

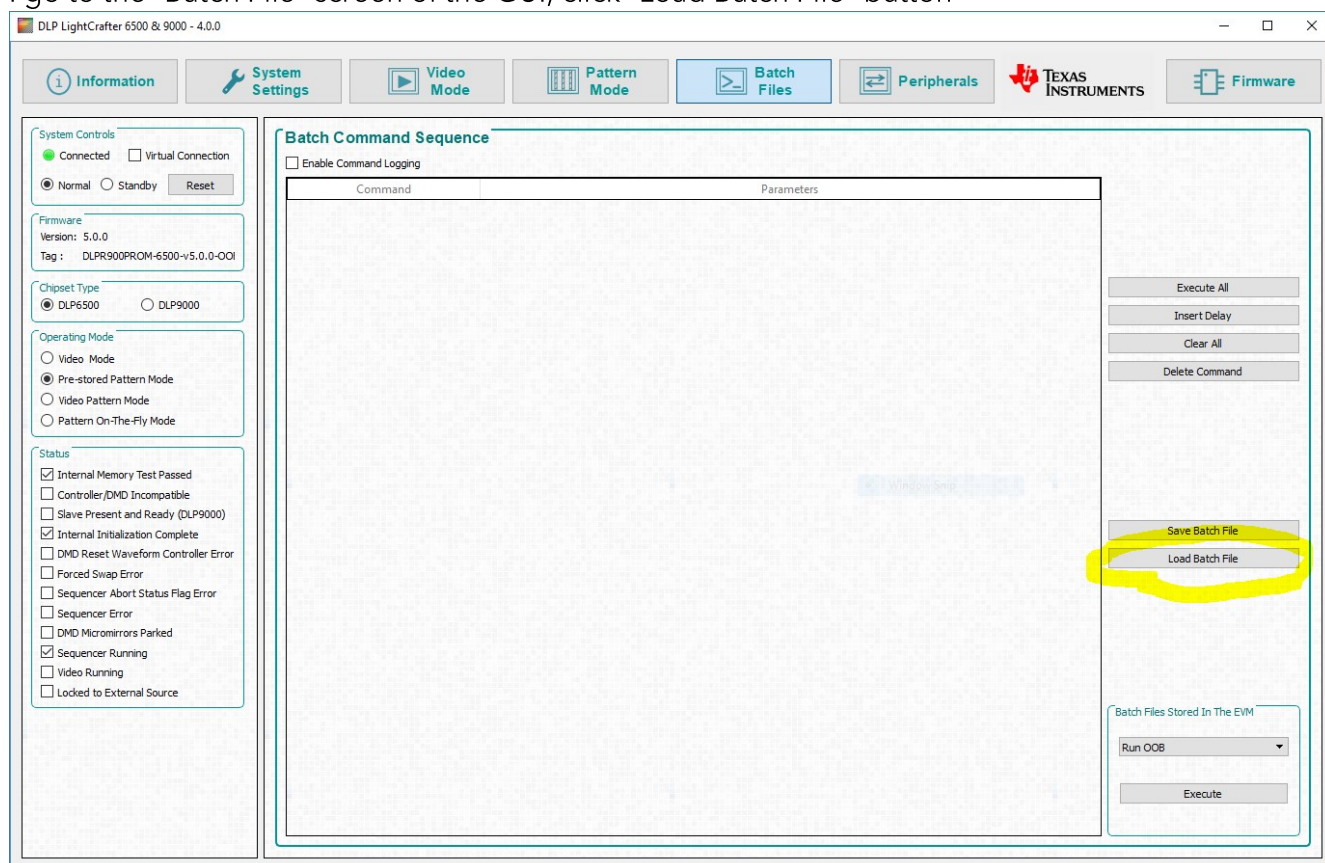
Steps I make setting up and calibrating the system:

Before I begin, let me say a couple of word on the setup:

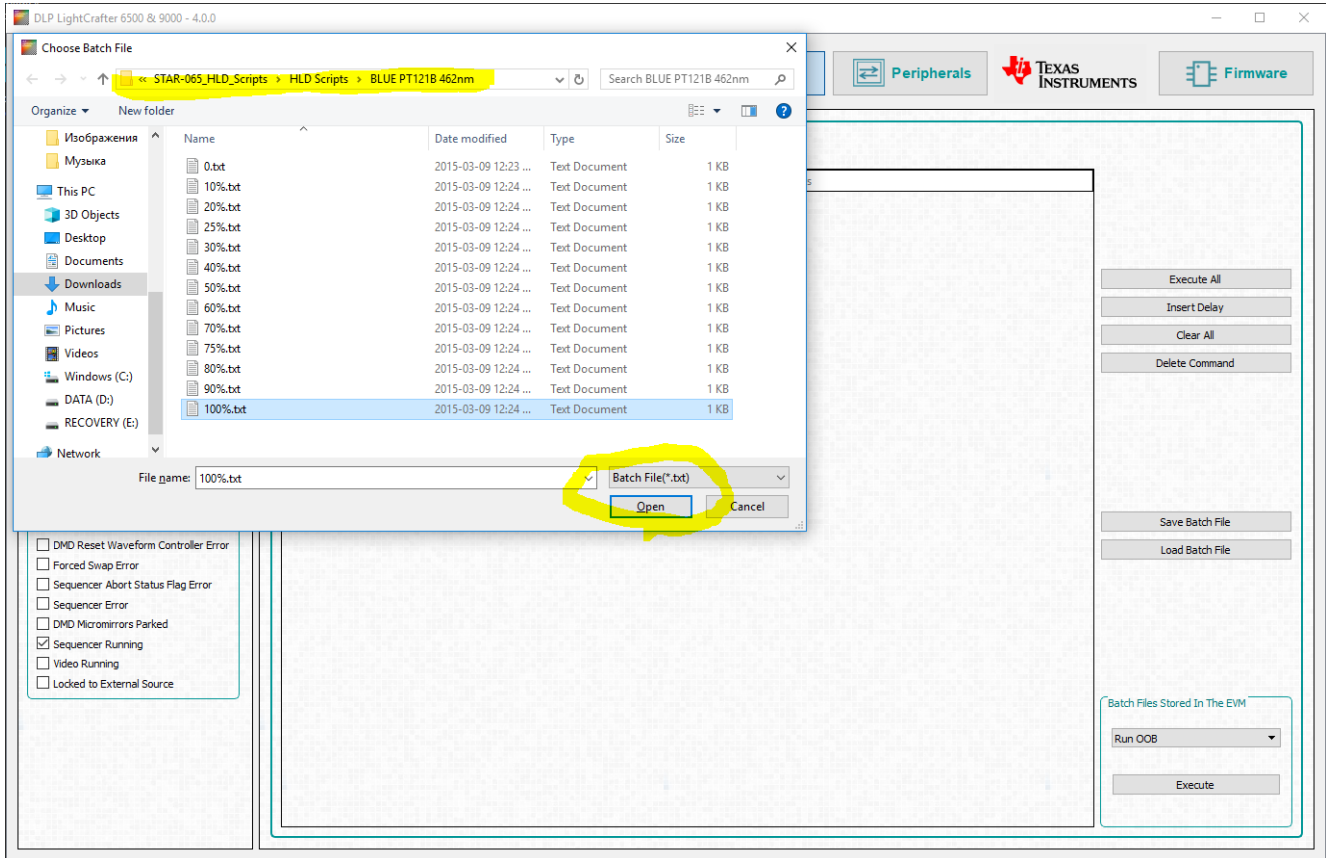
- Camera: PointGrey Grasshopper3 GS3-U3-41C6M-C
 - Camera lens: Tamron Ultra High Resolution 2/3 8mm F1.8 C ø52
- Projector: ViALUX STAR-065 Type s600
- DMD: DLP6500 1080p
- Controller Board: DLP6500 chipset
 - Firmware: v.5.0.0 tag.DLPR900PROM-6500-v5.0.0-OOI
- OS: Win10
- CPU: Intel® Core™ i7-7700HQ @ 2.8GHz

1. Assuming system is a cold start, firstly I open the DLPLCR GUI Dash and run a script to initialize the projector.

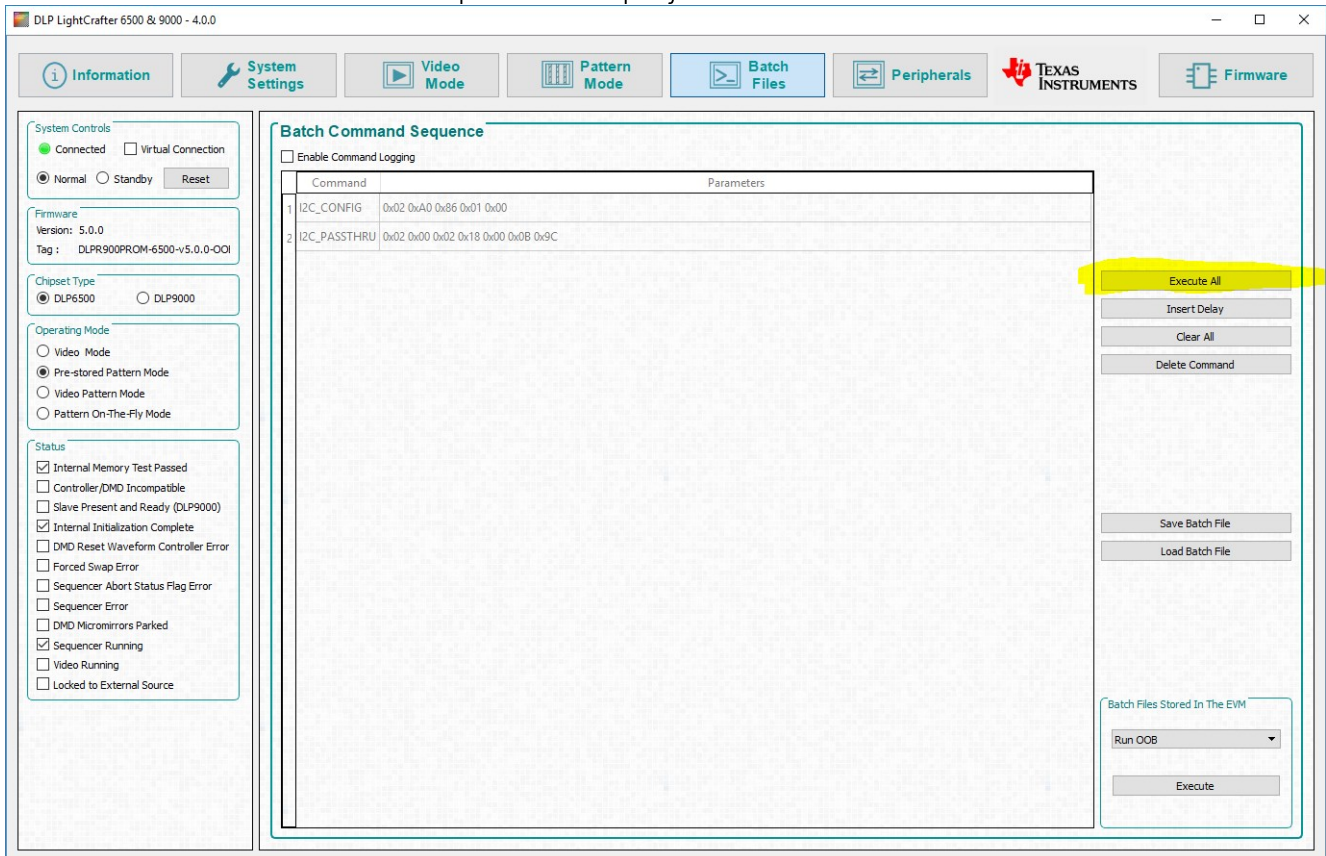
a. I go to the "Batch File" screen of the GUI, click "Load Batch File" button



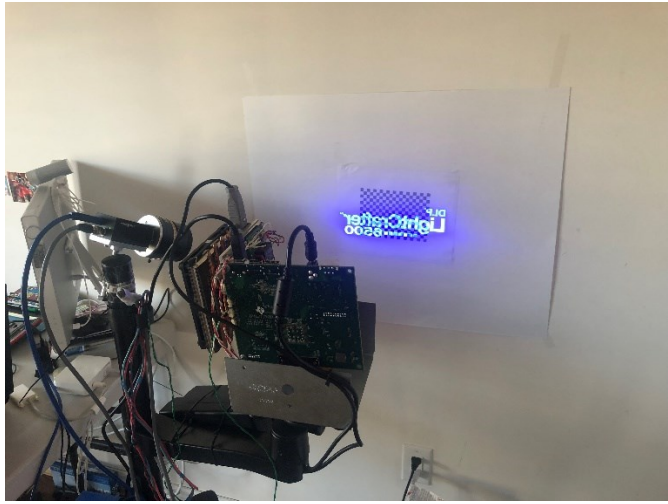
b. Then I pick the script file for the projector, downloaded from ViALUX website for 100% brightness



c. Press "execute all" button and script starts the projector.



d. Right away the projector starts.



2. Preparing for Calibration. I will provide the screenshots along with the actual output images below.

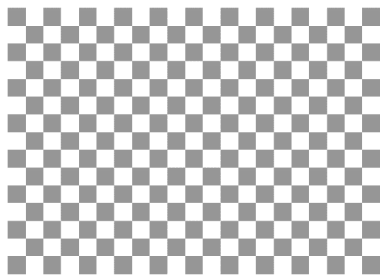
- a. Before running "DLP_LightCrafter_6500_3D_Scan_Application.exe" I close the DLPLCR GUI Dashboard.
- b. Right after starting the application I press "1" to generate the calibration board (see resized board below)

```
C:\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LCr6500_MachineVision_build\...
Connecting to projector...
I2C Configure = 11
I2C Write = -1
Configuring projector...
Compress image 0
Compress image 0
Connecting to camera...
Configuring camera...

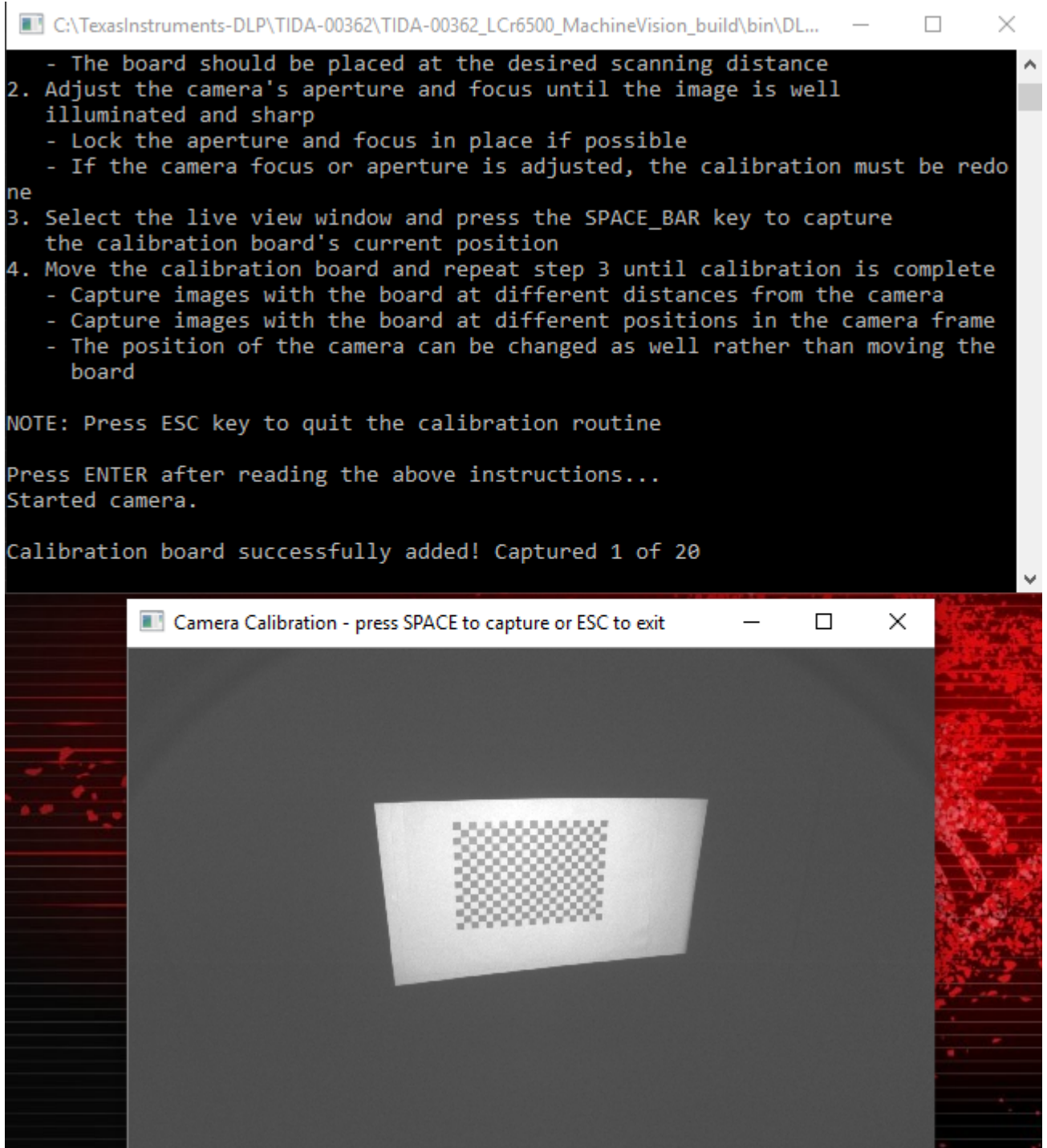
Texas Instruments DLP Commandline 3D Scanner

0: Exit
1: Generate camera calibration board and enter feature measurements
2: Reserved
3: Prepare system for calibration and scanning
4: Calibrate camera
5: Calibrate system
6: Perform scan (vertical patterns only)
7: Perform scan (horizontal patterns only)
8: Perform scan (vertical and horizontal patterns)
9: Reconnect camera and projector

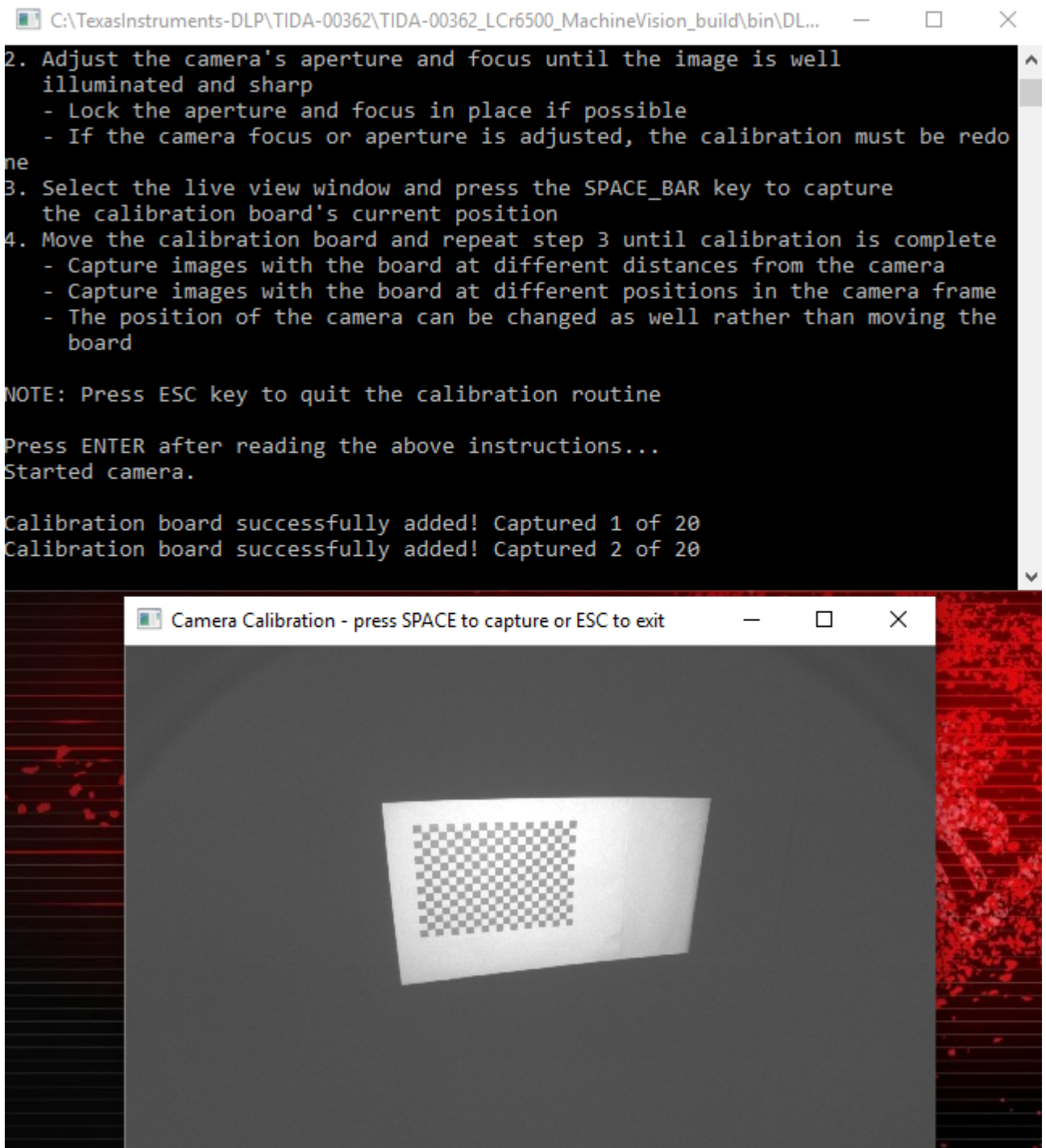
Select menu item:
```



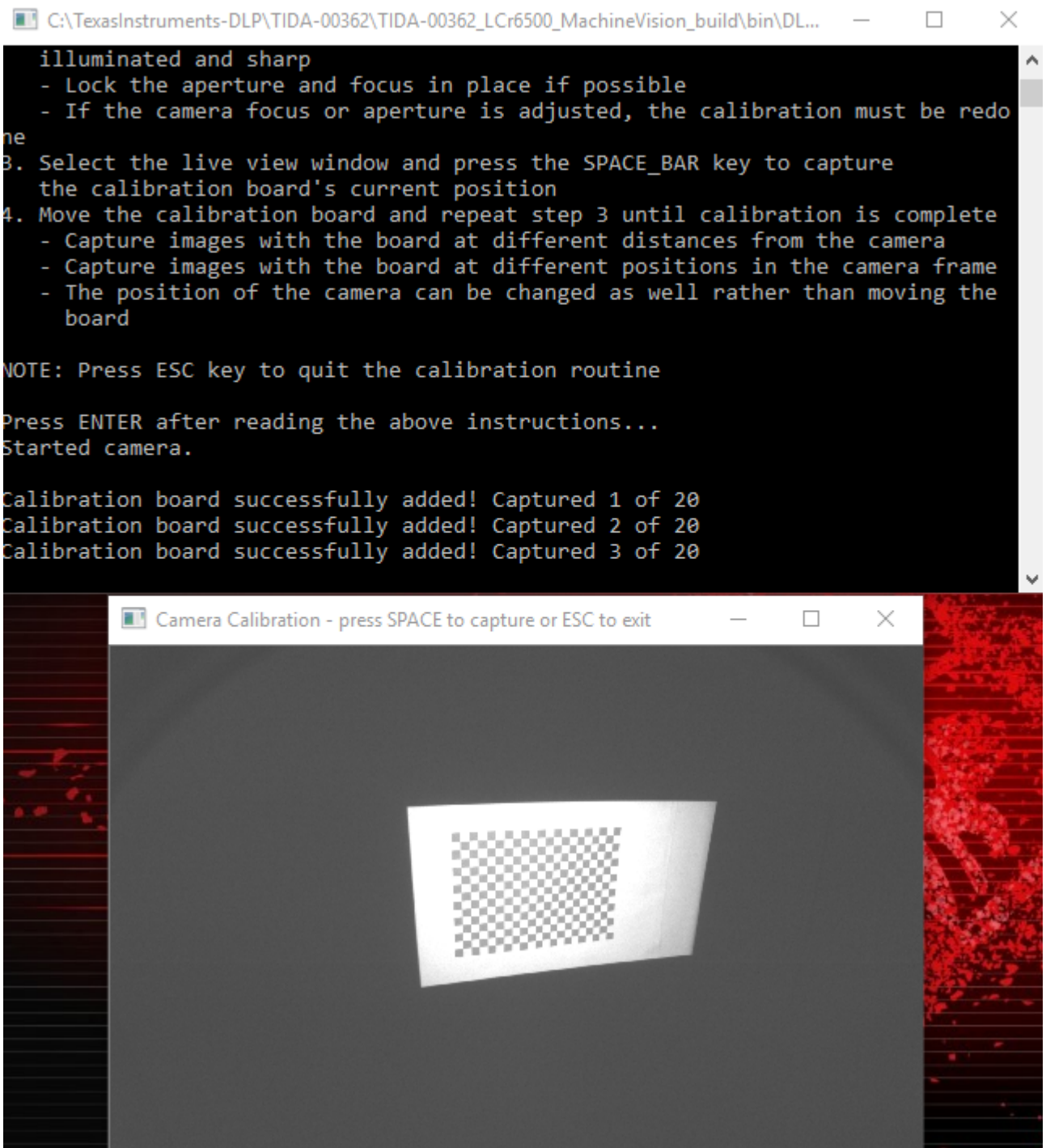
d. Calibration image 1



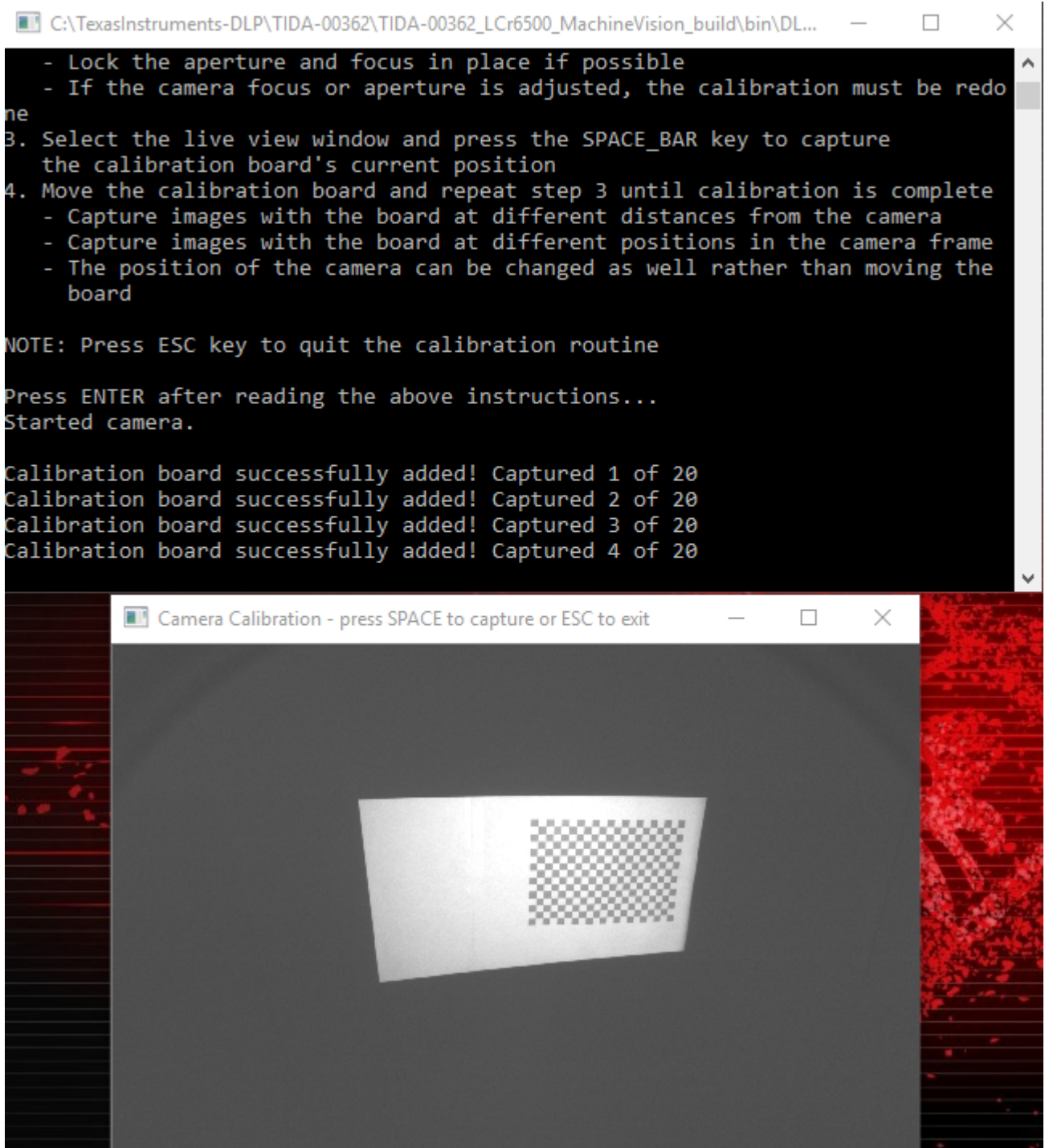
e. Calibration Image 2



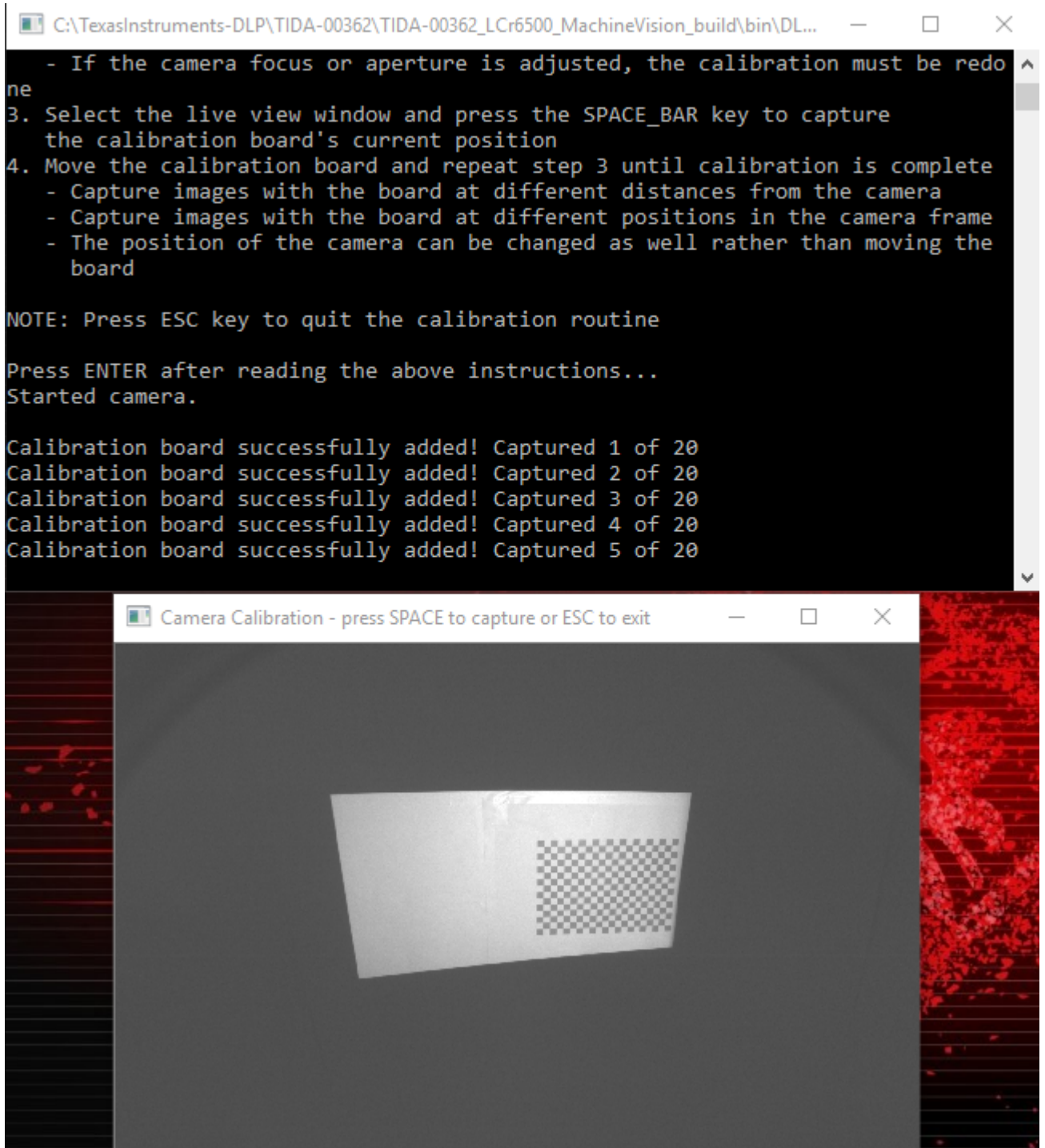
f. Calibration Image 3



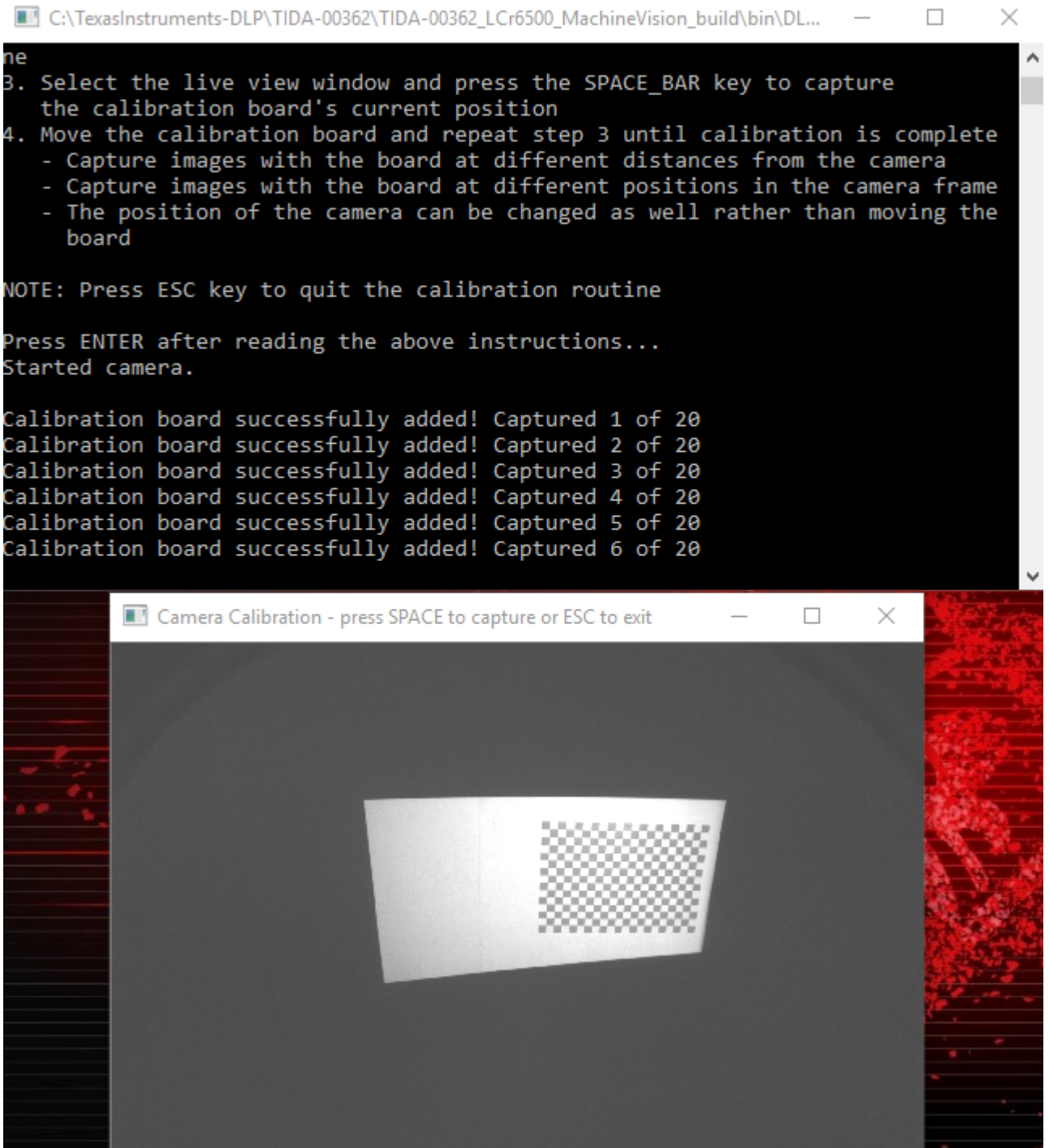
g. Calibration Image 4



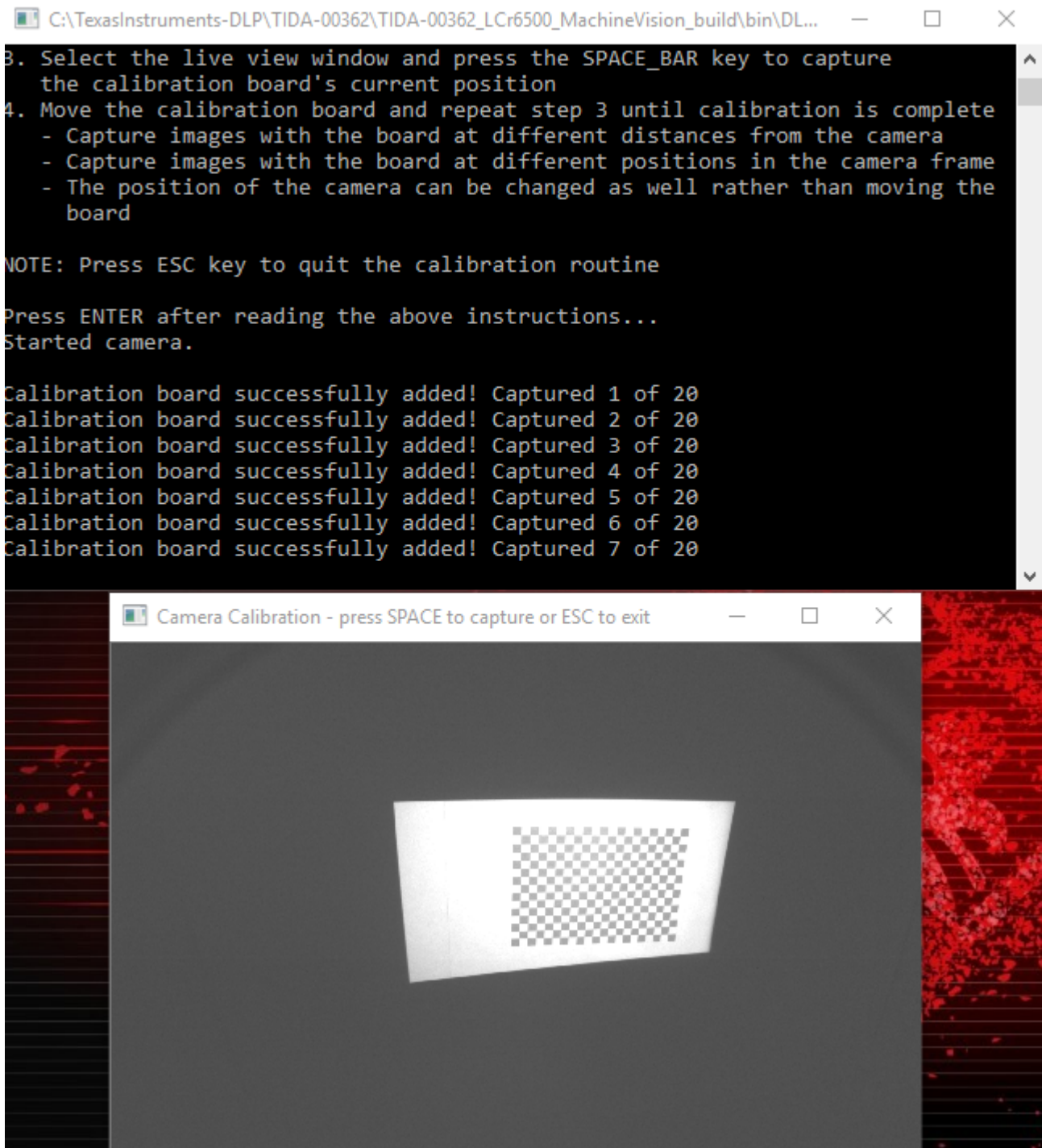
h. Calibration Image 5



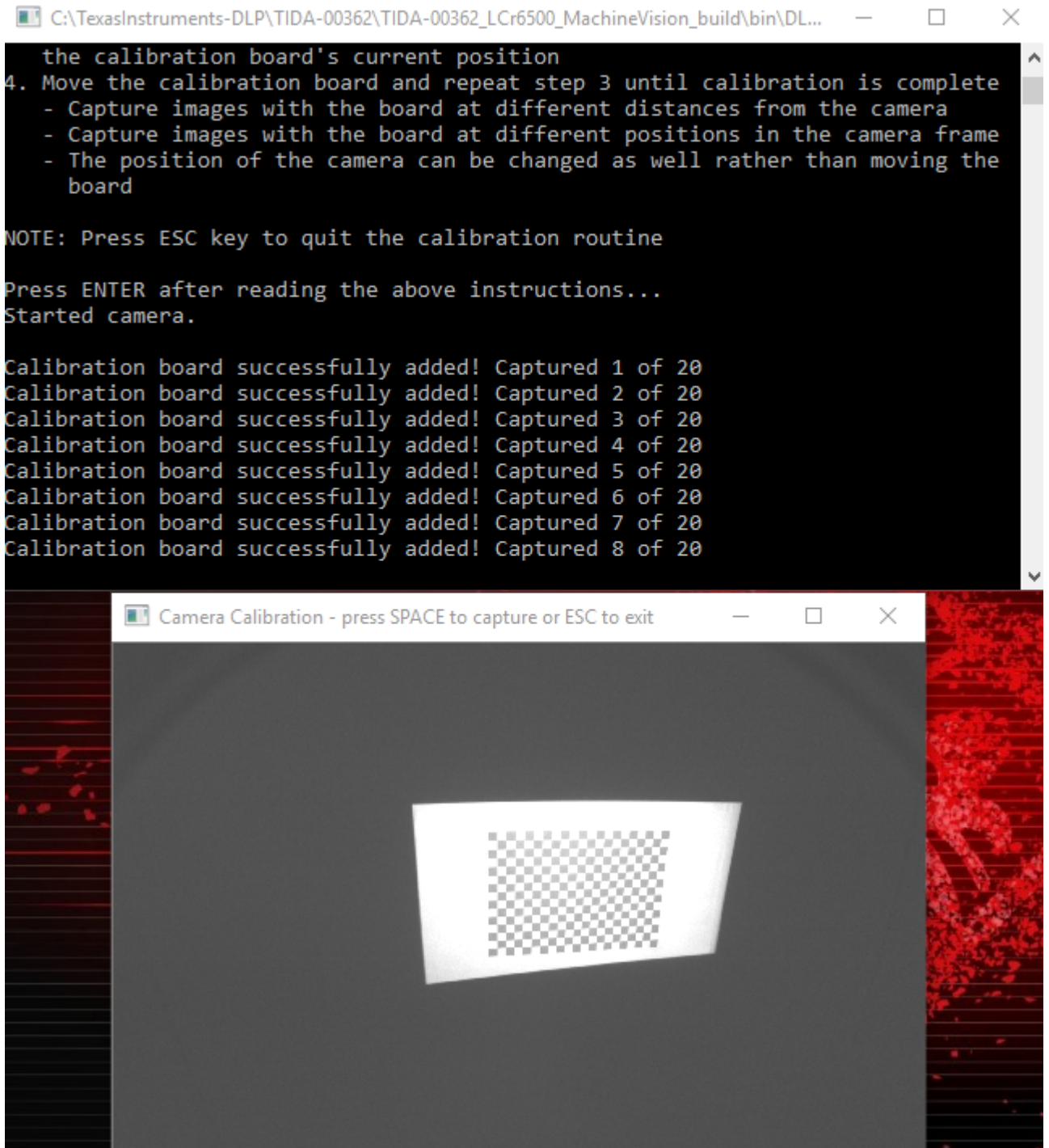
i. Calibration Image 6



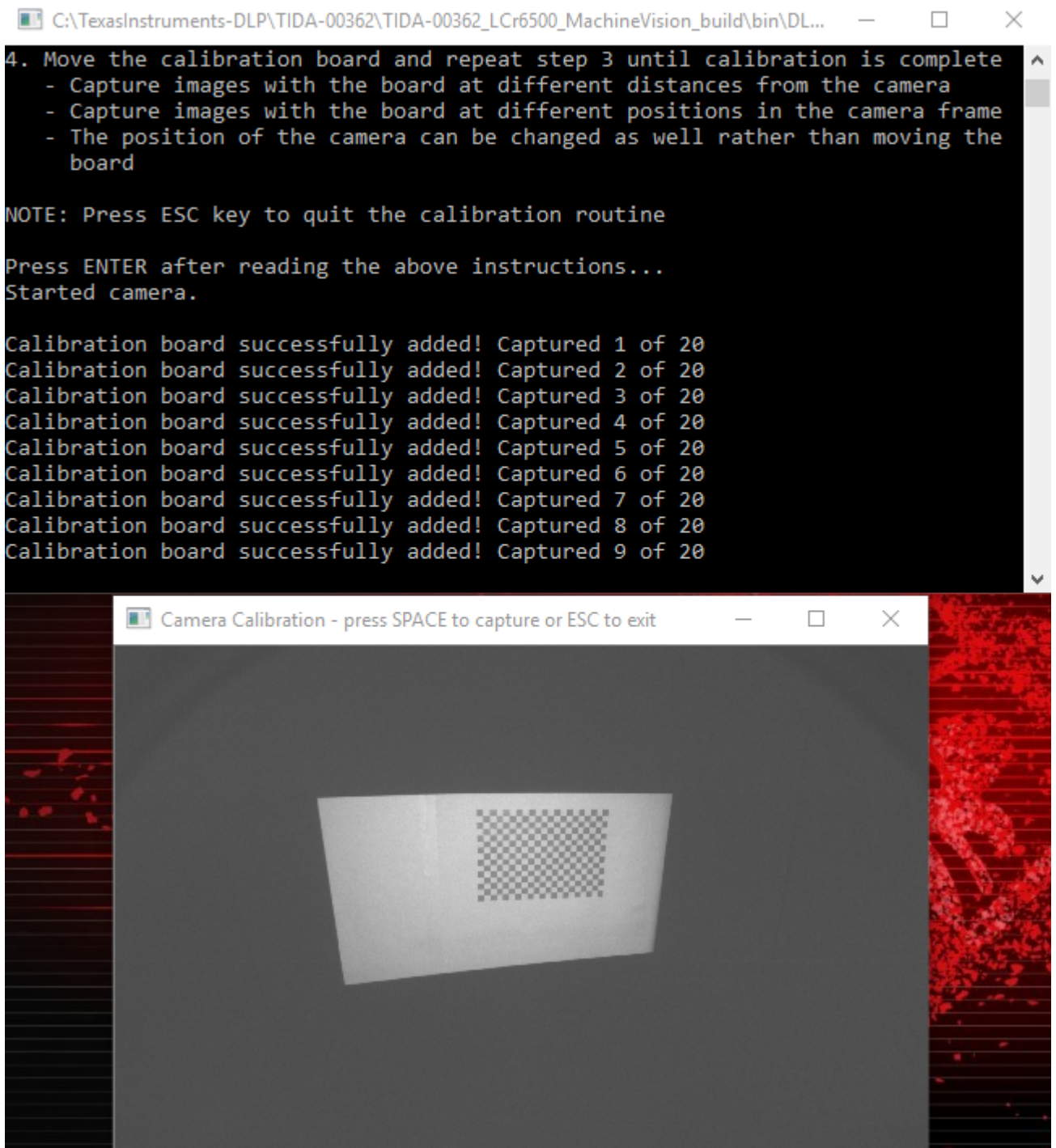
j. Calibration Image 7



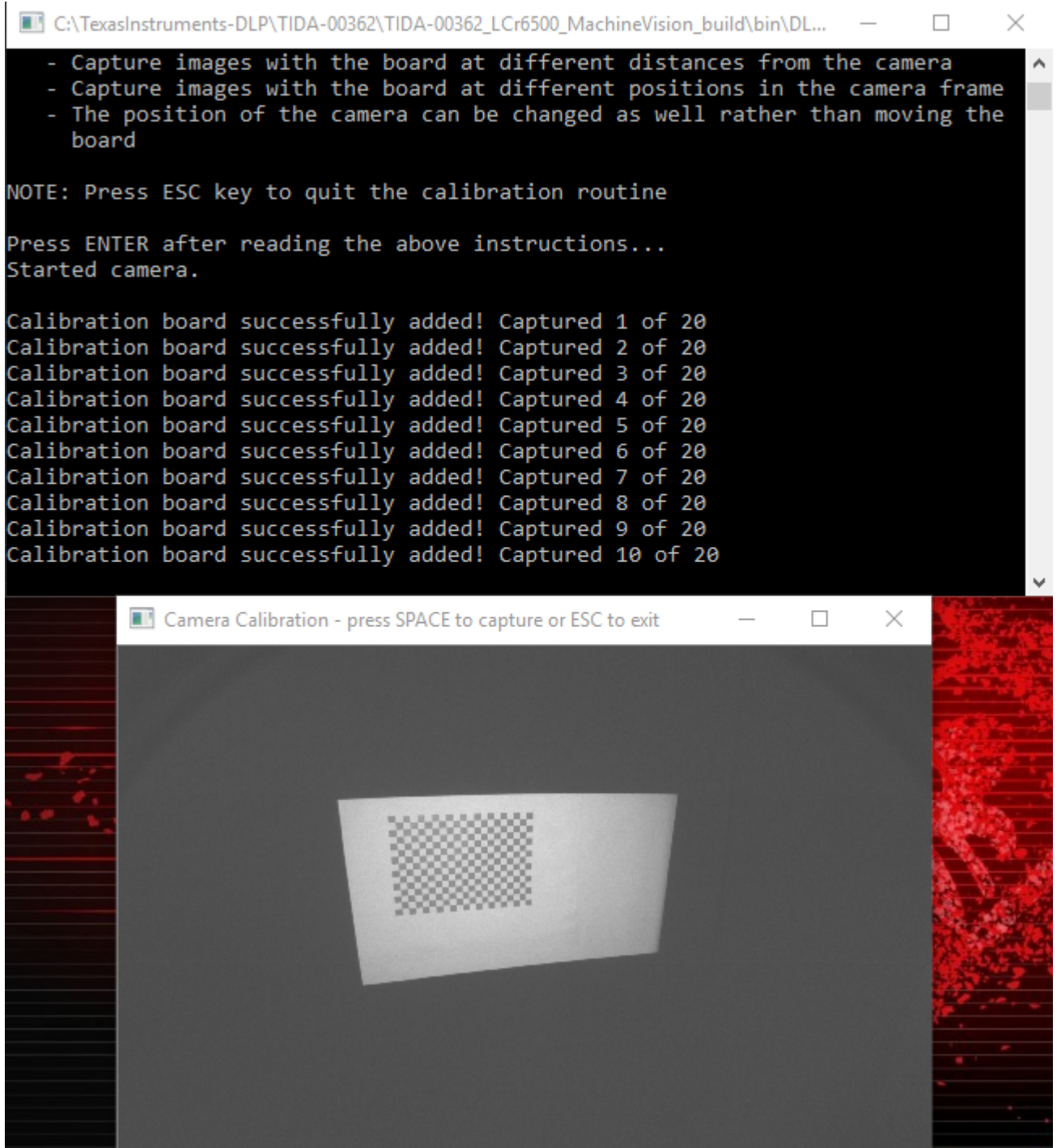
k. Calibration Image 8



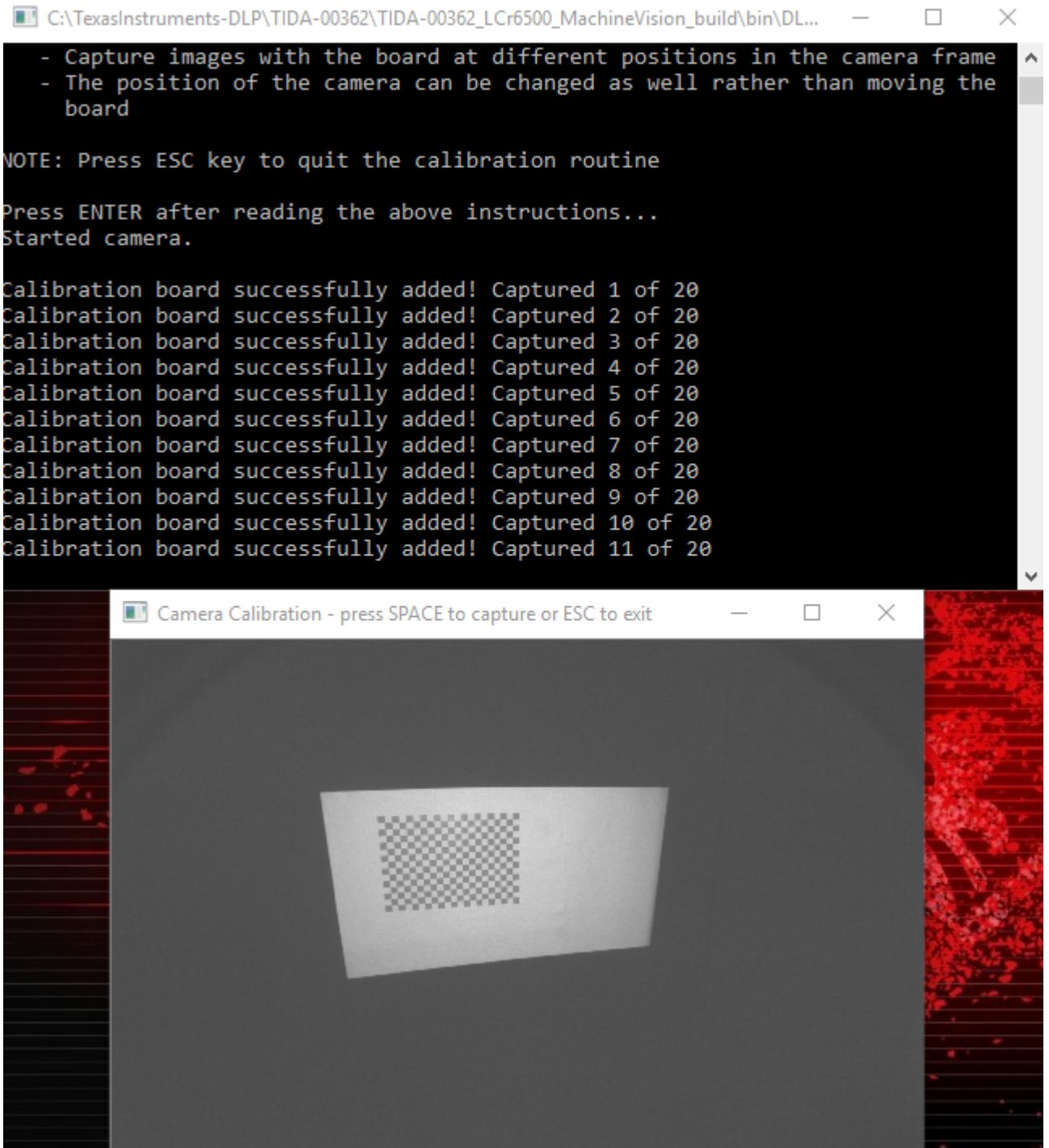
I. Calibration Image 9



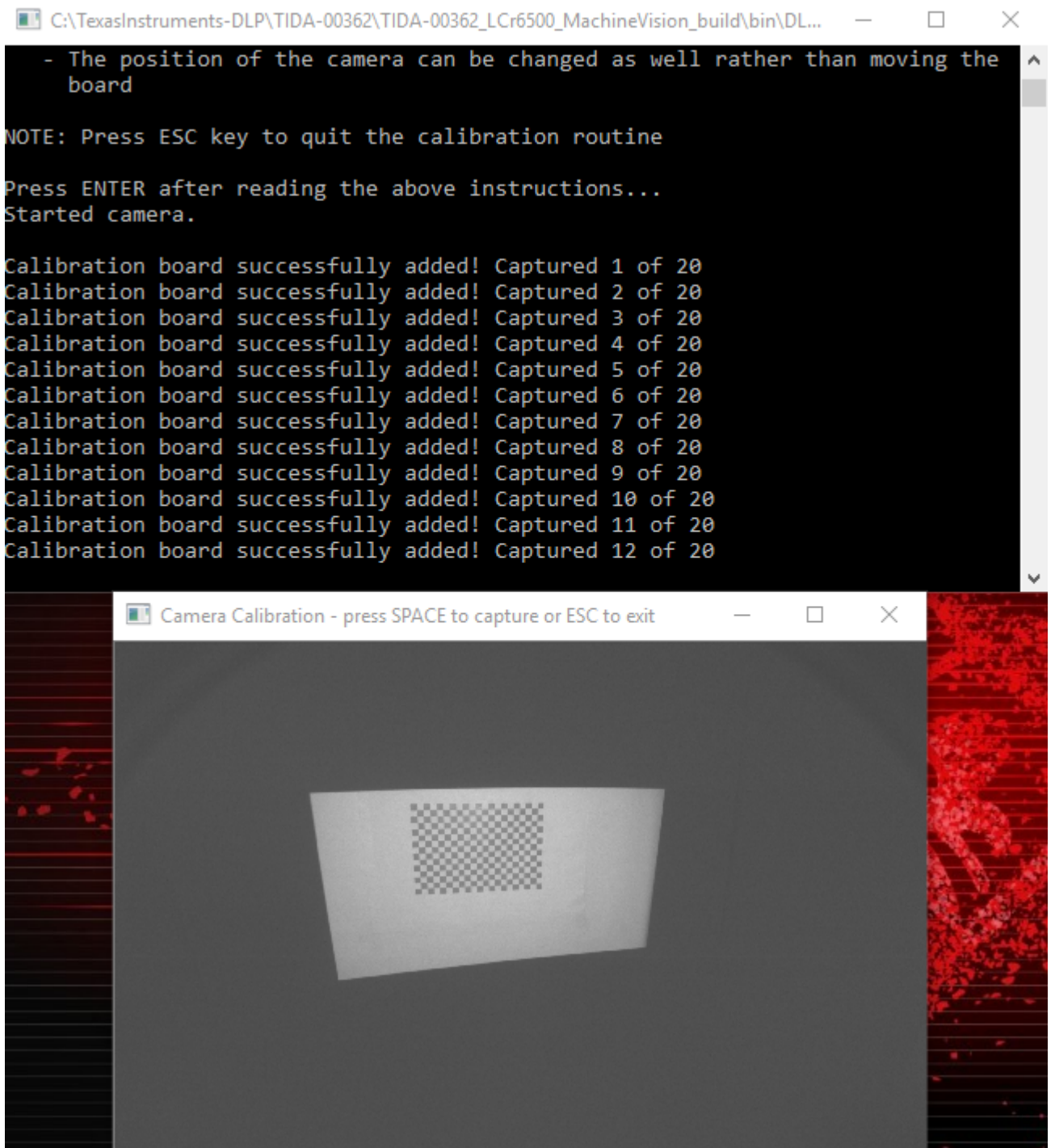
m. Calibration Image 10



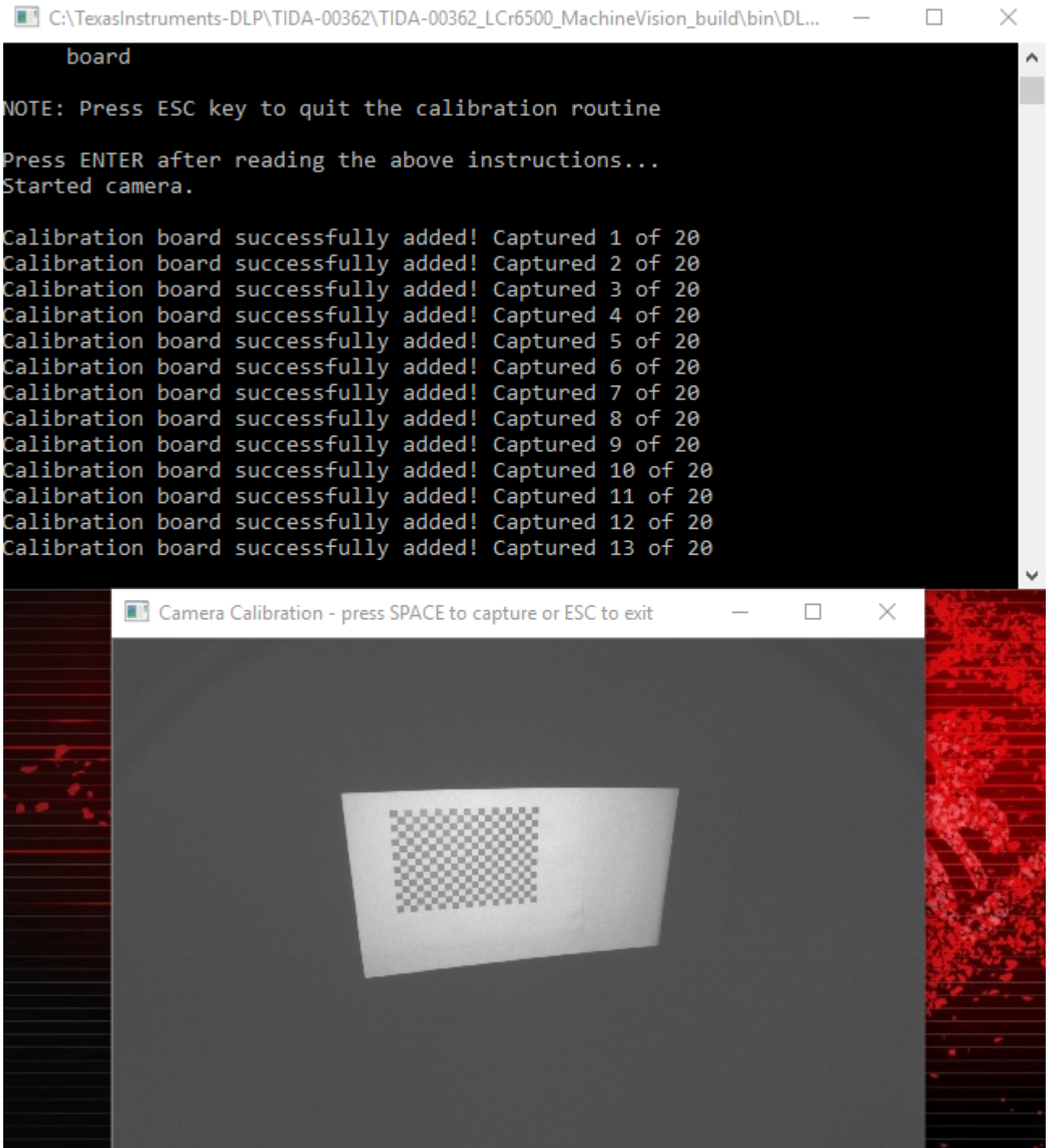
n. Calibration Image 11



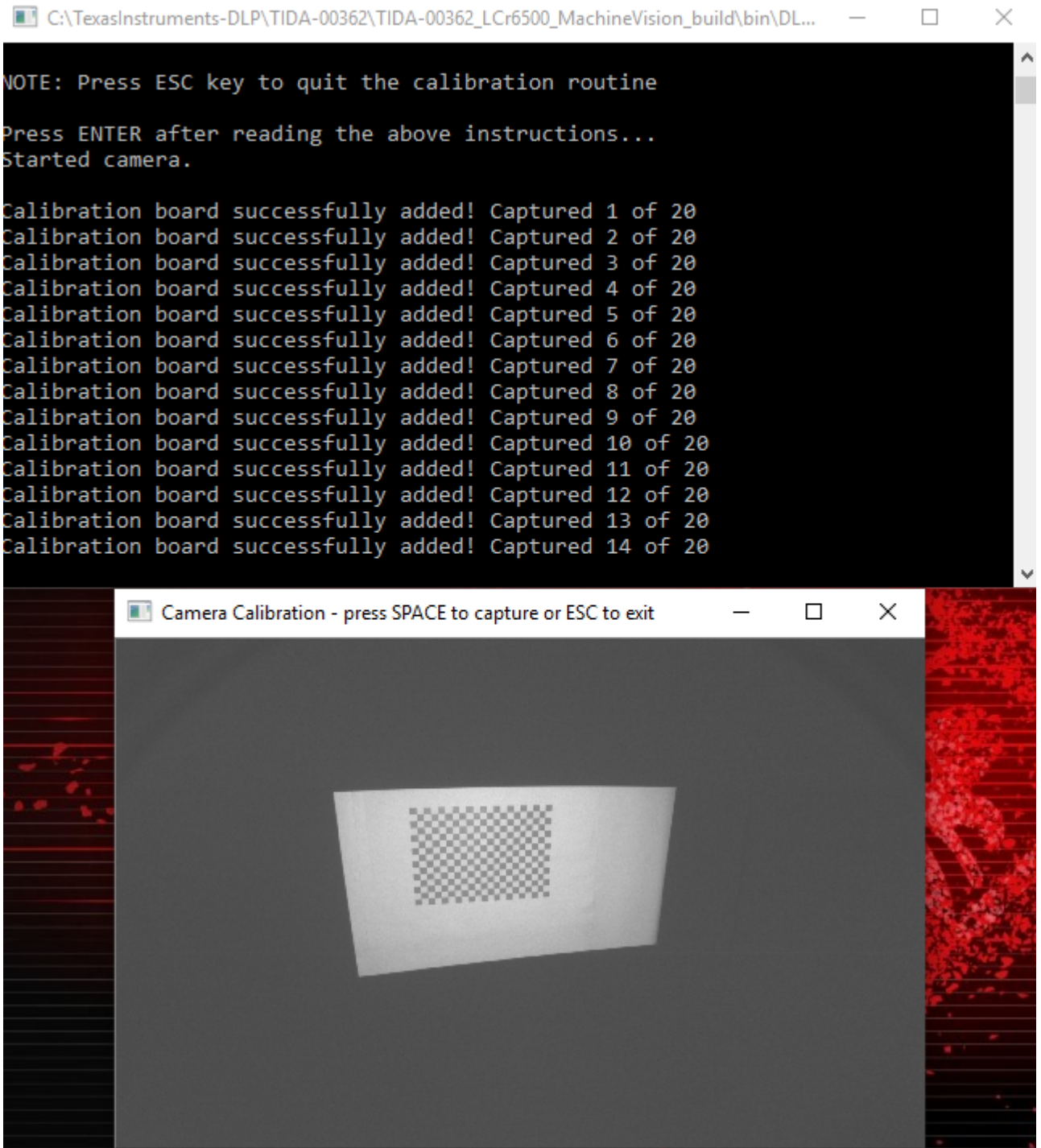
o. Calibration Image 12



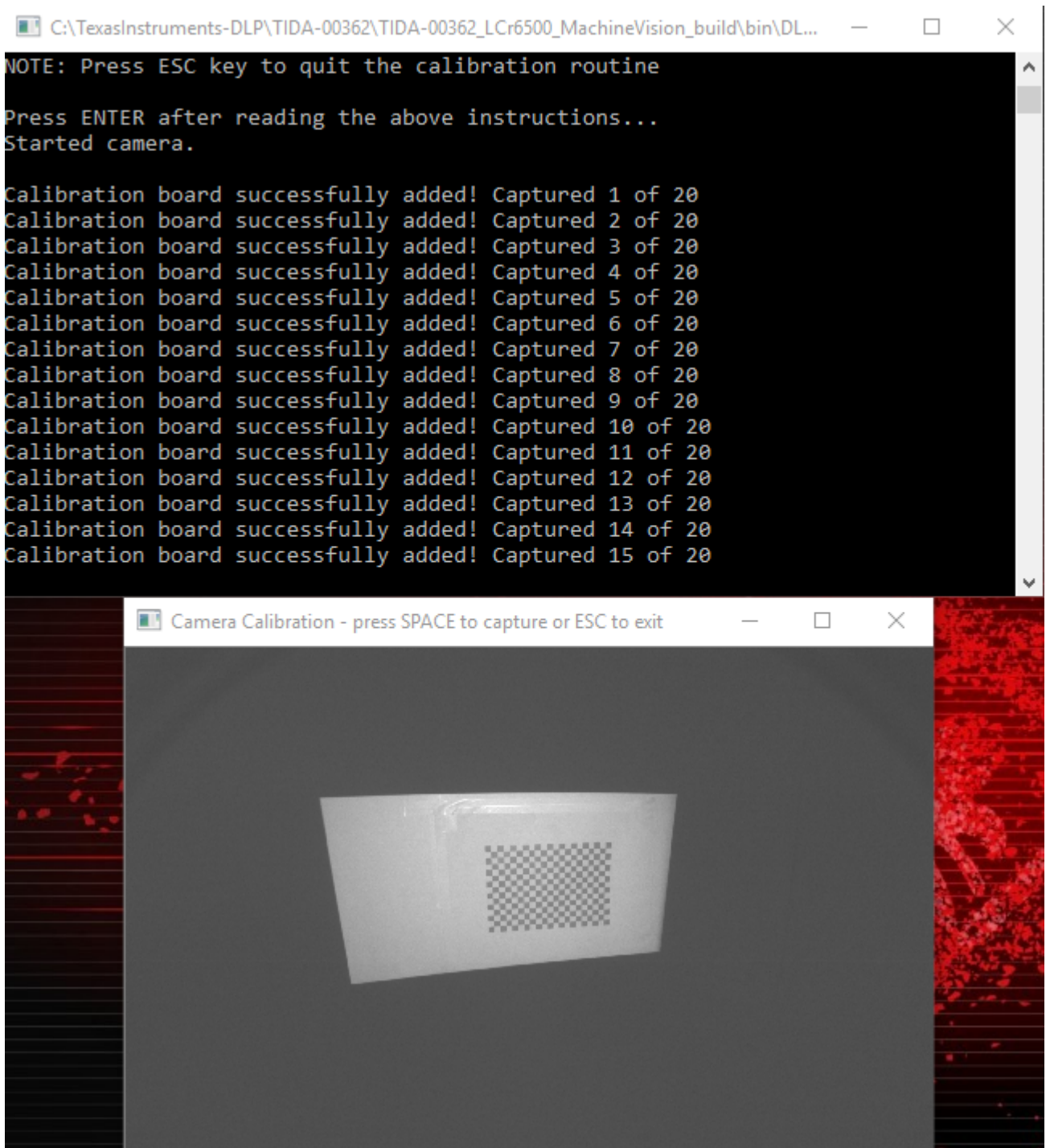
p. Calibration Image 13



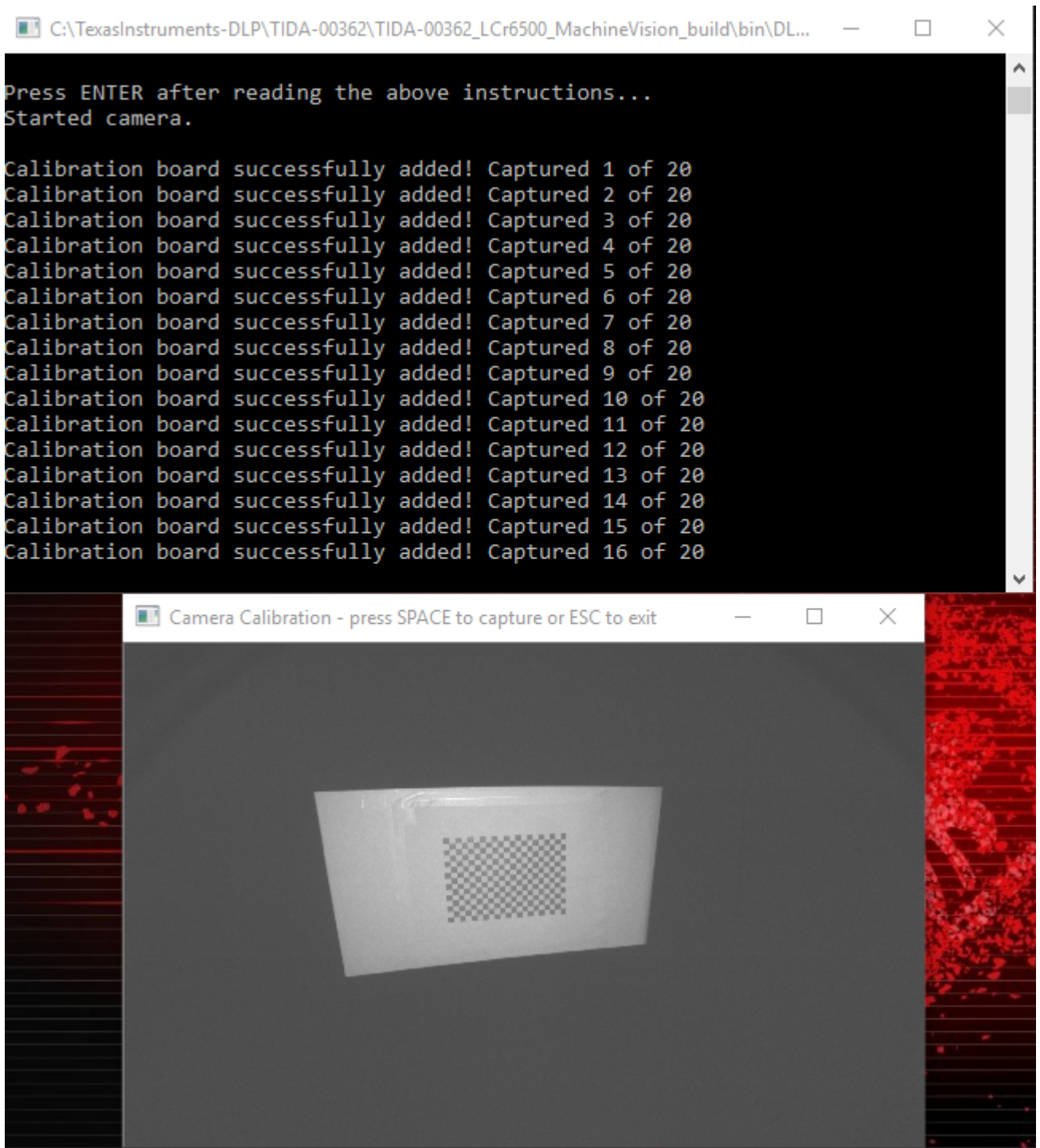
q. Calibration Image 14



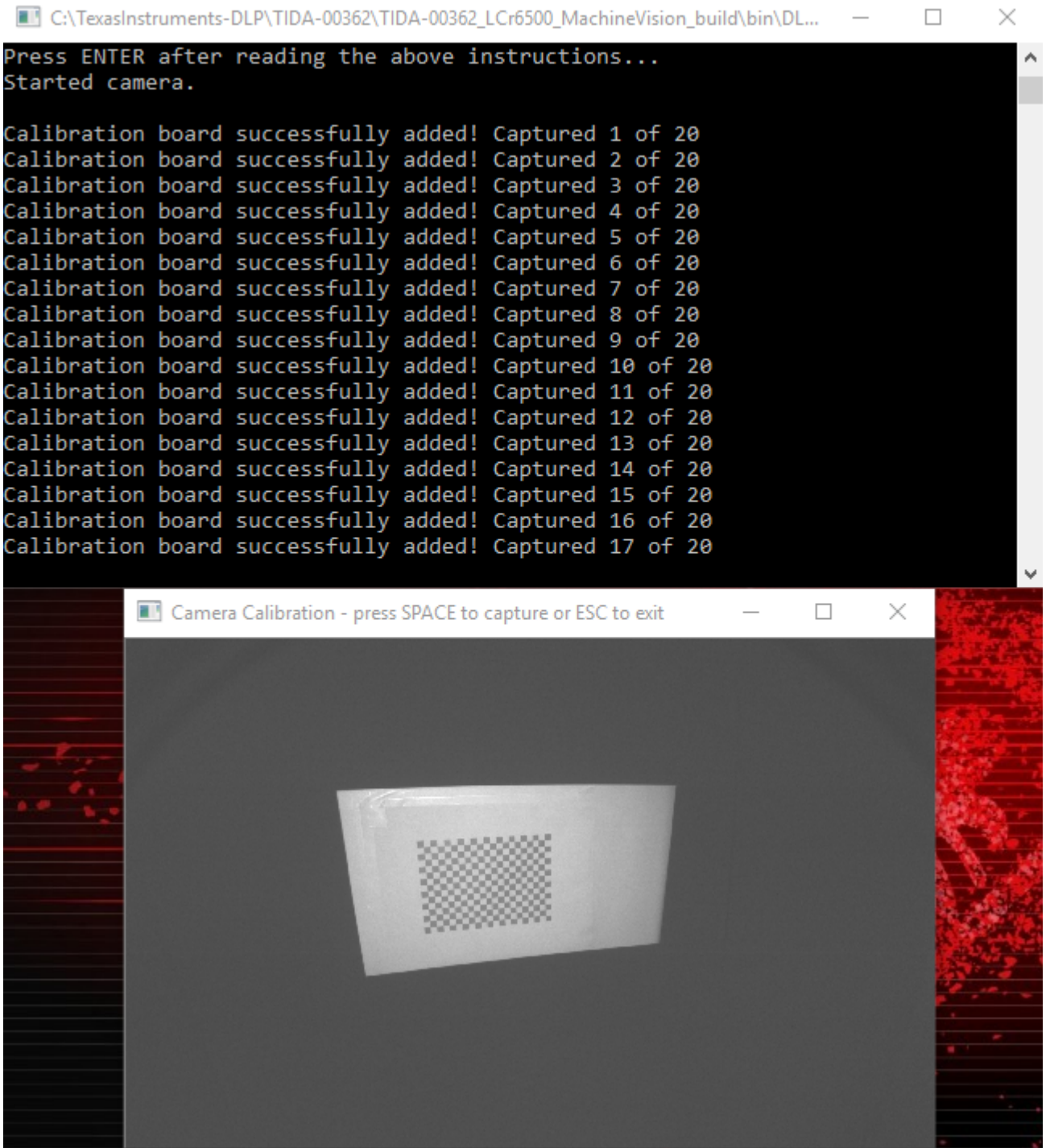
r. Calibration Image 15



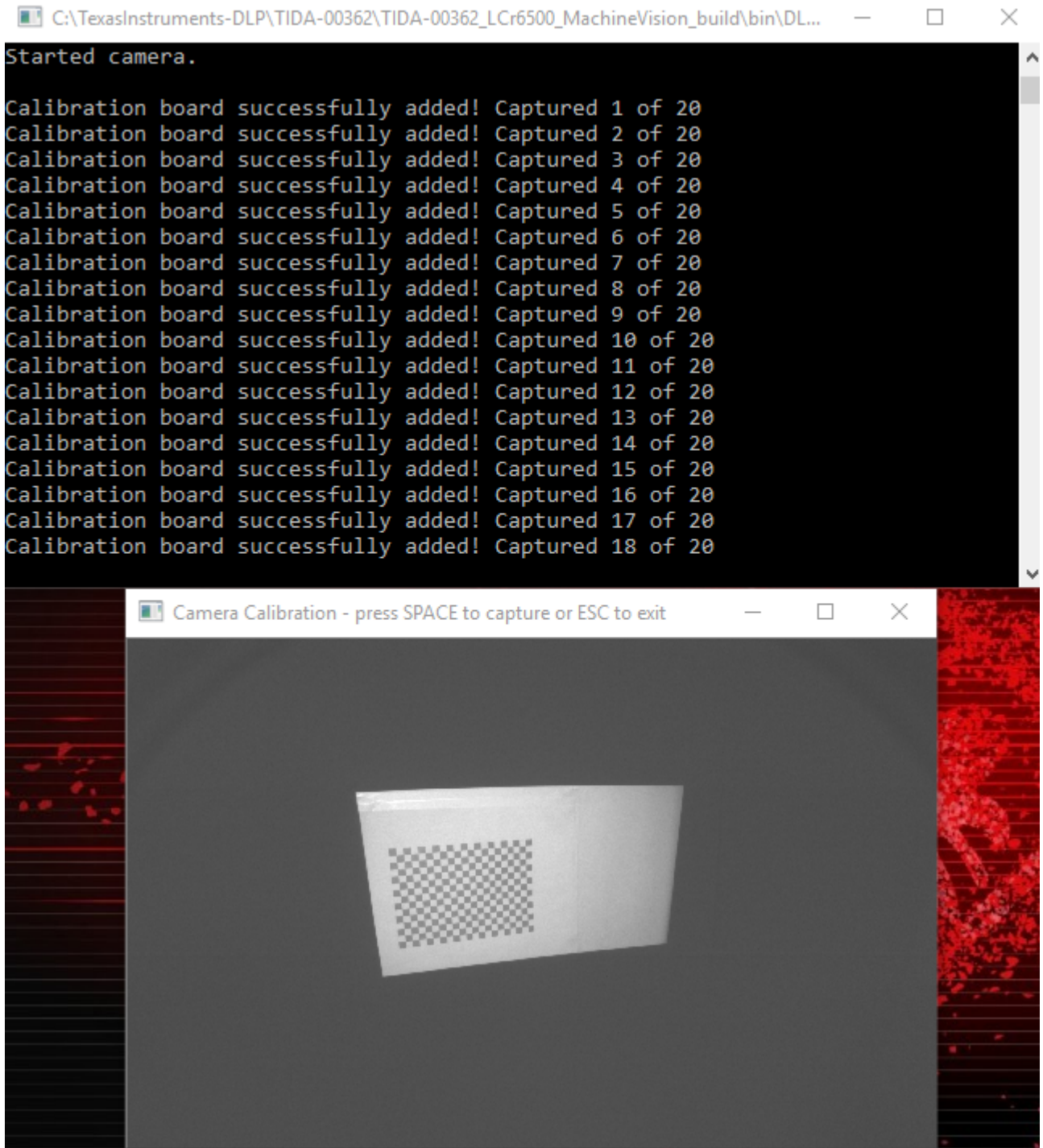
s. Calibration Image 16



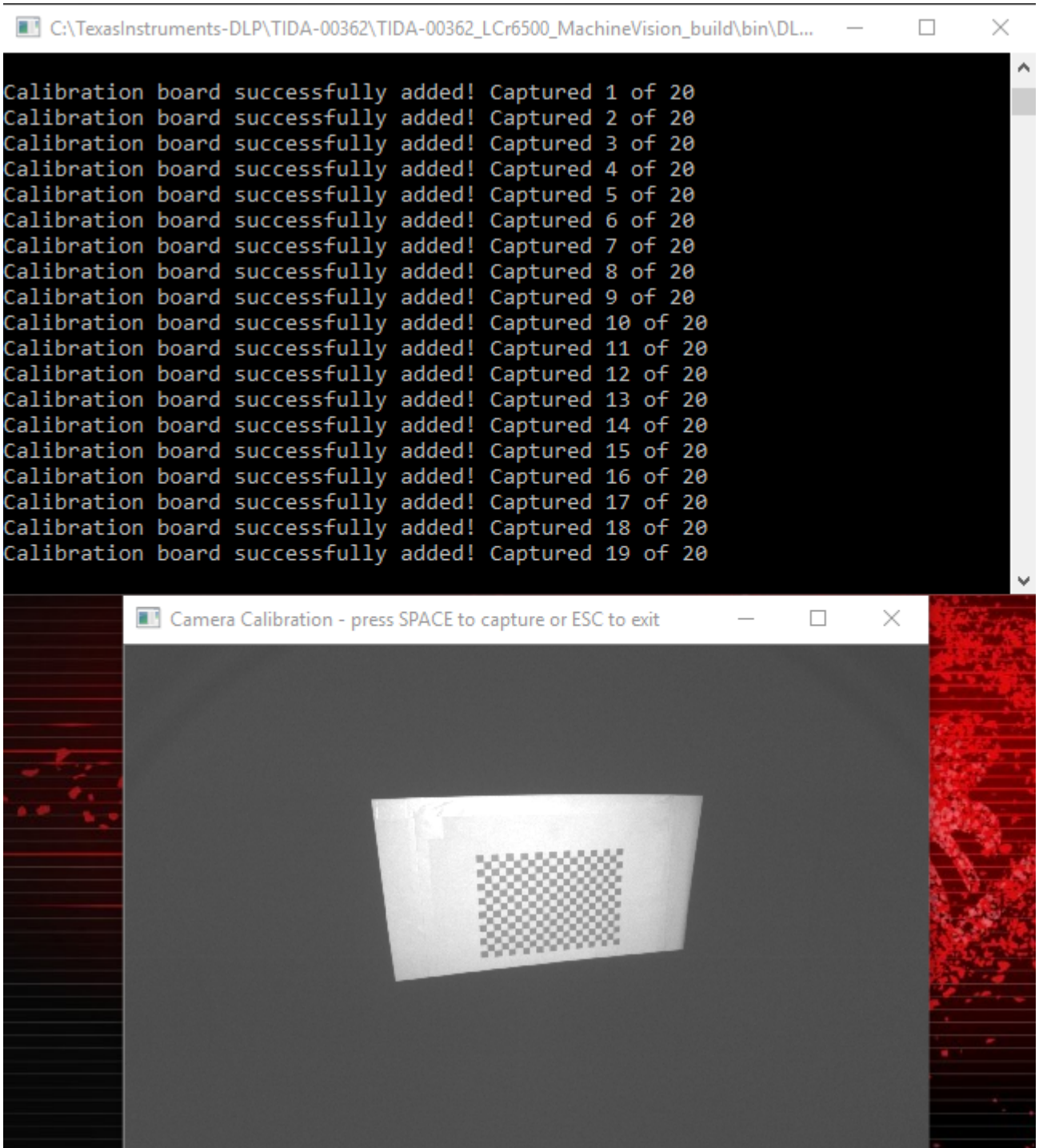
t. Calibration Image 17



u. Calibration Image 18



v. Calibration Image 19



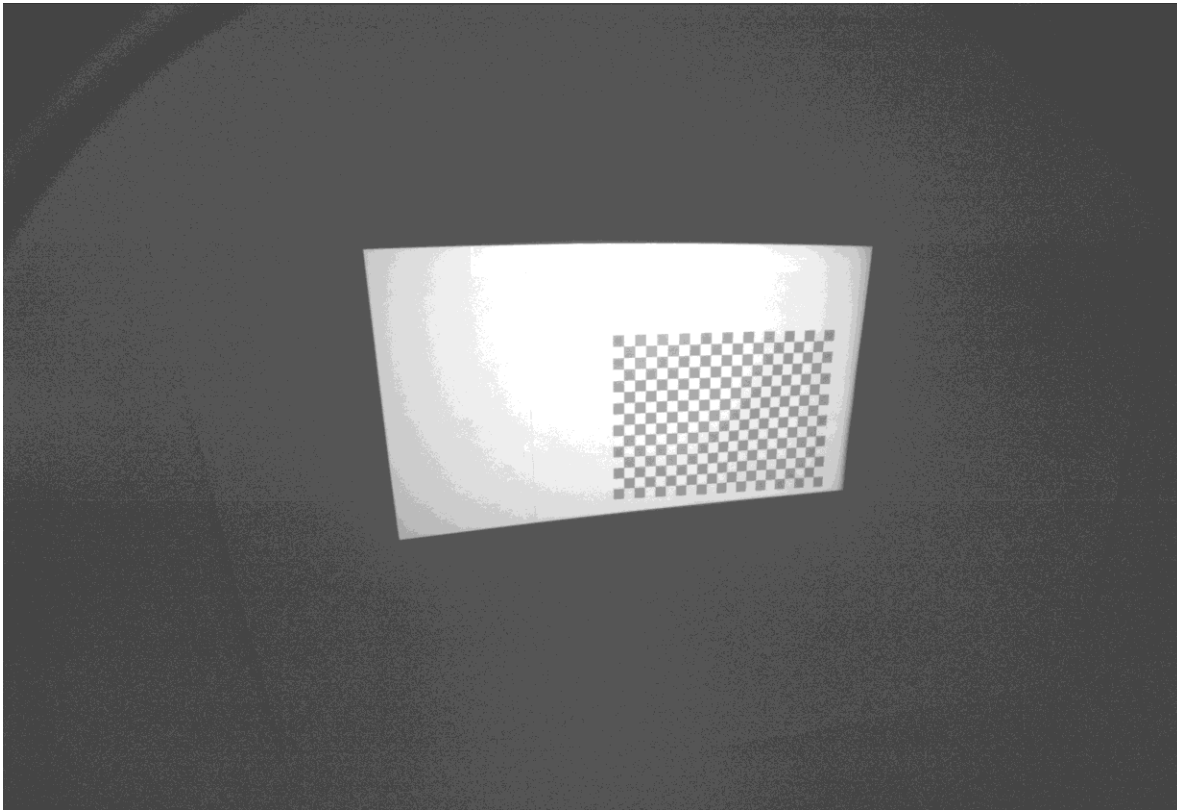
w. Calibration Image 20

```
C:\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LCr6500_MachineVision_build\bin\DL...
Calibration board successfully added! Captured 14 of 20
Calibration board successfully added! Captured 15 of 20
Calibration board successfully added! Captured 16 of 20
Calibration board successfully added! Captured 17 of 20
Calibration board successfully added! Captured 18 of 20
Calibration board successfully added! Captured 19 of 20
Calibration board successfully added! Captured 20 of 20
Camera was successfully calibrated!

Reprojection error (closer to zero is better) = 0.544408
Camera calibration data saved to :calibration/data/camera.xml

Texas Instruments DLP Commandline 3D Scanner

0: Exit
1: Generate camera calibration board and enter feature measurements
2: Reserved
3: Prepare system for calibration and scanning
4: Calibrate camera
```



x. Calibration is finished with 0.544408 Reprojection error.

4. Calibrating System. I will provide the screenshots along with the actual output images below

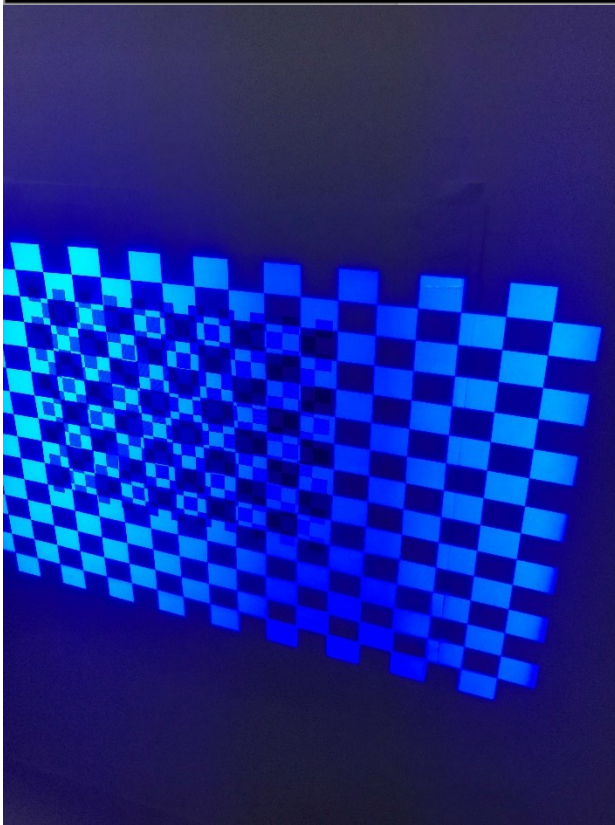
a. I press 5 to start the process and focus the projector

```
C:\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LCr6500_MachineVision_build\bin\DL...  -  □  X
1: Generate camera calibration board and enter feature measurements
2: Reserved
3: Prepare system for calibration and scanning
4: Calibrate camera
5: Calibrate system
6: Perform scan (vertical patterns only)
7: Perform scan (horizontal patterns only)
8: Perform scan (vertical and horizontal patterns)
9: Reconnect camera and projector

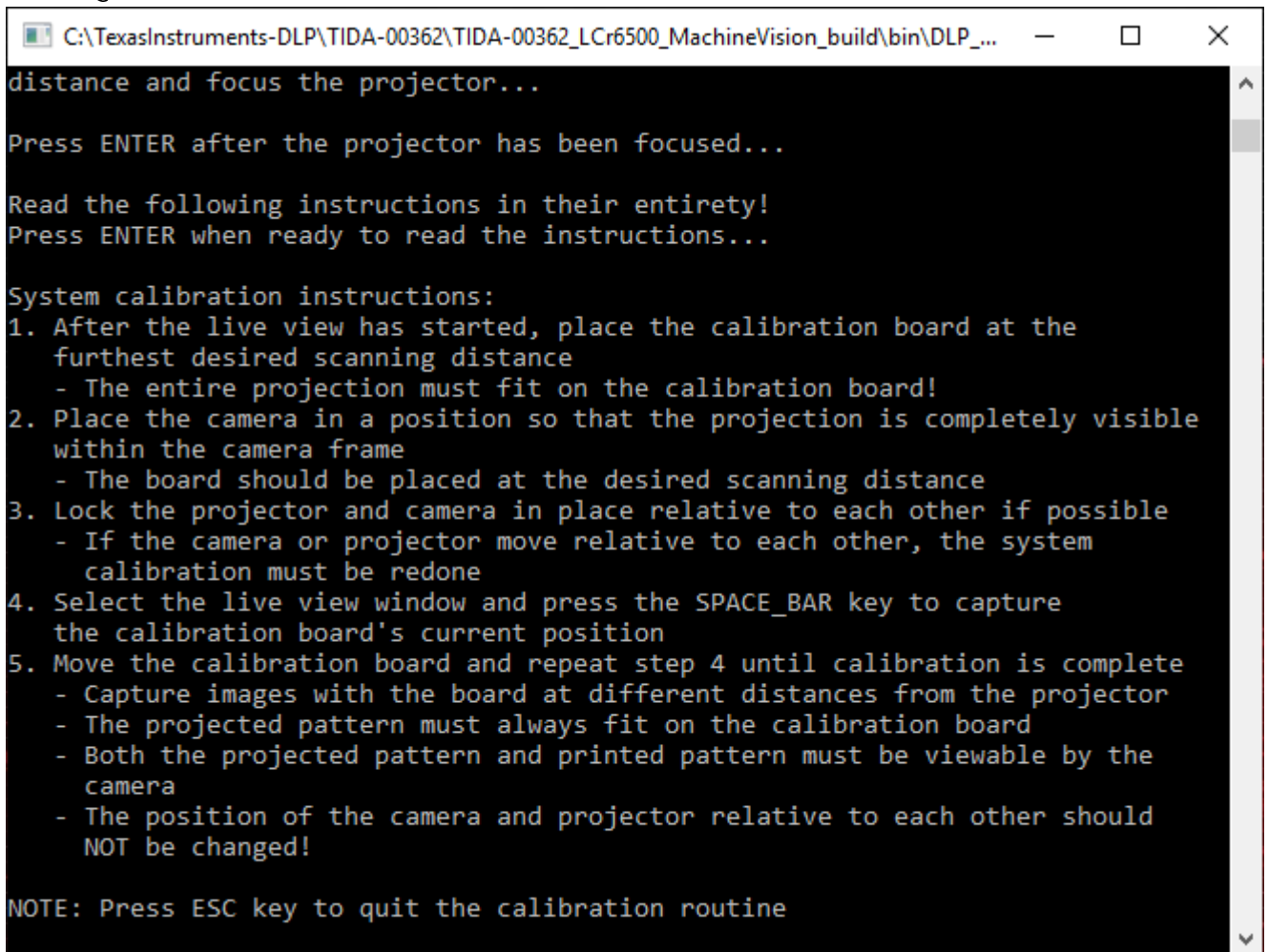
Select menu item: 5
Loading camera calibration settings...
Loading projector calibration settings...
Setting up camera calibration...
Setting up projector calibration...

Place the calibration board at the desired scanning
distance and focus the projector...

Press ENTER after the projector has been focused..._
```



b. Enter again to start the calibration



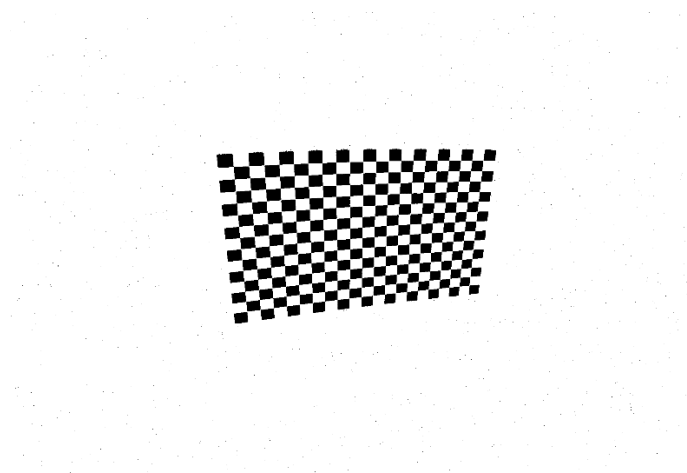
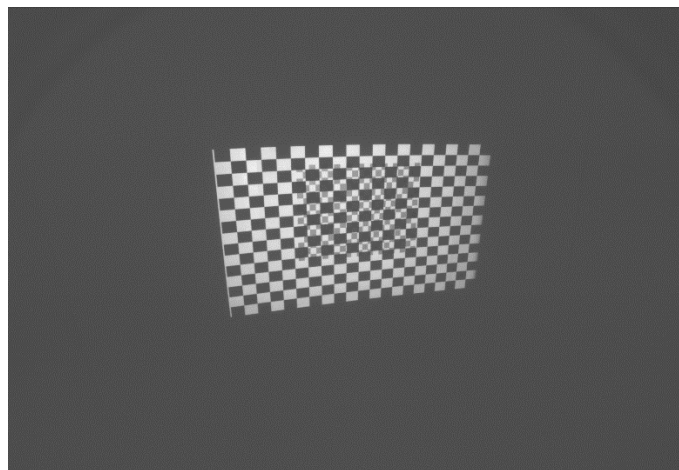
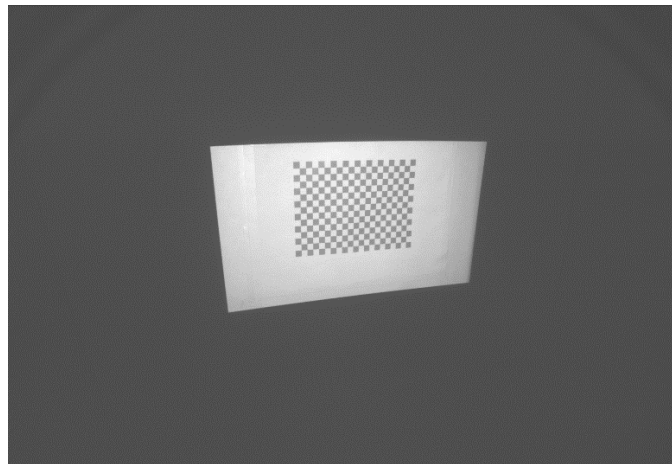
```
C:\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LCr6500_MachineVision_build\bin\DLP_...  -  □  ×
distance and focus the projector...
Press ENTER after the projector has been focused...
Read the following instructions in their entirety!
Press ENTER when ready to read the instructions...

System calibration instructions:
1. After the live view has started, place the calibration board at the
   furthest desired scanning distance
   - The entire projection must fit on the calibration board!
2. Place the camera in a position so that the projection is completely visible
   within the camera frame
   - The board should be placed at the desired scanning distance
3. Lock the projector and camera in place relative to each other if possible
   - If the camera or projector move relative to each other, the system
     calibration must be redone
4. Select the live view window and press the SPACE_BAR key to capture
   the calibration board's current position
5. Move the calibration board and repeat step 4 until calibration is complete
   - Capture images with the board at different distances from the projector
   - The projected pattern must always fit on the calibration board
   - Both the projected pattern and printed pattern must be viewable by the
     camera
   - The position of the camera and projector relative to each other should
     NOT be changed!

NOTE: Press ESC key to quit the calibration routine
```

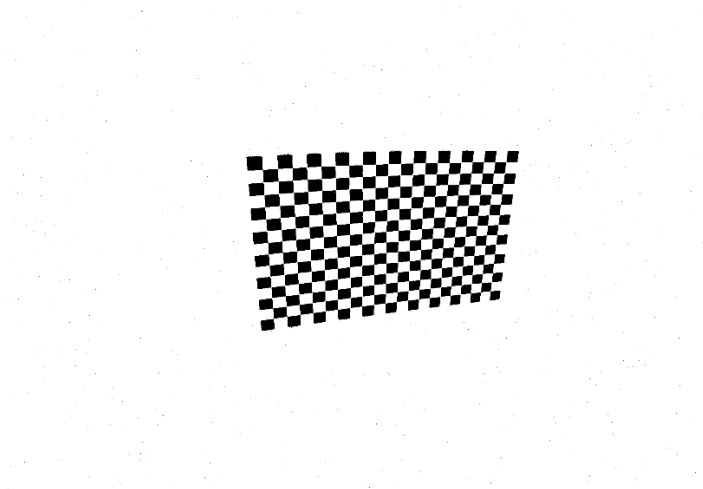
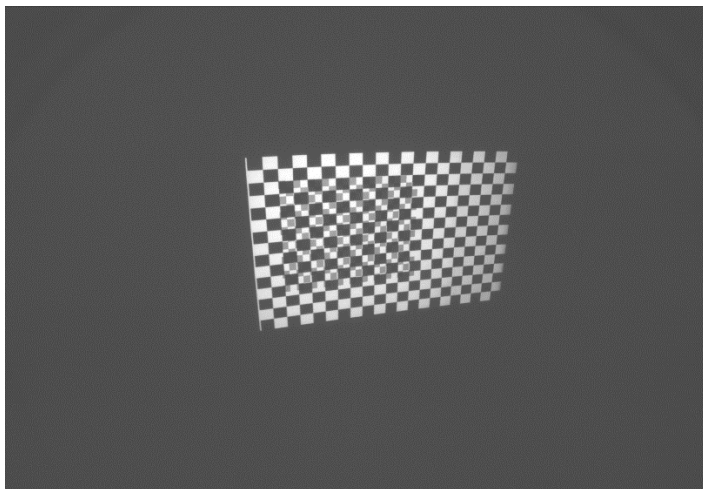
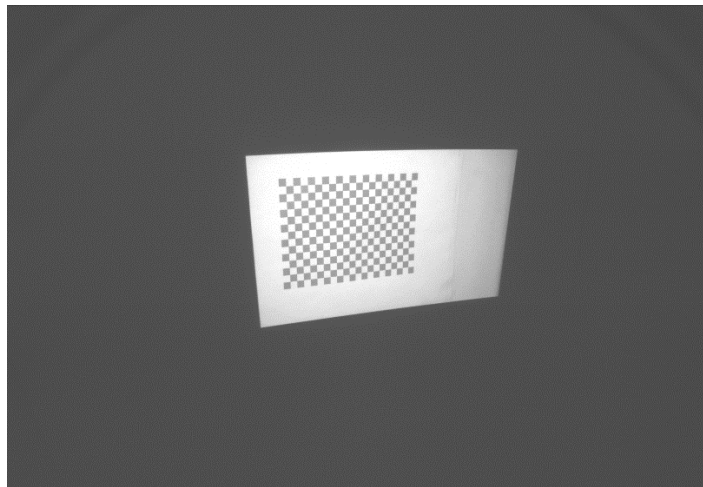
c. Set of Images #1

```
CA:\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LCr6500_MachineVision_build\bin\DLP...  
NOTE: Press ESC key to quit the calibration routine  
Press ENTER after reading the above instructions...  
Camera calibration board successfully added! Captured 1 of 10  
Projector calibration board successfully added! Captured 1 of 10
```



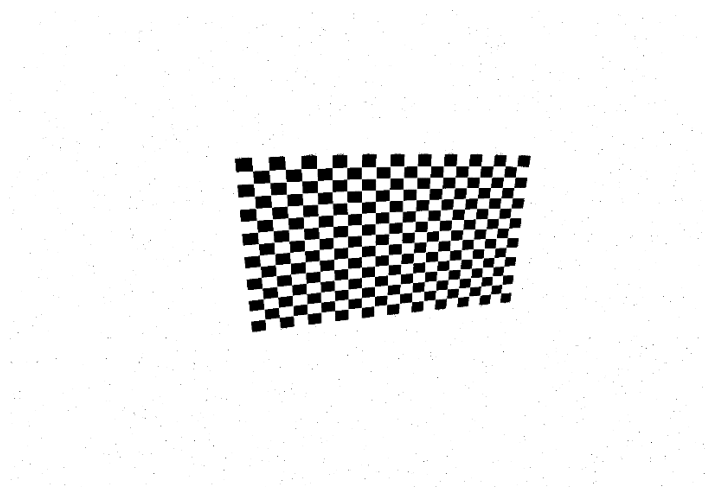
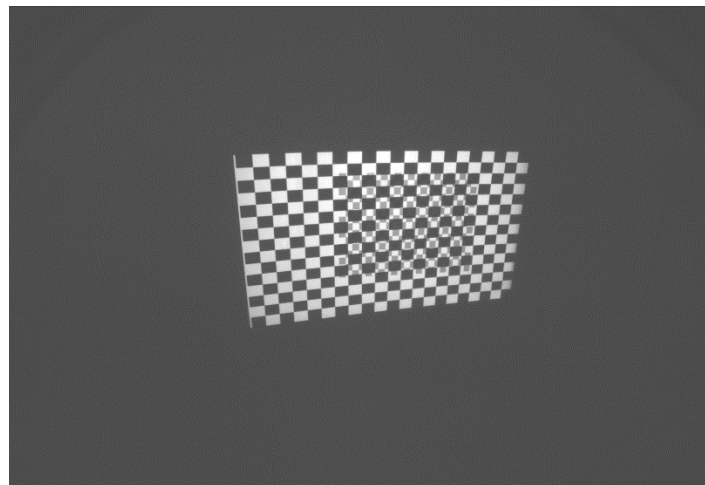
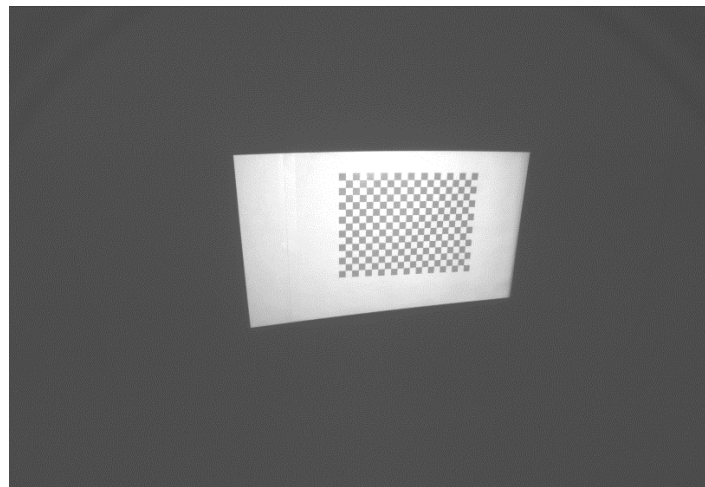
d. Set of Images #2

```
C:\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LCr6500_MachineVision_build\bin\DLP_...  
NOTE: Press ESC key to quit the calibration routine  
Press ENTER after reading the above instructions...  
Camera calibration board successfully added! Captured 1 of 10  
Projector calibration board successfully added! Captured 1 of 10  
Camera calibration board successfully added! Captured 2 of 10  
Projector calibration board successfully added! Captured 2 of 10  
_
```



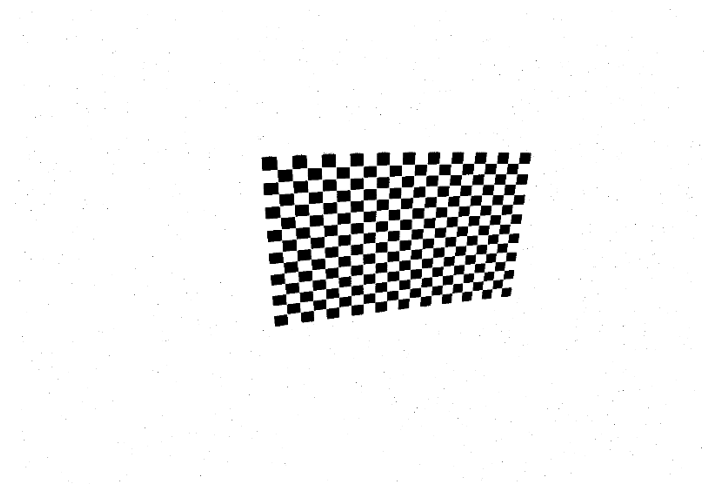
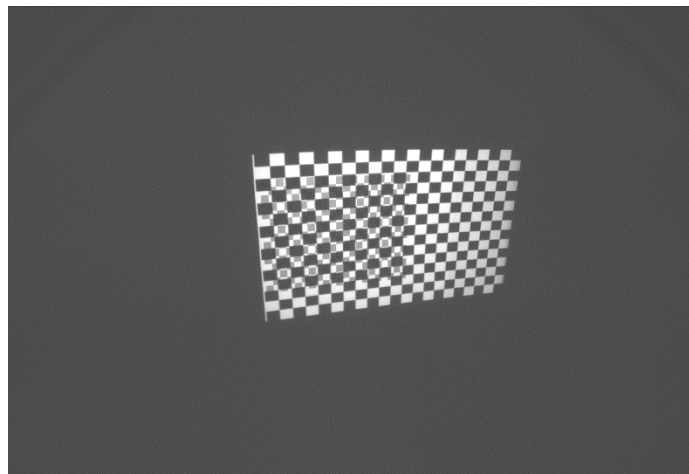
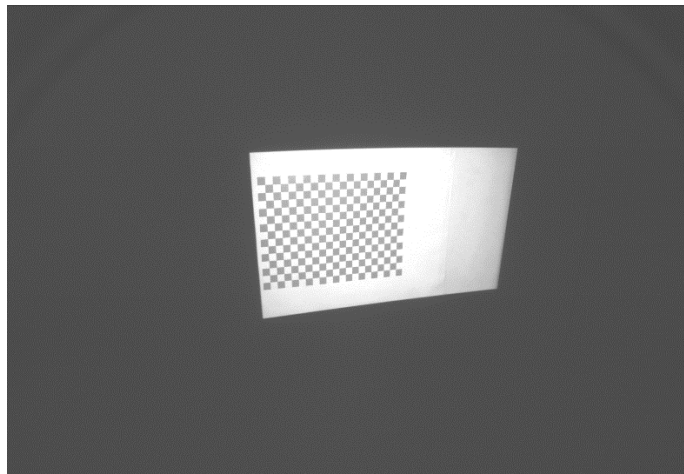
e. Set of Images #3

```
C:\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LCr6500_MachineVision_build\bin\DLP_...  
NOTE: Press ESC key to quit the calibration routine  
Press ENTER after reading the above instructions...  
Camera calibration board successfully added! Captured 1 of 10  
Projector calibration board successfully added! Captured 1 of 10  
Camera calibration board successfully added! Captured 2 of 10  
Projector calibration board successfully added! Captured 2 of 10  
Camera calibration board successfully added! Captured 3 of 10  
Projector calibration board successfully added! Captured 3 of 10
```



f. Set of Images #4

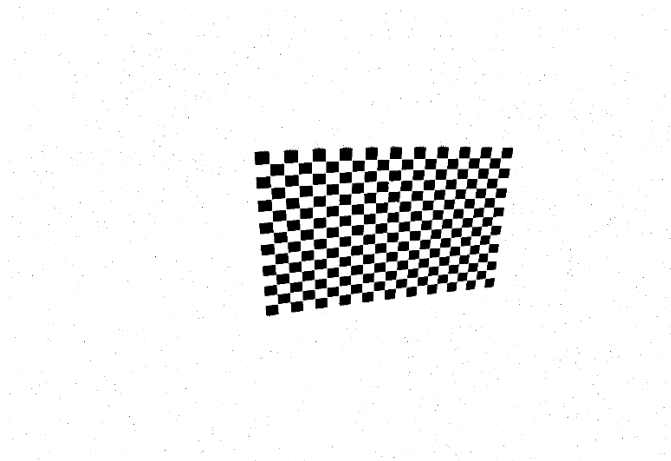
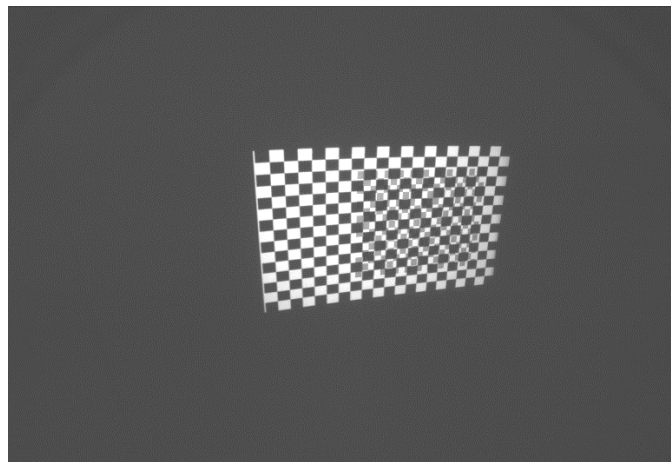
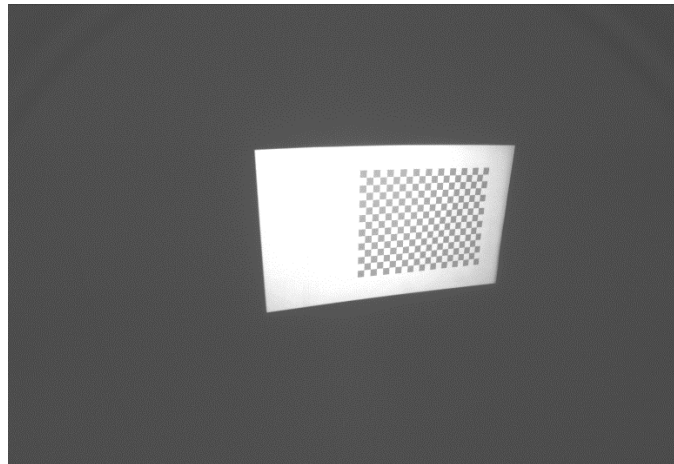
```
C:\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LCr6500_MachineVision_build\bin\DLP_...  
NOTE: Press ESC key to quit the calibration routine  
Press ENTER after reading the above instructions...  
Camera calibration board successfully added! Captured 1 of 10  
Projector calibration board successfully added! Captured 1 of 10  
Camera calibration board successfully added! Captured 2 of 10  
Projector calibration board successfully added! Captured 2 of 10  
Camera calibration board successfully added! Captured 3 of 10  
Projector calibration board successfully added! Captured 3 of 10  
Camera calibration board successfully added! Captured 4 of 10  
Projector calibration board successfully added! Captured 4 of 10
```



g. Set of Images #5

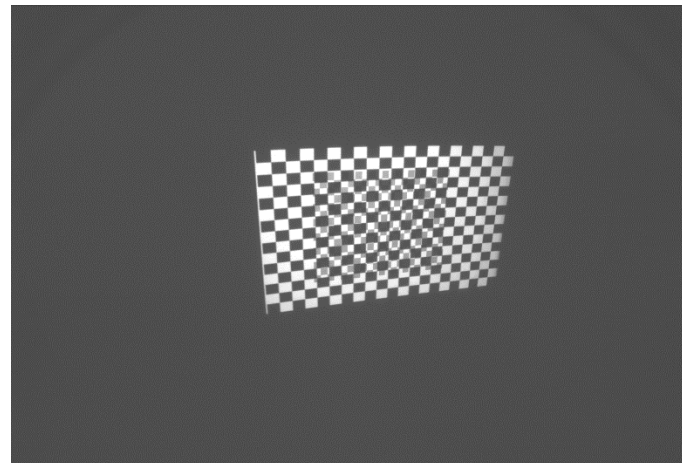
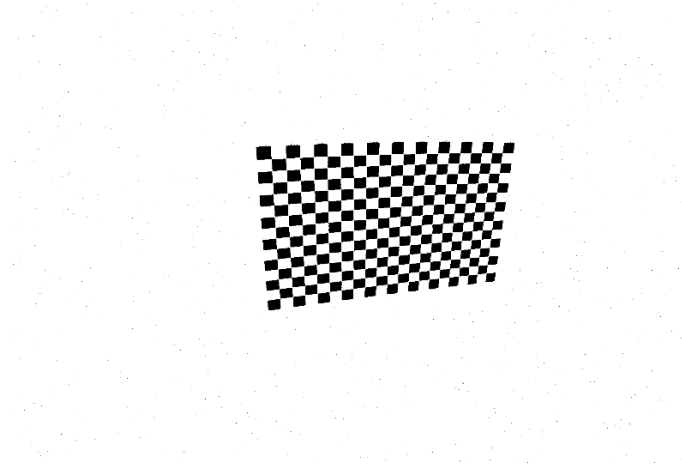
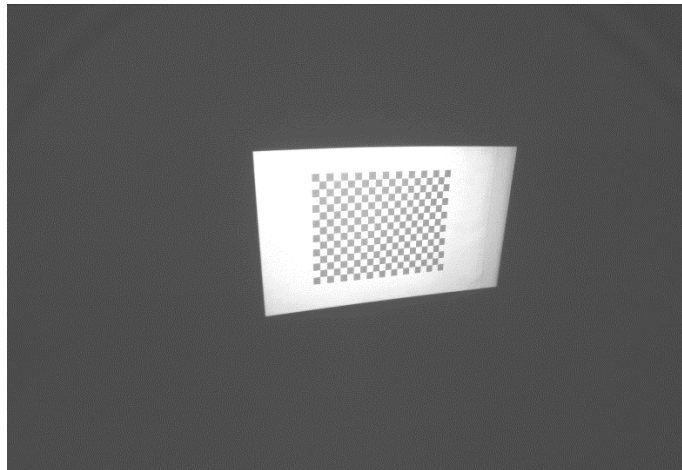
```
CA:\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LCr6500_MachineVision_build\bin\DLP...
NOTE: Press ESC key to quit the calibration routine

Press ENTER after reading the above instructions...
Camera calibration board successfully added! Captured 1 of 10
Projector calibration board successfully added! Captured 1 of 10
Camera calibration board successfully added! Captured 2 of 10
Projector calibration board successfully added! Captured 2 of 10
Camera calibration board successfully added! Captured 3 of 10
Projector calibration board successfully added! Captured 3 of 10
Camera calibration board successfully added! Captured 4 of 10
Projector calibration board successfully added! Captured 4 of 10
Camera calibration board successfully added! Captured 5 of 10
Projector calibration board successfully added! Captured 5 of 10
```



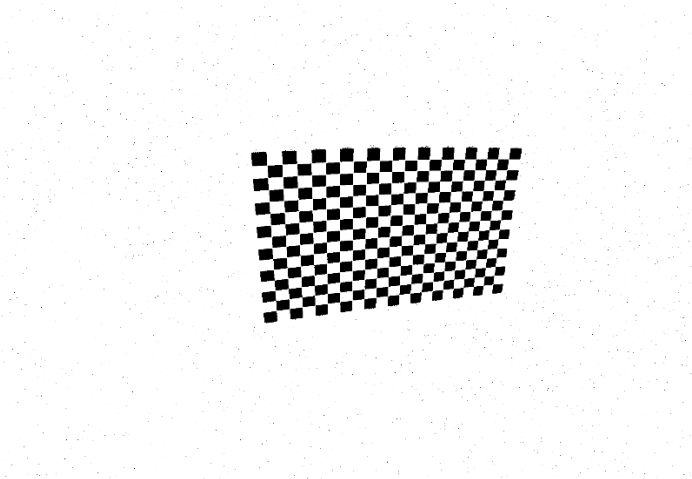
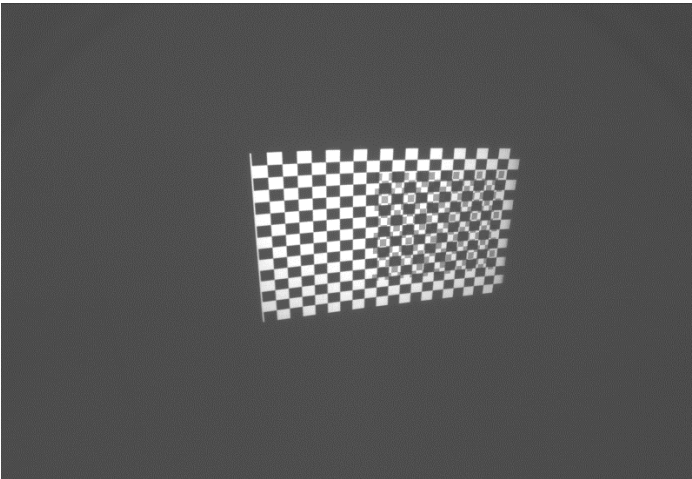
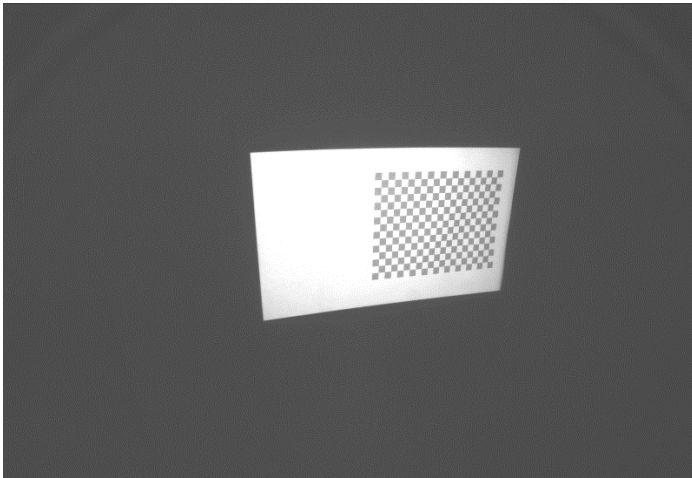
h. Set of Images #6

```
CA\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LCr6500_MachineVision_build\bin\DLP...  
Press ENTER after reading the above instructions...  
Camera calibration board successfully added! Captured 1 of 10  
Projector calibration board successfully added! Captured 1 of 10  
Camera calibration board successfully added! Captured 2 of 10  
Projector calibration board successfully added! Captured 2 of 10  
Camera calibration board successfully added! Captured 3 of 10  
Projector calibration board successfully added! Captured 3 of 10  
Camera calibration board successfully added! Captured 4 of 10  
Projector calibration board successfully added! Captured 4 of 10  
Camera calibration board successfully added! Captured 5 of 10  
Projector calibration board successfully added! Captured 5 of 10  
Camera calibration board successfully added! Captured 6 of 10  
Projector calibration board successfully added! Captured 6 of 10
```



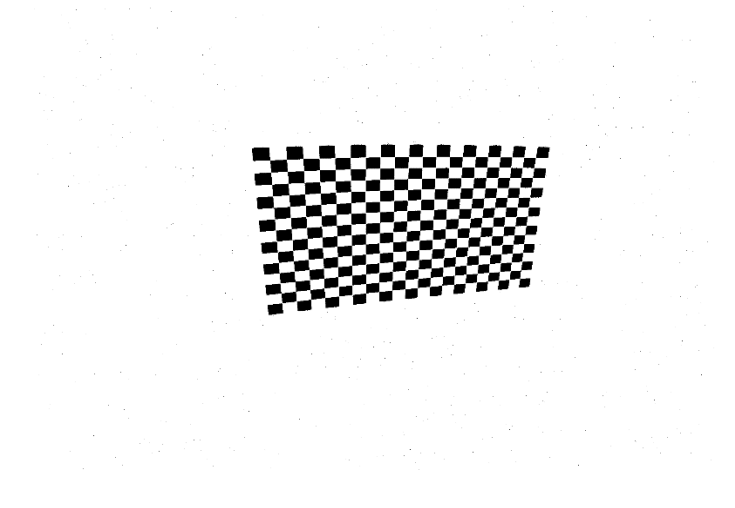
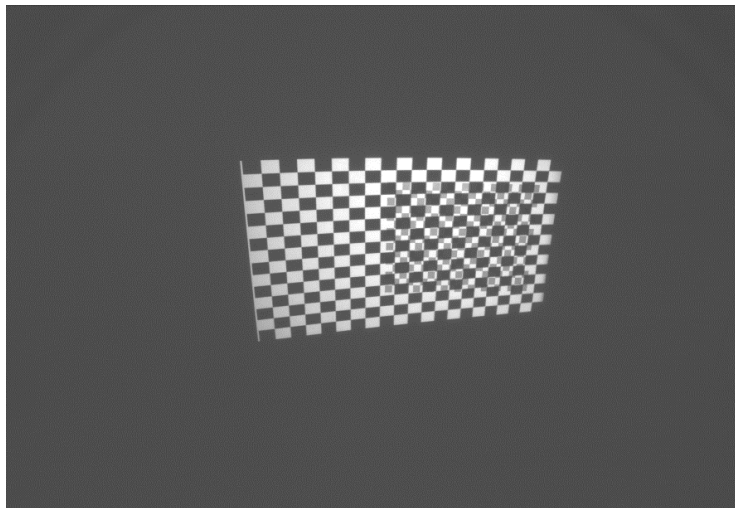
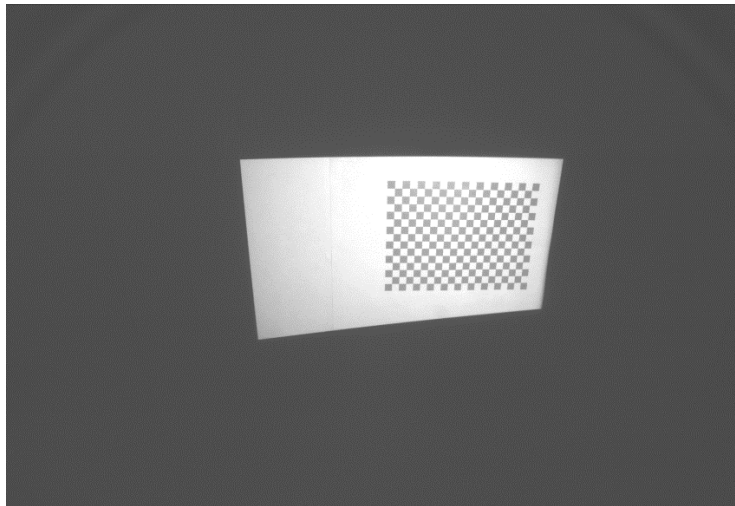
i. Set of Images #7

```
C:\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LC\6500_MachineVision_build\bin\DLP...  
Projector calibration board successfully added! Captured 1 of 10  
Camera calibration board successfully added! Captured 2 of 10  
Projector calibration board successfully added! Captured 2 of 10  
Camera calibration board successfully added! Captured 3 of 10  
Projector calibration board successfully added! Captured 3 of 10  
Camera calibration board successfully added! Captured 4 of 10  
Projector calibration board successfully added! Captured 4 of 10  
Camera calibration board successfully added! Captured 5 of 10  
Projector calibration board successfully added! Captured 5 of 10  
Camera calibration board successfully added! Captured 6 of 10  
Projector calibration board successfully added! Captured 6 of 10  
Camera calibration board successfully added! Captured 7 of 10  
Projector calibration board successfully added! Captured 7 of 10
```



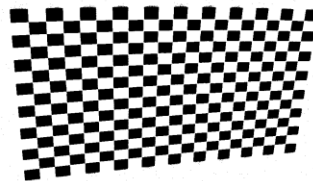
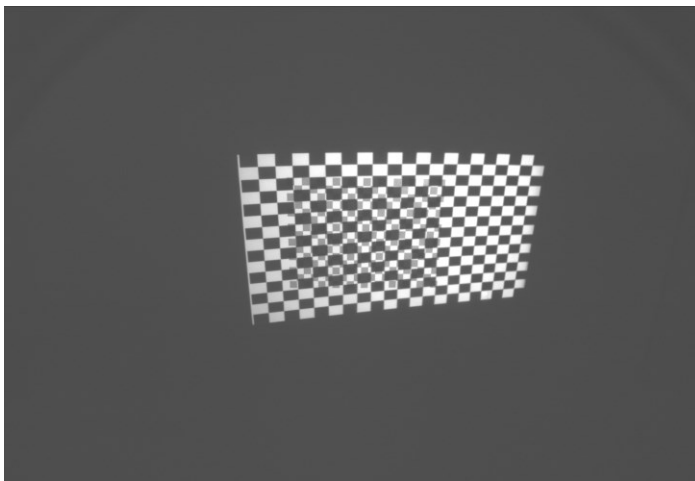
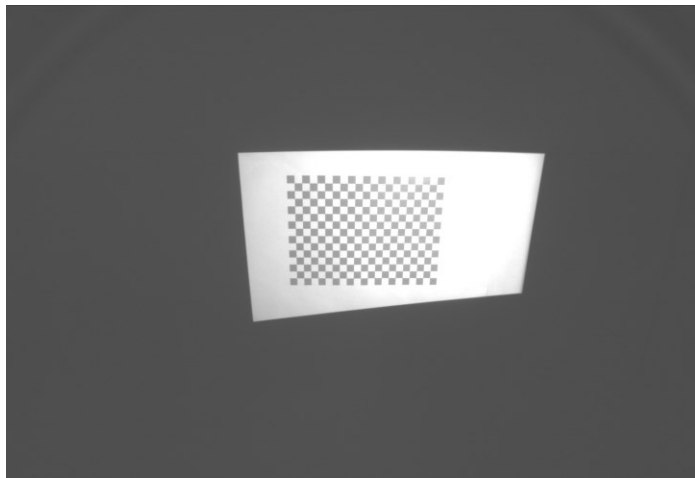
j. Set of Images #8

```
C:\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LCr6500_MachineVision_build\bin\DLP_...  
Projector calibration board successfully added! Captured 2 of 10  
Camera calibration board successfully added! Captured 3 of 10  
Projector calibration board successfully added! Captured 3 of 10  
Camera calibration board successfully added! Captured 4 of 10  
Projector calibration board successfully added! Captured 4 of 10  
Camera calibration board successfully added! Captured 5 of 10  
Projector calibration board successfully added! Captured 5 of 10  
Camera calibration board successfully added! Captured 6 of 10  
Projector calibration board successfully added! Captured 6 of 10  
Camera calibration board successfully added! Captured 7 of 10  
Projector calibration board successfully added! Captured 7 of 10  
Camera calibration board successfully added! Captured 8 of 10  
Projector calibration board successfully added! Captured 8 of 10
```



k. Set of Images #9

```
C:\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LCr6500_MachineVision_build\bin\DLP_...  
Projector calibration board successfully added! Captured 3 of 10  
Camera calibration board successfully added! Captured 4 of 10  
Projector calibration board successfully added! Captured 4 of 10  
Camera calibration board successfully added! Captured 5 of 10  
Projector calibration board successfully added! Captured 5 of 10  
Camera calibration board successfully added! Captured 6 of 10  
Projector calibration board successfully added! Captured 6 of 10  
Camera calibration board successfully added! Captured 7 of 10  
Projector calibration board successfully added! Captured 7 of 10  
Camera calibration board successfully added! Captured 8 of 10  
Projector calibration board successfully added! Captured 8 of 10  
Camera calibration board successfully added! Captured 9 of 10  
Projector calibration board successfully added! Captured 9 of 10
```

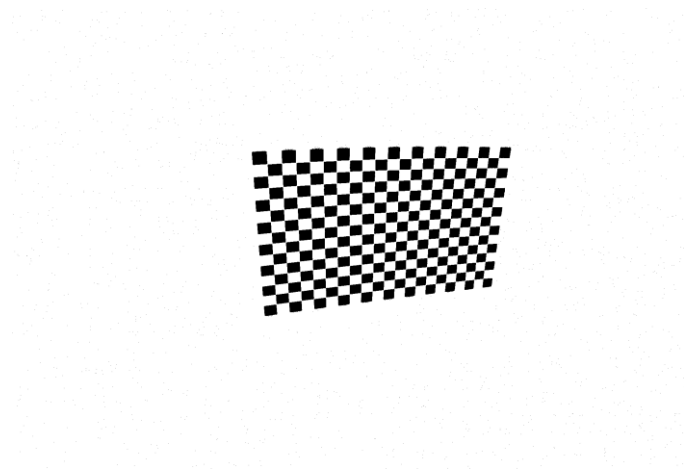
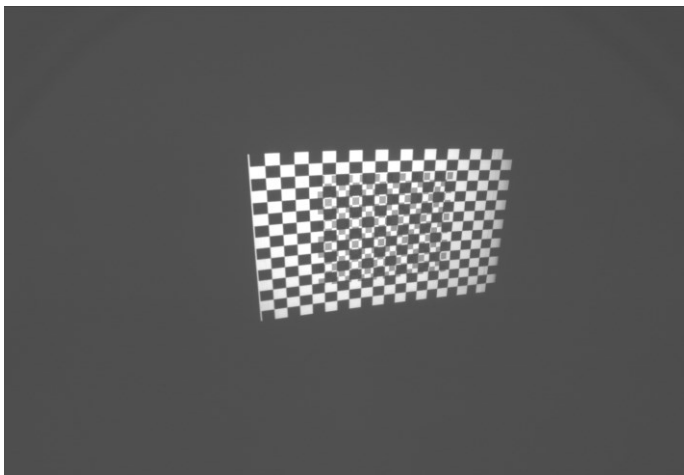
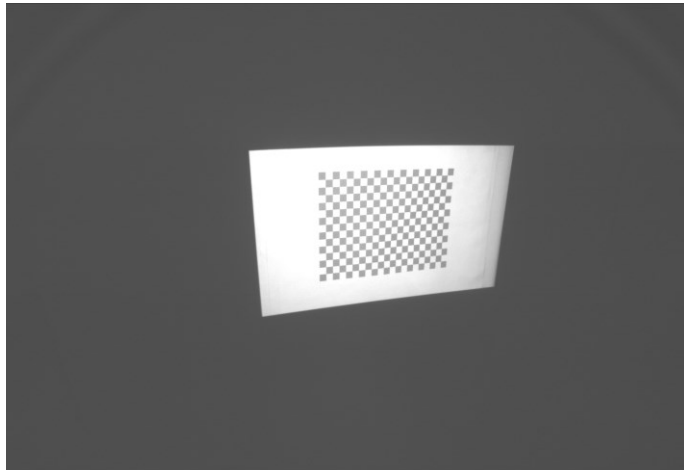


I. Set of Images #10

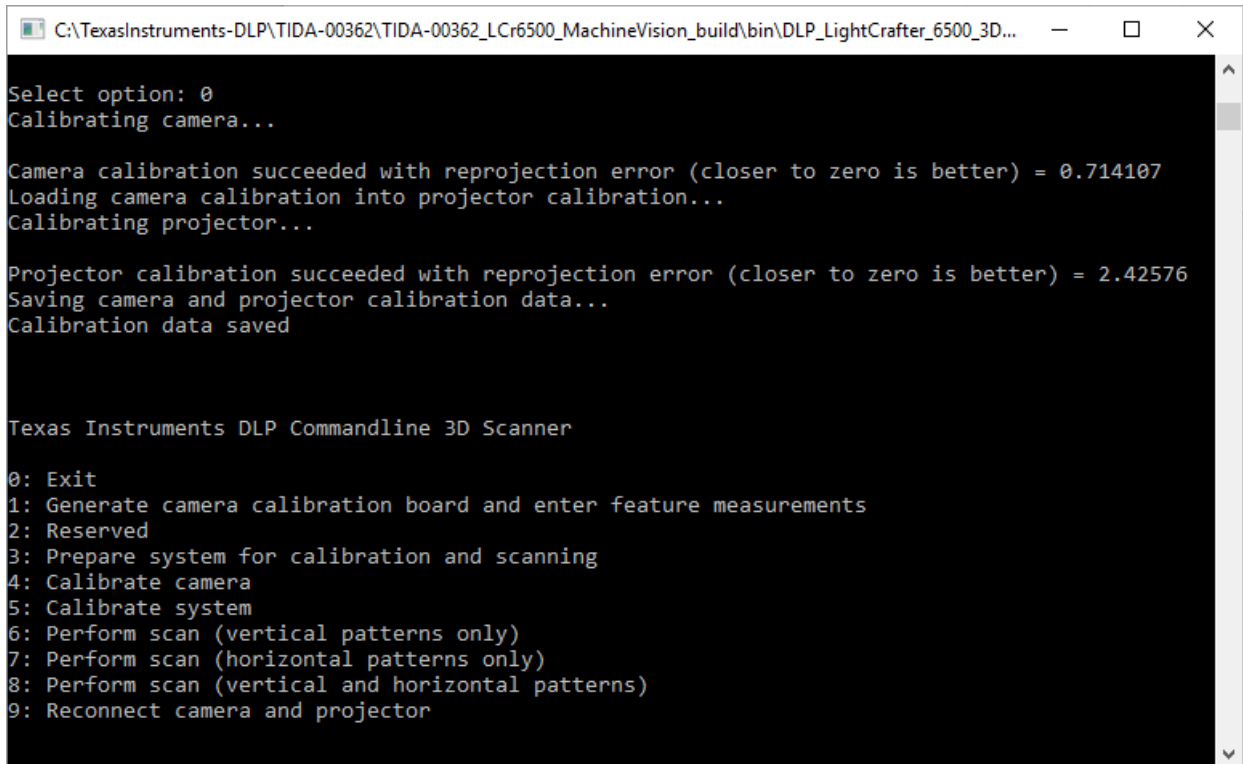
```
C:\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LCr6500_MachineVision_b...
Camera calibration board successfully added! Captured 8 of 10
Projector calibration board successfully added! Captured 8 of 10
Camera calibration board successfully added! Captured 9 of 10
Projector calibration board successfully added! Captured 9 of 10
Camera calibration board successfully added! Captured 10 of 10
Projector calibration board successfully added! Captured 10 of 10

Calibration Options:
0 - Update camera extrinsics (RECOMMENDED)
  + Uses a previously completed camera only calibration
1 - Update camera extrinsics, intrinsics, and distortion
  + Uses the camera calibration done with the system calibration

Select option:
```



m. Then I use option "0" as recommended.



```
C:\TexasInstruments-DLP\TIDA-00362\TIDA-00362_LCr6500_MachineVision_build\bin\DLP_LightCrafter_6500_3D...

Select option: 0
Calibrating camera...

Camera calibration succeeded with reprojection error (closer to zero is better) = 0.714107
Loading camera calibration into projector calibration...
Calibrating projector...

Projector calibration succeeded with reprojection error (closer to zero is better) = 2.42576
Saving camera and projector calibration data...
Calibration data saved

Texas Instruments DLP Commandline 3D Scanner

0: Exit
1: Generate camera calibration board and enter feature measurements
2: Reserved
3: Prepare system for calibration and scanning
4: Calibrate camera
5: Calibrate system
6: Perform scan (vertical patterns only)
7: Perform scan (horizontal patterns only)
8: Perform scan (vertical and horizontal patterns)
9: Reconnect camera and projector
```

n. System is calibrated with 2.42576 reprojection error