Calibration of 2-Axis Scan Head, MOVIA - Flatbed Scanner Method

1. Introduction

A correction table allows the scan controller to compensate for projection distortions caused by the physical geometry of the steering system, non-ideal opto-mechanical fabrication tolerances, electrical non-linearity of the galvanometer position control system, lens distortion, system misalignment and scaling errors. System accuracy is improved by a calibration process which involves creating and measuring scanning artifacts in an iterative fashion until a desired accuracy is reached.

This application note describes how to create and adjust a correction table for CT 2-axis systems. For further details please refer to the CalWizard Manual.

2. Two Axis Calibration

- MOVIA: +/- 10°
- PS1 and PS2: +/-11°
- LXP: +/-11°
- Lightning II: +/-11°

2.1 Needed Equipment

Before starting the Calibration process, you should make sure you have all the equipment needed. If you need help setting up the scan head please have a look at the MOVIA Quick Start Up Guide.

- The Calibration Wizard Software needs to be installed on your computer.
  The newest version of the software is available under the following link:
  https://novantaphotonics.com/secure-download-scanmaster/
- Marking material: e.g. Bindakote paper (CO2) or black anodized aluminum plate (Fiber) can be used
  - Supplier for anodized aluminum plates: https://www.gravotech.us/
  - Supplier for marking paper: https://com.europapier.com/
- Flatbed Scanner, currently three types of flat-bed scanners are supported:
  - Canon Canoscan 9000F
  - Epson Perfection V550
  - Plustek OpticPro A320
- NI Vision Development Module Run-Time License from National Instruments
- Characterization grid from Cambridge Technology
- Laser safety glasses
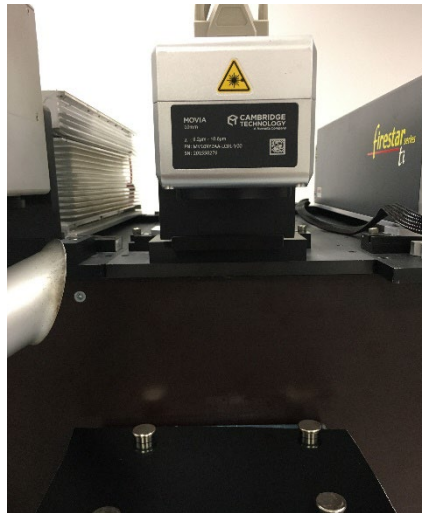
Figure 1: Calibration set up. To make sure that the bindakote paper is positioned straight and level, it is fixated with magnets. On the left you can see an air extrusion to prevent a contamination of the lens.

2.2 Calibrate Flat-bed Scanner

This process is required only once; if a file already exists, then it may be skipped.

Turn on the flat-bed scanner and place the characterization grid into the scanner. Open CalWizard and click on 'Create Correction Table'. To prevent erroneous clearing of information, the following confirmation pop-up appears:

Press 'Continue' to open the correction table editor window. Select 'Measure' → 'Calibrate flat-bed scanner' as shown in figure below. Pop-up windows will show and ask to:

1) Select the flatbed scanner type
2) Enter the file name that will be the scanner calibration file for future use
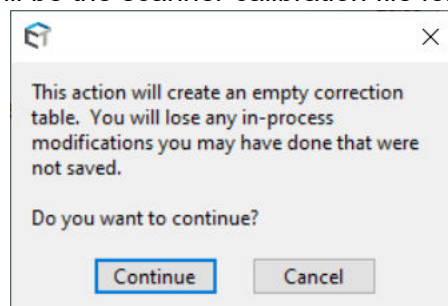
Figure 2: The confirmation window will show before the correction table editor window is opened

3) Select the Scanner

The analysis of the grid will start automatically. Once the analysis of the grid is done, the Correction table displays the result as shown below.
Exit Correction Table Editor without accepting any changes in the field.
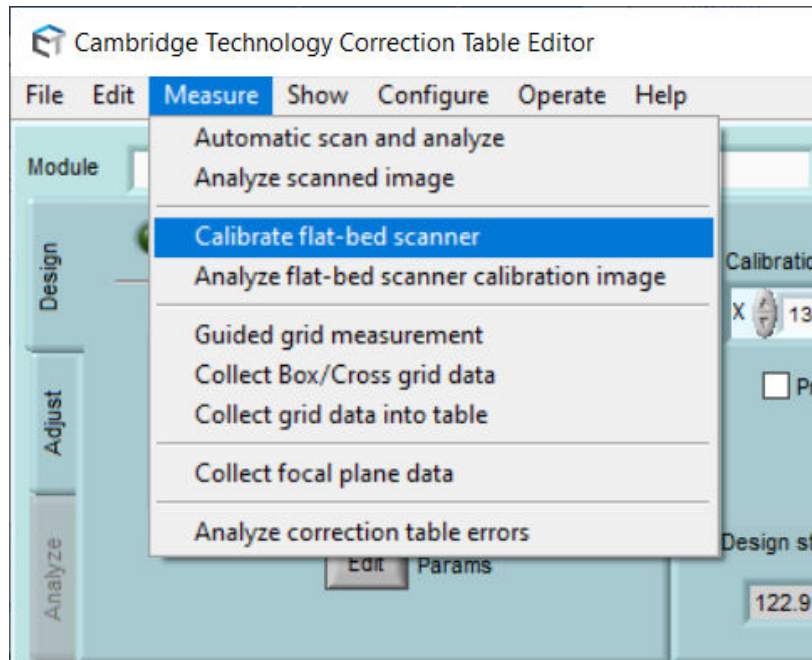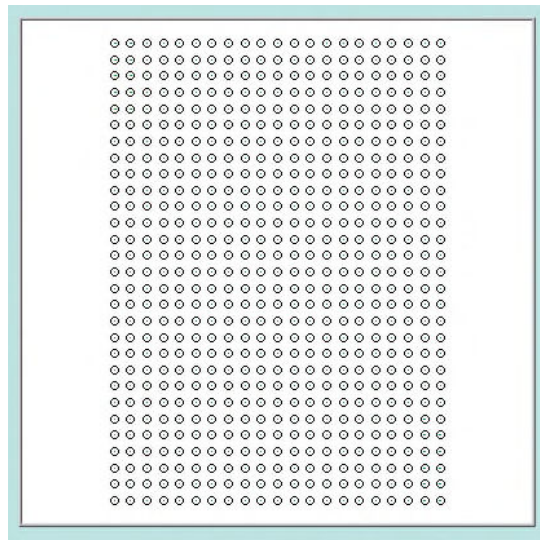

Figure 3: Start the flat-bed scanner calibration

Figure 4: The result of the calibration is displayed in the graph
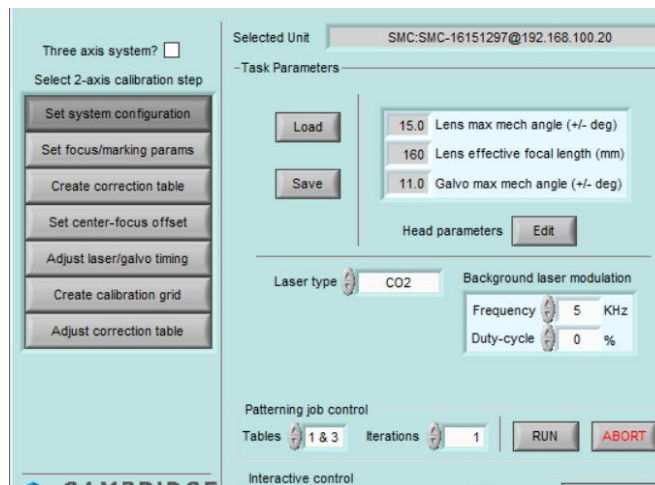
To set the system configuration go to 'set system configuration' as shown in Figure 6. Here you can choose the laser type you are using. The scan head parameter can be left in default at this point. The defined system configuration can be saved through the file menu.

2.3.3   Set Focus/Marking Parameters

In the next tab 'Set Focus/Marking Parameters' Marking speed, jump speed, frequency and laser power can be selected for different modes of operation. They can be readjusted during the calibration procedure if necessary.
-    Marking: Medium power level to leave a clear mark on the media
-    Focusing: Low power level to enhance variations in the mark due to focus quality
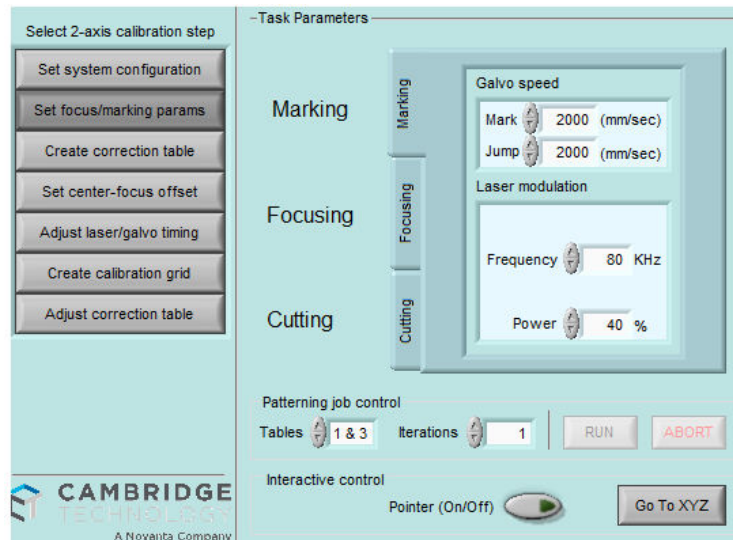-   Cutting: High power level to cut the marked pattern to be measured

Figure 7: Set marking and focusing parameters

2.4   Create Correction Table

2.4.1   Open Correction table Editor

Start to create a new correction table by clicking on the 'Create correction table' tab. To prevent erroneous clearing of information, the following confirmation pop-up appears. Press 'Continue' to open the correction table editor window.
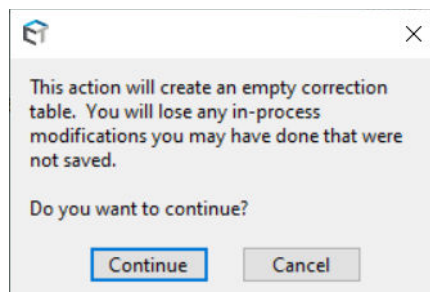
2.4.2   Load from dual axis scan head library or Edit Parameters

Go to 'File → Load → Correction table → From the dual-axis scan-head library' to check if there is already a default calibration table available for your scan-head and F-Theta combination. If so, load the correction table, skip step 1.4.3 and go straight to step 1.4.4. If there is no suitable table in the library, press the 'Edit' button and type in the parameters of your scan head and F-theta lens in the parameter box and proceed with step 1.4.3.

For the maximal mechanical angle, the following values apply:

- MOVIA: +/- 10°
- PS1 and PS2: +/-11°

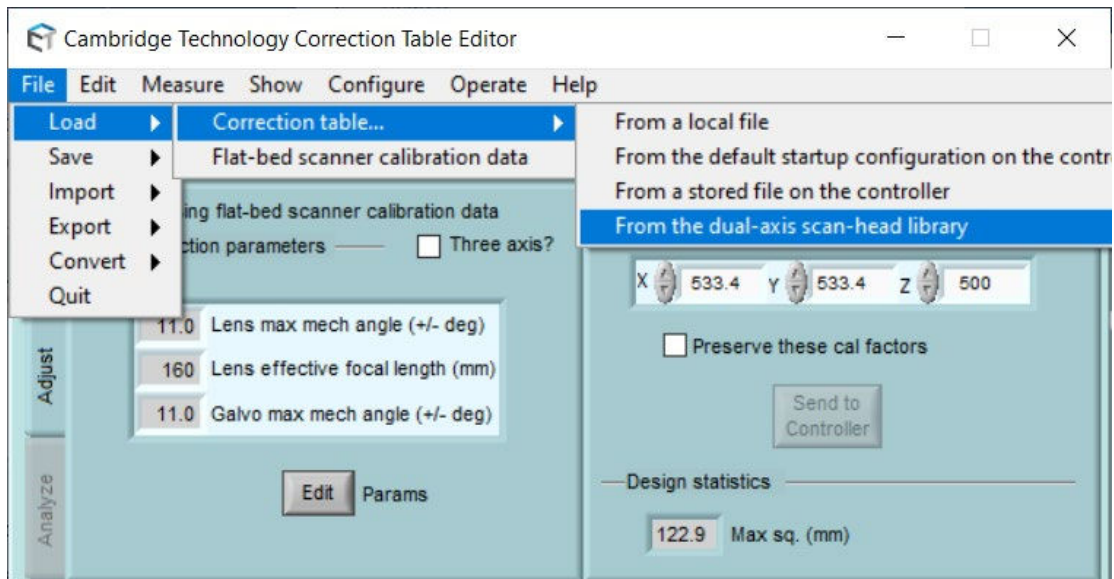- LXP: +/-11°
- Lightning II: +/-11°

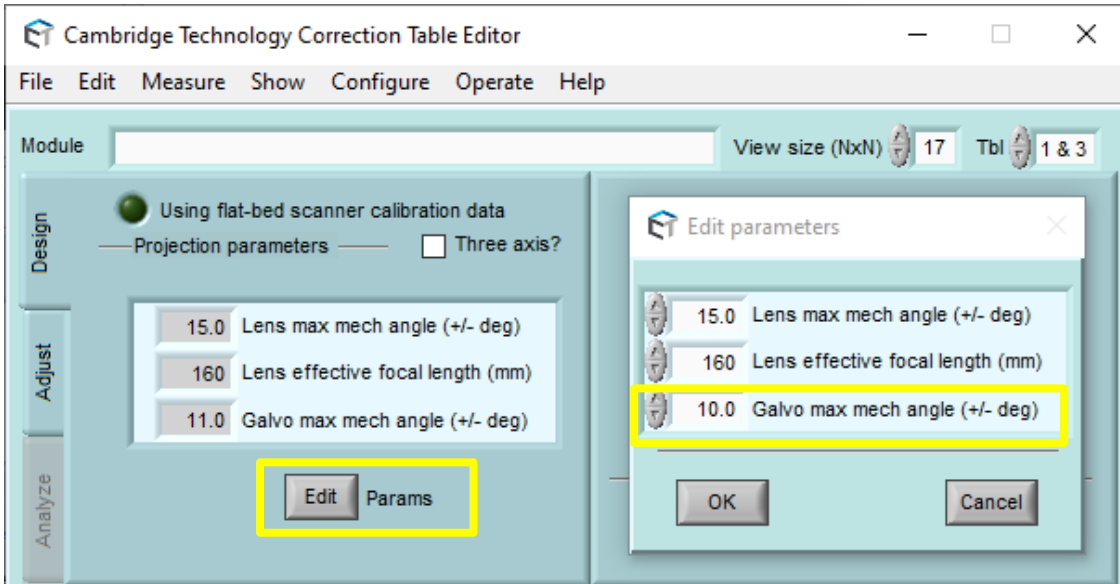*Figure 8: Load a correction table from the scan-head library*

Figure 9: Set parameters in the parameter box: After pressing the Edit button (left), a pop-up window for parameter editing will appear (right). For MOVIA scan heads type in 10 for the max. mechanical angle.

2.4.3   Synthesize Baseline Corrections

Check the Parameter settings, if all is set to your satisfaction go to 'Edit' and select 'Synthesize Baseline corrections'. The editor calculates a pin-cushion distortion compensation derived from mirror spacing, and lens
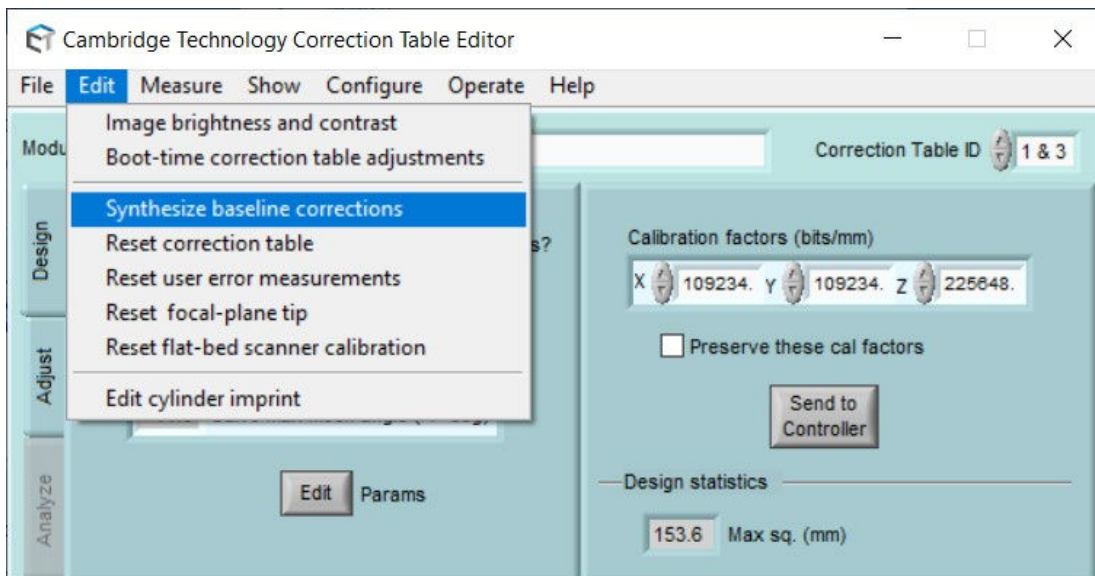

Figure 10: Synthesize Baseline Corrections

distortion compensations. After the process is complete, the new table is displayed. As an example, see figure 11, below.
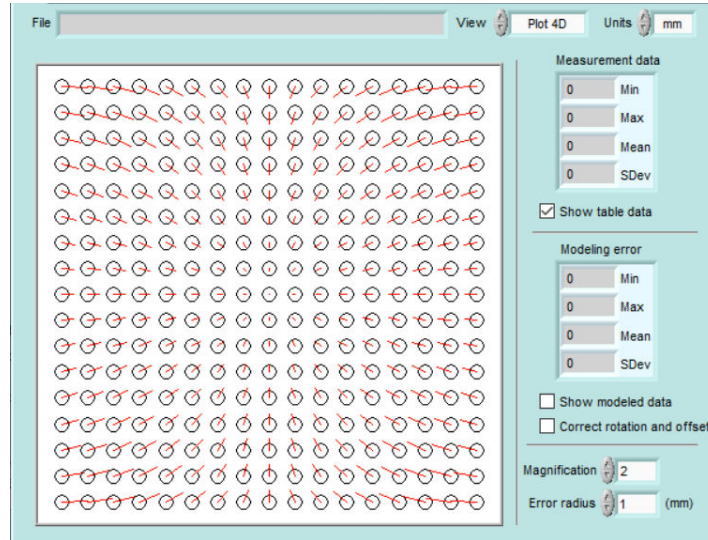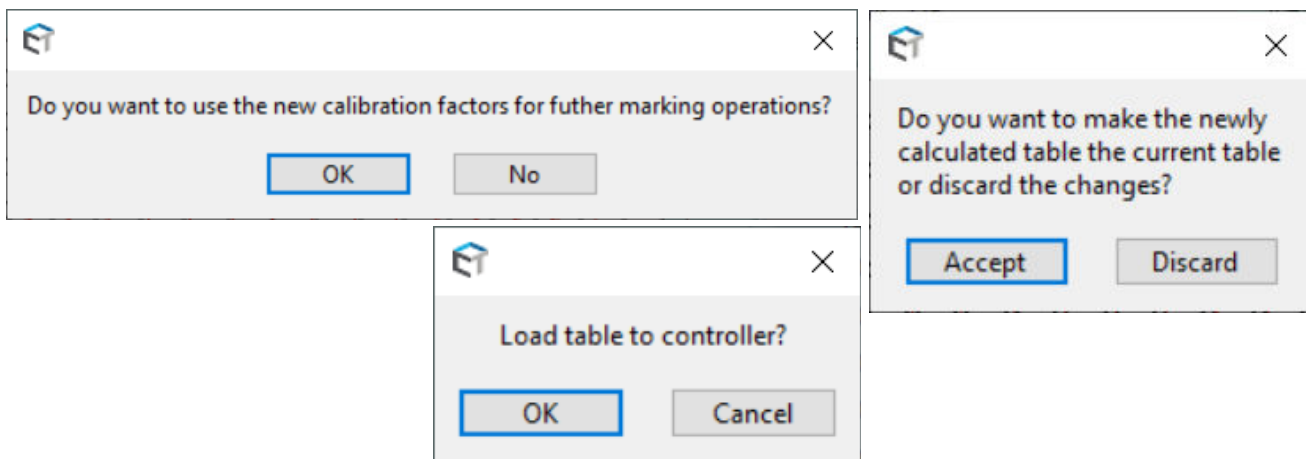

Figure 11: Presentation of the correction table after synthesizing the baseline corrections

2.4.4 Close Correction table Editor & Save changes

Close the correction table editor window, accept the following pop-up messages, and save your correction table to your computer. File revision is optional and can be left blank.

2.5 Find Focus

In this step, you adjust the system to achieve a focused beam at the center of the field.
1. Go to the 'Set center-focus offset' tab.
2. Define grid size of the pattern

3. Click the "Run" button to mark the grid.
4. Check the marked grid and adjust the working distance.
   The closer you get to the focus, the clearer the grid will be marked. Above and beneath the focus the marked grid will faint symmetrically (Figure 12).
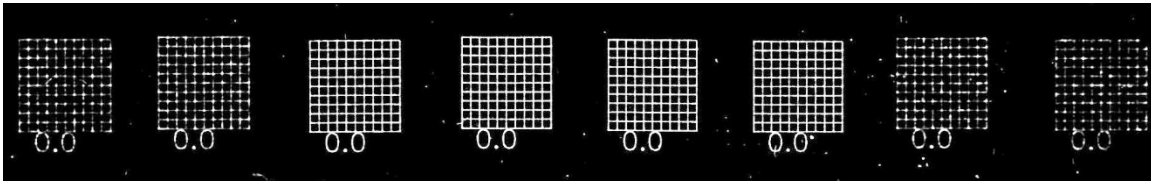5. Repeat steps 3 & 4 until you get a well-focused mark.

Figure 12: Example of focusing procedure. Above and beneath the focus the grid might look fainted or less defined (left and right), once you get closer to the focus the grid appears clearly visible (center).

2.6 Adjust delays

For a quick start use the delays shown in the table below.

	MOVIA 10mm Scan Head	MOVIA 14mm Scan Head
Mark Delay	130 µs	TBD
Jump Delay	260 µs	TBD
Poly Delay	65 µs	TBD
Laser On	Laser Dependent	
Laser Off	Laser Dependent	

For use in the actual application you will want to refine these delays more using CalWizard's "Adjust Laser/Galvo Timing" tab and following the instructions in the manual, Appendix A.

Figure 13: Example of badly adjusted delay settings (left) and well-adjusted delay settings (right)

2.7   Create Calibration Grid & Analyze

Adjusting the correction table requires comparison of a known pattern's coordinates with measurements of actual coordinates on a marked piece. The 'Create calibration grid' tab provides parameters to define a grid pattern. For the Flatbed-Scanner Method a line grid with 20 x20 crossings is recommended. The margin needs to be set correctly so the flatbed scanner can easily detect it, 5 mm have, are usually a good value.
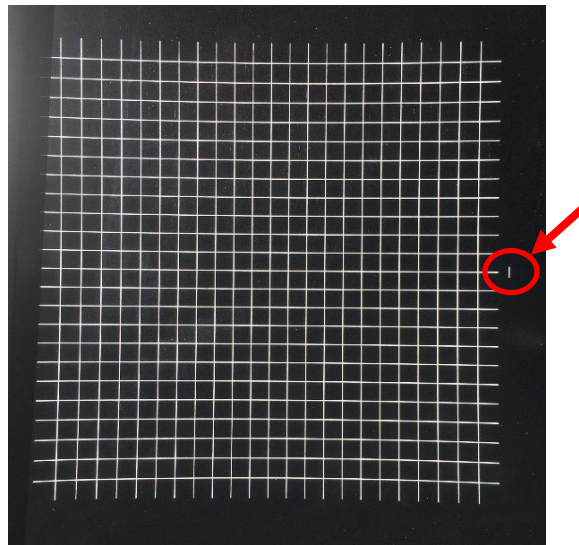

Figure14: The 1st marked grid will show clear distortion errors. If a correction table from the 2 axis scan head library was used, the grid will show less distortion. On the right, you can find a small orientation marker, which marks the positive x-direction .

1. Once all parameters are set, press "Run" to mark grid. The marked grid will look like the example in figure 14. On the picture on the right, you can find a small mark which is used for orientation.
2. Place the marked grid in the flatbed scanner. For orientation there is a small mark on one side of the grid.

3. Click on "Edit table" to open the Correction Table Editor. Under 'Measure' click 'automatic scan and analyze'. Make Sure that the green LED 'Using flat-bed scanner calibration data' is light up. If the LED
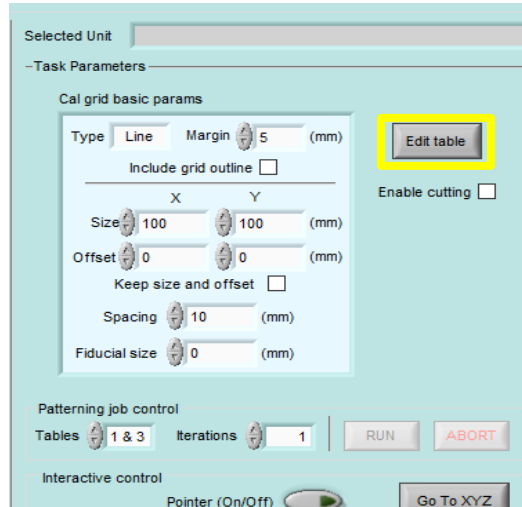

Figure 15: Under "Create Calibration Grid", clcik the "Edit table" button to open the Correction Table Editor.

is off, go to 'File → Load → Flat-bed calibration data' and choose the calibration file.

4. A pop-up window will show and ask to choose the flatbed scanner type you want to use (Figure 17).
5. After this you will define the orientation of the marked grid with respect to the flat-bed scanner. Use the previously mentioned marker for orientation. It marks the positive x-direction and is also indicated in the "*Select Field Orientation*" pop-up window. Once all parameters are set, the analysis of the grid will start automatically.
6. After the analysis is complete, a .pset file is created from the scanned image and saved to a location that you choose through a dialogue box.
7. Close the correction table editor, as before click 'Ok' on all pop-up windows

8. Repeat step 1) to 6) and check the standard deviation (SDev) after each iteration. We recommend having an SDev value less than 0.05 in the measurement Data.
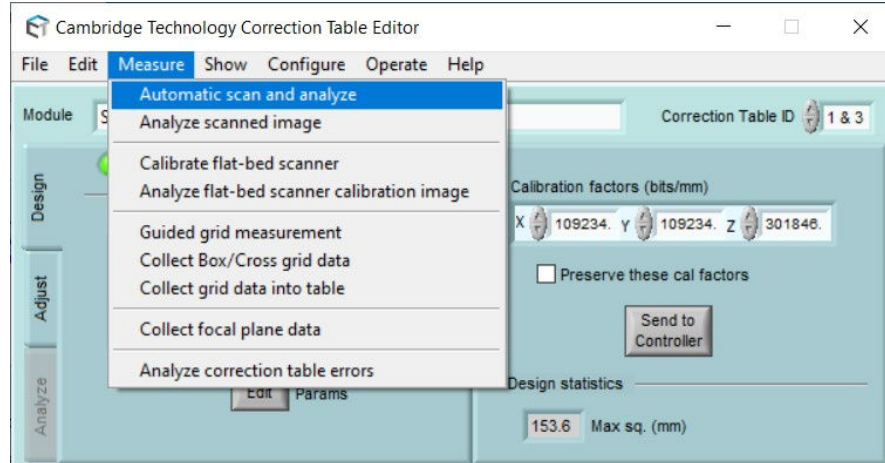

Figure 16: Start Automatic Scan and Analyze. Make sure that the green LED 'using flat-bed scanner calibration data' is light up.
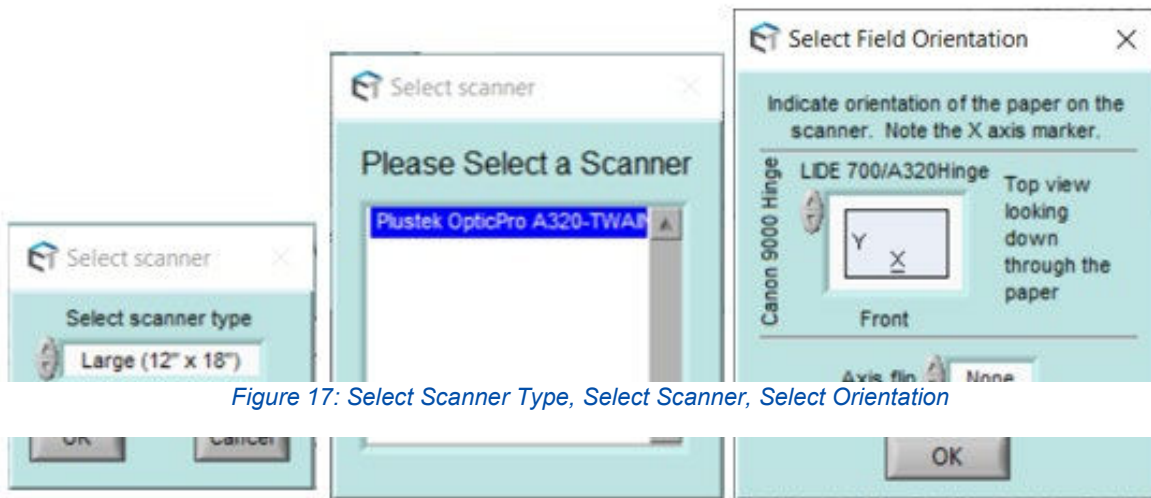

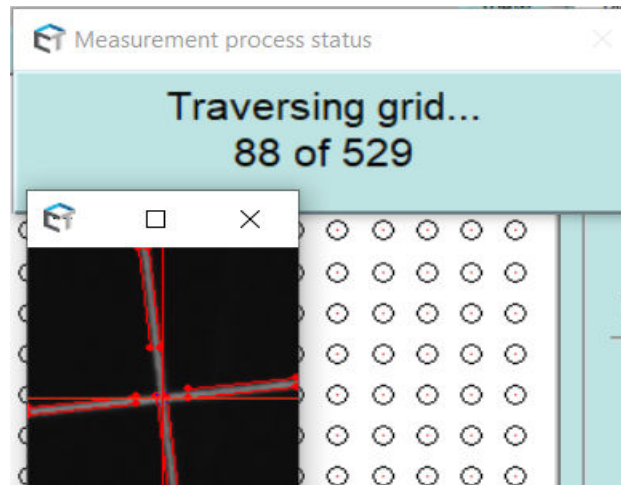*Figure 17: Select Scanner Type, Select Scanner, Select Orientation*

Figure 18: The software will automatically scan and analyze each section of the grid

2.8   Save Calibration and load to the controller

Once measurement is completed and gives good accuracy, go to Edit Table → File → Save→ Correction table…→ to the controller. CalWizard will prompt you to save the calibration file to local drive, too. Press "Yes"
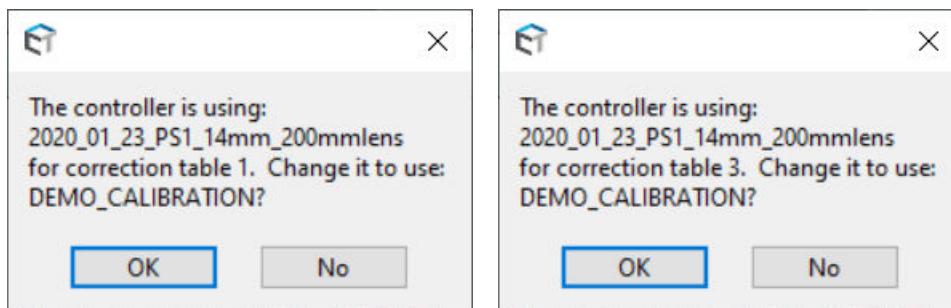

Figure 19: Change the correction table to the newly created one by clicking 'OK'

to save on local drive. CalWizard asks permission to make the most recent calibration file active as Table 1 and Table 3 as shown in figure 19. Press "OK" both times. When Closing the CalibrationWizard you will be asked if you want to restore the SMC to the current configuration file contents, click on Leave as-is and close the program. The SMC controller is ready to use with new correction file.
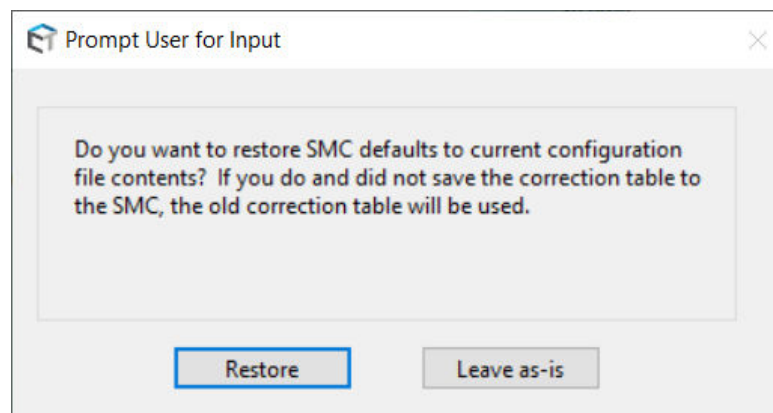
3. Troubleshooting

Even though we are continuously working on making the Calibration as user friendly as possible. There might be some troubles you could possibly run into. Some of them are listed here and explained how to solve.

2.1 Error could not connect to SMC

If you cannot connect to the SMC here are some possible reasons:
- SMC is already connected to other software. Disconnect from other software and try again
- firewall settings wrong, allow the software to communicate through the windows defender wall
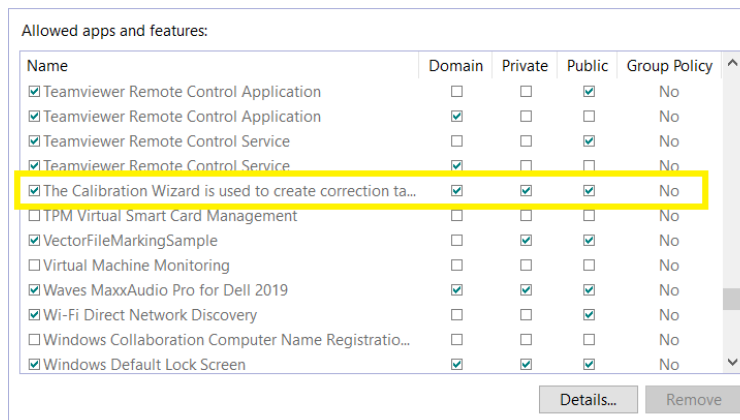
- IP address is not set correctly, check if the IP address of your ethernet adapter match with the one of the SMC. The default SMC IP-address is: 192.168.100.20

2.2 Error reading Calibration Grid

If the flat-bed scanner cannot find all expected grid points, Cal Wizard will show you the following error message:
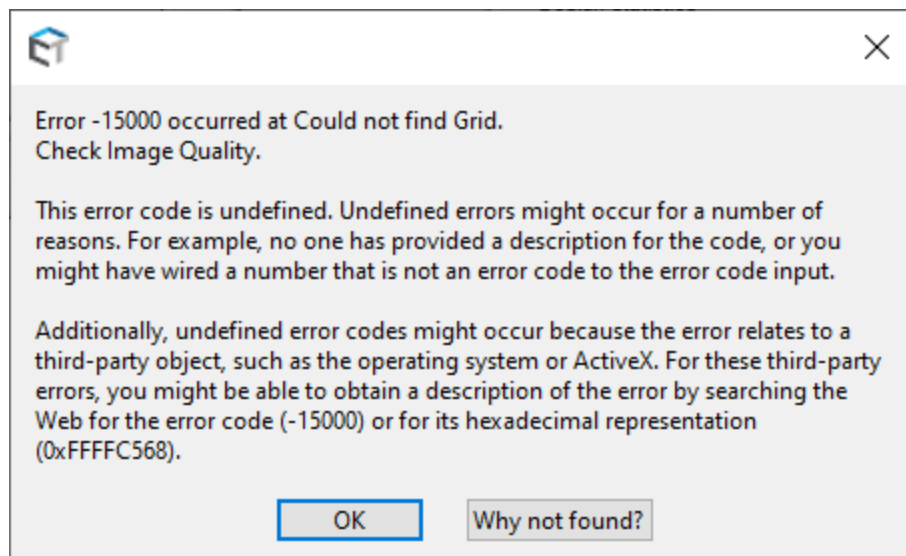
This error can be easily fixed:
- Check if the contrast of the marked grid is strong enough, if not try to mark the grid with higher power or slower mark-speed settings.
- Try to adjust the delay settings as described in chapter 1.6. If there are any tails or if parts of the mark are missing this might confuse the flat-bed scanner

2.3 Barrel/Pincushion effect is still strongly visible after several iterations

If, even after several iteration the grid still shows a strong distortion it might be because you forgot to synthesize the baseline correction. Please open a new calibration table and synthesize the baseline correction before marking and measuring the grid.

Another reason for a strong distortion could be that the SMC is missing the Lens File. If this is the case, open CalWizard and load the correction table from the controller or the saved location. Resave it to the SMC.

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