



BATTLESPACE VISUALIZATION AND INTERACTION (BVI) SAND TABLE

Setup and Calibration Instructions

MAR 2023

[DIVISION/UNIT] | [RANK] [FIRSTNAME LASTNAME], [GROUP]

OBJECTIVES



Set up and calibrate the BVI Sand Table Projection Mapped Viewer

PARTS LIST



Hardware:

- 7'x4' Sand Table
- Sand
- Television + Projector Stand
- Projector Mount
- 3 x Heavy Duty Sawhorse
- 2 x Custom Camera Shelves
- Laptop / Keyboard Cart
- Quick-Release Mount (Kinect)

Electronics:

- Windows 10 PC with ARES
- 55" Samsung Television
- Samsung Galaxy Tablet
- Tablet Case
- Optoma Projector
- * Xbox Kinect
- * MS Azure Kinect
- Wireless Keyboard + Mouse
- Wireless AC Router
- Logitech Webcam
- Xbox Wireless Controller
- Xbox Wireless Adapter for PC
- 7-port USB 3.0 Hub

Cables:

- Uninterruptible Power Supply
- 12-Outlet Surge Protector
- 2 x 15' Ethernet Cable
- 6' HDMI Cable
- 15' USB 3.0 Type A to B Cable
- 25' DisplayPort to HDMI Cable
- 15' Power Cord – Right Angled

** The sand table system either has the Xbox Kinect or the MS Azure Kinect*

TV STAND SETUP



- Assemble the TV Stand according to the assembly instructions packaged in the box
- Attach the 4 wheels to the base of the TV Stand using the provided hardware



TV STAND SETUP (CONT.)



- Attach the main TV stand central beams to the base
- Extend each of the TV stand inner poles from outer poles and raise them to maximum height, securing them in place using a single hex screw as shown below





TV STAND SETUP (CONT.)

- Slide the 2 TV mount fixture arms onto each pole and secure them using a single hex screw
- Set the height appropriately to ensure the entire television screen is visible above the edge of the table



TV MOUNT ASSEMBLY



- Locate the appropriate screws from the mounting hardware to mount the two brackets on the back of the TV using the TV Vesa mount holes.
- **Note:** Each TV model may contain varying size VESA mount holes, locate the size of screw appropriate for the holes



TV MOUNT ASSEMBLY (CONT.)



- Spacers are included in the mounting hardware in case they are needed
- Lift the TV and align the top 2 Hex screws on the top TV bracket with the holes on the TV mount arms on the TV stand
- Secure the bottom bracket with 2 more hex screws



TV STAND SETUP (CONT.)



- Use a single Hex screw to secure the camera shelf pole to the top of the extended TV stand pole
- Do this once more for the second camera shelf pole



PROJECTOR MOUNTING



- Verify that the Kinect shelf arm is comprised of 3 sections; one long and two short.
- If both are currently equal, one short-length section is repurposed from the projector arm to the Kinect's arm.
- Attach the projector to the mount on the camera shelf (as seen in the image).
- Slide the camera shelf arm with the projector over the top of the TV stand pole and make sure it is positioned near maximum height, leaving room for the Kinect above it.
- Tighten the camera shelf arm in place using the small lever.



KINECT SENSOR MOUNTING: XBOX KINECT



If the system has the MS Azure Kinect sensor, proceed to slide 13 for mounting instructions

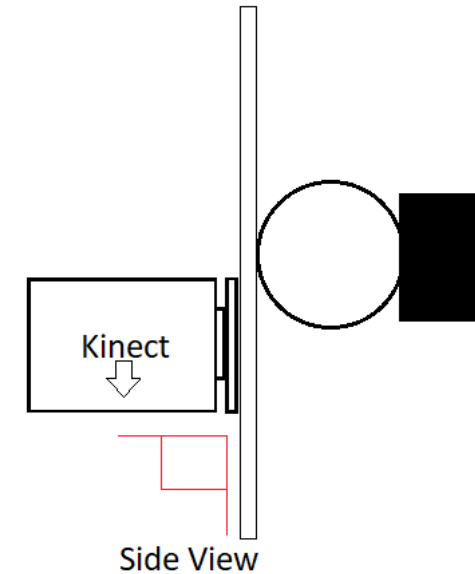
- Attach the Kinect to the mount on the camera shelf (as seen on image).
- Slide the camera shelf arm with the Kinect over the top of the TV stand pole and make sure it is positioned higher and over the projector.
- Tighten the camera shelf arm in place using the small lever.



KINECT SENSOR MOUNTING: XBOX KINECT (CONT.)



- Ensure sure the Xbox Kinect Sensor is positioned over the center of the table and is level with the table. Keep Kinect as close to perpendicular to the mounted shelf as possible. It is OK to tilt the camera slightly to keep the whole table in frame (as seen in image below).



KINECT SENSOR MOUNTING: MS AZURE KINECT SENSOR



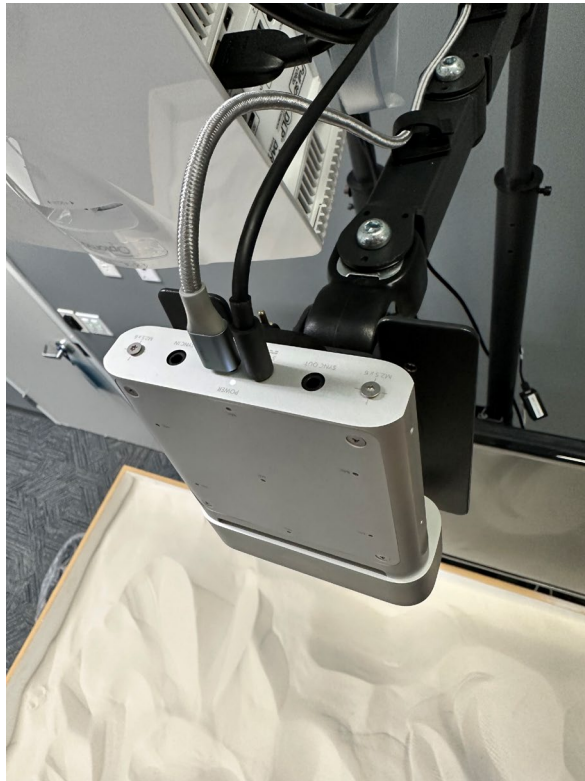
- Connect the Quick release plate to the MS Azure Kinect Sensor.
 - The small side will point in the direction of the camera lens



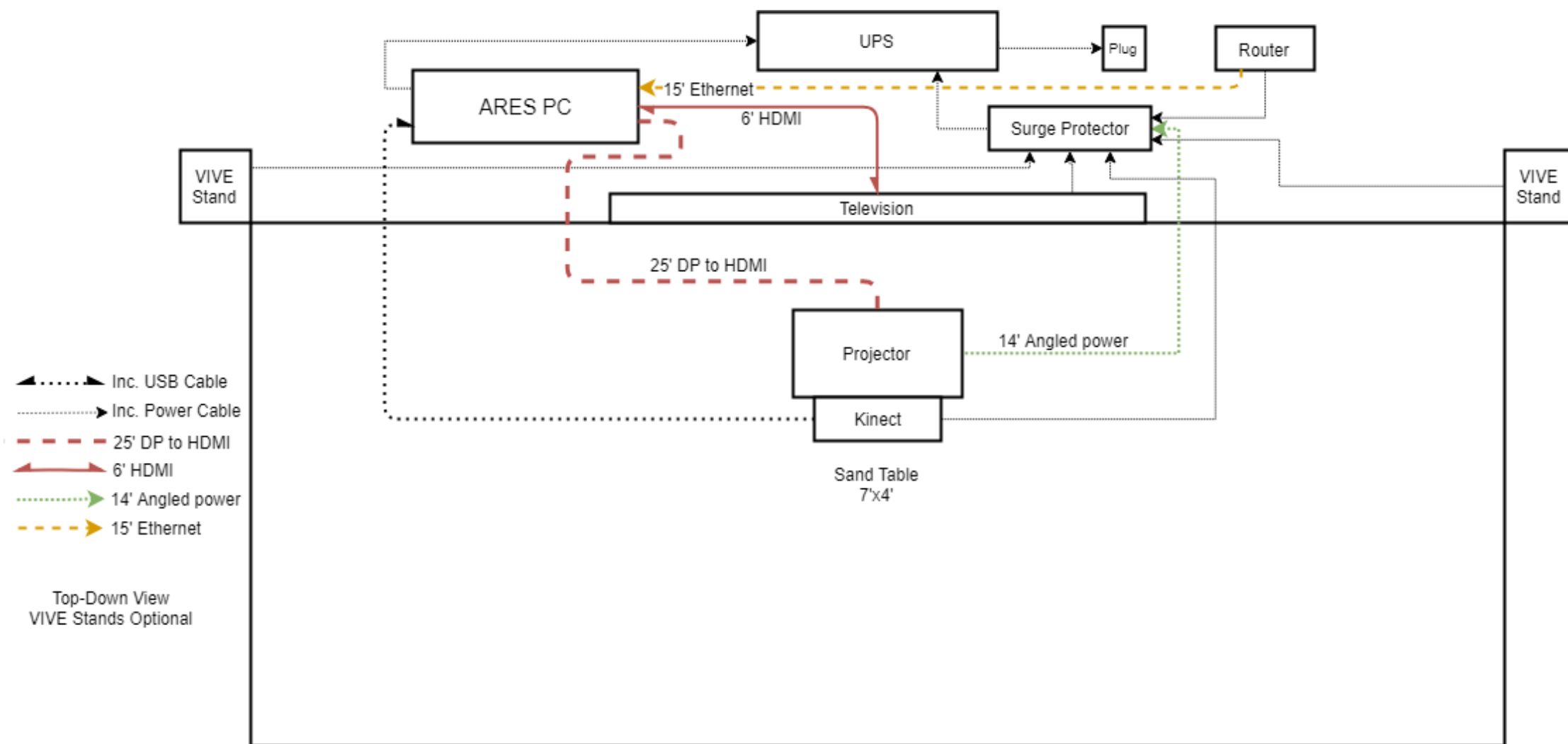
KINECT SENSOR MOUNTING: MS AZURE KINECT SENSOR (CONT.)



- Mount the Azure Kinect plate to the quick release
- Position the Azure Kinect slightly below the projector (as seen in image)
- Plug in the USB 3.0 into the computer into a 3.0 port
- Plug in the USB-C cable into the Azure
- Connect the power supply



SETUP CHECK—CABLING DIAGRAM



SAND TABLE SETUP



Important Note:

- Before filling the table with sand, ensure the base of the sand table is no taller than 27" and adjust the sawhorse heights accordingly.
- Optimal height is between 23" and 25".

SETUP CHECK



Hardware – Aligning the projector:

- Power on the projector and cast a visible image onto the table. You can achieve this by enabling the 'Test Pattern' option in the projector's menu.
- The goal of this alignment is to cover as much of the four inner walls of the sand table as possible.
- Part of the projection will fall outside of the table; this is normal and will be adjusted through software at a later stage.





SETUP CHECK

Hardware – Aligning the Kinect:

- Open DepthProducer.ini, found at C:\ProgramData\ARES\DepthProducer.ini
- Find 'show_images:' and change 'false' to 'true', then save.
- Start the BVI application—a preview of the Kinect's camera will appear on-screen.
- Using the preview screen, adjust the Kinect's position to ensure the entire table is in-view and that it's alignment is squared.



ARES PROJECTION MAPPED VIEWER



- The ARES Viewer uses data acquired through the calibration process to provide an image that accounts for the deformation of the projection on the sand.

SETUP CHECK



Software

- Open “DepthProducer.ini” located at “C:\ProgramData\ARES” in text editor and verify that Full_Color_Frame_Scale=1.0
- Measure distance from center of table (under the sand) to the Kinect device in millimeters
- In DepthProducer.ini, record this distance in mm as:
 - Camera_Distance_From_Table_mm=XXXX
 - Subtract 150 from this value and record the number under Min_Depth_Value=XXXX
 - Add 100 to this value and record the number under Max_Depth_Value=XXXX
- “C:\ProgramData\ARES” should also contain a “table_transform.yaml” file.
 - If it does not, “C:\Program Files\ARES\<ARES Build>\ares.viewer_proj\assets\ares\” contains a “default_table_transform.yaml” file. Copy it to the \ProgramData\ARES\ folder and rename it to “table_transform.yaml”.
- Right-Click on the desktop and select “Display Settings”. Make sure Scale (“Change the size of text, apps, and other items”) is set to 100% for all displays.

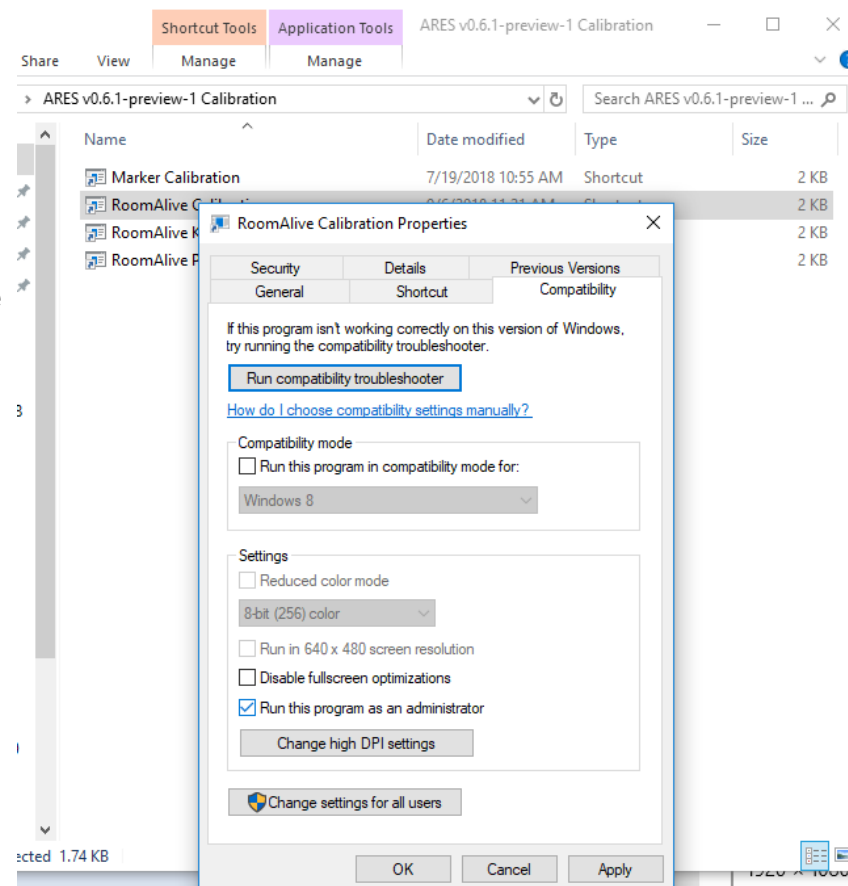
CALIBRATION



Procedure

- Make sure the BVI application is NOT running
- Open Calibration folder located on the Desktop
 - NOTE: When running applications for the first time you will be prompted for network permissions. Make sure to give full domain permissions.
 - If you believe this has not been done, go to the windows firewall and change the permissions.
 - NOTE: Set all shortcuts to run as administrator
 1. Right-Click on the shortcut
 2. Select "Properties"
 3. Click on the "Compatibility" tab
 4. Check the "Run this program as an administrator" box under settings
 5. Click "Apply" and "OK"
 6. Repeat for all calibration shortcuts

Note: The instructions on following slide are for the Xbox Kinect. If using the Azure Kinect, skip to slide 23.





CALIBRATION: XBOX KINECT

Procedure

- Launch the RoomAlive Kinect Server
 - There should be output on the console (see right)
 - If the window is blank, check the following.
 - Did you run as administrator?
 - Does the KinectServer have firewall permissions?
 - Is the Kinect in use by another application? (Is BVI running?)
- Launch the RoomAlive Projector Server
 - No output is expected in this window.

A screenshot of a Windows console window titled "RoomAlive Kinect Server". The window has a black background with white text. The text displays various calibration parameters and error values. At the bottom, it shows "33 ms".

```
RoomAlive Kinect Server
212.713555995805
0.0522452631477539
-0.158673619469984

FakeCalibration :
n = 2357
color error = 0.179119672306853
depth error = 0.0844752466540642
depth reprojection error = 0.01427213459453
color reprojection error = 0.064167714014629
depth camera matrix =
367.773433179511, 0, 261.261225804894
0, 367.807784836168, 212.713555995805
0, 0, 1

depth lens distortion =
0.0522452631477539
-0.158673619469984

color camera matrix =
1065.27881935412, 0, 985.852029041445
0, 1066.28452633407, 539.245430499819
0, 0, 1

color lens distortion =
0.013464777420981
-0.00298489968892774

33 ms
```



CALIBRATION: MS AZURE KINECT

Procedure

- Launch the Azure Kinect Server located in C:\Program Files\ARES\(build)\ares.roomalive\AzureKinectServer
 - There should be output on the console (see right)
 - If the window is blank, check the following.
 - Did you run as administrator?
 - Does the AzureKinectServer have firewall permissions?
 - Is the Kinect in use by another application? (Is BVI running?)
- Reopen the Calibration folder
- Launch the RoomAlive Projector Server
 - No output is expected in this window.

```

RoomAlive Kinect Server
212.71355995885
0.8522452631477539
-0.158673619469084

FakeCalibration :
n = 2357
color error = 0.179119672306853
depth error = 0.0046752466548842
depth reprojection error = 0.01427213459453
color reprojection error = 0.064167714014629
depth camera matrix =
367.773433179511,    0,    261.261225004894
0,    367.807704036180,    212.71355995885
0,    0,    1

depth lens distortion =
0.8522452631477539
-0.158673619469084

color camera matrix =
1065.27001935412,    0,    985.852029041445
0,    1066.28452633407,    539.245430499819
0,    0,    1

color lens distortion =
0.013464777420981
-0.0029848998092774

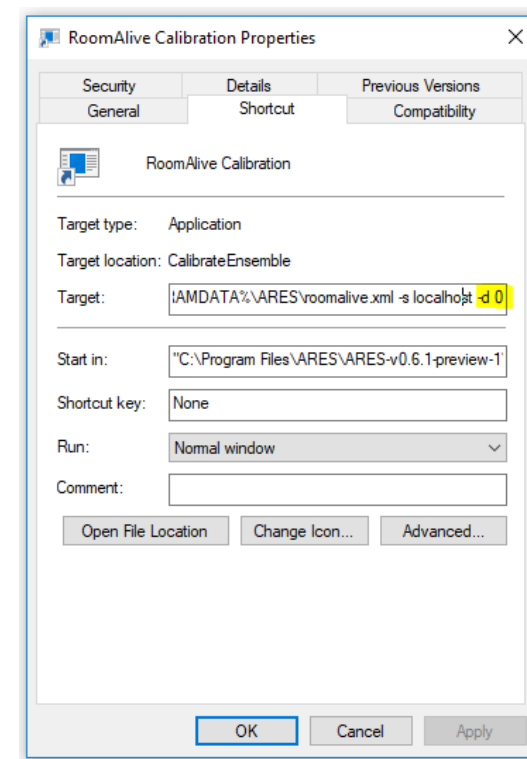
33 ms
  
```


CALIBRATION



Procedure

- Disturb the sand so that it's mostly uneven.
- If the sand table includes a television above the table, open Notepad and maximize the window during calibration. This will prevent reflections from interfering with calibration
- Launch the RoomAlive Calibration
 - ***NOTE*: The** shortcut takes a run-time argument that determines which display (designated by a number) the calibration images are displayed on.
(Properties → shortcut → target → '-d X' where X is either 0 or 1)
 - Let it run until the output stops and says “Solve complete”.
- Close ALL running RoomAlive applications.
(Kinect Server, Projector Server, Calibration)

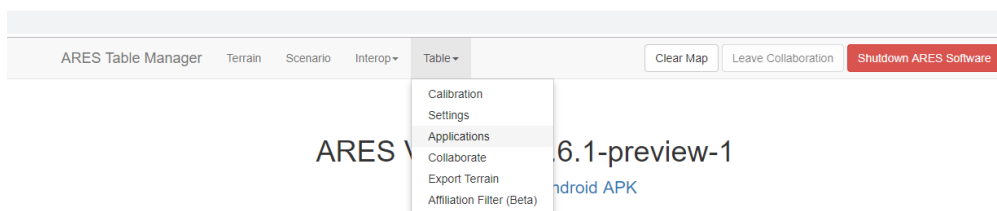




CALIBRATION

Procedure

- Start the BVI application from the desktop.
- Stop the ARES Viewer through Table Manager (<http://localhost:9080/table/processes>)



BVI Table Manager Terrain Scenario Interop ▾ Table ▾

Clear Map Leave Collaboration Shutdown BVI Software

System Processes

Name	Description	Active	Actions			
3D View		No	Start	Stop	Restart	View Logs
ARES Playback Tool		Yes	Start	Stop	Restart	View Logs
ARES Viewer		Yes	Start	Stop	Restart	View Logs
AWES Server		Yes	Start	Stop	Restart	View Logs
Frame Streamer		Yes	Start	Stop	Restart	View Logs
Military Symbol Server (Mission Command)		Yes	Start	Stop	Restart	View Logs
Military Symbol Server (Spatial Illusion)		Yes	Start	Stop	Restart	View Logs
RabbitMQ		Yes	Start	Stop	Restart	View Logs
Web Tactical Planner		No	Start	Stop	Restart	View Logs
Web Veritas		Yes	Start	Stop	Restart	View Logs

CALIBRATION



Procedure – Marker Calibration

- In the lower-left, lower-right, and upper-right corners, dig out enough sand to expose the table's surface and place the markers in their respective corners. Be sure to place them in their correct orientation.
 - Each marker is labeled with their location on the table, along with the orientation they should be placed in. Ex. The words “upper-right” on that marker should be positioned towards the upper-right corner of the table.
- Back in the Calibration Folder, run Marker Calibration
 - Click “Find Markers” button.
 - A white screen will be projected on the table when finding the markers.
 - Close when finished.





CALIBRATION

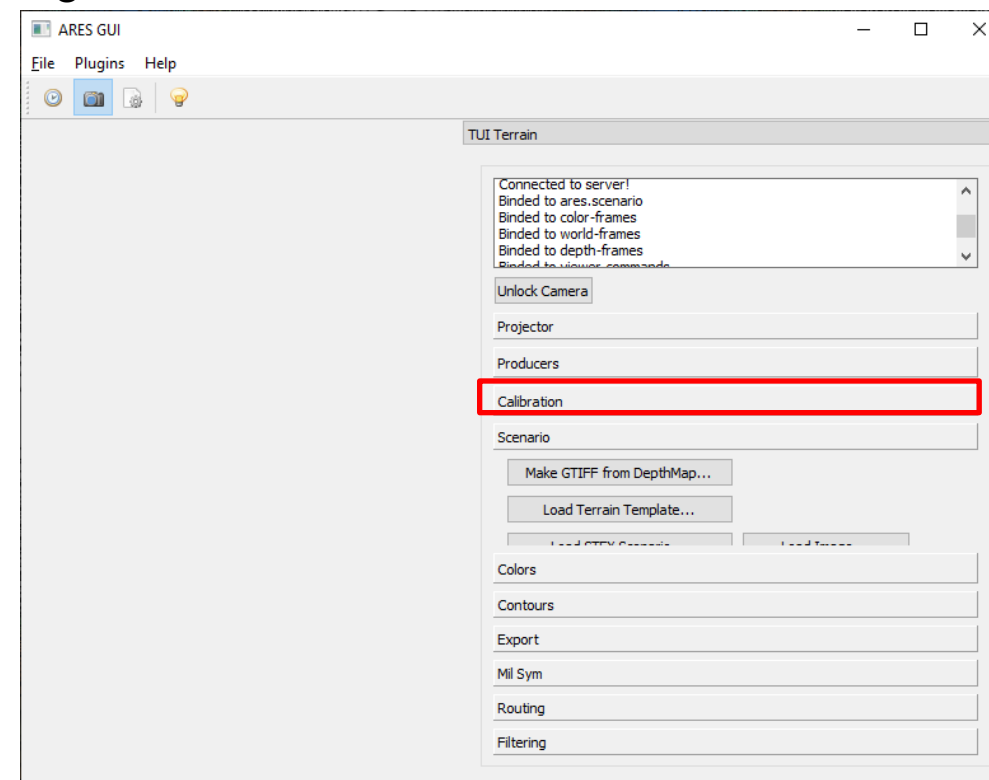
Procedure

- Start ARES Viewer again from the System Processes user interface.
- Once ARES Viewer starts again, move your mouse down onto the ARES GUI located on the task bar. Select the 'G' key to open the calibration menu.
- Find and click the Calibration section in the menu on the right side, shown here.

BVI Table Manager Terrain Scenario Interop ▾ Table ▾ Clear Map Leave Collaboration Shutdown BVI Software

System Processes

Name	Description	Active	Actions
3D View		No	Start Stop Restart View Logs
ARES Playback Tool		Yes	Start Stop Restart View Logs
ARES Viewer		Yes	Start Stop Restart View Logs
AWES Server		Yes	Start Stop Restart View Logs
Frame Streamer		Yes	Start Stop Restart View Logs
Military Symbol Server (Mission Command)		Yes	Start Stop Restart View Logs
Military Symbol Server (Spatial Illusion)		Yes	Start Stop Restart View Logs
RabbitMQ		Yes	Start Stop Restart View Logs
Web Tactical Planner		No	Start Stop Restart View Logs
Web Veritas		Yes	Start Stop Restart View Logs



CALIBRATION



Procedure

- Under the "Calibration" menu there are two sections of controls, *Manual Projector Adjustments* and *Manual Table Adjustments*.
- *Manual Projector Adjustments* controls the scale and positioning of the contour lines.
- *Manual Table Adjustments* controls the placement of edges and changes perceived heights of the projection.
- Best practice is to make necessary adjustments to the contour lines first, then move on to modifying the heights and edges through *Manual Table Adjustments*.

The screenshot shows the 'Calibration' window with two main sections:

Manual Projector Adjustments (Adjusts the image)

More Translate	0.000	0.000	0.000
Projector fx,fy	1013.36	1013.36	Scale
Projector cx,cy	961.49	1234.25	Translate
More Rotate	0.00		
More Pitch	0.00		
More Roll	0.00		

Manual Table Adjustments (Adjusts the edges and heights)

More Translate	0.004	0.014	0.000
More Rotate	-1.000		
More Pitch	0.000		
More Roll	0.000		
More Scale	1.030	1.040	1.000

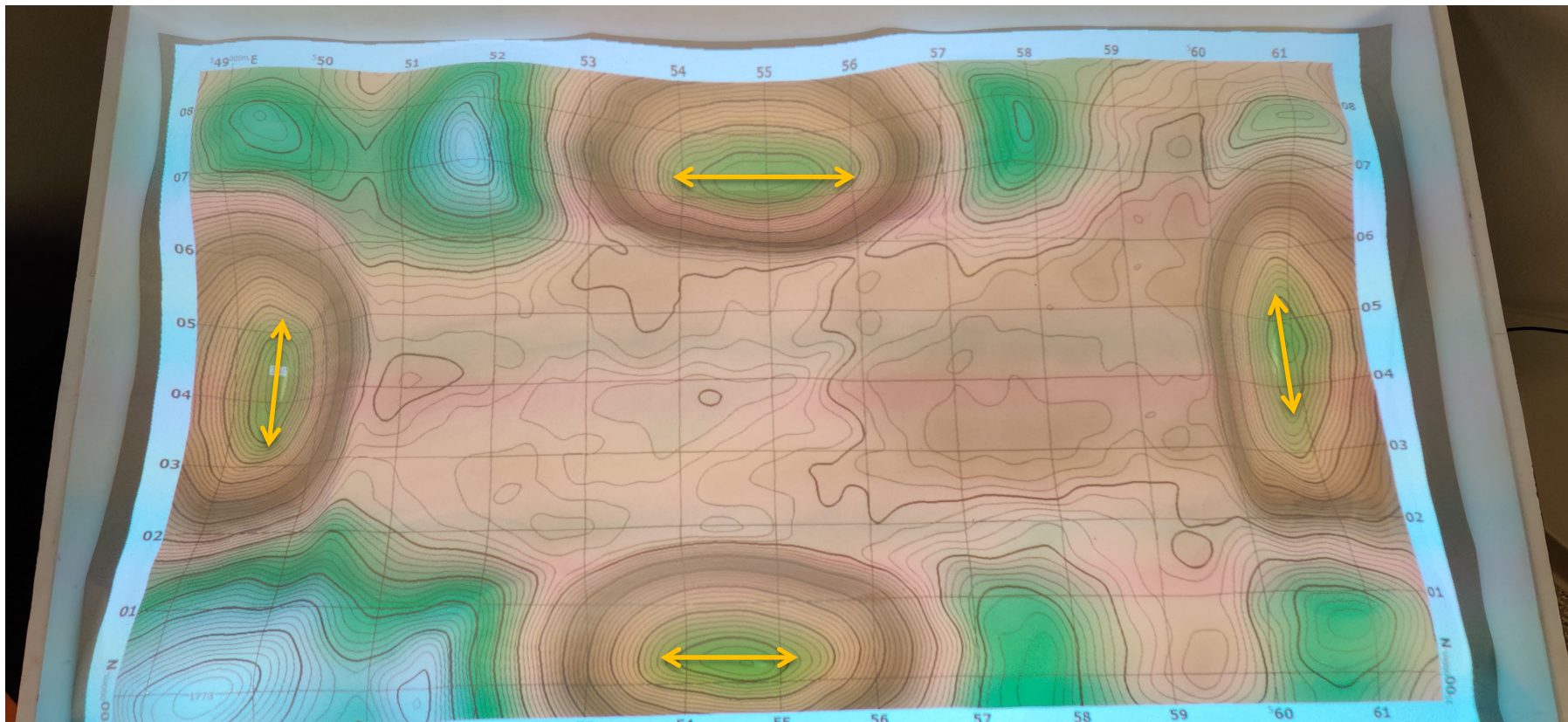
Red annotations in the image highlight specific controls: 'Edges' points to the 'More Translate' and 'More Rotate' controls in the Manual Table Adjustments section; 'Heights' points to the 'More Pitch' and 'More Roll' controls in the Manual Table Adjustments section; 'Scale' points to the 'Projector fx,fy' control in the Manual Projector Adjustments section; and 'Translate' points to the 'Projector cx,cy' control in the Manual Projector Adjustments section.

CALIBRATION



Procedure

- Dig vertical trenches on the left and right of the table, as well as horizontal trenches along the top and bottom



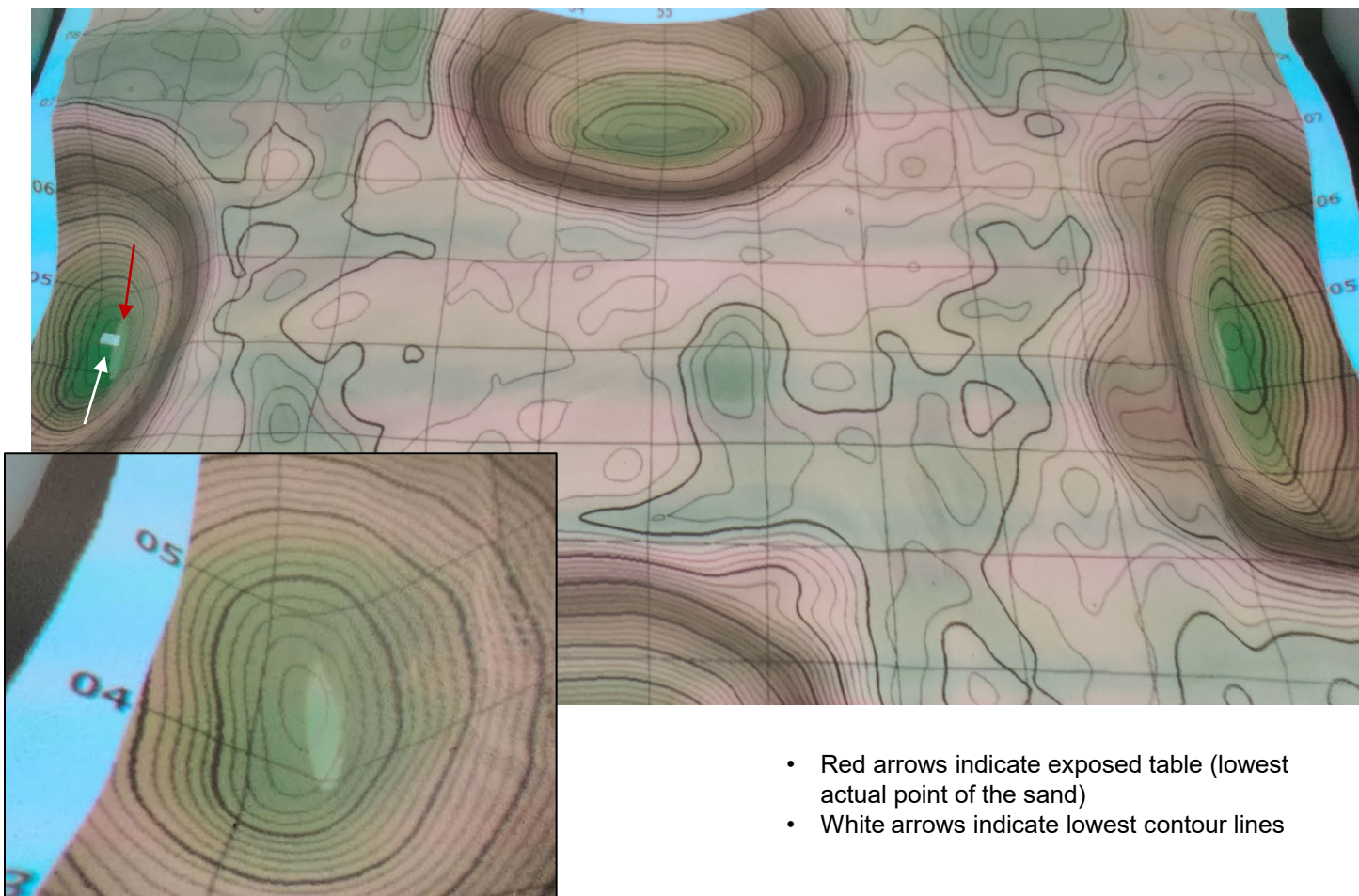
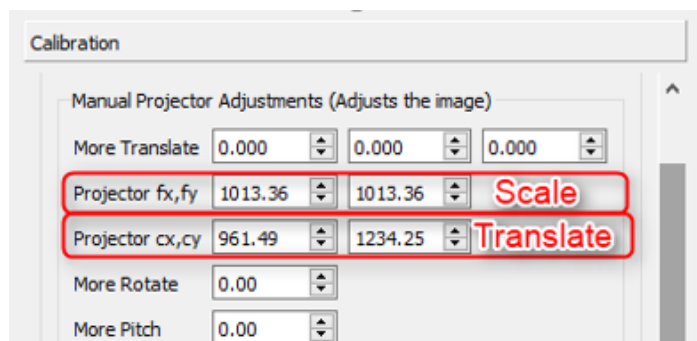
CALIBRATION



Controls

- **Scale:** In the image to the right, the projected *contour lines* for the lowest points appear wider than the *exposed table* on both sides.
- In this case, we'd scale down the projected image on the x-axis.

****Note:** You can use the scroll wheel or the arrow keys to change these values incrementally



- Red arrows indicate exposed table (lowest actual point of the sand)
- White arrows indicate lowest contour lines

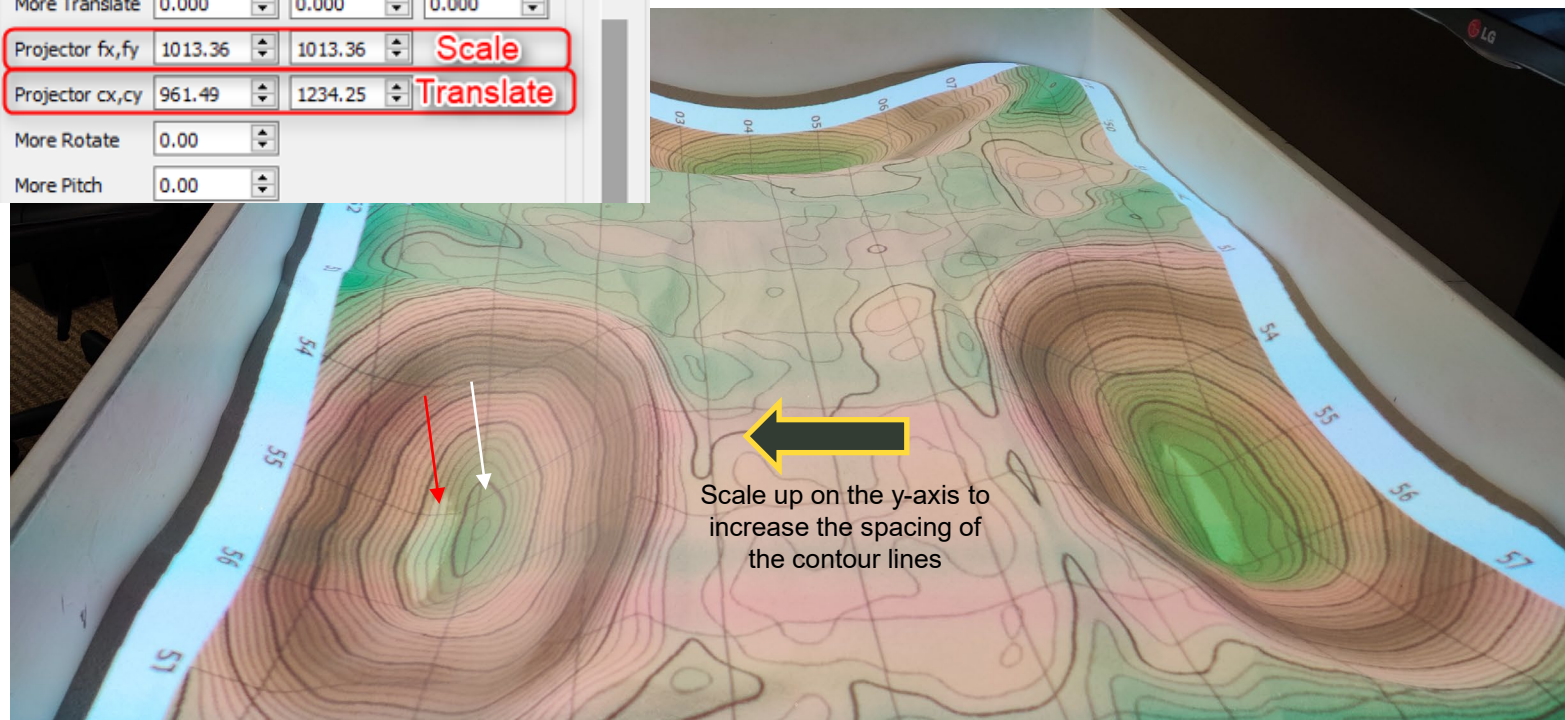
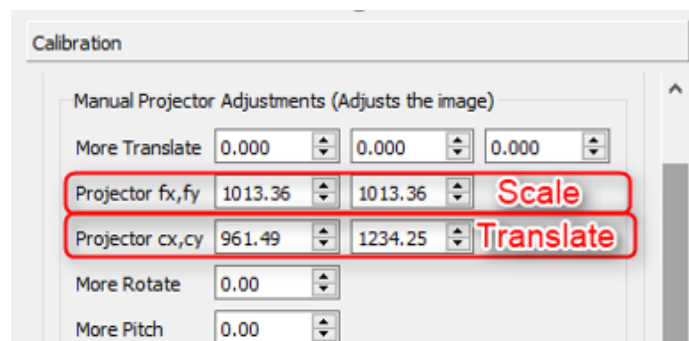


CALIBRATION

Controls

***Note*:** This image is taken from the side. Right side of the image is the top of the table.

- **Scale:** Here, we can see the *contour lines* on the right side of the image match the location of the *exposed table*.
- On the left, the *contour lines* are located above the *exposed table*.
- In this case, we'd scale up on the y-axis.
- When scaling on the y-axis, a mixture of scaling and translating will be necessary to align the contour lines. Translating is explained on the next slide.



- Red arrows indicate exposed table (lowest actual point of the sand)
- White arrows indicate lowest contour lines

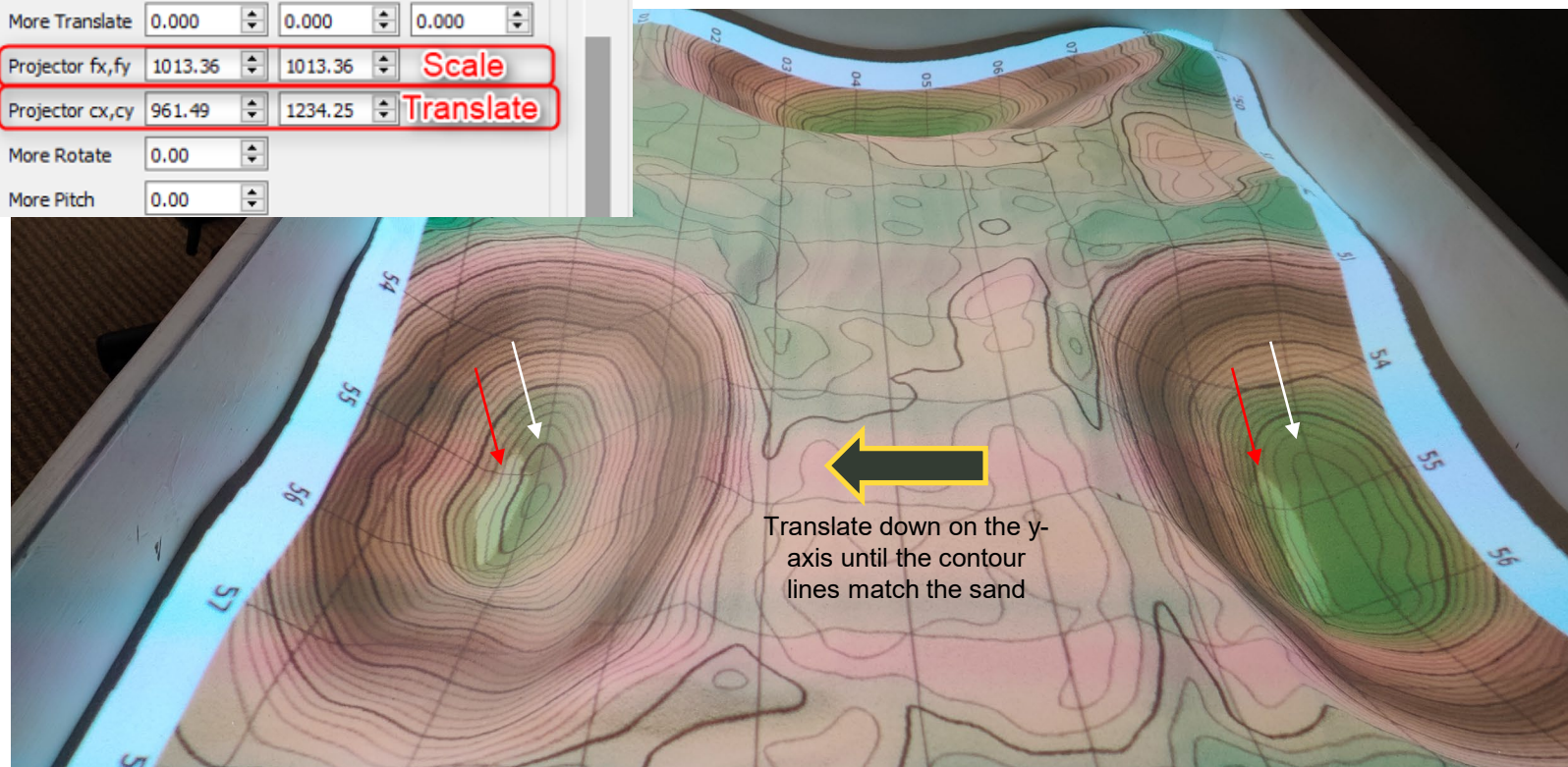
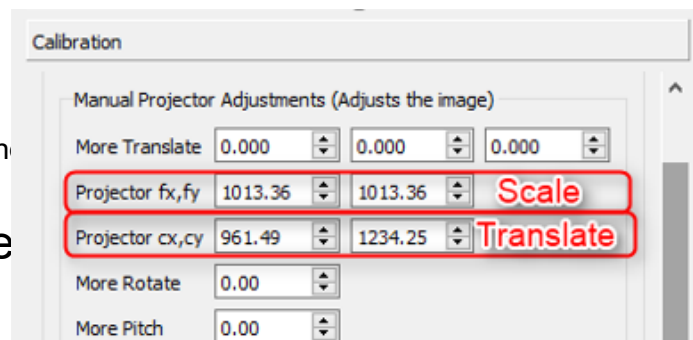
CALIBRATION



Controls

Note: This image is taken from the side. Right side of the image is the top of the table.

- **Translate**: Here, we can see the distance between the *contour lines (white)* and *exposed table (red)* are the same distance for both the top and bottom of the table.
- In this case, we'd translate the image down on the y-axis.



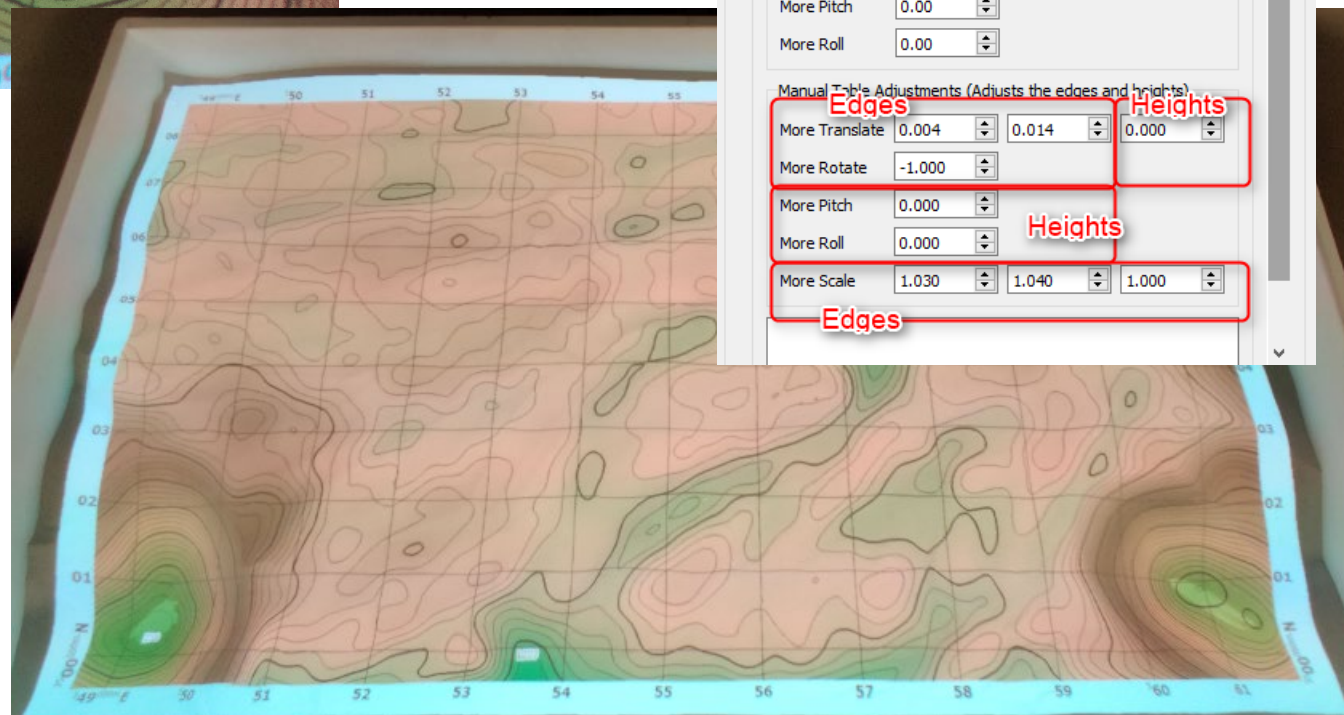
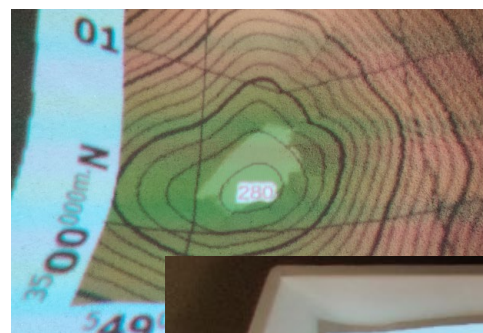
- Red arrows indicate exposed table (lowest actual point of the sand)
- White arrows indicate lowest contour lines

CALIBRATION



Controls

- **Heights:** Ares shows a numerical value in the perceived *highest* and *lowest* points on the table. Shown here is the *lowest point indicator*.
- Calibrating *Roll*:
 - In this image, the bottom-left corner is perceived as being far lower than the bottom right, despite the table being exposed in both corners.
 - Under *Manual Table Adjustments*, keep adjusting “More Roll” until the *lowest point indicator* changes to the opposite corner.
 - Once it changes to the opposite corner, you’ve hit an acceptable degree of accuracy in calibration.

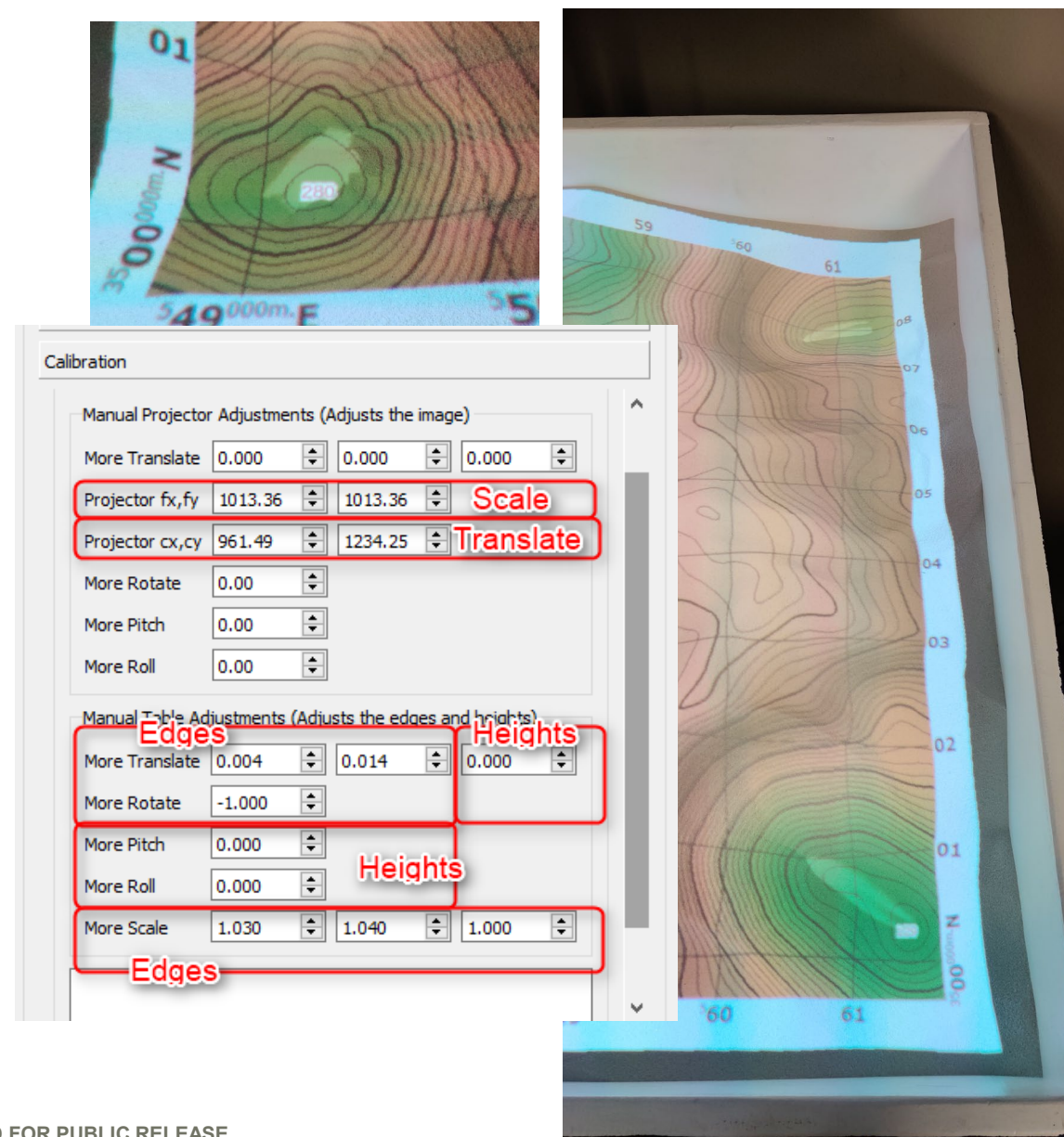


CALIBRATION



Controls

- **Heights:** Ares shows a numerical value in the perceived *highest* and *lowest* points on the table. Shown here is the *lowest point indicator*.
- **Calibrating *Pitch*:**
 - In this image, the bottom-right corner is perceived as being far lower than the top right, despite the table being exposed in both corners.
 - Under *Manual Table Adjustments*, keep adjusting “More Pitch” until the *lowest point indicator* changes to the opposite corner.
 - Once it changes to the opposite corner, you’ve hit an acceptable degree of accuracy in calibration.

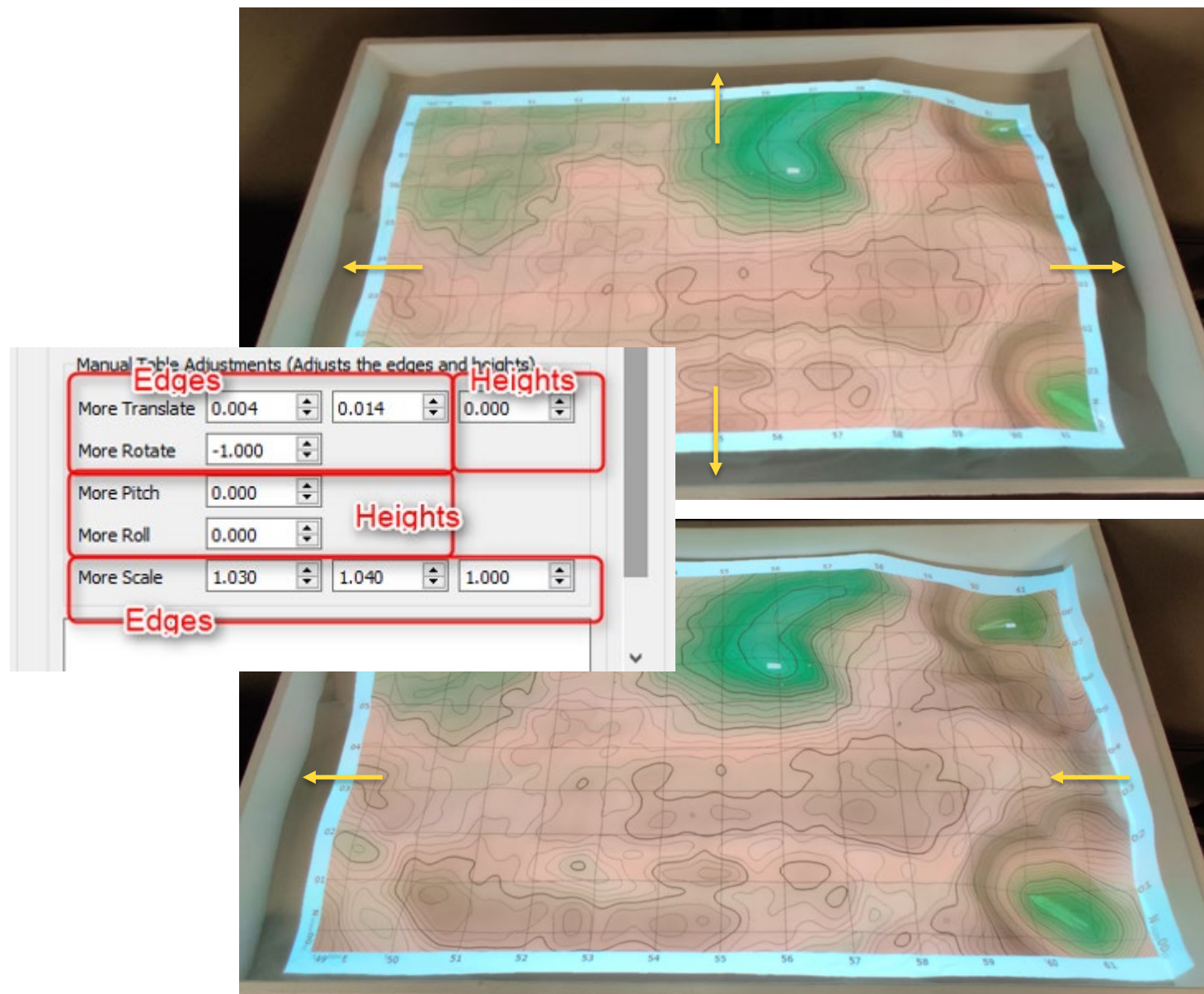


CALIBRATION



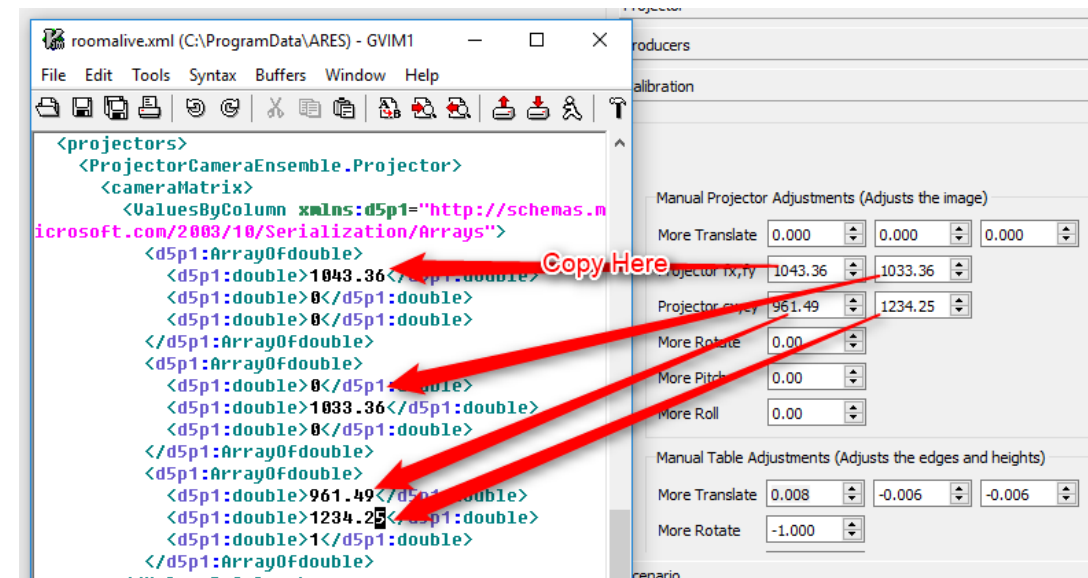
Controls

- **Edges:** After *contour lines* are calibrated, the edges of the projection may be misaligned. Use the controls in *Manual Table Adjustments*, shown here.
- **Adjusting Edges:**
 - In the top image, the projection is smaller than the available space. Increase the scale on both the x and y axes in *More Scale*.
 - In the bottom image, the edges of the projection are casting too far to the right. Use the x-axis in *More Translate* to move the edges to the left.



Procedure

- The four values changed under *Manual Projector Adjustments* are manually updated in the *roomalive.xml* file.
- Navigate to and open
c:\ProgramData\ARES\roomalive.xml
- The <projectors> section shown here is roughly three quarters of the way down the document.
- Update these four values using the image to the right and save the file.
- Afterwards, hit 'G' again to close the Calibration GUI.





Calibration Complete!