Projector Alignment for
Science On a Sphere® (SOS)
Using a Nintendo Wii Remote Control

User Manual

Version 3.4.2+

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SECTION I: SETUP

What is Projector Alignment?

SOS is a room-sized display system that uses 4 projectors to display planetary datasets onto a 6 foot diameter sphere. The projectors are located about 17 feet away from the center of the sphere and are mounted approximately 90 degrees apart from each other. Each projector projects a portion of a dataset (which is either an image or a video) onto its quadrant of the sphere.
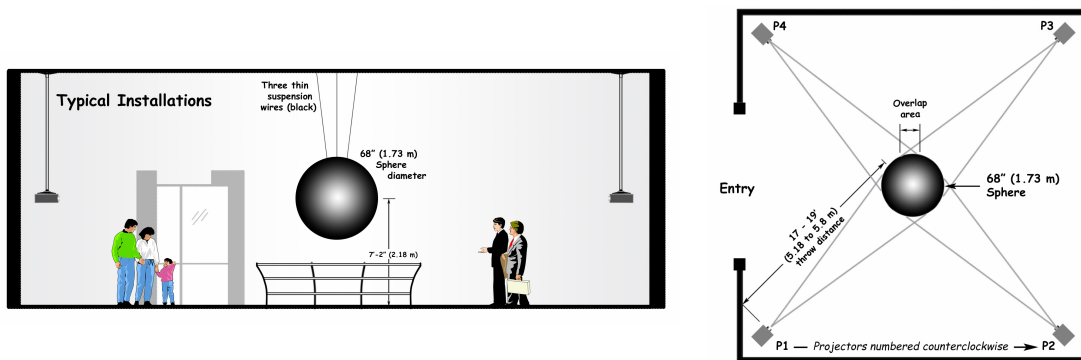
Light from adjacent projectors overlap and create edges in these overlap regions (also called blend regions). This causes the appearance of disjoint images in the areas of overlap. Projector alignment is the process that allows a dataset to be displayed by 4 projectors such that the dataset appears as one continuous image wrapped around the sphere, rather than 4 disjoint images.
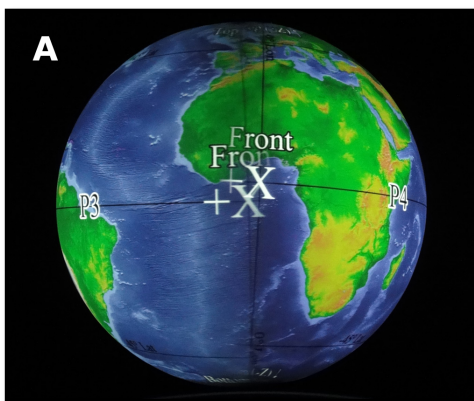
[A] shows the overlap region between 2 unaligned projectors; the 2 images look disjoint.
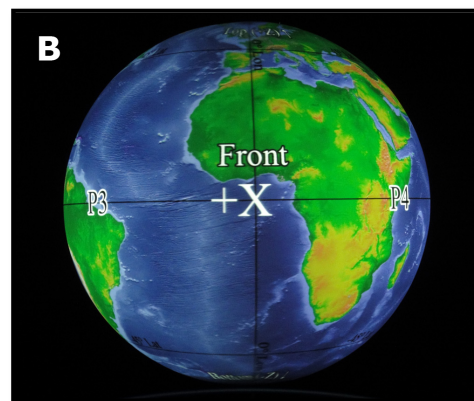
[B] shows the overlap region between 2 aligned projectors; the 2 images look continuous.

Requirements

If this is the first time you are doing alignment, you will need anywhere from 1 to 2 hours to complete the alignment process. For first time users, it takes some practice, so be patient. If you have done alignment before, or if the alignment is just being tweaked, the process may take anywhere from 15 minutes to 1 hour to complete, depending on what point in the process you are starting at.

To perform projector alignment for an SOS installation, you need to have access to the main SOS computer. (For sites that are still using the 5-computer system, you will only need access to the main SOS NC computer.) In order for alignment results to be saved, you must be logged in as user "sos".

You also need to have access to the Wiimotes which are included in the SOS installation.

STEP 1: Turn On the Projectors

"ProjectorControl.gui" is an application that allows you to easily switch your projectors ON or OFF at the click of a button. This application is typically set up on your SOS computer by the SOS Team during installation.

If this application is not already running on your SOS computer's Desktop, double click the "Projector Control" icon located on the Desktop. Then, click the "Turn Projectors ON" button.

If this application was not installed at your site, turn on each projector by using the projector's remote control.

NOTE: It is recommended that the projectors are on for about 20 minutes before starting alignment.
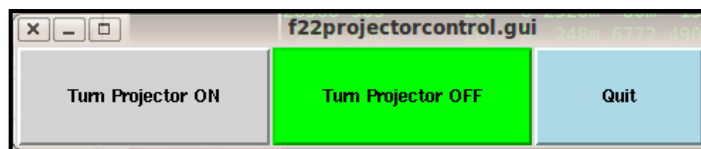
STEP 2: Set Projector Settings

NOTE: In most cases, you can skip this step, as the SOS Team would have adjusted your projector settings during installation. However, if a projector's settings are accidentally changed, or if a new projector is swapped in for an old one, some settings on the projector may need to be modified.

Lamp Mode: If a room is reasonably dark, use the projector's lower lamp mode setting (if this feature is available). If the room is bright, set the projector to a higher lamp mode setting for greater light output. In general, all projectors should have the same lamp mode setting so that one projector is not brighter or darker than the others.

Lens Shift: If your projector has the option for vertical lens shift, shift the lens down to its lowest point. This is typically the standard point at which a projected image shoots straight out of the projector without any vertical shift. If your projector has horizontal and/or diagonal shift, keep these shifts at their default settings.

Keystone Correction: If your projector is mounted such that it is tilting up or down instead of mostly straight, you may have to use the projector's keystone correction feature to make the projected image more rectangular.

Resolution: The projector's resolution should be set to its native resolution. Many projectors offer a higher resolution option that is greater than the native resolution. Regardless, you still need to use the projector's native resolution.

STEP 3: Edit the SOS Configuration File

NOTE: In most cases, you can skip this step, as the SOS Team would have set up your SOS configuration file during installation. However, if a new projector is swapped in for an old one, or a projector location and/or mount has been changed, or the sphere location has been shifted, some settings in the SOS configuration file may need to be altered.

(A) Measure the height (in inches) from the ground to the sphere's equator. Write this value down.

(B) For each projector, measure the height (in inches) from the ground to the center of the projector's lens. Write each value down.

(C) For each projector, measure the distance (in inches) from the center of the

projector's lens to the center of the sphere. Write each value down.

(D) Log on to the main SOS computer as the user "sos". The sos account is set up with administrative privileges and is necessary for editing alignment files. The sos account password will be what was provided to you during installation.

(E) Open the config file: "sos_stream_control.config". This file is located in the directory "/home/sos/".

(F) Modify the appropriate values in the config file to match what you wrote down in parts **(A)**, **(B)**, and **(C)**.

(G) Save the config file and then close the file.

STEP 4: Start the SOS Application on the SOS Computer

In order to perform projector alignment, the main SOS application, called "SOS Stream GUI", must be open and running on your SOS computer. If it is not running, double click on the "Start SOS" icon located on the SOS computer's Desktop to launch the application.

NOTE: If the SOS application was already running on your SOS computer but you had to edit the SOS configuration file as detailed in STEP 3, then close the SOS application and restart it.

STEP 5: Connect the Wiimote

To connect the Wiimote to your SOS computer, simply press any button on the Wiimote. After pressing any button, you should see blue lights flashing at the bottom of the remote. Once the remote is connected, it will vibrate once and one blue light will be on.

If the remote does not work, close the "SOS Stream GUI" application and restart it. Then, try to connect the remote again. If it still will not connect, try unplugging the Bluetooth dongle and try to connect again. If you are still having trouble connecting the Wiimote, please see **sos.noaa.gov** for Wiimote troubleshooting information.

Connect the nunchuck attachment to the Wiimote.

The following list describes each control you will need to use with the Wiimote when aligning the sphere.
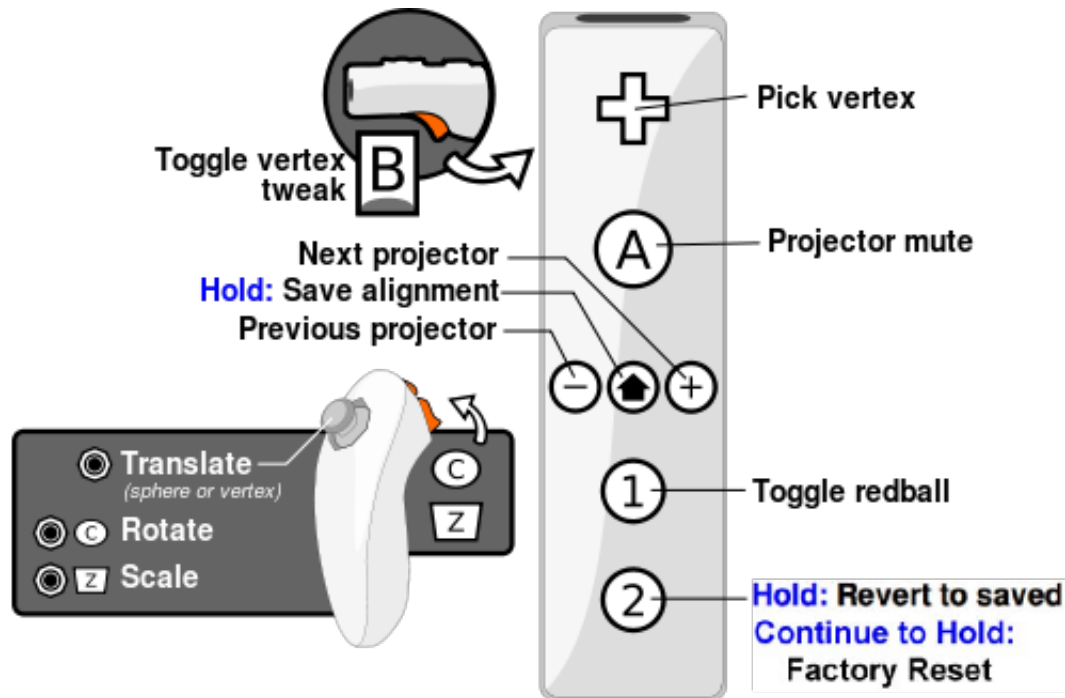
Select Projector: Use the "+" or "-" button to select the projector you would like to work on. The 4 blue lights at the bottom of the Wiimote indicate which projector is selected. The first blue light corresponds to projector 1, the second blue light corresponds to projector 2, and so forth.

Projector On/Off: To turn a projector's signal on or off (mute), make sure it is the selected projector and then press the "A" button. Note that this does not turn off the actual projector.

Red Ball On/Off: To turn the Red Ball on or off, press "1" on the Wiimote.

Translate: To translate, use the joystick on the nunchuck to move the image up, down, left, or right.

Scale: To scale, hold down the "Z" button on the nunchuck while using the joystick. In scale mode, up on the joystick makes the image taller, down on the joystick makes the image squatter, right on the joystick makes the image wider, and left on the joystick makes the image thinner.

Rotate: To rotate, hold down the "C" button on the nunchuck while using the joystick.

Vertex Tweaking On/Off: To turn on Vertex Tweaking, press the "B" button on the Wiimote. The currently selected projector will display a grid with vertices numbered 1-9 on the sphere.

Vertex Selection: To select a vertex when Vertex Tweaking is on, use the D-Pad on the Wiimote to select the desired vertex. The selected vertex will be highlighted in a cyan color on the sphere.

Vertex Adjustment: To adjust the currently selected vertex on the sphere, use the joystick on the nunchuck to stretch the image up, down, left, or right. Note that the image will only stretch near the selected vertex number.

Save: To save the current alignment of all projectors, press and hold the "Home" button down for a few seconds (this is the small button located between the "+" and "-" buttons). A message will appear on the sphere indicating that the alignment has been saved.

Revert: To revert to the last saved alignment settings, press and hold the "2" button down for a few seconds.

Factory Reset: To do a factory reset, press and hold the "2" button for 6 seconds. You will lose all of your current alignment settings, so do this with caution.

STEP 7: Open the Alignment Interface

To open the Alignment interface on your SOS computer, double-click the "Alignment" icon on the Desktop. This will launch a standard web browser with the alignment software.

Click on the link that says "Alignment" to open the window that allows you to start alignment. In this window, click the "Start Alignment" button and then select "Red grid (coarse)".
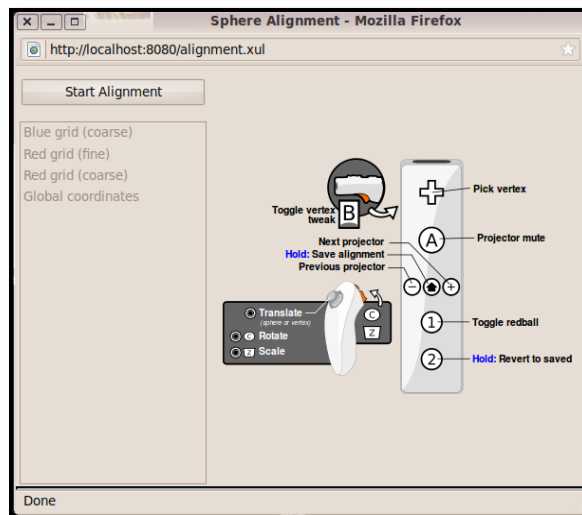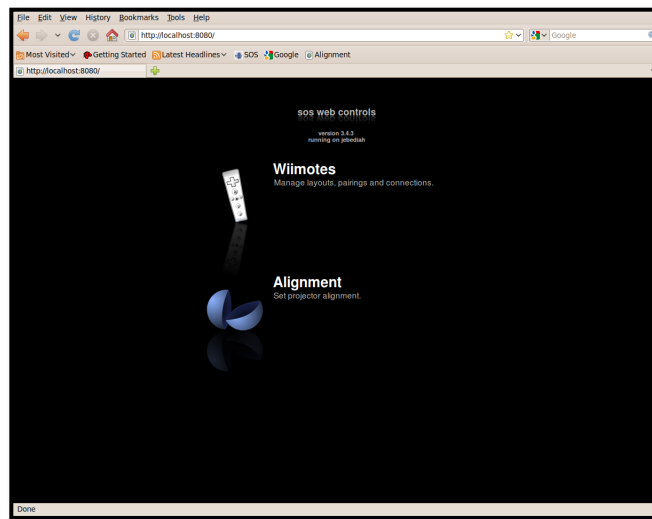
STEP 8: Factory Reset

NOTE – PROCEED WITH CAUTION: *A Factory Reset will completely reset the alignment of the projectors in your SOS system. This should **only** be done if the projectors have been physically moved a lot, or if you have replaced most or all of the projectors, or if the alignment is significantly off. **Otherwise, skip to the next section, "SECTION II: ALIGNMENT".***

To reset the projectors to their default alignment settings, press and hold the "2" button on the Wiimote for 6 seconds.

SECTION II: ALIGNMENT

The following 3 steps use the SOS software to bring the projectors into alignment. If this is the first time the projectors are being aligned, or new projectors have been swapped in for old ones, or the alignment is significantly off, start with the next step, "STEP 9: Red Ball Alignment".

However, if the projectors are mostly aligned and just need some tweaking in a few places, you can skip "STEP 9: Red Ball Alignment" and proceed to "STEP 10: Grid Alignment" and/or "STEP 11: Vertex Tweaking".

IMPORTANT: *Vertex Tweaking should only be used for fine local adjustments. Do not skip Red Ball Alignment or Grid Alignment if your projectors need more than just fine local adjustments.*

NOTE: Please read through the "Alignment Tips" section at the end of this document before beginning for some extra pointers and things to be aware about during alignment.

The closest projector to the SOS computer is typically called projector 1 (P1). The other projectors are named sequentially from 2 to 4 in a counterclockwise direction. See diagram below.
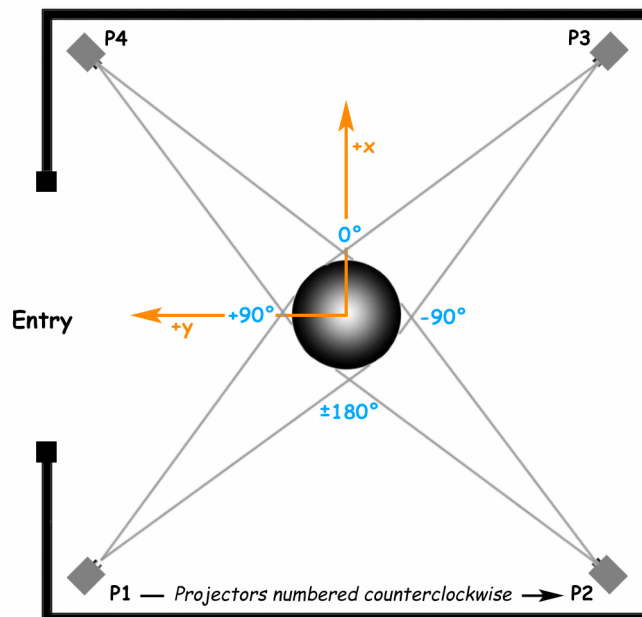

Note that the Entry may be at a different location for your site.

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STEP 9: Red Ball Alignment

In Red Ball alignment, a red ball against a cyan background is displayed by each projector onto the sphere. The goal of Red Ball alignment is to have the red ball cover the surface of the sphere in front of the projector and not overshoot the sphere on any side. You also do not want to see any cyan color on the sphere.
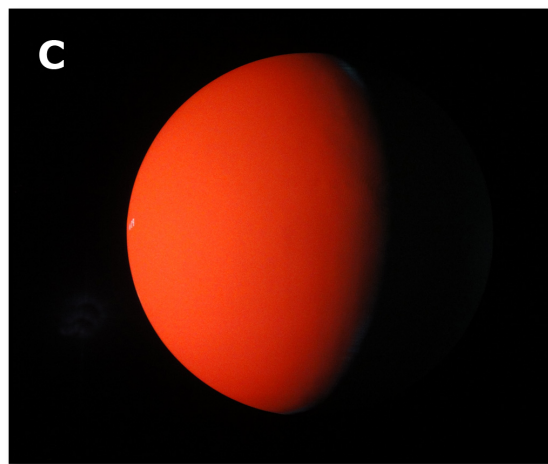
Study the following images before beginning Red Ball alignment.
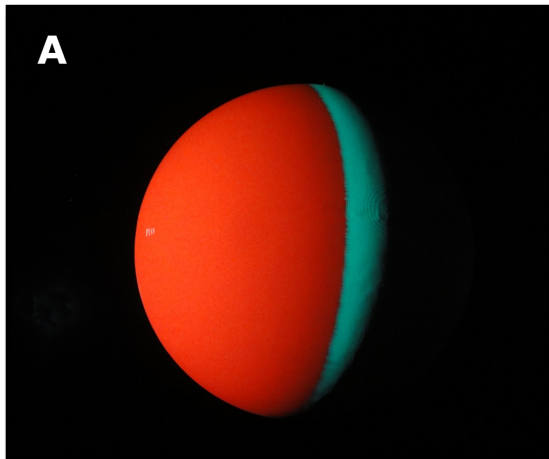
[A] shows the red ball displayed by 1 projector with the cyan background visible behind it.
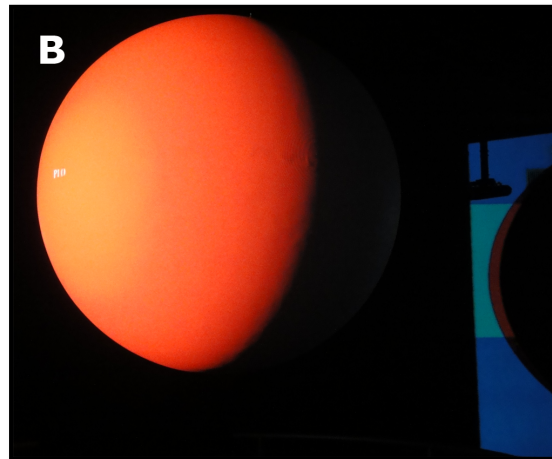
[B] shows the red ball displayed by 1 projector with the red overshooting onto the room's wall.

[C] shows the red ball displayed by 1 projector with no cyan background showing and no overshooting off of the sphere.

*Note: Please refer to **STEP 6: Learn the Wiimote Alignment Commands** to get further information on how to use the Wiimote to perform the following actions.*

(A) Turn on the Red Ball. Each projector will display a red ball onto the sphere.

(B) During Red Ball alignment, only one projector should be on at a time. Toggle off all projectors except for projector 1. **Re-select projector 1 and make sure it is on.**

(C) Use the Translate, Scale, and Rotate controls to adjust the position and size of the red ball of projector 1 so that the red ball covers up the cyan background, and the red ball does not overshoot the sphere on any side.

In this step, it is important to make sure that the red ball is *evenly* positioned on the sphere.

One way to ensure evenness is to first stand in front of the projector. Then, use the Scale controls to evenly scale the red ball down to a small enough size so that you can see cyan color all around the red ball (top, bottom, left, and right). Then, use the Translate controls to center the red ball so that the cyan color is even all around the red ball. To check the evenness of the cyan color, you will have to keep walking from side to side of the red ball as you are adjusting and looking up and down.

Once the red ball is centered, use the controls to expand it until it covers the quadrant of the sphere that you are looking at. As much as possible, you want to prevent the red ball from overshooting onto the room's walls, and you want to cover up most of the cyan. If a tiny bit of cyan color is still showing on one side or another of the sphere, that is okay.

NOTE: As you are making adjustments, you will have to keep going back and forth between the different Translate, Scale, and Rotate (less common) controls because you cannot cover the cyan background with the red ball with just one control. In addition, you can't just stand in front of the projector. You will have to keep moving from side to side of the sphere to observe the red ball as you are making adjustments.

(D) Save the current alignment. Note that you can save at any time during the alignment process, and it is recommended that you save your changes often. Also note that saving will save the changes for all projectors at once, not just the currently selected projector. If changes are made that

you don't want to keep, you can revert back to the last time you saved by tapping the "Revert button.

(E) Repeat **(B)**, **(C)**, and **(D)** for projectors 2, 3, and 4.

(F) Turn off the Red Ball.

STEP 10: Grid Alignment

In Grid Alignment, a white grid against a red background is displayed by each projector onto the sphere. The goal of Grid alignment is to have the grids line up between all the projectors so that there appears to be one seamless image wrapped around the sphere.

Study the following images before beginning Grid alignment.
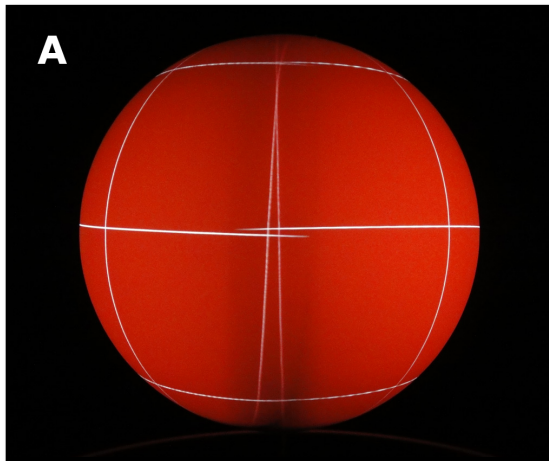
[A] shows a view of the grids from 2 projectors that are unaligned in the overlap region.
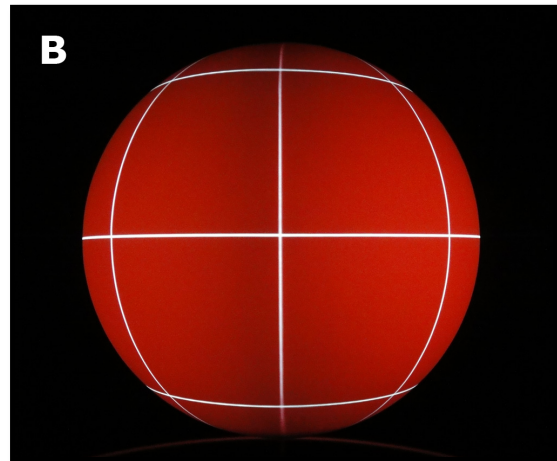
[B] shows a view of the grids from two projectors that are aligned in the overlap region.

Note: Please refer to **STEP 6: Learn the Wiimote Alignment Commands** *to get further information on how to use the Wiimote to perform the following actions.*

(A) Make sure Red Ball is turned off. Each projector should be displaying a white grid against a red background onto the sphere.

*NOTE: If this is the first time the sphere is being aligned, or the alignment between some are all projectors is significantly off, it is very useful to use a laser level at this point before proceeding. Ideally, you want horizontal grid lines projected onto the sphere (lines of latitude) to be parallel to the horizontal plane of the room. To help achieve this, set up the laser level so that it projects a level horizontal line on the sphere's equator in front of projector 1. Then, use the Wiimote to select projector 1. **Use ONLY the Rotate controls to rotate the grid of projector 1 so that its horizontal grid lines are parallel to the laser level's line.** Repeat this procedure for projectors 2, 3, and 4. Then, use the Wiimote to save your changes.*

(B) Select projector 1. In Grid Alignment, you typically want all projectors on most of the time. However, it is often handy to intermittently toggle adjacent projectors on or off in order to see which projectors are causing overlap.

(C) Use the Translation, Scale, and Rotation controls to adjust the position size of the grid displayed by projector 1. You want the grid to line up as closely as possible to the grid lines displayed by the projectors to the left and right of projector 1. **Note that the controls for Grid alignment affect the projector's grid as a whole. You cannot alter specific lines on the grid.**

It is better to move the grid of one projector half way and then move the grid from an adjacent projector half way and have them meet in the middle rather than moving one grid all the way over to the other grid. To do this, you will have to switch over to the adjacent left or right projector in order to adjust their grids slightly, and then switch back to projector 1 to readjust it.

When trying to adjust a grid, it can be confusing as to which projector is displaying which grid. So again, remember to toggle projectors on/off to be clear on which projector is displaying which grid and which projector's grid lines actually need to be moved.

Remember that even though we may be adjusting multiple projectors (for example, projector 1 plus the adjacent projectors), our intent here is to focus on projector 1 while toggling between the adjacent left and right projectors (projectors 2 and 4 – see diagram at beginning of document for room and projector layout). With this in mind, it is important to just focus on the seams (the overlap regions) between projectors 1 and 2 and projectors 1 and 4.

TIP: In most cases, only the translation and scale controls will be used,

and you will not need to use the rotation controls, as rotating will rotate the lines parallel to the equator out of horizontal, which in general we want to avoid.

TIP: When performing Grid Alignment for the first time, adjust the horizontal grid lines of all projectors first (via translating in the left/right directions, and scaling if necessary in the left/right directions), and then go back and adjust the vertical grid lines.

TIP: If the top vertical lines between two overlapping projectors (let's say p1 and p2) are together, but their bottom vertical lines are crisscrossing, though it might not be intuitive, translate both p1 and p2 up by one or more pixels and see if that improves the alignment in the bottom area. Same idea if the top vertical lines are crisscrossing...in this case, translate both p1 and p2 down by one or more pixels.

TIP: At the end of Grid Alignment, if you get to the point where you can't fix one grid without making the adjacent worse, try Vertex Tweaking those areas.

(D) Save the current alignment. Note that you can save at any time during the alignment process, and it is recommended that you save your changes often. Also note that saving will save the changes for all projectors at once, not just the currently selected projector. If changes are made that you don't want to keep, you can revert back to the last time you saved by tapping the "Revert button.

**(E)** Repeat **(B)**, **(C)**, and **(D)** for projectors 2, 3, and 4.

STEP 11: Vertex Tweaking

Once the image is fairly close to being seamless, Vertex Tweaking is the final step used to further perfect the alignment. In Vertex Tweaking, a set of numbered vertices corresponding to specific areas of the grid image are displayed by each projector onto the sphere. The goal of Vertex Tweaking is to fine-tune the alignment near these specific areas.

Study the following images before beginning Vertex Tweaking.
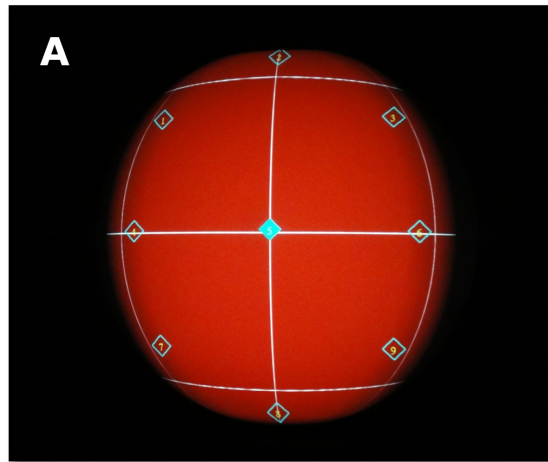
[A] shows the set of vertices displayed by 1 projector
(the two adjacent projectors have been toggled off).
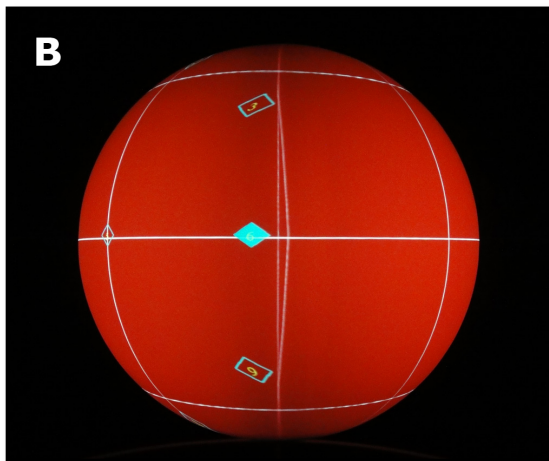
[B] shows the overlap region between 2 projectors with the vertices displayed by the projector on the left. A selected vertex (a numbered diamond shape filled in with cyan color) is also shown. The line near this vertex is out of alignment.
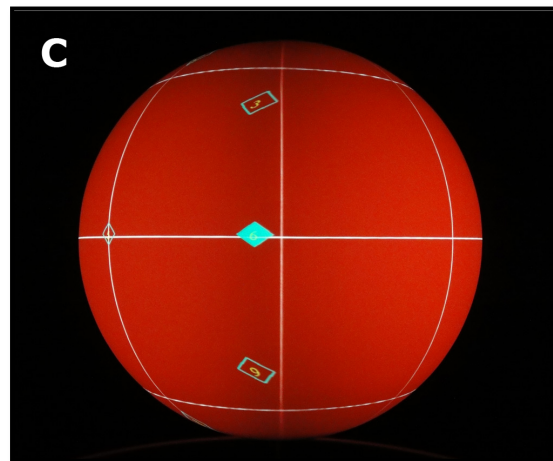
[C] After the Vertex Tweaking procedure, the line near the selected vertex is in alignment.

*Note: Please refer to **STEP 6: Learn the Wiimote Alignment Commands** to get further information on how to use the Wiimote to perform the following actions.*

(A) Select projector 1 and turn on Vertex Tweaking for that projector. A set of vertices numbered 1 through 9 will be displayed onto the sphere by projector 1. In Vertex Tweaking, you typically want all projectors on most of the time. However, it is often handy to intermittently toggle adjacent projectors on or off in order to see which projectors are causing misalignment in the overlap region.

(B) Select a vertex you would like to adjust. Use the Translate controls to move the image up, down, left or right. The image will only stretch near the selected number. So for example, if a whole side needs to move left, you need to stretch it by adjusting the top, middle, and bottom vertices to the left.

It is sometimes confusing to figure out which projector is displaying a grid line in the overlap region, so it is helpful to toggle the adjacent projectors on and off to differentiate between the grid lines and to know which projector's grid line actually needs to be moved.

Also, if two lines from two adjacent projectors are separated that shouldn't be, it is better to move each line from each projector half way and have them meet in the middle rather than moving one line from one projector all the way to the other. To do this, you will have to switch over to the adjacent left or right projector, adjust that projector's relevant vertex slightly, and then and then switch back to projector 1 to readjust its relevant vertex.

Remember that even though we may be adjusting multiple projectors (for example, vertices of projector 1 plus the vertices of the adjacent projectors), our intent here is to focus on projector 1 while toggling between the adjacent left and right projectors (projectors 2 and 4 – see diagram at beginning of document for room and projector layout). With this in mind, it is important to just focus on the seams (the overlap region) between projectors 1 and 2 and projectors 1 and 4.

TIP: Consider starting the process of Vertex Tweaking by adjusting the vertices 4 and 6 first, followed by vertices 1, 3, 7, 9, and finally vertices 2 and 8.

(C) Save the current alignment. Note that you can save at any time during

the alignment process, and it is recommended that you save your changes often.   Also note that saving will save the changes for all projectors at once, not just the currently selected projector. If changes are made that you don't want to keep, you can revert back to the last time you saved by tapping the "Revert button.

(D) Repeat **(B)** and (**C**) for any other vertices you would like to adjust for projector 1.

(E) Repeat **(A)**, **(B)**, **(C),** and **(D)** for projectors 2, 3, and 4.

(F) Turn off Vertex Tweaking.

(G) Click on the "Stop Alignment" Button in the Alignment Interface on your SOS computer. When you stop alignment, your Wiimote should return to its normal mode wherein its buttons are used to control the playlist and tilt the sphere.

(H) This completes the alignment process.

Alignment Tips

• When adjusting grids in Grid Alignment or Vertex Tweaking modes, if you find that you need to make more than one adjustment (for example, one tap of the translation control), then switch back and forth between adjacent projectors so that the grid lines will eventually "meet in the middle".

• It is recommended that the projectors are on for 15-20 minutes before starting alignment as we have found that the images sometimes move slightly as the projectors warm up.

• On the Alignment interface window on your SOS computer, you can select the "Red Grid (fine)" option in order to display a grid that is higher resolution and with thinner grid lines. This will help you to fine tune your alignment even more while you are making your translation/scale/rotation adjustments.

• It is recommended that you save the alignment several times throughout the alignment process so that if you adjust a projector but immediately decide that you need to revert that adjustment, you will be taken back to the most recently saved alignment that you were satisfied with.

• If your projectors are significantly out of alignment, don't just use Vertex Tweaking to try to fix it. Vertex Tweaking is meant only for fine local

adjustments.   If you just use Vertex Tweaking for gross alignment, you may begin to see significant image tearing and other artifacts on the sphere. Go through each of the 3 alignment steps (Red Ball, Grid, Vertex Tweaking) in order to fix the alignment.

- If you are checking your alignment every few weeks, and you find that the alignment is only slightly off, often times this indicates that a projector has been slightly moved (maybe due to a projector being bumped, room vibration from large crowds, etc). Try using the Grid alignment interface and only the Translate controls to adjust it. This may be enough to bring the projector back into alignment. In addition, check to make sure the projector mount screws are tight, and that the mount itself is stable and tight.

- After Grid alignment, vertical grid lines should be parallel to each other. If you find that some vertical lines at the top or bottom of the sphere are diverging or crisscrossing in the overlap regions between projectors, this may indicate that the ground to sphere center measurement was not optimally measured (see STEP 3). Re-measure the distance from the ground to the sphere center. If it is indeed accurate, consider adding or subtracting 1 inch from this measurement and then re-entering it into the SOS configuration file as described in STEP 3. Be sure to re-start the main SOS application after making this change. Then, re-run the Grid alignment interface to see if that made a difference.

- If you swap out a new projector for an old projector, you may need to change your computer's "xorg.conf" file so that the computer will know the correct configuration (screen resolution, etc.) for your projector. Please contact sos.gsd@noaa.gov to ask for technical assistance about how to do this.

- The SOS computer automatically backs up alignment files every day. If you want to reset your alignment files to an older backup, open a terminal and run the following command (note that you must be logged on to the SOS computer as the "sos" user to perform this operation):

cp   /shared/sos/site-backup.your-computer-name/date/shared/sos/site-config/site-config/alignment/*   /shared/sos/site-config/alignment/

where **your-computer-name** is the name assigned to your computer and **date** is the timestamp of the alignment files you are interested in restoring (for example: 2012-01-26-00:8:30).

Exit the SOS Stream GUI application on the SOS computer and then restart it in order for the new alignment files to take affect.

CONTACT

If you have any questions regarding alignment, please contact:
sos.gsd@noaa.gov