Height Aware 3D Application Documentation

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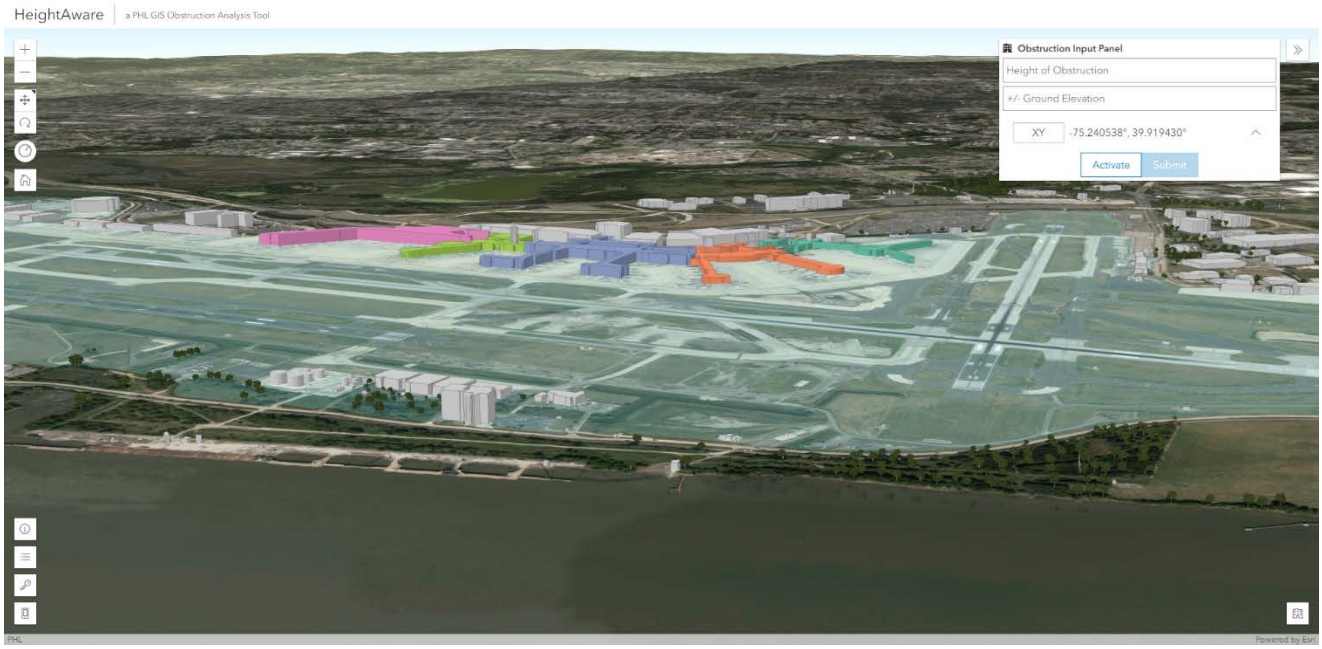


FIGURE 1 THE DEFAULT APPLICATION VIEW AFTER INITIAL LOADING

Background

The PHL HeightAware 3D application is an update to the original HeightAware application which rendered airspace surfaces within the application strictly in 2D. This revised application provides much of the same functionality for analyzing proposed obstacles and includes several enhancements made possible by leveraging the esri 4.x api to render the data in a 3d view. The goal of this application is to provide a streamlined and easy-to-use tool for analyzing potential obstructions in 3D. A major feature enhancement of this application is that the extent of the underlying elevation model has been greatly increased to equal the extent of all the surfaces in the application. The resulting DEM is a 25 mile x 25 mile raster resampled to 1ft resolution. In figure 2, the original 1ft dem is placed at the center of the larger USGS dem and symbolized with its own renderer based on the elevation range within its data to make the roads and bridges visible.

Included Aerial Imagery Service

The Imagery sources for this application include 2015 NAIP Imagery at the full extent and the PHL 2016 Aerial Imagery exists around the airport property. The Imagery has been resampled to 1ft, mosaiced, and split into several equal sized .tif files that are stored in a folder registered with the GIS Server. The rasters are made available through a Map Service with the tile cache built and stored on the GIS Server.

The USGS NAIP imagery is originally 1 meter resolution and in the compressed .jp2 file format. When downloading the files from USGS, there are a few dates of collection for the imagery within the project extent. The first step is to add all of the source jp2 files to a Mosaic Dataset. Then after footprints are built, open the attribute table for the footprints and attribute ones to be removed if they are duplicated. There will be a color change between imagery captured on different dates. To maintain image quality, remove rasters from the Mosaic Dataset that are duplicates and don't match the adjacent collection dates. When satisfied with the mosaic, input the mosaic into the Split Raster GP Tool and specify the output as tiff files with a 1 mile x 1 mile tile size. After that has completed, resample all of those split rasters to a 1 ft x 1ft resolution.

The PHL Aerial Imagery is originally a 6 inch resolution raster in jp2 format. The first step is to run the resample GP Tool to create a 1ft x 1ft tiff. Then input that new raster into the Split Raster GP Tool and create 1 mile x 1 mile tiles.

Create two new mosaic datasets, one for NAIP_Splits and one for PHL_Splits. Add the split rasters to each dataset according to their source. Perform a Select by Location to select the footprints from the NAIP_Splits that are completely within the PHL_Splits boundary. Attribute these selected footprints as "removed", then remove these rasters from the NAIP_Splits mosaic dataset. Export the final footprints attribute table to store the names of the NAIP images used.

!! Modify the ArcMap Options such that raster layers by default don't have a symbology stretch when added to the map. Create a Total Splits mosaic dataset and add both the NAIP_Splits and PHL_Splits mosaic datasets. Configure the mosaic dataset to look correct and verify the stretch on the symbology tab is set to none. Also, verify that the gamma

stretch is set to none. When satisfied with the mosaic, run it through the Split Raster GP Tool to create 1 mile x 1 mile tiles. These tiles are what are uploaded to the web server and published as the imagery map service.

Elevation Sources

The original dem was built using 1ft contours generated in 2013. In the original application, estimating obstruction heights outside of this dem extent required that users enter the elevation manually before submitting the request. By leveraging the USGS 10m dems and resampling them to 1ft, this updated application provides estimated ground elevations for the entire airspace. The final dem in this 3D application was created from USGS 10m rasters with the time period of the content specified as 2015 and the published data of 3/29/2017.

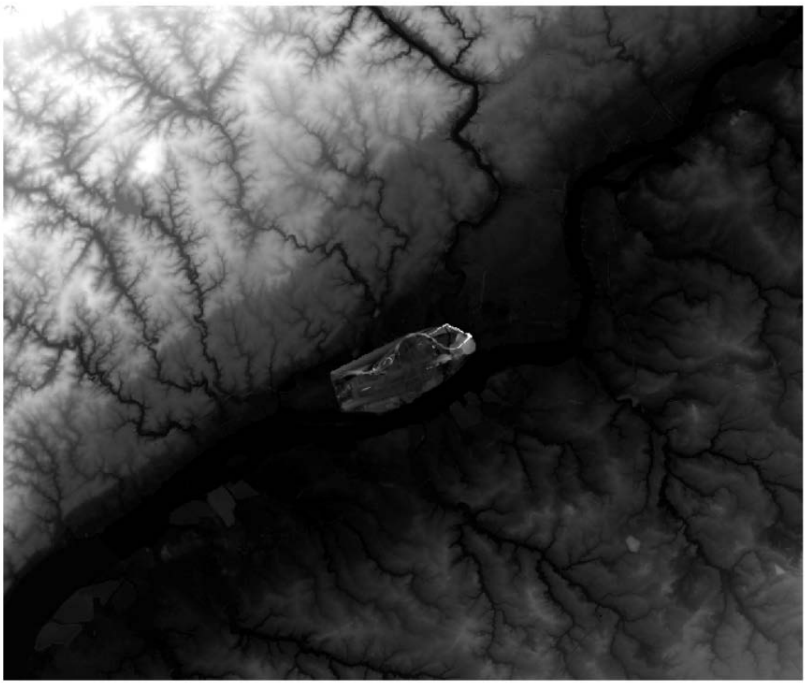


FIGURE 2 THE ORIGINAL 1FT DEM AT THE CENTER OF THE USGS 10 METER DEMS RESAMPLED TO 1FT

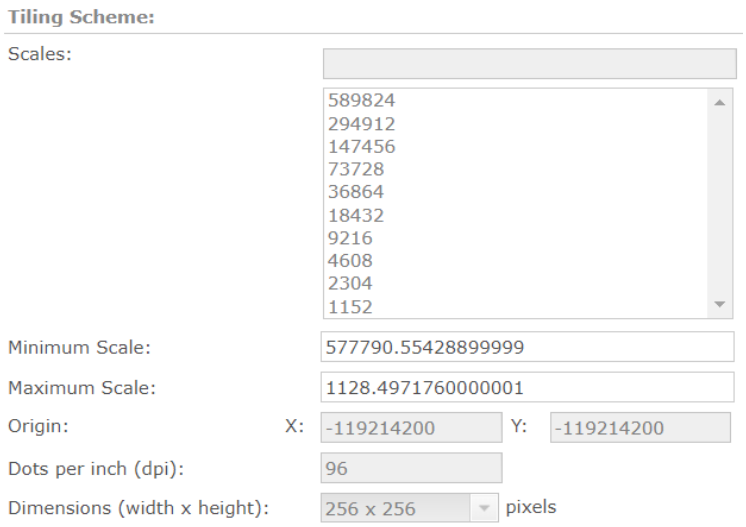
FIGURE 3 THE ORIGINAL 1 FT. DEM MERGED WITH THE FINAL USGS RESAMPLED 1FT DEM

In Figure 3, the original 1ft dem has been merged with the USGS dems to create the final dem used in the application. The elevations of the bridges in the original dem are visible as light colored areas to the east of the airport. The USGS dems do not include any bridges or manmade structures.

Elevation Image Service

A 1ft. DEM was created by resampling USGS 30m DEMS to 1ft, resampling the PHL 5ft DEM to 1ft, and mosaicking all the rasters into a single tif image. This 1ft DEM is published as an Image Service with a tile cache built using the LERC compression and stored on the server. The Image Service provides the full extent for the Web Scene and is also provides the ground elevation for rendering features using Z-values in 3D.

The ArcGIS Server is utilized to create the tile cache at these scales in the State Plane projection (wkid: 2272) native to the Master Geodatabase:



The Image Service url is passed into the Elevation Layer constructor in the esri jsapi. The Elevation Layer is set as the only elevation layer in the array of the elevation layers comprising the ground of the WebScene.

When performing an obstruction analysis, the Ground Raster provided by PHL and contained in the Map Service, is queried and if the location is within the raster boundary that elevation will be used to perform the analysis. If a valid elevation value is not returned when querying the PHL dem, then the Image Service elevation from the app will be used to perform the analysis. In the results panel, text is added next to the ground elevation value to show the source of the ground elevation used in the analysis.

The user can modify the Ground Elevation before clicking submit in the Obstruction Panel and that value will be used instead of either dem. The text 'Manual Override' will appear next to the elevation in the results panel.

Ground Elevation: 35 feet MSL *source:Manual Override (27.99 ft.)*
Obstruction Height AGL: 196.99 feet
Obstruction Elevation MSL: 231.99 feet

Included Map/Feature Services

To provide the airspace GIS data and querying capability for this obstruction analysis application, there is one map service containing all of the airspace surface polygons and their derived (5' x 5') rasters. Due to the large number of layers in that service, additional GIS data is served through the **ContextFeatures** FeatureServer.

1. **Surfaces** (MapServer) – Used as the input to the GIS Server Identify Task which performs a server-side query and returns the data that populates the 'Results of the Obstruction Analysis' panel. Both 2D and 3D surfaces are provided. Refer to the outline below for the schema of the map service.

2. **Surfaces** (FeatureServer) – Used as the input to the Airspace Surface Feature Layers with rendered in the app. Both 2D and 3D surfaces are provided. Refer to the outline below for the individual layers on the FeatureServer and their indexes. They symbology of the published surfaces is used as published in the app rather than creating new renderers for each surface type.
3. **ContextFeatures** (FeatureServer) – Used as the input to the Feature Layers containing structures and obstructions with elevations. Tree is a subset of the Obstruction Points created by applying a definition query on the Tree layer in the mxd when it was published. The ABOVEGROUN attribute is used by the Feature Layer renderer to generate 3D trees in the app. Building contains structures with valid structure heights. The colorful symbology for the buildings is controlled by the Feature Layers in the app rather than the map service. Tank Site's TOPELEV field is attributed with the height above ground elevations recorded on the obstruction points at that location. The tanks are extruded in feet above the ground surface.

The **Surfaces** (MapService) Schema:

- Part77 3D Surfaces (0)
  - Transitional (1)
  - Approach (2)
  - Horizontal (3)
  - Conical (4)
- Critical 3D Surfaces (5)
  - TERPS (6)
  - Departure (7)
  - OEI (8)
- Critical 2D Surfaces (9)
  - RunwayHelipadDesignSurface (10)
  - AirOperationsArea (11)
- 3D Surface Rasters (12)
  - 9L / 27R (13)
    - SI34VISAREA_9L_27R_51 (14)
    - SI34VISAREA_9L_27R_77 (15)
    - SI20VISAREA_9L_27R_48 (16)
    - SI20VISAREA_9L_27R_71 (17)
    - OEI_9L_27R_41 (18)
    - OEI_9L_27R_75 (19)
    - DEPART_9L_27R_39 (20)
    - DEPART_9L_27R_78 (21)
  - 9R / 27L (22)
    - SI34VISAREA_9R_27L_59 (23)
    - SI34VISAREA_9R_27L_89 (24)
    - SI20VISAREA_9R_27L_100 (25)
    - SI20VISAREA_9R_27L_104 (26)
    - OEI_9R_27L_67 (27)
    - OEI_9R_27L_69 (28)
    - DEPART_9R_27L_2 (29)

        - DEPART_9R_27L_66 (30)
    - 8 / 26 (31)
        - SI34VISAREA_8_26_108 (32)
        - SI20VISAREA_8_26_95 (33)
        - OEI_8_26_43 (34)
        - OEI_8_26_72 (35)
        - DEPART_8_26_1 (36)
        - DEPART_8_26_6 (37)
    - 17 / 35 (38)
        - SI34VISAREA_17_35_73 (39)
        - SI34VISAREA_17_35_27 (40)
        - SI20VISAREA_17_35_19 (41)
        - SI20VISAREA_17_35_63 (42)
        - OEI_17_35_107 (43)
        - OEI_17_35_50 (44)
        - DEPART_17_35_22 (45)
        - DEPART_17_35_29 (46)
- Part 77 Rasters (47)
    - HORZ77_Null_36 (48)
    - CONL77_Null_25 (49)
    - 9L / 27R (50)
        - PIRAS77_9L_27R_24 (51)
        - PIRAS77_9L_27R_85 (52)
        - PIRTS77_9L_27R_8 (53)
        - PIRTS77_9L_27R_65 (54)
        - PIRTS77_9L_27R_17 (55)
        - PIRTS77_9L_27R_64 (56)
        - PIRTS77_9L_27R_31 (57)
        - PIRTS77_9L_27R_23 (58)
    - 9R / 27L (59)
        - PIRAS77_9R_27L_88 (60)
        - PIRAS77_9R_27L_97 (61)
        - PIRTS77_9R_27L_12 (62)
        - PIRTS77_9R_27L_92 (63)
        - PIRTS77_9R_27L_9 (64)
        - PIRTS77_9R_27L_83 (65)
        - PIRTS77_9R_27L_32 (66)
        - PIRTS77_9R_27L_13 (67)
    - 8 / 26 (68)
        - PIRAS77_8_26_84 (69)
        - PIRTS77_8_26_42 (70)
        - PIRTS77_8_26_79 (71)
        - VISAS77_8_26_68 (72)
        - TRNS77_8_26_3 (73)
        - TRNS77_8_26_28 (74)
    - 17 / 35 (75)
        - TRNS77_17_35_4 (76)
        - TRNS77_17_35_74 (77)

        - PIRTS77_17_35_94 (78)
        - PIRTS77_17_35_26 (79)
        - NPIRAS77_17_35_45 (80)
        - PIRAS77_17_35_11 (81)
- RasterGround (82)

The **Surfaces** (FeatureServer) Schema:

- Transitional (1)
- Approach (2)
- Horizontal (3)
- Conical (4)
- TERPS (6)
- DEPARTURE (7)
- OEI (8)
- RunwayHelipadDesignSurface (10)
- AirOperationsArea (11)

The index associated with each layer on the FeatureServer is derived from the corresponding layer index on the Surface (MapServer) map service.

The **ContextFeatures** (FeatureServer) Schema:

- Tree (0)
- TankSite (1)
- Building (2)

App Widgets

- **Obstruction Input** – Obstruction Analysis Input Panel allowing users to propose obstacles and view the potential impact with airspace surfaces.
- **Obstruction Results** – Opens the Panel containing the results of the obstruction analysis. Clicking on rows in the tables provides interactivity with the layers in the scene.
- **Legend** – Provides a small graphic for each feature type along with the layer title to assist with comprehending the surfaces displayed in the app
- **Position** – The Panel for this widget contains information about the position of the user's view in relationship to the ground. Heading, Tilt, Eastings, Northings, and Camera Height are updated in this panel as the user navigates the app. The Position is recorded in feet according to the State Plane Projection.
- **Site Description** – Opens on app start and cannot be closed until the user agrees to the disclaimer. This widget panel can be reopened at any time and the user is not prompted to accept the disclaimer. This panel contains a link to the user guide pdf that opens in a new browser tab. The intended use of the app is outlined in the site description panel.

User Story 1: Obstruction Input Panel (OIP)

After accepting the disclaimer, the Obstruction Input Panel (OIP) is opened in the upper right. Clicking 'Activate' will enable the mouse tracking event that updates the ground elevation and the X-Y coordinate values by querying the elevation surface at the mouse point location as it moves around the map. When in the activated mode, clicking on the map will place an obstruction with the height specified from the OIP. If the height value is not specified at the time an obstruction is placed, then a height equal to 200 ft. minus the ground elevation at that location is used as the peak height for the obstruction. The ground surface elevation at the clicked point is set as the demGroundElevation property on the widget. If placing an obstacle is no longer desired, clicking 'Deactivate' will remove the mouse tracking events and an obstruction will no longer be created when clicking on the map. The mouse click location will update in the CoordinateConversion widget, but those coordinates are not used when submitting a new obstacle with a modified base elevation or height.

Once an obstruction is placed, the X/Y location is immediately sent to the GIS Server using the Identify Task against the Surfaces map service through the submit method. The preconfigured map service, with rasters representing the airspace surfaces, allows the differences in elevation to be calculated using simple subtraction calculations. All layers that intersect the X/Y coordinate are returned through the IdentityResults. Since we know the layer Ids for each layer in the map service, we are able to perform the calculations, build the Layer Results, and pass the values to the Obstruction Results Widget which updates it properties and table collections with the new values.

While the IdentifyTask is submitted to the GIS Server, the airspace surfaces are filtered in the Scene View using the geometry of the proposed obstacle graphic in the "Placed Obstruction" layer. This filtering creates definition expressions on the layers and sets the default layer visibility property on the Results Widget. All surfaces that intersect the X/Y location are returned. Z-values are not supported in geometry operations within the javascript api so penetration values are only available from the calculations performed using the results from the Identity Task.

When the IdentifyResults are returned from the GIS Server, they are passed into the buildObstructionSettings function. Within this method, if the PHL Dem is returned as an intersecting layer, the cell value is set as the demGroundElevation for the widget and the server_dem_bool value is set to true. Otherwise, server_dem_bool is set to false and the demGroundElevation property persists using the value from the 1ft elevation surface in the Scene. This allows elevations to be derived from a high resolution dem on the server, or through the 1ft resolution dem in the app. The user can modify the ground elevation and/or the obstruction height regardless of the dem source. Once modified, the Submit button becomes enabled allowing the user to reprocess the calculation using the updated height and base elevation values. The X-Y location of the obstacle cannot be modified for the purposes of resubmitting an obstacle calculation.

When Submitting the Input Panel with modified values, the Ground Elevation html input value is set as the userGroundElevation property on the widget. This userGroundElevation is compared to the demGroundElevation property on the widget. If it is different, then the modifiedBase property is set to true. The difference between the userGroundElevation and the demGroundElevation is set as the elevation_change property on the Results widget.

The Coordinate Conversion widget provides the user with multiple coordinate systems to view the obstacle location when placed. To input a predetermined coordinate for placing an obstacle, click on the pencil icon. Select a coordinate system that the input coordinate will be in. Click the checkbox next to 'Go to location'. Click Convert. If satisfied with the location on the map, click the 'Activate' button and place an obstacle at that location.

Modifying the values for the height of the obstruction and/or the ground elevation then clicking Submit will update the obstacle graphic in the map, resubmit an IdentifyTask, and update the Obstruction Results with the new values from the calculation. Even though the coordination conversion widget still updates as the mouse moves, the X-Y coordinate of the obstacle when it is placed is persisted when calculations are reprocessed with modified height and base elevation. The application supports the analysis of only a single location.

The results from the Obstruction Analysis are calculated by subtracting the proposed obstacle height from the pixel values in the associated surface raster(s) located in the **Surface** map service. If the resulting value is negative, then the clearance value is negative, and the table cell is colored red.

User Story 2: Obstruction Results Panel

When Obstruction Results widget is instantiated and assigned as a property of the Obstruction Input widget during its creation. There are two grids, 3D and 2D, that get created using a predetermined set of columns. Listeners on the widget will update these grids when the results from the ObstructionResults are set onto the widget from the Obstruction Input widget.

Attributes of the analyzed obstruction are shown in the top section of the results panel. If the elevationChange property is truthy, the dem source will include the elevationChange value in parenthesis.

Clicking on the 3D Surfaces tab will show the obstruction results for the 3D surfaces. If a feature is calculated to have a penetration equal to or less than 0, the clearance column will be colored red. Clicking on a row or multiple rows in the table will make the selected features visible in the scene and hide the others. Pressing the Ctrl button while clicking on a row will deselect that row. When all of the rows are deselected, the feature visibility is set back to the default visibility that was set when the obstruction analysis was originally performed.

Clicking on the 2D Surfaces tab will show the obstruction results for the 2D surfaces. Clicking on a row or multiple rows in the 2D table will highlight those features in the scene. Similar to the 3D grid, pressing the Ctrl button will deselect the row and remove the highlight.

Clicking on the metadata fields tab will show the fields defined as containing metadata information. The tab will turn to a blue color. When it is blue, the metadata fields will be visible while switching between the 3D and 2D tables.

Each of the columns in the grids are sortable by clicking on the field header cell.

Data Flow / Testing Points

Disclaimer Widget –

- Refresh the app.
- The Site Information widget should be open.
- Clicking outside the panel should have no effect.
- Select the checkbox to agree with the disclaimer, the Proceed button should become enabled.
- Click Proceed to close the widget.
- Reopen the widget by clicking the Site Information icon in the lower left.
- The panel should no longer contain the disclaimer information.
- Click the User Guide link and verify that the pdf opens in a new tab.
- Click anywhere outside the panel to close the widget.

Obstruction Input Widget –

- Click Activate.
- The X-Y locations and the Ground Elevation values should update with the mouse location.
- Click on the map near the airport to place an obstruction.
- The Submit button should be enabled and turn blue.
- When the results are returned, check that the elevation value is updated from the DEM on the server.
- Modify the Base Elevation value and click Submit.
- Verify that the placed obstruction graphic gets taller/shorter by the modified amount.
- Modify the Height of Obstruction value and click Submit.
- Verify that the placed obstruction graphic gets taller/shorter by the modified amount.
- Each time that new values are submitted, verify that they are correctly shown in the Results Panel

Obstruction Results Widget –

- Use the Input Widget to place a new obstacle in the map and perform the Identify Task against the map service.
- Modify the base elevation and click Submit.
- Verify that the Ground Elevation shows the correct value along with the text Manual Override followed by the change in elevation (ft).

- Modify the base elevation back to its original value and click submit.
- Verify that the Ground Elevation shows the dem source as PHL dem or USGS dem
- Verify that the Ground Elevation plus the Obstruction Height AGL equals the Obstruction Height MSL value.
- For each record in the 3D results table, verify that the Obstruction Elevation MSL – Clearance = MSL (ft.) rounded to one decimal place.
- For each record in the 3D results table, verify that the Obstruction Elevation AGL – Clearance = AGL (ft.) rounded to one decimal place.
- Click a row in the table and verify that the feature is the only feature visible.
- Hold Ctrl and click on multiple rows in the table. Verify that those features are the only features visible.
- Hold Ctrl and click on the previously selected rows. Verify that all the features that are penetrated are visible.
- For each record in the 2D results table, click on the row and verify that the feature is highlighted.
- Hold Ctrl and select multiple rows. Verify that multiple features are highlighted.
- Hold Ctrl and deselect the previously selected rows. Verify that all the highlights are removed.

Maintenance and Recovery Plan

This 3D Web Mapping Application requires ArcGIS Server to host the feature server and the image server. At the time of development only one GIS Server is needed. Adding more GIS Servers to the site would allow for a failover in the event that the GIS Server needs to be taken offline. The steps for adding a GIS Server to an existing site are available here https://enterprise.arcgis.com/en/server/latest/install/windows/join-existing-site.htm.

The code base is maintained using GitHub which allows the files to be versioned into development and production branches at a minimum. Deploying the application files onto a new web server is as simple as cloning the GitHub repo and running the build script (grunt –force) which transpiles the typescript into javascript. The /src folder containing the index.html file must be registered as an application on IIS.

A web server is required to host the application files (.js, .css, and .html). We use Windows Server's IIS in development and in the cloud "production" site due to the large percentage of projects where it is the web server. It is possible to deploy this application onto any http web server that has ports 80 and 443 opened.

To support Integrated Windows Authentication, an Active Directory group should be created and all the users who should have access to the app need to be added to the group as members. In the IIS Web Server, the URL Authorization feature must be enabled. Access to the application can then be granted to users who are a member of the newly created Active Directory group.