Exercise 2: Perform spatial analysis on BIM data

Technical note

1. You will make full use of web mapping services throughout this course. You will need a robust web connection to complete this exercise and the exercise that follows.
2. Use the latest version of Google Chrome, Mozilla Firefox, Apple Safari, or Microsoft Edge. Other web browsers may not display your maps and apps correctly.

Note: For information on supported web browsers for ArcGIS Online, go to ArcGIS Online Help: Supported browsers (https://links.esri.com/SupportedBrowsers).

Note: For information on requirements for using Scene Viewer on either mobile devices or desktop web browsers, go to ArcGIS Online Help: Scene Viewer requirements (https://links.esri.com/SceneViewerRequirements).

Software requirements

- An updated web browser

Introduction

Spatial analysis allows you to solve complex location-oriented problems, explore and understand your data from a geographic perspective, determine relationships, detect and quantify patterns, assess trends, and make predictions and decisions. Spatial analysis goes beyond mapping and allows you to study the characteristics of places and the relationships among them. Spatial analysis lends new perspectives to your decision-making.

Using spatial analysis, you can combine information from many sources and derive new information and insights by applying a set of spatial operators. ArcGIS Online supports analysis and decision-making using spatial information and GIS technology throughout the AEC project life cycle, allowing you to make smarter, more informed decisions. Spatial analysis can reveal pivotal insights about detailed infrastructure assets and help you solve critical problems at any point during a project, thereby reducing costs and delays. Spatial analysis in ArcGIS Online is not only available in 2D maps but also extends to 3D and even through time. A typical spatial analysis workflow involves the following steps:

- Frame the question that you want to answer.
- Find and prepare the data and make it ready for analysis.
- Explore the data to better understand it.
- Perform the spatial analysis, using the right tool or set of tools to answer the question.
- Share your results to communicate your findings.

When performing spatial analysis using GIS and BIM data, there are several tools unique to the 3D environment with which you should become familiar. Some of these tools you have previously used in this course, such as the Slice tool or the Elevation Profile tool. In this exercise, you will use a few more tools to answer questions about the new building projects on or near the Esri campus in Redlands, California.

Note: The exercises in this course include View Result links. Click these links to confirm that your results match what is expected.

Scenario

Imagine that you are an analyst who must evaluate the new building projects on the Esri Redlands campus. The new building, Building E, which is nearing completion, and a newly proposed building near the campus have come under local scrutiny. Being good stewards of the natural and built environment, stakeholders have asked your firm to assess the impact of the new buildings on the natural environment and ensure that they fit within the campus environmental design. You will use some of the tools available in Scene Viewer to perform this analysis.

Estimated completion time: 30 minutes

Expand all steps | Collapse all steps

- Step 1: Measure a distance and elevation in Scene Viewer

To address the stakeholders' request, you will first answer the following questions:

- What is the distance between the two new buildings?
- What is the elevation difference between these buildings?

You have used several analysis tools already in previous exercises. Now you will use an additional analysis tool to answer these questions. This simple measurement tool introduces the tools available to measure distances between two points and calculate areas in your scene.

a In a web browser, return to your Redlands Scene (<MOOC student account>) web scene.

Note: Your initial view may differ slightly from the preceding graphic, depending on the location and viewing angle when you saved your web scene.

- Hint

  If you closed your web browser, perform the following steps:

  1. Open a web browser in private or incognito mode and go to **www.arcgis.com**.
  2. Sign in to ArcGIS Online using your MOOC student account credentials.
  3. Click Content.
  4. From the My Content tab, for the Redlands Scene (<MOOC student account>), click the More Options button ••• and choose Open In Scene Viewer.

b Use your navigation skills to orient your web scene so you can view both the 3D mesh of Building E and the building scene layer of the new Redlands building.

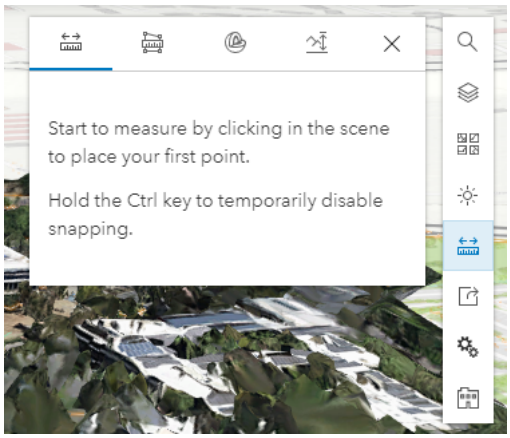
- Hint

  A view from the south looking north similar to the preceding graphic is recommended.

First, you will use an analysis tool in Scene Viewer to measure the distance between the two new buildings on the campus. This simple measurement tool introduces the tools available to measure distances between two points and calculate areas in your scene.

c On the right side of your web scene, click the Analyze button .

d In the Analyze window, click the Measure Distance button , if necessary.



*Step 1d***: Measure a distance and elevation in Scene Viewer.*

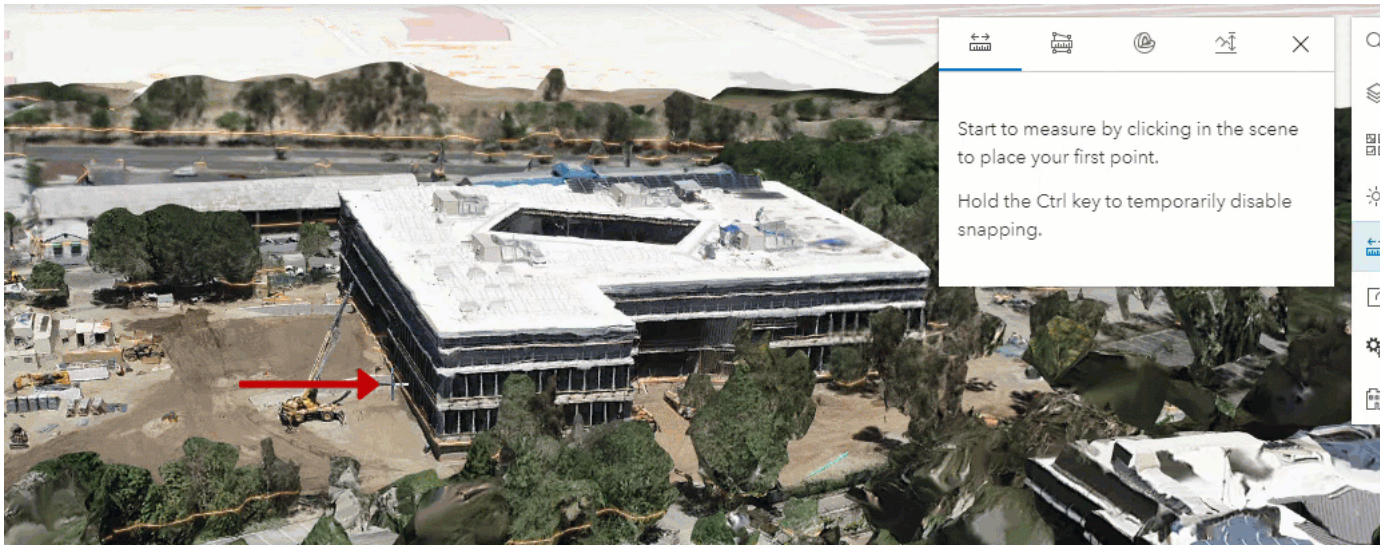
Note: The Elevation Profile result from the previous exercise may still be visible when you open the Analyze window.

When you click the Measure Distance tool or Measure Area tool in Scene Viewer, horizontal laser lines are projected on the terrain and objects in the scene, showing the vertical height of the pointer in the scene as you measure. It is helpful to see the heights of objects relative to other objects and the terrain. For example, you can hover over a smaller building and see that height highlighted relative to another part of the terrain.

When the distance between the points is greater than 100 kilometers, a circular laser line appears, indicating that Scene Viewer has switched to geodesic mode. In geodesic mode, Scene Viewer calculates only the horizontal and vertical distances, taking into consideration the curvature of the earth (that is, ellipsoid-based geodesic distance). The Direct distance option is unavailable when these types of distances are being measured.

Note: In local scenes, it is important to know that measurements are displayed as Euclidean values and may not be accurate, depending on the scene's projected coordinate system. Web Mercator scenes display the accurate geodesic values.

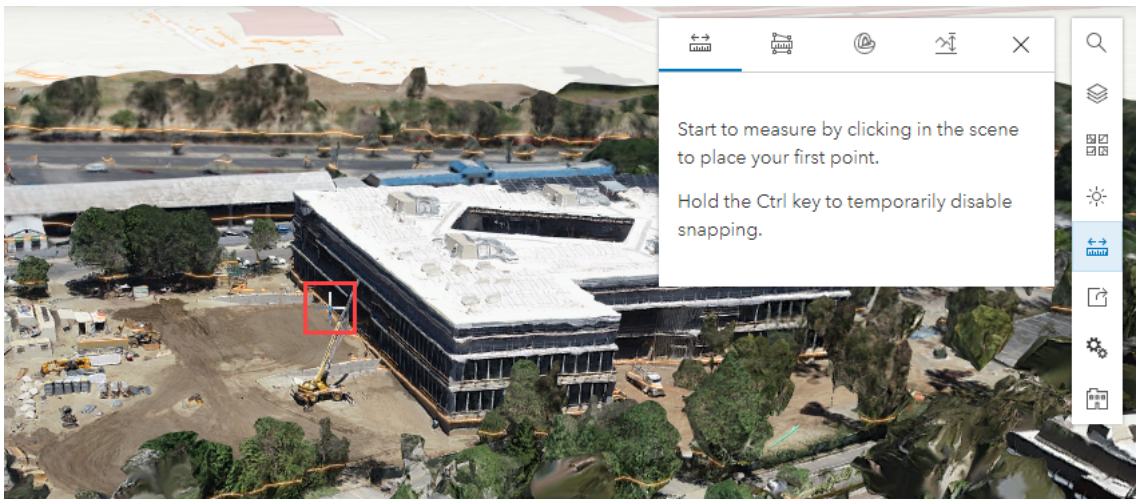
e In the scene view, move your cursor up and down the west face of Building E to observe the laser lines in your scene, as indicated in the following graphic.



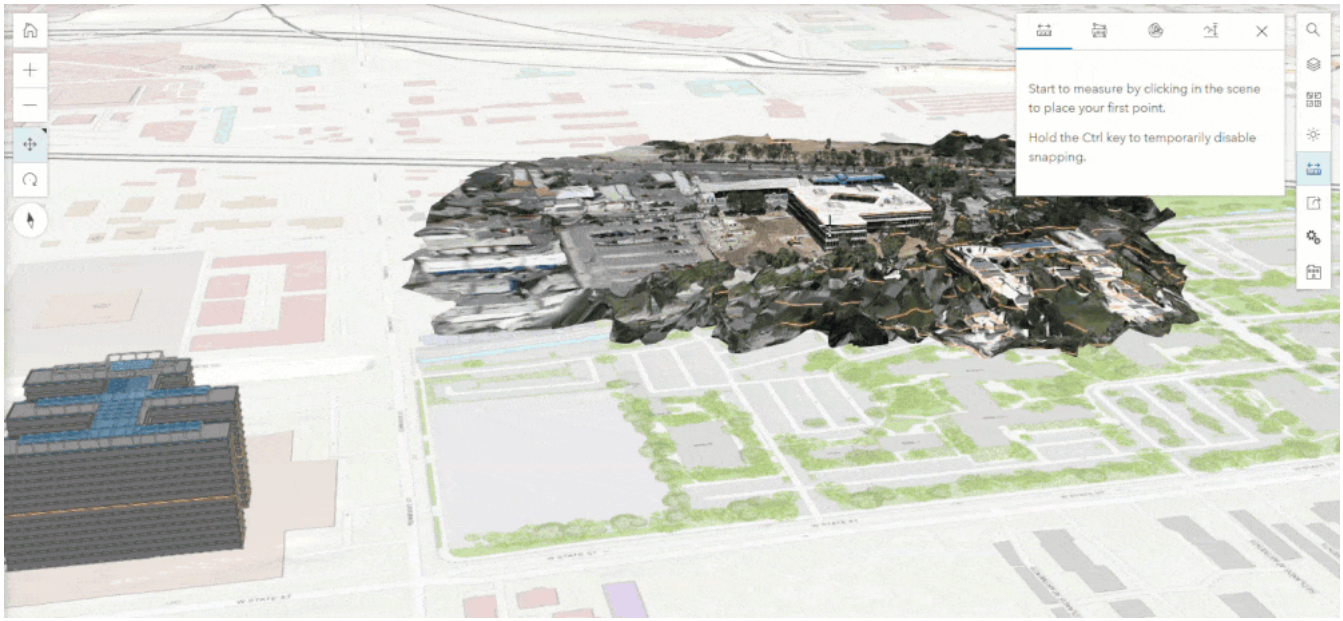
Replay

The laser lines appear on both the terrain and any vertical objects that intersect the vertical, or elevation, plane relative to your cursor location. This functionality makes it easy to see where heights are in relation to one another, as shown in the following graphic.

f Click a point near the west side of the foundation of Building E to start your measure line, as indicated in the following graphic.

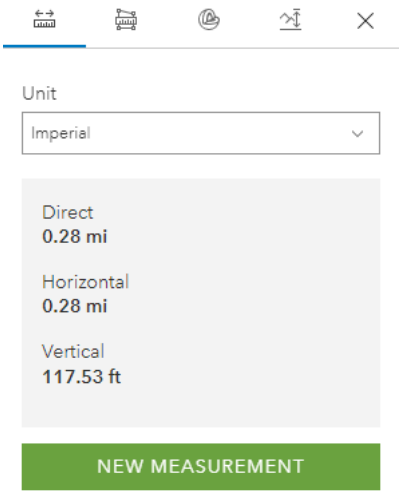


g Move your cursor to the model of the new Redlands building to the southwest of the 3D mesh and double-click to finish the line.



Replay

h In the Measure window, notice the measurements that are listed.



*Step 1h***: Measure a distance and elevation in Scene Viewer.*

Note: Your direct, horizontal, and vertical measurements may vary slightly from the preceding graphic, depending on your start and end points.

The Measure window records the direct, horizontal, and vertical distance between your two points.

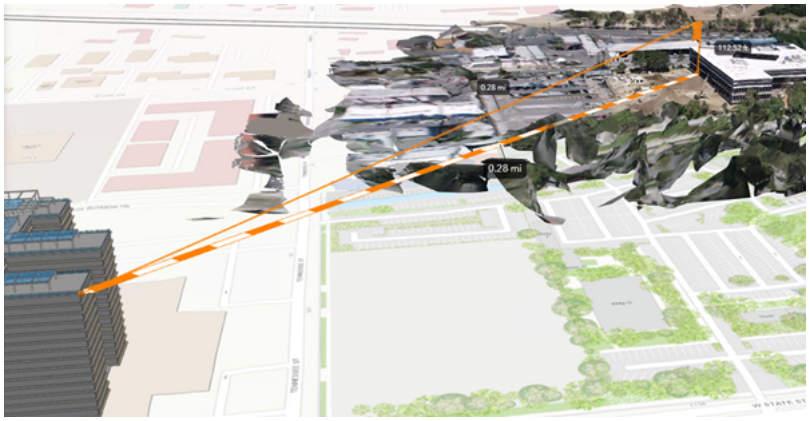
The direct measure is represented by the orange and white checkered line and is the straight line distance from one point to the other. The horizontal measure is the level elevation measure between the two points. The default unit of Imperial can make the numerical difference between the two seem negligible. You can change the unit of measure in the Measure window by selecting options such as Feet or Meters from the Unit drop-down menu. These units can help provide more granular measurements.

Finally, the vertical measure, or elevation, shows the difference in height between these two points. In the example of the measurement that you just performed, you are provided with not only a difference in the height but also an easy visual comparison of the two building heights against one another.

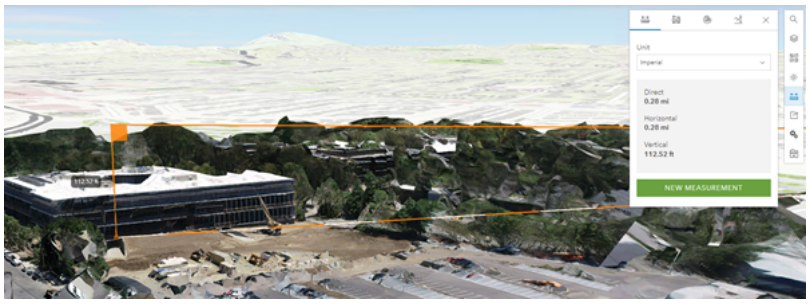
Note: If you need to restart your measure, click New Measurement.

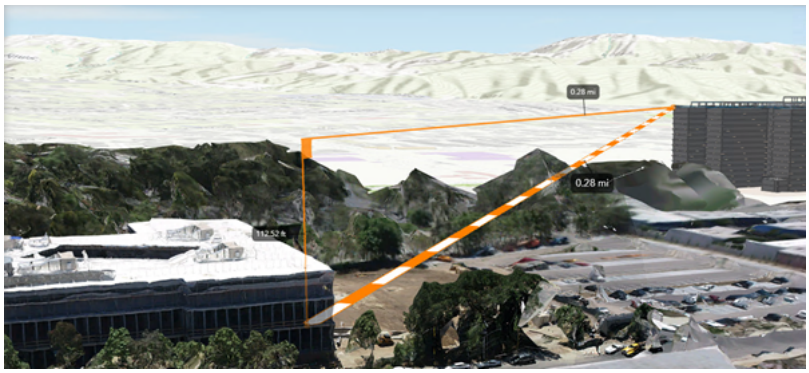
i On your own, use your navigation skills to explore different view angles of your measurement.

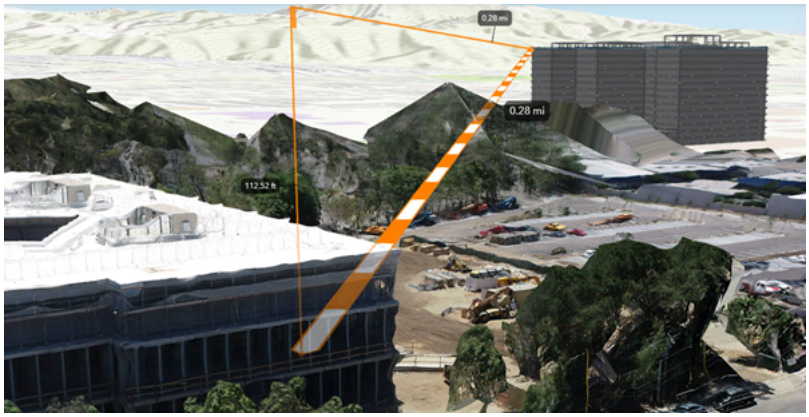
The following graphics show different view angles of the measurement.


112.52 ft
0.28 mi
0.28 mi

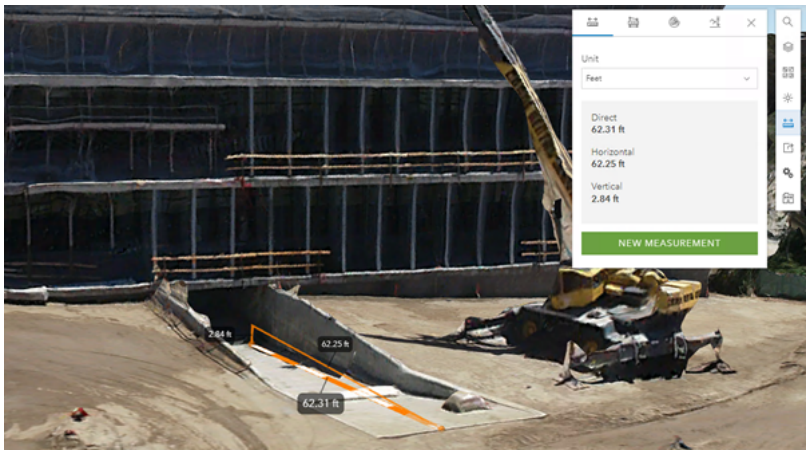

112.52 ft


Unit
Imperial
Direct
0.28 mi
Horizontal
0.28 mi
Vertical
112.52 ft
NEW MEASUREMENT
112.52 ft


0.28 mi
0.28 mi
112.52 ft



You can use these tools not only for long distances but also to evaluate your construction site. The following example shows a measure performed on the southern loading ramp on the west side of Building E. While the initial elevation drop and opening seem quite large, a measurement of the site shows different results. This type of quick analysis can not only help with potential safety evaluations but also to verify construction against plans or, if necessary, meeting specific code requirements.



? Based on this measurement, what is the slope of this ramp into the basement level of Building E?

- Answer

The formula to compute slope is Slope = Rise/Run. Using these numbers, the slope is a gentle 4.5 percent.

j On your own, explore and examine other areas of the Building E construction site or the building scene layer model of the off-campus building to discover what other types of evaluations that you can make using the Measure tools.

k Save your web scene.

Now that you have explored the Measure tools available in a 3D scene view, you will use some other analysis tools. Instead of using tools in this web scene, however, you will use another tool in a web app.

- Step 2: Configure layers in a web app

To help communicate more of your findings to your stakeholders, you will use a web application (or web app) that one of your colleagues created. In this step, you will configure the layers in the web app in preparation for further analysis.

a Click Redlands - Building Project - 3D WebApp to open this web app in your web browser.

b On the left side of the web app 3D scene view, click the Open Slides button and select Building E (Context).

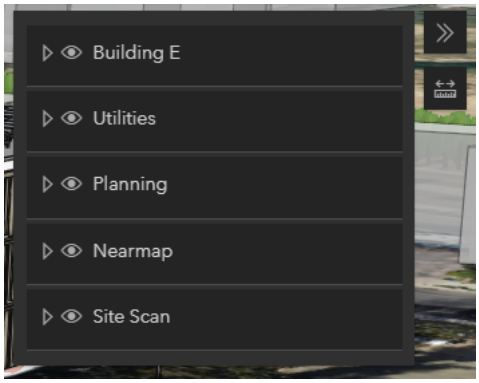
*Step 2b***: Configure layers in a web app.*

The view in the web app will navigate to a new field of view and update the visible layers.

c Click the Open Slides button .

You can configure the display of the content in the web app as necessary to improve performance and clarity for your analysis.

d On the right side of the web app, click the Open Layer List button .

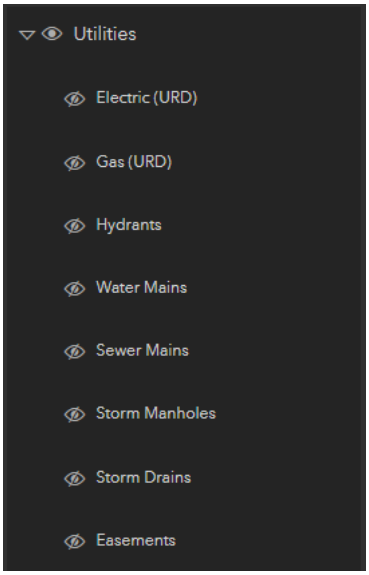


*Step 2d***: Configure layers in a web app.*

The layer list shows a number of different integrated layers in this web app. There is a building scene layer (Building E), GIS layers (Utilities and Planning layer groups), and imagery (Nearmap and Site Scan layer groups). Currently, all layer groups are visible, but there are individual layers within each of these groups that are turned off and on.

Your stakeholders would like to know what is visible from the third story of Building E as well as from general points on campus. You will now configure your view in preparation for performing a line of sight analysis.

e In the Layer List panel, click the arrow next to Utilities to expand its contents.

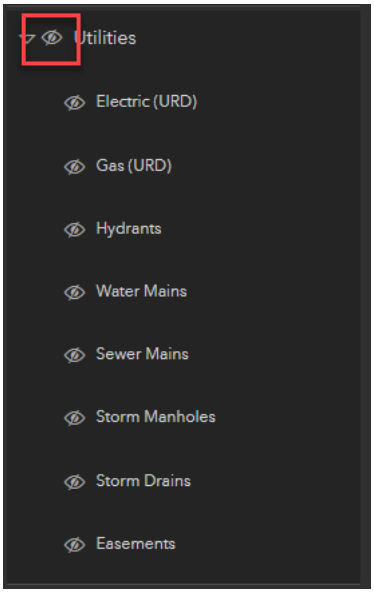


*Step 2e***: Configure layers in a web app.*

The visibility is turned off for all layers in this layer group. While it is not necessary to turn the visibility of the entire layer list off, it can help when looking at the larger list to know when lists are on and off.

f For Utilities, click the Hide Layer button to turn the entire layer list off.

g When you turn the layer list off, notice that the icon changes to reflect that the visibility of the layer is off, as indicated in the following graphic.

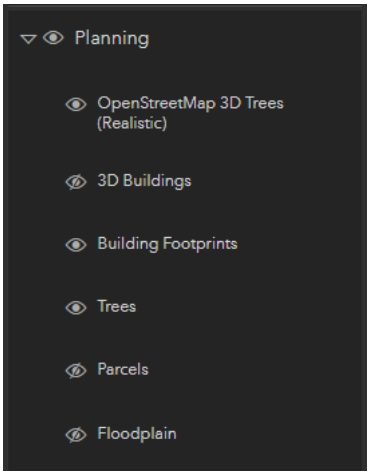


h Click the down arrow to collapse the Utilities layer list.

i On your own, for the Planning layer list, modify the layers to show or hide them as specified below:

- Show
  - OpenStreetMap 3D Trees (Realistic)
  - Building Footprints
  - Trees
- Hide
  - 3D Buildings
  - Parcels
  - Floodplain

j Ensure that the visibility is on for the entire Planning layer list.



*Step 2j***: Configure layers in a web app.*

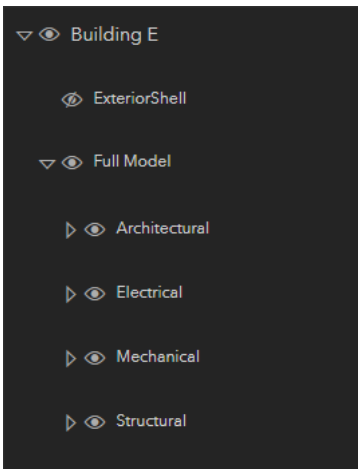
k Hide both the Nearmap and the Site Scan layer list.

*Step 2k***: Configure layers in a web app.*

Finally, you will configure the building scene layer.

l In the Layer List panel, expand Building E, and then under Building E, expand Full Model.

m If necessary, under Full Model, turn on the visibility for all layers.



*Step 2m***: Configure layers in a web app.*

If you recall, when building scene layers are shared to ArcGIS Online, both the ExteriorShell and the Full Model are included. While you are using a web app in this step, the layers shown here were shared from ArcGIS Pro in the same manner that you used in the previous exercise. Web apps can be configured for various visualization and analysis needs. By default, the ExteriorShell of a model is the view normally rendered. However, this web app is configured to show the Full Model as the default view, with all the construction disciplines available in the model as well. You can explore each of these individual disciplines on your own, but for the line of sight analysis, they are unnecessary. For this analysis, the ExteriorShell will be all that you need.

n For ExteriorShell, click the Show Layer button to turn the visibility on for this layer.

o For Full Model, click the Hide Layer button to turn this group layer off.

Because you are turning off the Full Model group layer, there is no need to turn off the visibility of the individual layers. The ExteriorShell of this building scene layer is fairly extensive and contains a lot of information and detail. For the additional analysis that you plan to perform, this portion of the model will serve your purpose with the added benefit of making navigation in your web scene faster.

p On the right side of the web app, click the Open Layer List button .

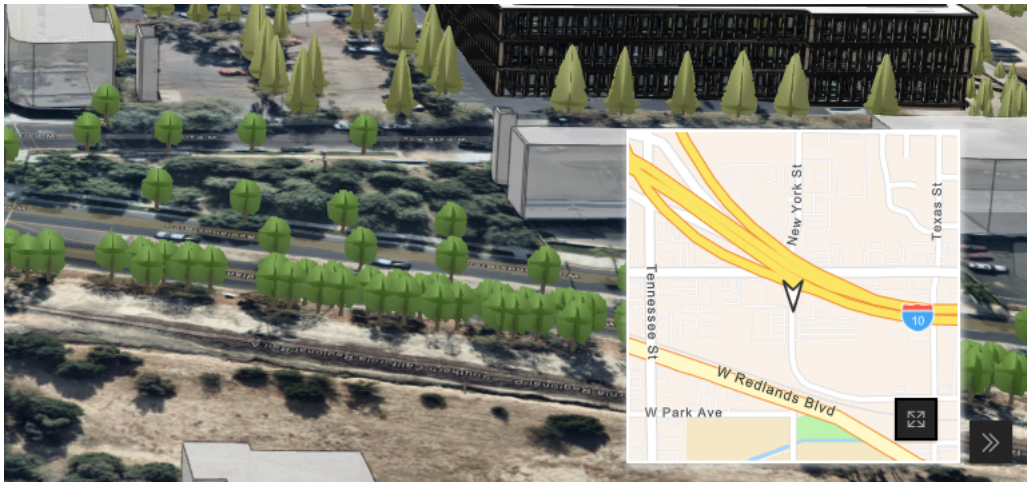
Now that you have configured the layers in this web app, you can perform additional analysis.

- Step 3: Perform a line of sight analysis

During the design phase of a project, engineers, architects, and other stakeholders may be interested in what can be seen from the new building and from where within the surroundings the new building can be seen. Using 3D visibility analysis, you can analyze and visualize the line of sight from one location to one or more target (end) points. In this step, you will use the Line of Sight tool in ArcGIS Online to perform 3D visibility analysis to provide your project stakeholders with this information to ensure that the new building fits within the campus environmental design.

a In the web app, orient your view to look south along New York Street on the Esri Redlands campus, as shown in the following graphic.

b If necessary, click the Open Overview Map button to help set your location, as shown in the following graphic.



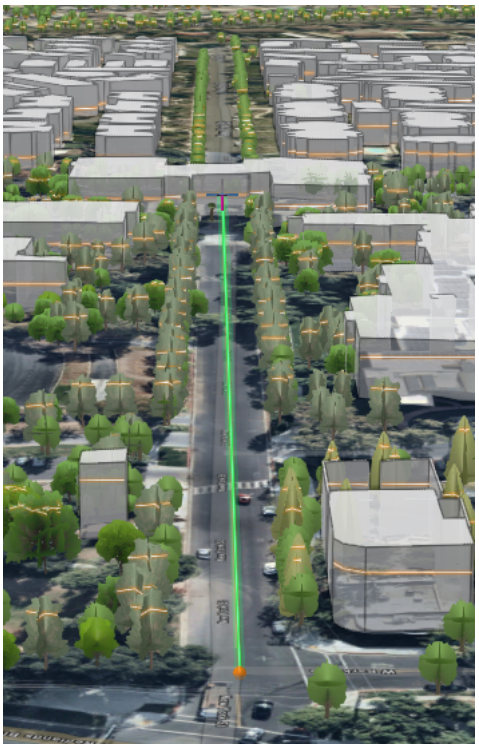
c On the right side of the web app, click the Open Line Of Sight Tool button and click New Analysis.

The Line of Sight tool uses an observer point and one or more target points to calculate visibility against the currently displayed content in the view, including ground, integrated meshes, and 3D objects, such as buildings or trees. To begin the analysis, you will first identify an observer point.

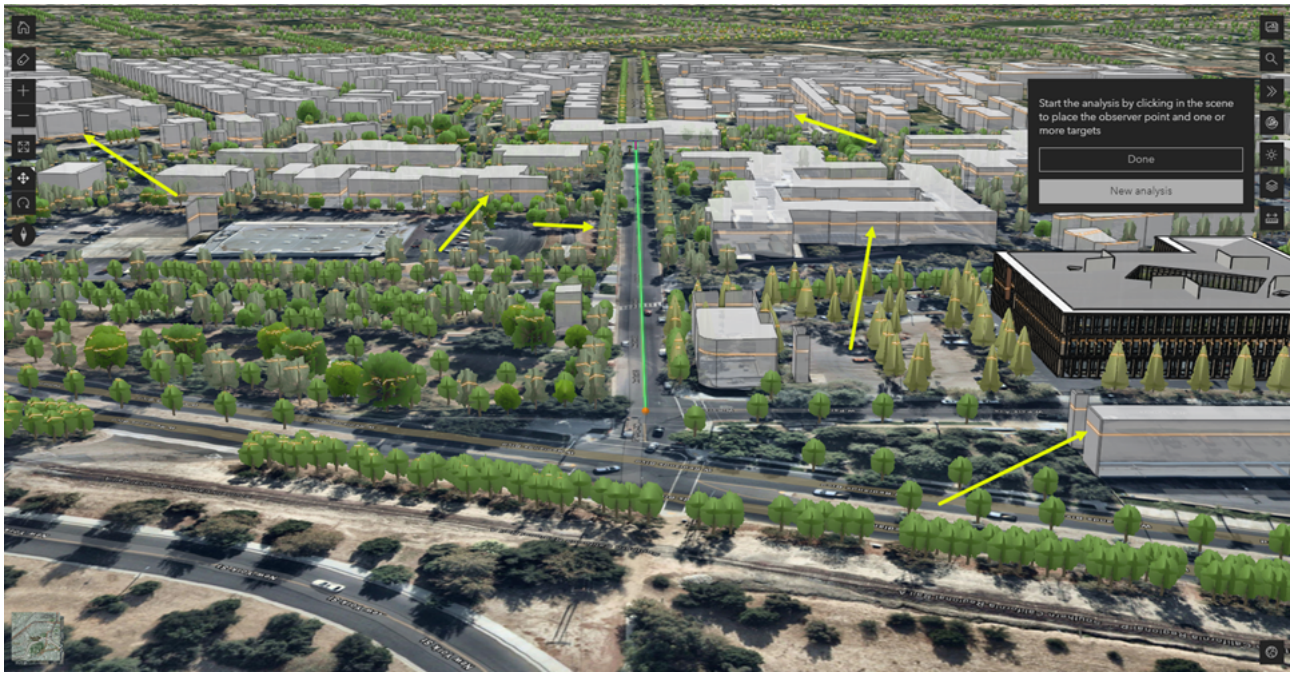
d In the web app, move your cursor to the intersection of New York St. and W. Park Ave. and click to place an observer point to begin your analysis, as indicated in the following graphic.

From the observer point, you can move your cursor to various target points within the scene to determine visibility. Beginning with a clear line of sight is a good place to start to validate your observer point.

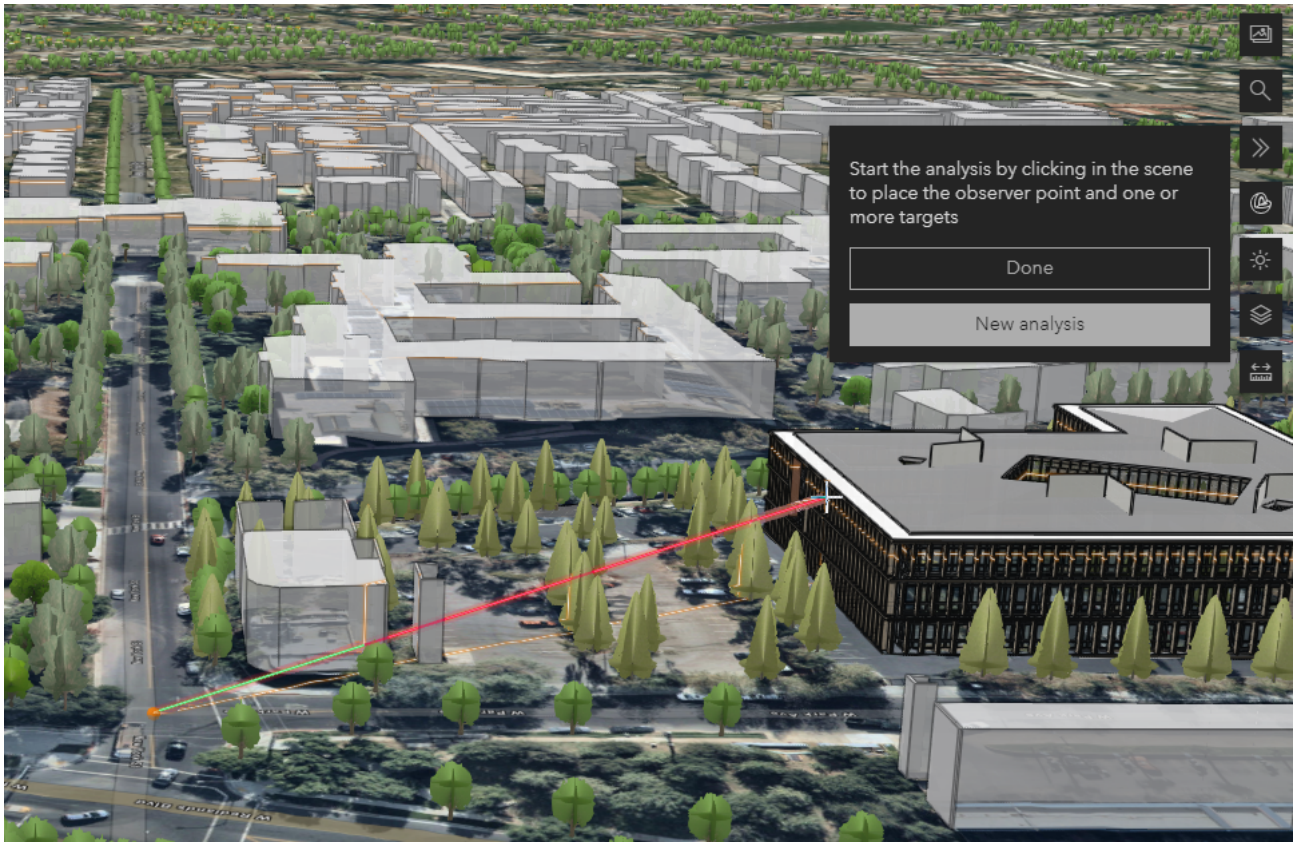
e Move your cursor south along New York St. until it intersects the 3D building footprint at the end of the road but do not click to end the line.



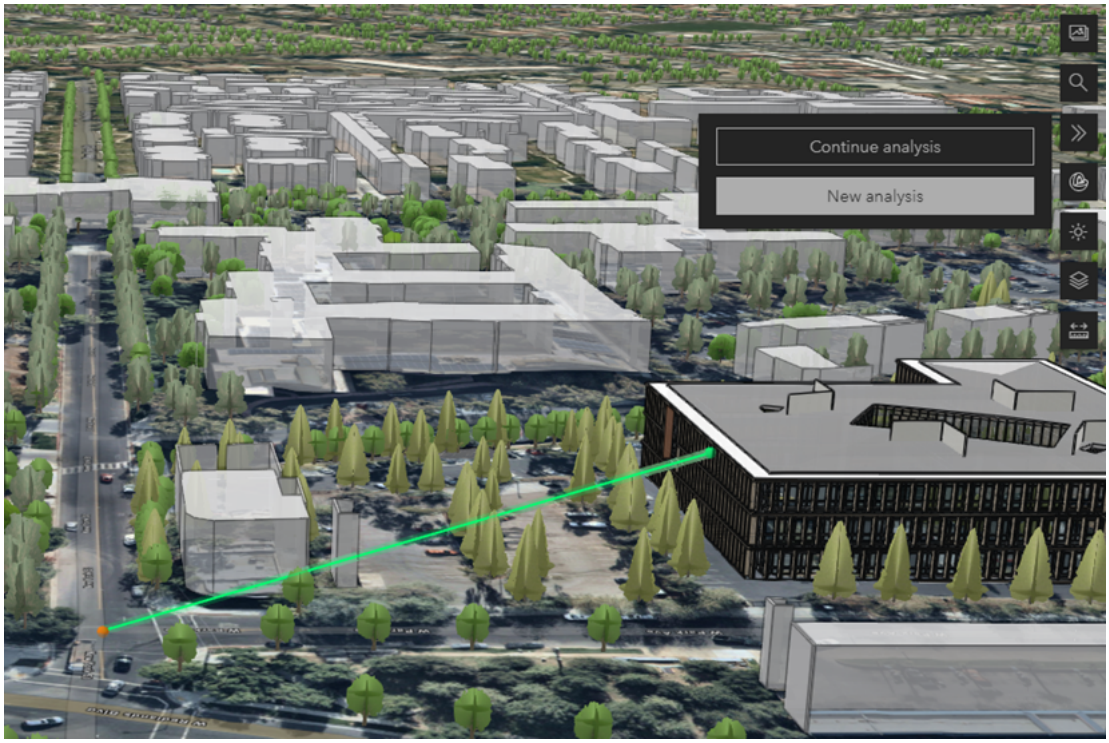
As you move the endpoint of your line in the scene, you will observe that the laser line is visible on all 3D surfaces throughout the scene in a manner similar to the Measure tool. The line of sight analysis appears as lines and spheres—green lines are the visible part that the observer can see, and red lines are the occluded part. Also, green spheres indicate visible targets in which the full line is green; red spheres indicate the occluded targets. When the line of sight cannot be calculated, it is displayed with a gray color, which happens when either the target or the observer are not in the view or when neither of them are in the view.



f Move your cursor so that your line endpoint intersects Building E.



g Continue to adjust your endpoint so that the entire line segment is green and double-click to end the line.



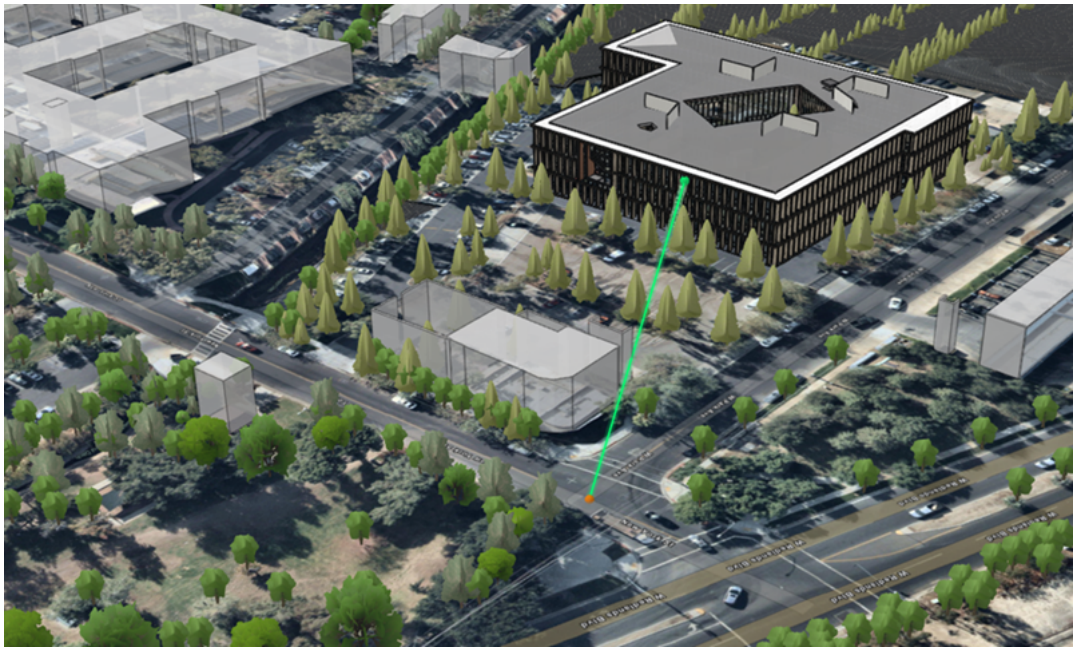
*Step 3g***: Perform a line of sight analysis.*

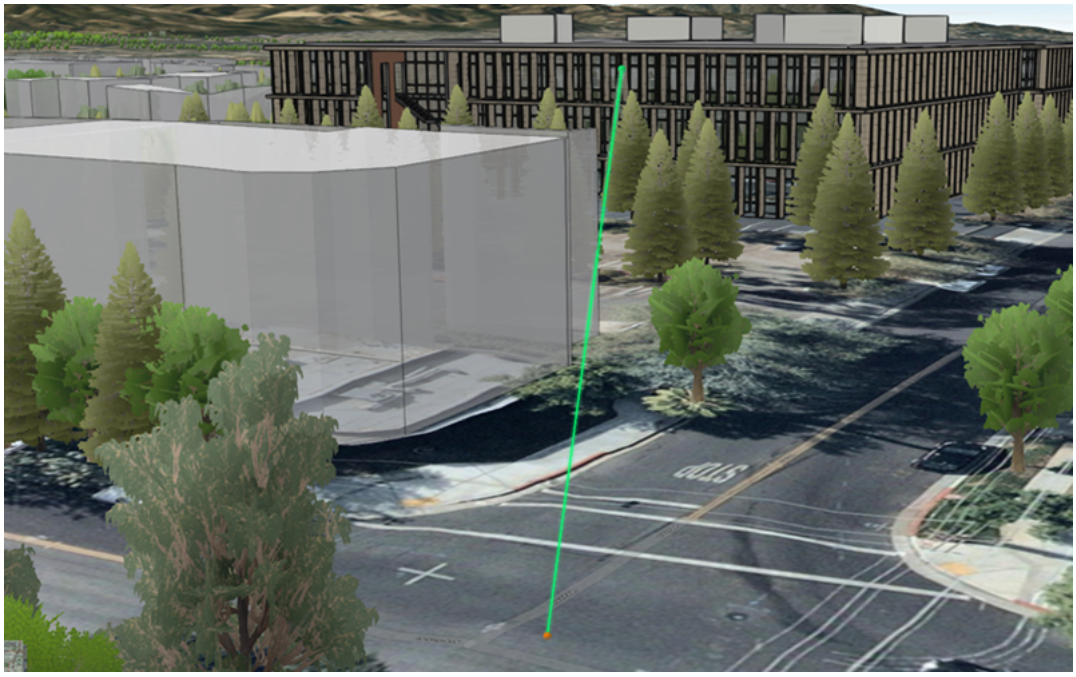
Note: After you double-click to end the line segment, the endpoint becomes the target point of your visibility line.

- Hint

  It may take a few tries to find a visible line of sight from your observer point to Building E. If necessary, you can click New Analysis and place a new observer point at the intersection to make it easier.

h Navigate in the web app to make additional observations about your line of sight, as shown in the following two graphics.





Note: Your line segment may appear slightly different from the preceding two graphics, based on your observer point and target point.

You are not restricted to a single target (or visibility line) in your line of sight analysis. You will add another target for additional line of sight context.

i In the Line Of Sight tool, click Continue Analysis, and then move your cursor in the web app.

A new line emanating from the same observer point will be visible.

j On your own, select another endpoint and double-click to close the line.

*Step 3j***: Perform a line of sight analysis.*

k After you have selected a second endpoint, click New Analysis, and then click Done.

l Click the Open Line Of Sight Tool button .

Now that you have experience with the Line of Sight tools, you can explore other observer points around the campus. If desired, you can return to your web scene with the 3D mesh and the building scene layer and add a line of sight layer to experiment with data that you shared to your web scene. For more information on how to add a line of sight layer to a web scene, go to ArcGIS Online Help: Add a line of sight layer - Create a line of sight layer.

Another analysis tool available as part of ArcGIS Online and in web scenes is the Daylight tool. This tool allows you to change how sunlight and shadows affect your scene, and 3D objects in your scene, during different times of the day and year.

The final part of spatial analysis that you need to perform will be to evaluate the daylight exposure in the Building E atrium.

- Step 4: Evaluate sunlight and shadows

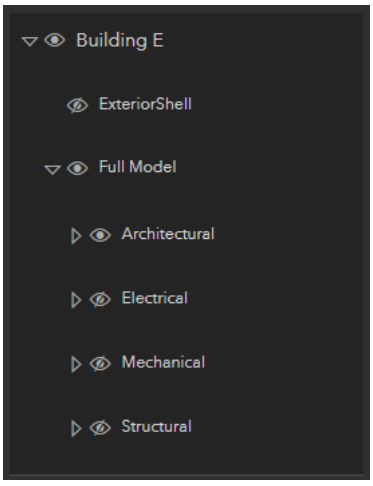
The design of Building E includes a uniquely oriented landscaped central atrium with outdoor seating and a pond. This design is not merely an aesthetic choice made by the architect. The original design had the atrium in a more traditional alignment parallel to the exterior building walls. However, when examining this initial design and modeling the sunlight and exposure, the design team recommended a change that is visible in the final as-built configuration in the building scene layer visible in the web app.

To verify that the final as-built design of the atrium will allow for adequate sunlight both for employees in the new building and to support the landscape design, you will perform a shadow analysis.

In this step, you will examine the sunlight exposure in the atrium during different times of the year.

a In the Redlands - Building Project - 3D WebApp, navigate and orient your view to look at Building E from the southeast, looking northwest, as shown in the following graphic.

b Configure the building scene layer to show the Full Model with only the Architectural layers showing and not the ExteriorShell.



*Step 4b***: Evaluate sunlight and shadows.*

- Hint

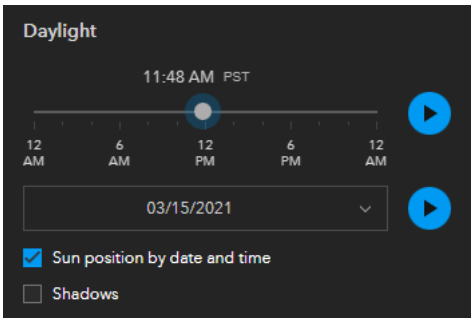
  Click the Open Layer List button and set the visibility for the ExteriorShell and Full Model.

c If you like, turn on the Floors, Furniture, and StairsRailing sublayers within the Architectural layer so your scene matches the example graphics.

*Step 4c***: Evaluate sunlight and shadows.*

The Full Model of Building E will be visible in the web app. There are some details inside the atrium with the Full Model that you want to expose for your analysis.

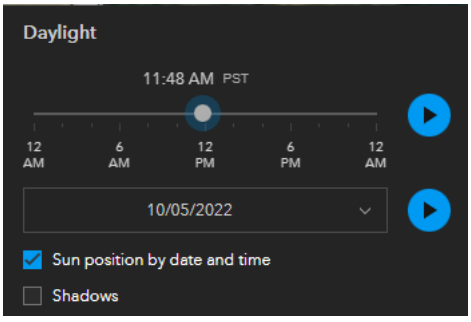
d Click the Open Daylight Tool button .



*Step 4d***: Evaluate sunlight and shadows.*

The Daylight tool allows you to set a date and time for the sun position as part of the analysis, which can be useful to understand how sunlight and shadows affect your scene during different times of the day and year.

e For the date, click the down arrow and use the calendar to set the date to October 5, 2022.



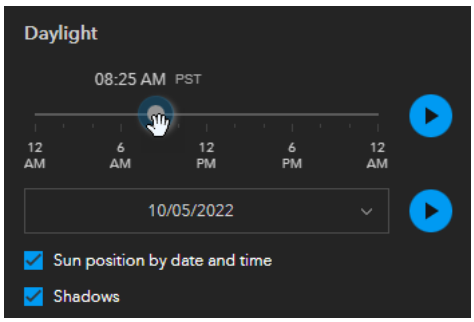
*Step 4e***: Evaluate sunlight and shadows.*

Note: You can set this parameter for any date that you desire; however, for purposes of this exercise, the date used will be 10/05/2022.

f Check the box for Shadows to turn shadows on in the web app.

After you turn the shadows on, the visualization will represent the shadows for the set date and time of year.

g In the Daylight window, click the Sunlight slider and move it to the left and right through the timeline to view the sunlight and shadows simulated at different times on this date in your scene, as shown in the following graphic.



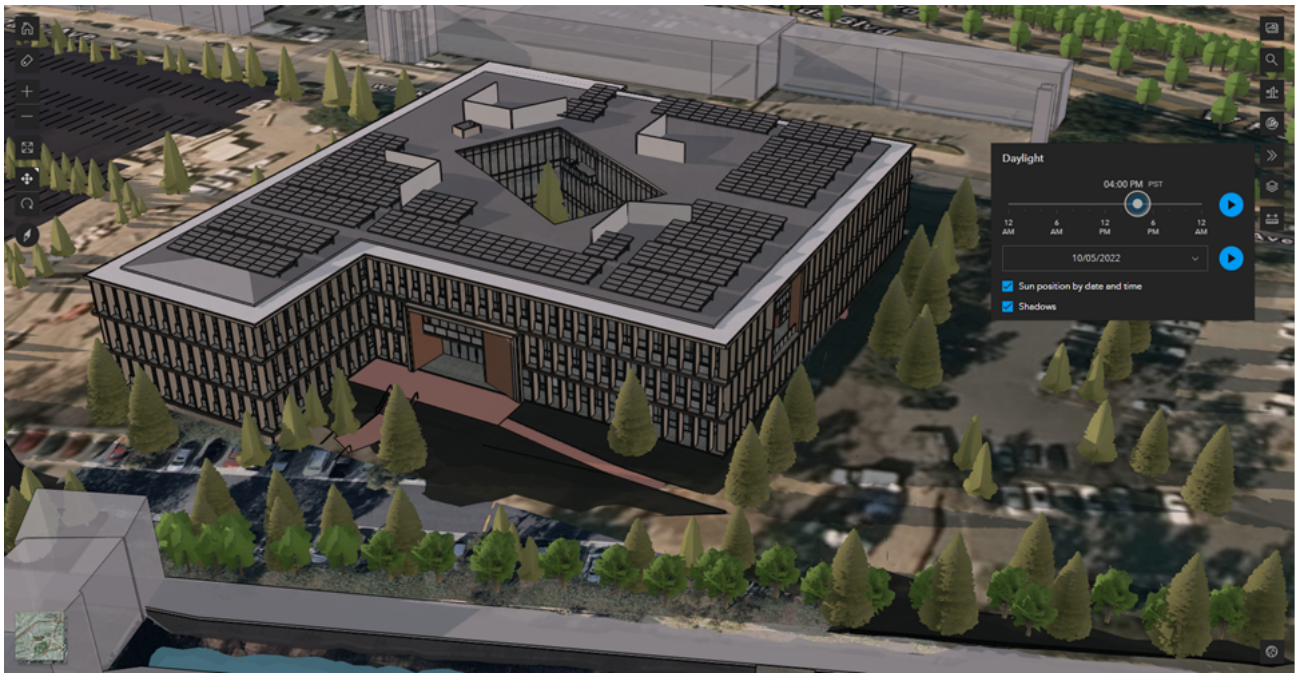
You can also create an animation of the sunlight and shadows throughout the day.

h Set the time to approximately 6:30 a.m.

*Step 4h***: Evaluate sunlight and shadows.*

i In the Daylight window, click the top Play button to animate the sunlight and shadows throughout the day.

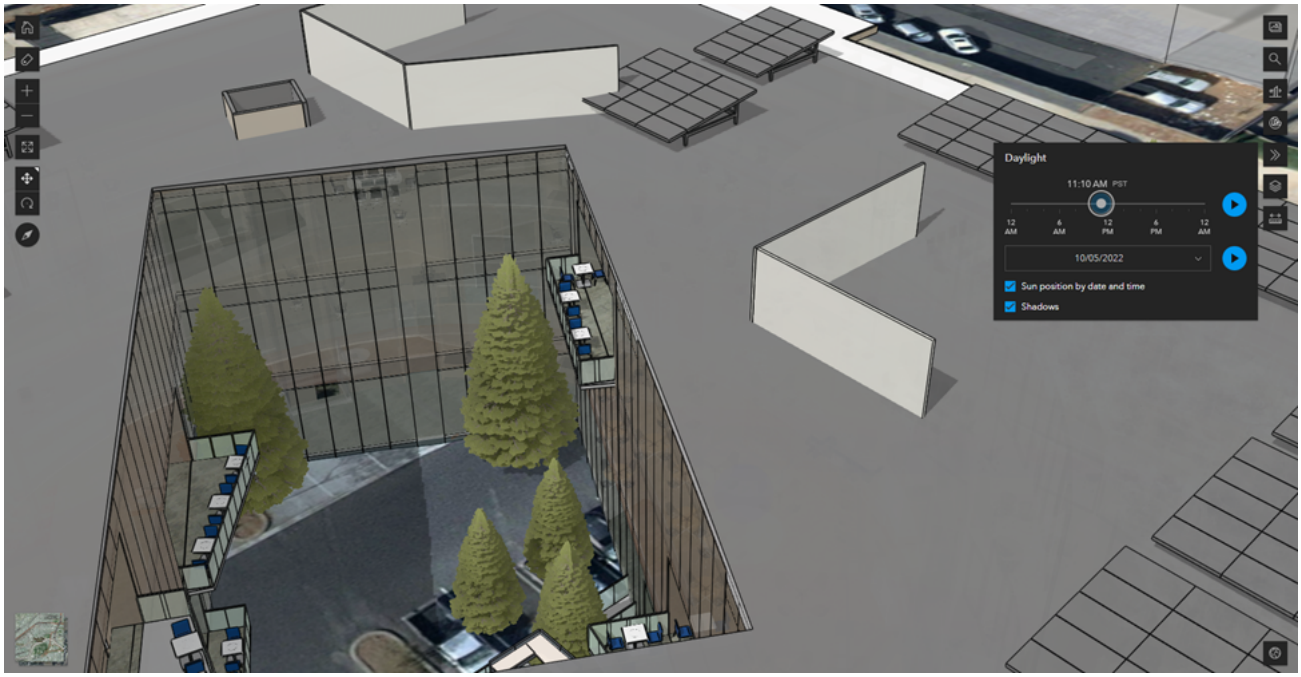
j Click the Pause button to stop the animation sometime near 4:00 p.m.



*Step 4j***: Evaluate sunlight and shadows.*

Note: You can also use animation to progress through the calendar date, and not just the time of day, to observe the sunlight differences throughout the year.

k In the web app, navigate to observe inside the atrium.



*Step 4k***: Evaluate sunlight and shadows.*

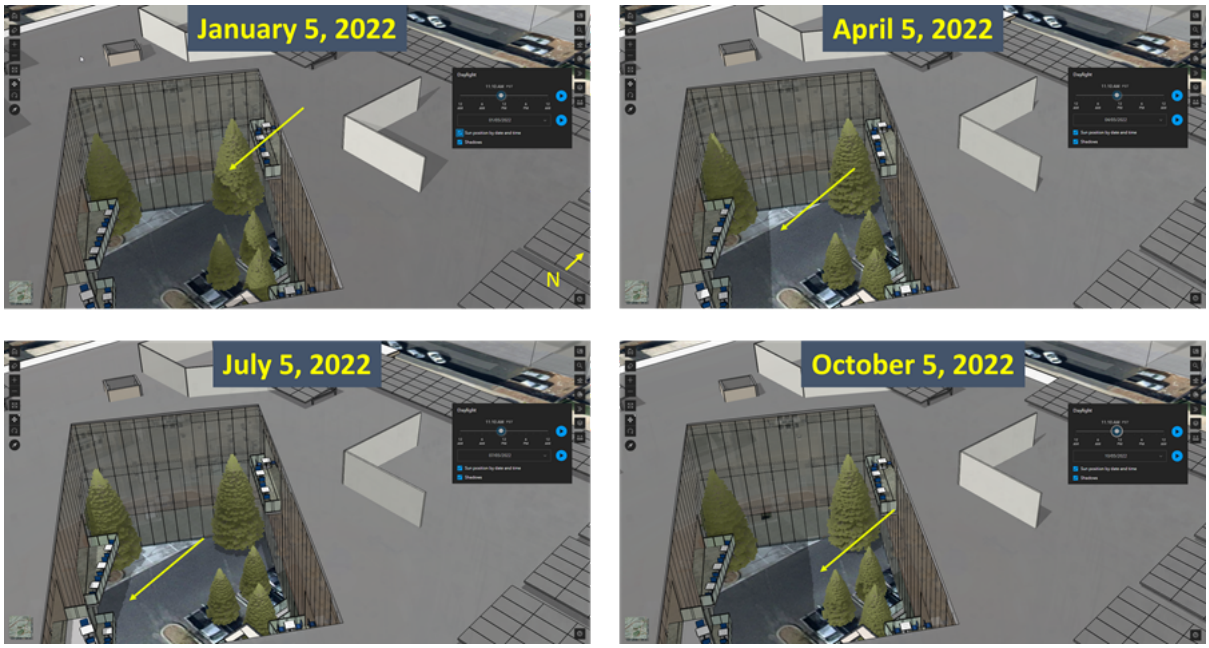
Depending on your viewing angle, you can easily see the shadows cast inside the atrium.

l Move the Sunlight slider back and forth to watch the sunlight and shadows progress throughout the day.

Now you will examine the shadow and sunlight exposure in the atrium throughout the year. As you examine each day, move the Sunlight slider back and forth through the daylight hours to see how the atrium is affected by the changing conditions.

m For the date, click the down arrow and use the calendar to set the date to different dates throughout the year and observe the shadows.

The following graphic shows examples of different dates used.



Note: The shadows in your view may vary slightly, depending on the dates that you select in your calendar.

n For each day that you set, slide the Sunlight slider throughout the day to observe the shadows.

? What observations can you make about the shadows in the as-built atrium configuration?

- Answer

Answers and analysis will vary but can include the following observations:

- While the sunlight and shadows vary throughout the year, there does not appear to be a time of year where sunlight is blocked in all portions of the atrium.

- The offset alignment evens out exposure throughout the year.

Based on the initial assessment of your sunlight and shadow analysis, does it appear that the as-built adequately addresses the concerns and design constraints for employees and the atrium's landscape design?

- Answer

Answers and conclusions may vary but can include the following:

- Because of the variability of sunlight throughout the day, and even throughout the year, the landscape design should be sustainable and stable.
- Most areas and floors near the atrium will receive adequate amounts of natural light during the day to satisfy workplace requirements.
- Eating and break facilities (balconies) are oriented and placed to take advantage of the atrium orientation and provide enough variability for employee well-being.

o Keep the Redlands - Building Project - 3D Web App web browser tab open.

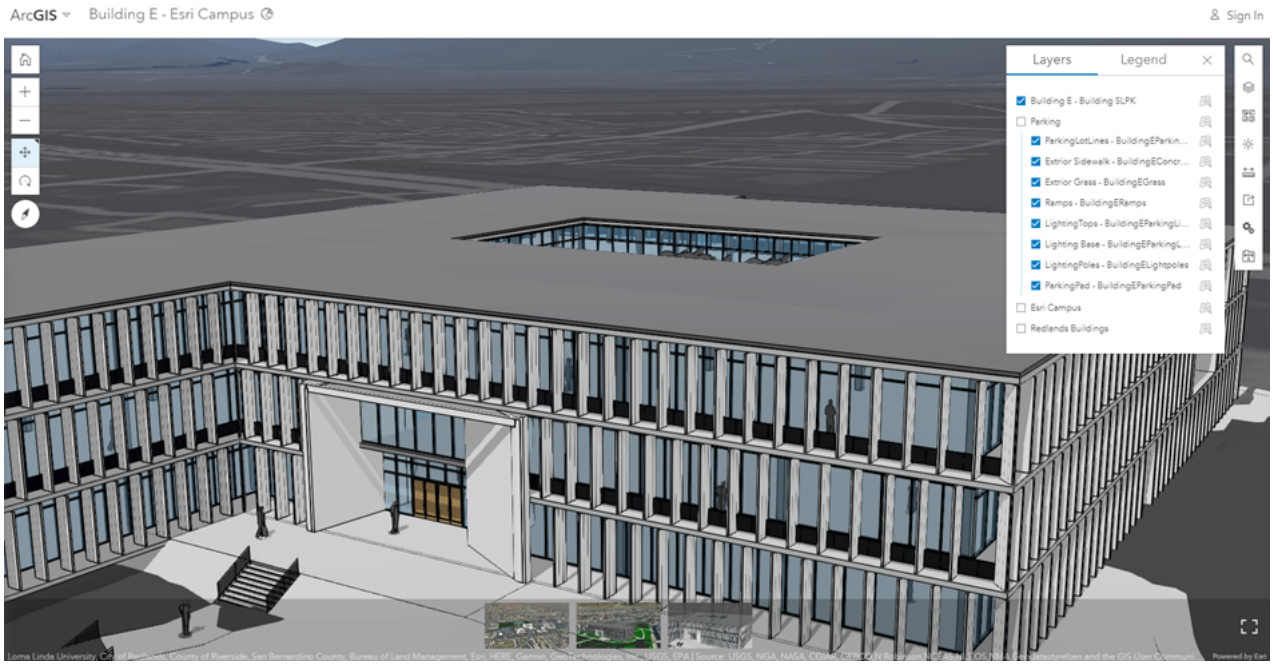
As previously mentioned, the original design of Building E did not include an offset of the atrium. Project changes can alter schedules, increase costs, and negatively impact stakeholder relations. To evaluate the implications of a design change, such as the offset of the Building E atrium, you will next compare the original design against the as-built. You will be able to see how spatial analysis supported that change and helped provide information for project stakeholders to make important decisions earlier in the project life cycle.

To better assess the implications of this design change, in the next step, you will compare the as-built configuration to the original design.

- Step 5: Compare the original design against the as-built

Another web app containing a web scene is available that contains a building scene layer of the original design. It is not as detailed as the as-built model that you used in the previous step, but it does show the atrium in its original configuration. In this step, you will use this web scene to perform a comparative analysis between the original design and as-built and the sunlight exposures and resulting shadows in the atrium throughout the year.

a Click Building E - Esri Campus to open this web app in your web browser.



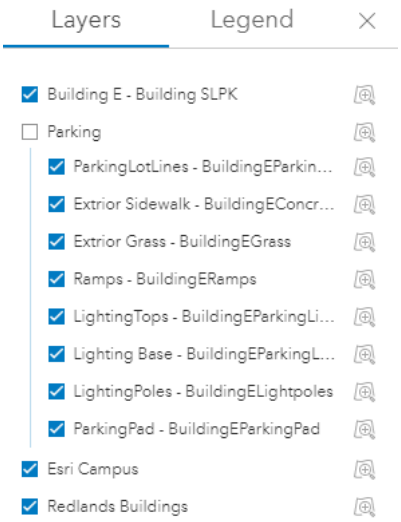
*Step 5a***: Compare the original design against the as-built.*

b At the bottom of the web scene, click the Esri Campus - Redlands slide.

*Step 5b***: Compare the original design against the as-built.*

This slide makes all layers visible. While the campus and other building may be important for aspects of the analysis, the Parking area is not relevant to the analysis.

c In the Layers window, uncheck the box for the Parking layer.



*Step 5c***: Compare the original design against the as-built.*

Note: If desired, you can turn the Esri Campus and Redlands Buildings layers off, but they may provide additional context for your overall evaluation.

d Close the Layers window.

e Navigate to a viewing point to see all of Building E.

*Step 5e***: Compare the original design against the as-built.*

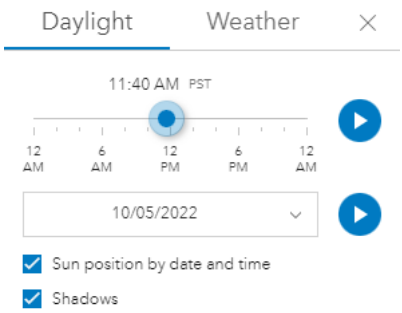
f Observe Building E in the web scene and specifically pay attention to the orientation of the atrium in relation to the larger building footprint.

g On the right side of the web scene, click the Daylight/Weather button .

This tool has the same interface that you used in the previous step, but it also contains a Weather tab. To enhance the visualizations in your scenes, you can add weather effects, such as snow, rain, or fog, using the Weather settings. You can explore the Weather tool at the end of this exercise if desired.

h For the date, click the down arrow and use the calendar to set the date to October 5, 2022.

i Check the box for Shadows, if necessary.



*Step 5i***: Compare the original design against the as-built.*

j Use your navigation skills to set a position to observe the sun angle and exposure in the atrium's original design configuration.