding more points. E.g. concentrate on Reference Points in areas where the projected images are still "off" when looking at the real object.

**Limited Scene Depth and number of Reference Points**

Meshes/Objects that are flat or have little depth are more difficult to use for calibration. This is even more problematic if the real world object has few or no visible features, like a wall where only 4 corners are easily usable as Reference Points.

However, with 4 correspondence point pairs it's already possible to do a simple calibration (usually IterLM algorithm). This calibration is not able to calculate internal lens parameters such as lens shift or throw ratio. It will take values for these parameters from the manual projector settings. Note that these settings are still editable when using QuickCal with under 6 points, or if certain algorithms are set. It
can be difficult to get these values right by hand, but if the throw ratio and lens shift of the physical projector is roughly known, then adjusting this can help improve the calibration significantly.

With 6 or more correspondence point pairs a different algorithm is used (usually Zhang algorithm), which also calculates lens shift and throw ratio parameters automatically. If the Reference Points provide little or no depth, then this algorithm has problems finding a good projector matrix. This is because mathematically it is very difficult to differentiate between some internal lens parameters and 3D parameters. For example throw ratio (or focal length, if you prefer) and distance to an object are interchangeable to a certain degree. Think of the famous Dolly Zoom effect used by Hitchcock in the film "Vertigo", where the face always stays the same size, only fore- and background objects get smaller or disappear). This ambiguity can only be resolved by more depth. It is necessary to line up more points from the scene background/foreground to constrain the calibration better, essentially thereby increasing the calibration volume.

In practice, it may be preferable in certain rare situations to stick with 4 or 5 points, rather than adding a 6th, because the switch to the different algorithm may make the visual result worse rather than better.

Correspondence Point influence on calibration

A correspondence point pair is not like guide points for splines, or a fixed warp or rule that associates the two to each other.

Instead, they are inputs into an iterative algorithm that tries to solve a matrix so that all of these point pair conditions are (more or less) satisfied. But due to mesh/reality discrepancies, line-up inaccuracies, constraints of the optical model, even rounding errors, etc. there will never be a perfect matrix that fits all these pairs. There are many matrices though that will be good enough, so that the error for each of these point pairs is small (e.g. ideally below 1 pixel). If the inaccuracies in the input data are high, then some correspondence point pairs will basically contradict each other strongly. In that case the overall error will be high, too (e.g. 5-10 pixels, or even more). If the error is due to mesh/object discrepancies, then "cheating" might help (see below).

Cheating

If the 3D model and the physical object don't match exactly, then QuickCal allows to "cheat" a bit. "Cheating" isn't recommended, but often it's not possible to get a better 3D model while being on-site.

There are several ways to "cheat":
Moving the line-up cursor slightly off from where it should be, so that the overall calibration looks better and the reprojection error gets smaller.

Note that the advanced option 'Disable reference point bounds' allows moving the 2D line-up coordinate outside of the projector's image, e.g. to a negative value.

Moving a 3D Reference Point away from its original vertex position. In QuickCal this can be done in "Manage" mode by holding the Shift key and moving the 3D Reference Point left, right, up or down. This will move the point in 3D space according to the current visualiser view, and allows placing the point in a non-vertex position. By default, Reference Points snap to the nearest mesh vertex, indicated by a green cross.

The problem with any of these tricks is to know which Reference Points to cheat with, and how it eventually affects the calibration.
Creating and deleting reference points

To create reference points:

- Open the projector editor.
- Locate the Calibration tab.

Projector config editor selecting the configuration tab.

- click the configuration file to open the QuickCal editor. If left-clicking you will instead open the Projector Configuration manager which stores all the configuration files for the existing projectors.
Select **manage points**.

**Projector config editor, Selecting manage points.**

The d3 cursor will now turn in a circle. This indicates that you are in **manage points** mode and when you click on the model a reference point will be created at that location.

**Please note:** The reference points will automatically snap to a vertex near to where you clicked. If you have a really complicated model they may not snap to the correct position select the point you wish to move and hold down the left mouse button to drag it to the desired location.
Point creation cursor, Adding a point.

Create a minimum of 6 reference points and place them on clearly identifiable real-world reference points. This is to make it easier to link the virtual reference points to the corresponding real-world points at a later stage in the lineup process. Usually, there is no need to create more than 6-12 reference points per virtual projector but for more complex geometry it may be necessary to create more. Some complex building mapping projects have required up to 30 reference points per projector.

Notice that multiple projectors can use the same reference points.

Deleting a reference point

To remove a point:
Right click on the point that you wish to delete. An options menu will open.

Delete a reference point from the virtual model.

Left click on the delete button.

Warning: reference points that are lined up in another projector cannot be deleted (since this would affect the other projector's calibration).
Quick Calibrating projectors

Quick calibrating projectors:

- Right-click the projector you wish to line up.
- Right-click the configuration file to open the QuickCal editor.

Projector configuration menu.
At the top of the QuickCal editor select **line up points**.

![QuickCal Editor Screenshot](image)

**Line up point selection.**

Please note: You must have the projector you’re configuring assigned to an output otherwise the button is greyed-out.

- Left-click a point (representing a reference point on the video screen), hold the Left-click and drag the cursor in the output and match it to its physical corresponding point.

Please note: The output of the projector you working with will tinted the colour that you have set in the **appearance** tab in the projectors configuration.

- Once the point is in the right position release the point and now its set.

- To adjust cursor location using finer increments use the arrow keys to adjust in 1px movements.

Please note: When you have adjusted a point it will be displayed in the colour that matches the projectors colour.
Remove a reference point from the projector

This will remove the 2D lineup between the selected reference point and the current projector. The reference point itself will not be deleted.

To remove a reference point:

- Right-click on the reference point that you wish to remove from the projector lineup. An options menu will open.

To remove a reference point from a projector.

- Left click on the remove from projector button.

Rotate Controls

This option allows you to rotate your controls whilst lining up, This is especially useful when your projectors are rotated for example if they are portrait in orientation rather than landscape.

There are four options:

- None: Mouse and keyboard operate normally.
- 90 degrees clockwise: mouse and keyboard are rotated 90 degrees clockwise
180 degrees: mouse and keyboard are rotated 180 degrees.

180 degrees anti-clockwise: mouse and keyboard are rotated 180 degrees anti-clockwise.

**Lineup output mode**

Lineup output mode allows you to change what is applied to the output whilst lining up.

**Please note:** During QuickCal lineup all lined up reference points will be drawn on top of the selected output.

You can choose between the following output modes:

- **Content:** Outputs the content that's on the timeline.
**Wireframe:** Outputs the wire frame of the model.

Image of wireframe applied to Buckingham Palace.

**Identify:** Outputs a full colour grid that has the projectors name on it.
Grid: Outputs a grid that is applied to the model

![Image of grid pattern applied to Buckingham Palace.](image)

None: Outputs nothing but the line up points.

**Cursor Types**

There are four cursor types to choose from:
Horizontal

Image of horizontal lineup cursor.

Diagonal

Image of horizontal diagonal cursor.
Horizontal Lines

Image of horizontal lines cursor.

Diagonal Lines

Image of diagonal lines cursor.

Marker Size

This setting allows you to adjust the size of the marker that's left behind once you have calibrated a point. The default marker size is 16.

Reset options

To reset the projector so no points have been selected or calibrated either:

- select **reset reference point lineup (current pose)** to reset the points for that pose in a multi-pose line up (see the Multi-pose calibration sub-chapter for more info on this topic)
select **reset reference point lineup**

Reset reference point lineup.

A warning message will pop up when you select **reset projector config**, Click **yes** to **reset projector config**.

Confirm reset projection config.
Removing reference points

There are 3 options for removing reference points under the Reference points tab:

- **Delete unused reference points**: This option deletes reference points which have not been associated with a projector lineup.
- **Delete unparented reference points**: This option deletes reference points which are not parented to a screen.
- **Delete all reference points**: This option deletes all reference points from the virtual stage.

A warning message will pop up when you select delete all reference points, Click yes to delete all reference points.
Confirm delete of all reference points.

**Warning:** Delete all reference points is a global action, it will affect all the reference points on the model not just the ones associated with the current projector.

**Advanced options**

**Follow screen changes**

This option allows you to choose if the reference points follow screen changes. For example if you change your screen position the reference points will move with the screen.

**Warning:** This will automatically update any projector’s QuickCal calibration using the new 3D positions of the reference points

**Notify screen changes**

This option allows you to choose if you want to be notified of screen changes. For example if the screen position changes and the points move with the screen you will be notified. The notification will ask you whether you want to update the QuickCal calibration with the new 3D positions. It will also show by how much each reference point has moved.

**No. of moved reference points**

This informs you how many points have moved with a screen position change for example.

**Auto z-clipping**

If auto z-clipping doesn’t work, this means some parts of a Screen, which are either very close or very distant, may only be partially visible. Then manually adjusting these near/far values can make sure that
the projector renders the whole screen.

**Lineup Result**

Here is a real world photo of a lineup of Buckingham Palace without the edge blending.
OmniCal overview

OmniCal is a camera based calibration system which gives disguise the ability to "see".

One of the big frustrations of our powerful 3D workflow has always been achieving accurate 3D models and calibrating those - solutions so far have been based around laser scanning or having a skilled CAD person on site who can modify the CAD model when inconsistencies are found between the 3D mesh and reality.

OmniCal removes the requirement to have accurate 3D models using its powerful calibration and Mesh Deform tools.

Workflow

Features

- OmniCal uses structured light patterns to calibrate the relationship between projection surfaces, projectors and cameras.

- The captured images are used to construct a 3D representation of projection surfaces as a point cloud.

- Users then use the QuickAlign tool to manually align projection surfaces in the Disguise project to match their real world positions and proportions. This is an “offline” process which doesn’t require access to the physical stage.

- We provide a single click Mesh Deform tool which deforms a 3D Model to match the real world (using the point cloud data)
Single click recalibration is supported if only projectors have moved. If cameras or projection surfaces have moved then an operator will need to adjust the previous alignment using current camera images.

The disguise simulator also allows you to simulate cameras, view their coverage and perform test calibrations to ensure that the system will perform as required on site.

**Warning:** The simulator should be used as part of the production workflow to assess project suitability.

Supports 360° projection environments.

Designed for calibration of surfaces and scenes with 3D depth.

One camera option is available:

- OmniCal MV system: For fixed installs. Reliable, continuous Ethernet camera connection; choice of lenses for three different fields-of-view; cameras only need setting up once.

### Current limitations

- The quality of the calibration will depend on having suitable lighting conditions.
- Requires constant light levels during capture process.
- Works best with low ambient light levels.
- As mentioned above a Simulation must be run first to check project suitability. For large projects we recommend doing separate calibrations with groups of projectors and manually blending overlaps between the groups.
- Requires non-reflective, opaque projection surfaces (no gauzes or mirrors).
- Needs a few clearly defined feature points on the 3D mesh and real object, which can be visually identified on the camera images. Projection surfaces with sharp corners work well for example, but NOT smooth surfaces with no features.
OmniCal requires depth from the projectors point of view. Scene depth is particularly important when using moving elements such as Automation.

For a trained OmniCal operator

1. **Create a simulated Camera Plan**
   a. Use the disguise simulator to check project suitability.
   b. You can place virtual cameras and simulate a capture and calibration. You will need to have a project file with projectors and projection surfaces in the same configurations and positions as they will be on-site.
   c. The basic rule for camera placement is that at least 2 cameras need to see every point on your projection surface(s). Also cameras should also have a large angular separation. i.e the directions they face should not be parallel.
   d. The simulation will help you determine how many cameras are needed, their positions and lenses and the calibration parameters. It will also show you the ideal calibration results you should expect on-site. Note that these ideal results are without real-world influences like unsuitable lighting conditions, reflections, occlusions, movement in the scene during capture etc.

2. **Setup Cameras On-site**
   a. You will need to make sure the position, orientation and field-of-view of your real cameras matches your simulated Camera Plan. To help you with this, there is a camera setup editor that shows what the cameras are looking at.
   b. When mounting the OmniCal MV system, you need to manually adjust the physical focus and aperture (iris) on the lens, so that the images of the scene are sharp and well
exposed. Exposure time can be controlled from within Disguise.

c. From the Camera Setup tool you check how well Blob Detection is working (the dots that we project in the structured light patterns).

d. You may need to adjust camera parameters (like exposure time) according to the light level to get the best results.

3. **Capture**

   ! Warning: A clear stage without movement or major lighting changes is required for this.

   a. Capture is an automatic ‘one-button’ process that typically takes less than a minute. Exact duration depends on number of projectors, cameras and the resolution of the structured light pattern (number of blobs).

   b. Once this is complete, the physical stage is free. The next steps can be done “offline”.

4. **Calibration**

   a. You can view the point cloud after this stage and see check the calibration errors in pixels for each projector.

   b. You may need to adjust calibration parameters to get the best results, but usually these will be chosen automatically.

5. **Alignment**

   a. This is a manual step which aligns the point cloud with the projection surfaces in Disguise.
b. Users add alignment points to camera images to line up wireframe views of the projection surfaces with reality.

c. This only needs to be done once as long as cameras or projection surfaces do not move.

d. Re-shape points can also be added to correct the shape of the mesh. This can be thought of as a 3D warp from the camera’s point of view.

6. **Mesh Deform**

   a. This is a final key step which deforms a mesh in the disguise software to match the real world by using the depth information from the point cloud.

---

**For an untrained operator (recalibration)**

1. **Select Camera Plan**

   a. A user would select a Camera Plan previously created by a trained operator which contains known good settings for Capture, Calibration and Alignment.

2. **Rig Check**

   a. This tool allows a user to compare live camera images to those from a previous Capture to check whether cameras or projection surfaces have moved. If so, the user can adjust the alignment reference points by dragging them into the correct positions.

3. **Execute**

   a. A button which triggers a new Capture and Calibration using the settings from the Camera Plan.

   b. No user interaction is required after this point. Projectors will automatically be calibrated at the end of this process.
Hardware

OmniCal MV system

The OmniCal MV system come in kits up to 4 or 8 (depending on kit size) and are perfect for fixed installs. They are powered via PoE, so only require a single Ethernet connection.

Lenses including 6, 8 and 12mm are incorporated into the kit depending on your project needs with a total of 24 lenses available, allowing for on the fly customisation to ensure the perfect setup.

**Small Kit**

**Upper Foam**
Up to 4 disguise MV Cameras

**Lower Foam**
Up to 12 Lenses

Options Include:

- Fujinon 6mm Lens
- Fujinon 8mm Lens
- Fujinon 12mm Lens

**Large Kit**

**Upper Foam**
Up to 8 disguise MV Cameras

**Lower Foam**
Up to 24 Lenses

Options Include:
Fujinon 6mm Lens
Fujinon 8mm Lens
Fujinon 12mm Lens

Not included:

The kits do not contain network equipment like cables, switches or PoE injectors. The disguise MV cameras require a switch that provides at least 1 GBit/s bandwidth and supports PoE to power the cameras.

Tips & tricks

- The fast way to tell if you have a good calibration is to look at the reprojection scores for each projector and camera in the calibration report (this is found at the very bottom) - any score below 1 pixel is considered good, similar to the error margin that would be accepted when using QuickCal.

- Anything above 1 pixel usually indicates that something went wrong. In simulations you will normally see errors of around 0.5 pixels or below.

- Avoid reflective surfaces as they can cause issues with calibration.

- Use surfaces with a lot of depth features as they make the calibration more accurate. It is especially important to have depth from each projector's "point of view". For example, if all the visible blobs from a projector land on a flat surface it will not be calibrated correctly. One way to fix this is to place an object in your environment temporarily during a capture to provide depth information.

- Each blob needs to be seen by at least 2 cameras to be used in a calibration.

- Ensure blobs from across a projector's output can be seen. For example, if only blobs from the top left of a projector are detected it won't be calibrated correctly.

- Ensure a large difference in angles of attack between cameras.

- Capture Setup is important for good blob detection - you will most likely have to change the blob size, grid density and camera exposure to suit your environment.
Blobs should be as small as possible while still being detected by cameras. This improves the calibration accuracy. Also if they are too large they won't be detected at all.

Elongated blobs can cause higher calibration errors. Try reducing the blob size to handle this. Avoid large angles between the projector and projection surface normal e.g 45 degrees.

More blobs doesn't mean a better calibration. Usually the default of grid size of 32 is sufficient. Use more blobs if you require a detailed point cloud for Mesh Deform.

Avoid lighting gradients, if the light level changes across an image blob detection may not work as well.

If you are calibrating a perfectly flat surface and getting strange results, toggle the epipolar/homography camera calibration algorithm under the Plan's Calibration Setup window and see if you get a better result.

If most blobs are landing on a flat surface this can skew the calibration results in favour of those areas. Enabling planar point removal in the Plan's Calibration Setup window may improve your results.

It can be difficult to line up geometrically symmetrical shapes (cubes / pyramids / bowl shapes). You could embed features or identification letters and numbers into the OBJ. You can also name reference points in the Quick Align window.

Surfaces without corners or visible reference points such as domes and cylinders are difficult to line up.

If you need to use mesh deform, use the point cloud visualisation mode to preview the results.

Point cloud visualization affects performance, once you have verified the validity of your calibration, turn it off to ensure good performance.
Troubleshooting
**Start**

Camera and Projector errors under 1px?

- Yes
  - All good. Proceed with QuickAlign.

- No
  - Point cloud matches meshes?
    - Yes
      - Difference due to (partial) scale or local deformations
    - No
      - Check Camera Calibration algorithm. Epipolar when cameras see non planar points, Homography otherwise

Point cloud looks okay? (smooth & continuous)

- Yes
  - MV cameras: Check focal length settings
  - No
    - Check whether Projector point group filtering improves results

- No
  - For troubleshooting:
    - Calibrate with bundle adjust on “Cameras” only

Point cloud is disjointed or missing areas?

- Yes
  - Are all/most blobs detected?
    - Yes
      - Check environment: Lighting & exposure. Avoid reflections, obstructions, light changes.
    - No
      - Check camera placements: avoid (almost) parallel views and shallow viewing angles. Maximise camera coverage of projectors & blobs.

- No
  - Reshape in QuickAlign or MeshDeform, as required

Done :)

Return to Start

Check all camera pairs have enough overlap

key:
- : temporary adjustment for troubleshooting. Please change back to original value later!
OmniCal Camera setup

This camera setup must be done before you run the disguise software.

⚠️ Warning: OmniCal camera networks must use a separate network adapter to all other network traffic.

Workflow

1. Install Vimba Viewer to configure the cameras
2. Network setup
3. Verify camera connections
4. Adjust exposure & focal length

OmniCal MV system

Network setup

⚠️ Warning: OmniCal MV system cameras use all the available network bandwidth, so they must always remain on a dedicated network, away from any other traffic.
Please note: When Camera Discovery is enabled, machine vision cameras continuously capture images and send them to master. This only affects the camera network and not disguise directly, however it consumes CPU time processing these packets.

Please note: Camera Discovery can be disabled explicitly in the OmniCal Calibrator window and is also turned off automatically when the OmniCalCalibrator and Plan windows are not open.

Network infrastructure:

The OmniCal MV system is based on the GigE Vision (R) standard and requires a bandwidth of 1 Gb/s or higher. For example, on 10 Gb/s setups the discovery of disguise MV cameras and the transmission of captured images will be faster.

The disguise MV cameras are powered via PoE, which needs to be provided either by the network switch or a PoE injector. The power requirement over PoE is quite low at 2.8W.

Make sure that all parts of the network infrastructure (switches, cables…) match the desired bandwidth and power specifications.

In case of wired cables (as opposed to fibre), we recommend using at least Cat6 cables, because they are more reliable then Cat5e over longer distances or in the presence of electromagnetic interference (EMI).

Network Adapter Setup

You may need to update to the latest drivers to see some of these advanced options.

- Enable jumbo frames with size (MTU) 8228 or larger
- Interrupt Moderation Rate: Extreme
- Transmit buffers: 256 bytes
Receive buffers: Max setting available

See here for further explanation.

Please note: A 1 Gb port should work fine but we normally use a 10 Gb port when available as the max receive buffer size is larger. Some network adapters may show some of the above settings under an Advanced button. Others may not provide some at all. E.g. the external Promise SANLink3 adapter only offers the Jumbo Frames setting.

Switch Setup

1. Connect a PoE network switch with bandwidth 1 Gb/s or higher.

2. Enable jumbo frames/packets by setting the max packet size to the highest it will go (usually around 9k).

OmniCal MV system setup (in windows)

The Vimba software installs camera drivers, SDK and the Vimba Viewer application used for testing and trouble shooting.

1. Install Vimba for windows SDK from here.

Please note: We recommend Vimba Viewer v2.1.3

1. In the Vimba installer, select Application Development.

2. Keep install drivers checked and complete the installation as normal.

3. Hit Start.

   Open Vimba Viewer
4. Plug your cameras in if they are not already.
   
a. They will show up in the Detected Cameras list in Vimba, in white.
   
b. These may have a red lock icon on them if the disguise software is running. Camera access is exclusive to each application. I.e. if you have a camera capturing in the disguise software you will not be able to view it in Vimba and vice versa.

**Verify camera communication**

1. Open Vimba and select a camera.

2. Press play button and verify images are streaming

   **Please note:** In case camera connections are lost, and replugged, the software should detect them again, but in case they don’t you can press the refresh button in the top left corner.

**Troubleshooting**

- No image is displayed in Vimba Viewer: try disabling jumbo frames on the network adapter. We’ve seen this can be an issue on 4x4s. When using jumbo frames over 2034 bytes we aren’t able to get complete images from the cameras (due to packet loss). The other workaround is to limit the packet size on the switch. Use Vimba Viewer to verify the GVSP packet size setting is 2034 or below. This is negotiated automatically so you don’t set this directly.

- Network adapter becomes disabled after applying the above settings: try reverting the interrupt moderation rate to the default.

- Capturing images is very slow / cameras become unresponsive: try reverting the interrupt moderation rate to the default.
Configuring cameras in Vimba

You can right-click or double-click on the cameras to see and adjust metadata of the camera.

This window also shows the Play button in the top left hand corner, on pressing this the camera image should appear in this window, this can be zoomed using the mouse scroll button.

Focus, aperture and focal length

Align the cameras to look at the object that is to be projected onto. Adjust focus as needed. We recommend that you open the aperture as far as it can go, so you can use the exposure time to control the amount of light that comes in. Make note of the focal lengths used by the cameras, you will need these later.

The Brightness Tab

Exposure time

Exposure time will heavily depend on the light levels in the calibration environment. On the right hand side you will see a value in milliseconds that allows you to calculate roughly the FPS the camera is producing. High exposure time will make it slow.

The other parameter we will not touch. The only other tab we’ll interface with is the All tab.

All

Here we can type in a filter pattern and search through settings. We might need to change the DeviceUserID here. Just type it in and click search. The ID will be visible inside disguise.

Connecting to cameras in the disguise software

Part of the disguise software is a separate program called VimbaCamServer.exe which is used to discover and connect to one or more OmniCal MV system cameras on a network.

In the disguise software the OmniCal Calibration editor configures and enables camera discovery on the network.
Usually, the VimbaCamServer is launched automatically from within disguise, as soon as the Discovery Adapter is set to the localhost Loopback adapter. In that case, the network switch with the cameras needs to be connected directly to a separate network adapter on the disguise server.

The VimbaCamServer can also be run separately, e.g. on a standalone computer. In that case the Discovery Adapter inside disguise needs to be selected as the network port with which the disguise server machine is connected to this other computer. The disguise server then does not need a direct connection to the OmniCal MV system cameras or the network switch they are on.

In other words, the Discovery Adapter needs to be set to the network adapter that the camera server app is on. For an OmniCal MV system the VimbaCamServer can be anywhere as long as it can somehow see and connect to the cameras.

The Mobile Cameras button opens a list of cameras that are currently connected to disguise. If you have many MV cameras on a network (especially if it is only 1Gb/s), then the cameras may appear one by one over the course of several seconds.

Renaming cameras in Vimba Viewer

It is recommended to add unique names for each camera for easier identification within the disguise software. Follow these steps to set this up:

- Open Vimba Viewer

- Locate the setting "DeviceUserID" (not to be confused with a similar setting labelled "DeviceID" which can not be changed)
Rename the camera as desired
Controller for Mako G-507C (169.254.152.156)-50-0536902991(DEV_)

**Filter pattern:** [Example: Gain|Width]

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls</td>
<td></td>
</tr>
<tr>
<td>DeviceStatus</td>
<td></td>
</tr>
<tr>
<td>EventControl</td>
<td></td>
</tr>
<tr>
<td>GigE</td>
<td></td>
</tr>
<tr>
<td>IO</td>
<td></td>
</tr>
<tr>
<td>ImageFormat</td>
<td></td>
</tr>
<tr>
<td>ImageMode</td>
<td></td>
</tr>
<tr>
<td>Info</td>
<td></td>
</tr>
<tr>
<td>Device MAC Address</td>
<td>00:0f:31:5c:09:cf</td>
</tr>
<tr>
<td>Device Firmware Ver</td>
<td></td>
</tr>
<tr>
<td>Device ID</td>
<td></td>
</tr>
<tr>
<td>Device Model Name</td>
<td></td>
</tr>
<tr>
<td>Device Part Number</td>
<td></td>
</tr>
<tr>
<td>Device Scan Type</td>
<td></td>
</tr>
<tr>
<td>Device Scan Type</td>
<td></td>
</tr>
<tr>
<td>Device UserID</td>
<td>Cam 3</td>
</tr>
<tr>
<td>Device Vendor Name</td>
<td>Allied Vision Technologies</td>
</tr>
<tr>
<td>Firmware Ver Build</td>
<td>21000</td>
</tr>
<tr>
<td>Firmware Ver Major</td>
<td>1</td>
</tr>
<tr>
<td>Firmware Ver Minor</td>
<td>54</td>
</tr>
<tr>
<td>Sensor Bits</td>
<td>12</td>
</tr>
<tr>
<td>Sensor Type</td>
<td>Bayer</td>
</tr>
<tr>
<td>SavedUserSets</td>
<td></td>
</tr>
<tr>
<td>Stream</td>
<td></td>
</tr>
<tr>
<td>Stream Information</td>
<td></td>
</tr>
</tbody>
</table>

**DESCRIPTION:**
User-programmable Device Identifier.

**FEATURE NAME:** DeviceUserID
Press Enter and close this window. Note that Vimba must be closed in order for the re-name to be visible.
OmniCal Capture

Capture is the process of projecting structured light patterns and taking images of these to later use in the calibration process.

Overview

OmniCal Capture is the process of projecting structured light patterns, taking images of these and detecting blobs within these images.

Workflow

1. Define the position & properties of cameras and projectors.
2. Setup the Capture.
3. Perform the Capture.

Example

Defining cameras & projectors

1. Left click the OmniCal calibration editor from the stage editor to open it.
2. Create a new Capture Plan by right clicking the capture plan to open the capture plan manager, entering a name in the new plan field and clicking OK.
3. Right click the newly created capture plan.
4. At this point, if you wish to do a simulated capture, set **Use simulated cameras** to Yes.

5. Click the + icon to add each of your cameras to the plan.

6. Right click on each of the plan cameras. This will open up the Camera plan editor.
   
   a. Left click Mobile Camera and select the required camera from the list of available cameras.
   
   b. If you are doing a simulation, you can choose your virtual camera settings here.

7. Click the + icon to add your projectors to the plan.

**Setup capture**

1. Left click **Setup Capture** to open the Capture editor

2. Set the blob size and the grid size.

   a. The blob is the size of the blobs we are projecting in pixels.

   b. The grid size is the number of blobs projected horizontally.

   **Please note:** Generally speaking, blobs should be as small as possible whilst still remaining detected by all cameras. More blobs does not necessarily mean better calibration, but will increase calibration time. 32 blobs across should be sufficient for most use cases. More blobs can be useful in a scenario where mesh deform needs to be used.

3. Left click **Grid** to see how many blobs are projected, and how well they cover the surfaces you are calibrating.

4. Left click on **Blobs**. A test blob detection will be performed highlighted in the camera views. The colour coding of the blobs is based on the colour of the projector wireframe. The blobs
should be made as small as possible, whilst still being detected in this view.

a. At this stage, you may need to adjust camera exposure for better blob detection.

b. To adjust exposure, left click on the camera name and adjust exposure time in the camera plan editor.

Please note: A good way of getting setting a suitable exposure time, is turning continuous capture on, selecting grid mode and adjusting the exposure time and turning continuous capture off when you are happy the blob levels are clearly visible.

5. Ensure your Alignment level in the Capture setup is at a level where you can see the detail on your models clearly, as this image is the one that will be shown in Alignment.

Performing a capture

Warning: The stage should be clear.

Warning: No changing light levels.

Warning: No people walking across stage.

1. Click Capture from the OmniCal plan editor

2. The system will perform a capture, the time taken will depend on number of projectors & cameras and whether projectors are converging or not. For example, 4 cameras & 4 projectors non converging takes roughly a minute.

3. Verify the results of the capture by clicking View Capture.

4. Left click Blobs from the View Capture Editor.
5. Verify the blob detection results are as expected. These results should be consistent with what you saw in the capture setup. If something went wrong with the capture (change in light levels, people walking across stage), then perform the Capture process again.

**Camera Diagnostics**

![Camera Diagnostics](image)

Available in the camera collapsible widget.

1. This will only be enabled if there is a plan and there are plan cameras mapped to MV cameras.

   The following is shown for info:

   ![Camera Diagnostics](image)

2. Right click header to show columns:
3. This displays camera stats and feedback of settings (such as IP, name). The disguise software only displays plan cameras.

4. Click **Start Per Cam** to enable stats feedback.

Visit this link for additional information about each of the specific stats.

**Column descriptions**

- **Frames incomplete** is the only one measured by disguise and provides some feedback to the user as to the stability of the cameras in vimbacamserv.

This setting indicates that the disguise software failed to validate the frame data or there may have been an exception when handling frame data from vimba api.

- **Green** means cameras are ok and receiving data from vimbacamserv (with respect to the stats measuring incomplete frames between each receipt of stats).

- **Red** means there have been incomplete frames between the last read and the current read.

The count of incomplete frames will continue to increase.

The red colour will reset if there have been no incomplete frames between each read of the stats.

- **Grey** indicates the camera has been disabled.

- **Brown** indicates the camera is disconnected/ offline.
- Change mv camera BW to adjust bw per camera. This is split between cameras.

- The graph button will show the stats in graph format.

- Bandwidth allocation can be adjusted while diagnostics are running.

- Dropped packets means you need to lower the bandwidth settings or there is a physical problem like a bad cable.
OmniCal Calibration & alignment

Overview

The calibration process triangulates the position of the blobs detected in a capture as well as the relative positions of cameras & projectors and their lens intrinsics.

Alignment is the process of marrying the point cloud coordinate system with that of the disguise software.

Workflow

Calibration

- Once the calibration is completed, you can view the point cloud and check the error in pixels, for each projector.
- You may need to adjust the calibration parameters to get the best results, but usually these are chosen automatically.

Alignment

1. Manually align the point cloud with the projection surfaces in the disguise software.
2. Add alignment points to the camera images to line up wireframe views of the projection surfaces with reality.
3. This only needs to be done once as long as cameras or projection surfaces do not move.
4. Re-shape points can also be added to correct the shape of the mesh, this can be thought of as a 3D warp from the cameras point of view.

Example

Calibration

⚠️ **Warning:** From this point, you no longer need access to the physical stage to continue the calibration process.

1. Click **Calibrate**

The system runs the calibration and reports the calibration results in the calibration results widget. The pixel error per camera & projector will be displayed at the bottom of this widget. Values below 1px are considered good, and above 1px usually points to something going wrong in the process.

The generated point cloud will appear in the disguise stage visualiser at this point but will not be aligned to the stage, unless you previously performed an alignment.

Alignment

1. The generated point cloud will be aligned to the stage based on the previously performed simulated calibration. If no simulated calibration has been performed, the point cloud will be un-aligned with the stage.

There are some automatic options to automatically align the point cloud to the stage. Click **Quick Align**, and choose **Alignment Estimate** which is automatic alignment estimation based on point cloud and all projection surfaces.

**Align to plan cameras** which is the automatic alignment based on positions of plan cameras.
**Align to plan** which aligns to plan cameras and projectors.

**Align to point cloud** is useful for alignment using 2D camera reference points. Use this option when you want to apply the current alignment data to the stage.

If the Alignment assistance tools do not work, proceed to the next step.

2. Manually align the point cloud with the stage using **Initial position, Initial rotation** and **Initial scale** settings.

3. Once the point cloud is roughly aligned, you can perform a **Quick Align**.
   
   a. Left **Quick Align** to open the Quick Align editor.
   
   b. The top two views relate to cameras which can be chosen from the view tab.
      
      The bottom two views relate to the cursor location in the camera view. This is essentially a zoomed in view, for better view finding.
   
   c. Left click a point on the wireframe.
   
   d. Drag it to the corresponding point in the image. Do the same for the corresponding point in the second camera view.
   
   e. Repeat this process for a minimum of three points.
      
      i. Red point means this point is not being used as part of the alignment, but has been added to the view.
      
      ii. Yellow means it has been aligned in the current camera, but it is not being used in the calculations.
      
      iii. Orange means it has been aligned in a different camera.
      
      iv. Green means it has been aligned in both cameras and is being used in the calculation.
v. Selected points flash, and you can use the arrow keys to move them around.

vi. When points are selected, use **SHIFT** + arrow keys to move the point around & hold **CTRL** left click for fine control.

Alignment re-shape

If the proportions of the model are correct, the alignment should fit perfectly. If the proportions are not correct, you will need to perform a reshape. This can be done by holding **SHIFT** and left clicking a point which will turn it into a reshape point. Left clicking the point again will turn it back to an alignment point.

A reshape does not use the point cloud, and simply adjusts the proportions of the model to match.

Multi-screen alignment

- The master screen should be aligned first.

- It not moved on the stage. It acts as a registration point for other screens. Reshaping or scaling of the Master screen will therefore affect all other screens.

- When aligning secondary screens, they will be moved to the correct position relative the Master screen.

- Its best to choose a screen that does not move, for a master screen.

Mesh deform

⚠️ **Warning:** This may take a while, depending on mesh size, number of vertices and point cloud size.

If the depth of the mesh in the disguise software does not match the real world object, it will require mesh deforming. Mesh deform will deform the mesh to match the point cloud.
It is a good idea to try the default settings for mesh deform first, to see if you get a good deform. If not, proceed to tweak the settings as required.

You can quickly preview Mesh deform results by changing the Point Cloud visualisation mode to Deform in the OmniCal calibration editor. The results are updated in real-time so you can try out different deform settings using this. The lines indicate where each point on the mesh would be moved to.

**Please note:** You must have added re-shape points to the screens for Mesh deform to work.

1. To perform a Mesh deform, click **Mesh deform** from the Alignment tab of the Plan editor
2. Select the screen you wish to deform by left clicking the **screen property** in the deform editor.
3. Left click **Deform**
OmniCal Multi-pose alignment

Multi-pose alignment improves the way OmniCal works with objects controlled by automation.

Overview

OmniCal QuickAlign currently positions secondary (non-master) objects. Multi-pose adds the ability to do this in multiple positions, or “poses”. The automation system can then be given information about these poses and interpolate between them when moving objects.

Currently only movement along a linear path is supported, which requires 2 poses per object.

Prerequisites

- A master screen is required as well as the objects that are moving. The master screen must be stationary.

- Accurate Meshes: Multi-pose is designed to interpolate between object poses. These poses are determined by reference points, therefore an accurate model is required.

- It is recommended that the master screen matches the scale in the real world as this will define the scale for the whole calibration. If your master screen scale is incorrect, you may have to adjust the scale of all secondary screens.

Limitations

- Only supports linear paths, with a single input value from the automation system.

- Does not support calculating rotation pivot points. If an object rotates between poses, the system will simply linearly interpolate between these rotations, which may not be what is desired.

- Multi-pose alignment only uses a single calibration (it is not multi-pose calibration like QuickCal). Therefore there are some important requirements for projector calibration:

  Projectors need to be calibrated with depth using the DLT algorithm. Blobs cannot be on a single plane.
Projection will only be accurate within the calibrated "space", ie around same place where blobs land. Surface movement should be limited to this area.

- No mesh interpolation is done
- Mult-pose alignment is not supported by the Rig Check workflow. It shouldn’t normally be necessary to use multipose on a regular basis. It should only be necessary to redo it when there are changes to the automation system causing screens to move along a different path.

**Workflow**

1. Extract good Meshes
2. Setup automation axes for all moving screens
3. Perform a capture and calibration
4. Align master screen and all static screens in base pose
5. Create 2 poses for each moving screen

**Example**

**Extract Good Meshes**

The multi-pose workflow requires that you have accurate meshes. You can skip this step if you already have these or if you are in a simulation

Please see “Extracting a mesh using OmniCal” for further information

**Setup automation axes for all moving screens**

1. Create an automation device and driver using the regular workflow. For information on creating automation devices, visit this link.
   - Create 6 axes all with the same input ID from automation, for XYZ position and XYZ rotation of the object as follows.
Warning: Note that all 6 axes are required even if the object is moving in a single dimension and no rotation is expected. This is because QuickAlign will calculate a composite rotation and translation of the surface. Ignoring rotation will mean the translation will not be correct. This will become especially apparent when local origin of the mesh is far way from its centroid.

Perform a capture and calibration

Follow the regular OmniCal workflow capture and calibrate.

Open the Quick Align editor.

Align master screen and all static screens in base pose

1. Align the Master screen.
   a. Make sure the Current Pose is set to base, the Master Screen and Current Screen are set to the actual master screen object in the visualiser.
   b. Perform an alignment.
   c. Repeat for all static screens
      i. You can only use reshape tools in the base pose. In min and max poses, the current mesh is being moved, but no reshaping is supported. Note that the UI does not yet prevent you from turning alignment points into reshape points.
      ii. If you need to reshape a mesh for which you need to use the Multi-Pose workflow, then you can either do this by aligning and reshaping in the base pose, or doing it in a separate step, and export+re-import the mesh (probably preferred).

Create poses for each moving screen

1. With the Quick Align editor open, ask automation to move the moving piece to its minimum position.
2. Create min pose
   a. Click Create Pose
   b. This will take a capture and present the camera images for the user to align to. It will also take a snapshot of the current automation input values.
   c. Select the Current Screen as the object which has just been moved by automation to be aligned.
   d. Perform an alignment of the screen at the minimum position.
   e. Each pose can contain multiple screens so you can repeat this for each screen that is visible. Alternatively you could create a separate pose per screen.
   f. Click the Set Min Range in the automation section of the Quick Align editor.
   g. The minimum pose has now been set.
   h. You can right click on a pose to view the screens and automation data contained within it.

3. Keeping the Quick Align editor open, ask automation to move the moving piece to its maximum position.

4. Create max Pose
   a. Repeat the same pose creation steps and instead select Set Max Range in the automation section of the Quick Align editor.

5. Click Normalise Rotation (always required unless a rotation of >= 180 degrees is required between the poses)
   a. For example, after a multi-pose alignment, if you get -0.2deg as the min output and 359.7deg as the max output, then the min output should be set to 359.7 or the max output should be set to -0.3deg. This is because the direction of rotation is ambiguous.

6. Close the Quick Align editor and ensure automation is engaged.
OmniCal Rig-check

Overview

Rig check is the tool for quickly re-calibrating without advanced knowledge of the rest of the OmniCal system. It is primarily used by touring operators to re-calibrate shows moving into new venues.

Workflow

The Rig Check workflow is used after a full OmniCal calibration & alignment has been completed. The plan is used as a template to repeat the calibration with the same settings. The plan is not modified in this workflow.

1. Ensure that you have a plan already calibrated by a Trained user. It should be selected in the OmniCal Calibrator editor.

2. Left click Check Cameras in the OmniCal Calibrator editor.

3. Verify there are no errors when the Check Cameras window opens. Errors can include the following:
   a. Cameras are unavailable
   b. Camera names have been modified in the plan. The plan capture is used as a reference for Rig Check. Any changes to cameras names after the plan capture was done will invalidate it.

4. The Check Cameras window will open which shows camera pairs consisting of the original plan capture and a snapshot capture of the current stage. You can take a new snapshot using the Refresh Camera Views button.

5. Ensure that the camera views match:
   a. They don't need to be identical, but the coverage of projection surfaces should match and they should be in approximately the same positions.
b. The brightness of the images should also match. The exact camera settings specified in the plan (like exposure time) will be used here, so any differences would be either due to the physical aperture or focus of the camera lens (for machine vision cameras) or the lighting environment. It is therefore recommended that the focus and aperture of machine vision cameras be locked in place for repeatability

6. Once you are happy with the camera views, close the **Check Cameras** window.

7. Left click Execute Plan. This will perform a capture, calibration, alignment and optionally a mesh deform if it was configured to run automatically in the plan's deform settings. A new Result object is created which contains the capture and calibration.

8. Ensure that the correct Plan and Result are selected in the OmniCal Calibrator editor.

9. Left click **Check Result** in the OmniCal Calibrator editor. Note that this will apply the result's alignment to the stage (if it hasn't been applied already). This will update both projectors and projection surfaces if they have alignment points. If **Check Result** is greyed out a tool tip should tell you the reason, which can include the following:

   a. The Plan has no capture or calibration

   b. The Result has no capture or calibration

10. Verify there are no errors when the Check Result window opens. Errors can include the following:

   a. The camera names in the Plan and Result don't match. The Plan may have been modified since the Result was created.

11. The **Check Result** window will open which shows camera pairs consisting of the original Plan capture and the Result capture that was taken.

12. Left click on a camera image to open the Result Aligner window. If an Mesh Deforms have been applied these will be undone in order for alignment points to be editable.

13. On the left hand side is the camera view from the original Plan (read only) and on the right the Result. You can then update the alignment points on the right to match the left. This will update the alignment on the stage as you do it. The controls are identical to Quick Align.

14. Select the next screen by pressing the button at the bottom of the camera views or selecting it from the surfaces drop down and repeat the process of checking and adjusting alignment points.

15. Repeat this for all cameras. You could in theory only check cameras or projection surfaces which you know to have moved.
16. Close the Check Result window. You will be asked if you’d like to re-apply the mesh deform

**Warning:**
- The stage should be clear
- No changing light levels
- No people walking across stage

Example

**Accessing rig-check**

1. Open the stage editor by right clicking **Stage** from the dashboard or by right clicking the **floor** in the visualiser.

2. Left click **OmniCal Calibration** to open the OmniCal editor.

3. Ensure that you have a plan already calibrated by a Trained user.

4. Left click **Check cameras**.

**Using rig-check**

1. Ensure that you have a plan already calibrated by a Trained user. It should be selected in the OmniCal Calibrator editor.

2. Left click Check Cameras in the OmniCal Calibrator editor.

3. Verify there are no errors when the rig-check editor opens.
   - Errors can include the following:
Cameras are unavailable

Camera names have been modified in the plan. The plan capture is used as a reference for Rig Check. Any changes to cameras names after the plan capture was done will invalidate it.

4. The **Check Cameras** window will open which shows camera pairs consisting of the original plan capture and a snapshot capture of the current stage. You can take a new snapshot using the Refresh Camera Views button.

5. Ensure that the camera views match:
   
   a. They don't need to be identical, but the coverage of projection surfaces should match and they should be in approximately the same positions.

   b. The brightness of the images should also match. The exact camera settings specified in the plan (like exposure time) will be used here, so any differences would be either due to the physical aperture or focus of the camera lens (for machine vision cameras) or the lighting environment. It is therefore recommended that the focus and aperture of machine vision cameras be locked in place for repeatability

6. Once you are happy with the camera views, close the Check Cameras window.

7. Left click **Execute Plan**. This will perform a capture, calibration, alignment and optionally a mesh deform if it was configured to run automatically in the plan's deform settings. A new Result object is created which contains the capture and calibration.

8. Ensure that the correct Plan and Result are selected in the OmniCal Calibrator editor.

9. Left click **Check Result** in the OmniCal Calibrator editor. Note that this will apply the Result’s alignment to the stage (if it hasn't been applied already). This will update both projectors and projection surfaces if they have alignment points. If Check Result is greyed out a tool tip should tell you the reason, which can include the following:

   a. The Plan has no capture or calibration

   b. The Result has no capture or calibration
10. Verify there are no errors when the Check Result window opens. Errors can include the following:

   a. The camera names in the Plan and Result don’t match. The Plan may have been modified since the Result was created.

11. The Check Result window will open which shows camera pairs consisting of the original Plan capture and the Result capture that was taken.

12. Left click on a camera image to open the Result Aligner window. If an Mesh Deforms have been applied these will be undone in order for alignment points to be editable.

13. On the left hand side is the camera view from the original Plan (read only) and on the right the Result. You can then update the alignment points on the right to match the left. This will update the alignment on the stage as you do it. The controls are identical to Quick Align.

14. Select the next screen by pressing the button at the bottom of the camera views or selecting it from the surfaces drop down and repeat the process of checking and adjusting alignment points.

15. Repeat this for all cameras. You could in theory only check cameras or projection surfaces which you know to have moved.

16. Close the Check Result window. You will be asked if you’d like to re-apply the mesh deform.

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**Warning:**
- The stage should be clear
- No changing light levels
- No people walking across stage