XI. Terrain

Each simulation takes place within the extents of a terrain database. A terrain database provides three-dimensional information about a geographic area and provides the environment within which simulation objects function. With the information in a terrain database, VR-Forces calculates height, intervisibility, and other three-dimensional information.

VR-Forces allows you to load terrain data in these basic ways:

- Compose a terrain from elevation, imagery, and feature data.
- Open an MTF file.
- Stream terrain from local files or a terrain server such as VR-TheWorld Online.
- Open a terrain database in a supported format, such as FLT, DTED, or GDB.

The recommended work flow is:

1. Create an earth file.
2. Connect to the earth file.
3. Save the terrain as an MTF file.
4. Create a scenario and choose the MTF file as the scenario database.

The decision making process for choosing a terrain when you create a scenario is described in "Creating and Running Scenarios".

Terrain Databases Provided with VR-Forces

Table 1 describes the terrain databases provided with VR-Forces. These terrains were created for you to use in your simulations. You may also use them to help create your own terrains. Some have variants that may be a different coordinate system, subset of the data, or other variation on the terrain. Terrains with "(online)" in the title connect to VR-TheWorld or another online server and require an internet connection. Some terrains have variations that emphasize a particular set of features or other data. VR-Forces also has a supplemental data package that includes additional terrains. Please contact your MAK salesperson for download details.

Table 1. Terrain databases shipped with VR-Forces

Terrain Name	Description
Ala Moana.mtf	A high-resolution area of Honolulu, Hawaii, USA, set into a raster map of the world. This terrain is stored locally and does not require an internet connection.
ArrivalsHall.mtf	An interior model of an international arrivals hall with passport control stations.
Bakersfield Topo Map (online).mtf	VR-TheWorld with topographical maps for the area around Bakersfield, California, USA. This terrain contains some feature data that simulation objects in aggregate-level scenarios can take advantage of.
Brooklyn.mtf Brooklyn (online).mtf Brooklyn with Vegetation.mtf	A high resolution city center surrounded by an extruded cityscape. Located geographically in Brooklyn, NY, USA, but not an actual location in that city.
DestructibleTerrain.mtf	A small terrain for demonstrating destructible terrain based on switch nodes.
Grid.mtf	A basic, flat terrain featuring only a simple grid design. This terrain is not suitable for VR-Forces scenarios.
Ground_DB II.mtf	FBX. A simple, generic ground terrain, including a road and some buildings, surrounded by water.
MAK Earth (online).mtf MAK Earth (online) - Simple For High Fliers.mtf	VR-TheWorld terrain with high resolution insets for California, Honolulu, Hawaii, and some other cities. Includes streaming feature data. The simple version is intended for use when the observer will be high in the air. It is a more basic version of the MAK Earth (online) terrain.
MAK Earth Aggregate (online).mtf	VR-TheWorld terrain designed for use in aggregate-level scenarios. When in 2D projection (plan view), you can choose the appearance from the 2D View Layer list. For example, use OSM TOPO for a view that is more like a paper map.

Table 1. Terrain databases shipped with VR-Forces (continued)

Terrain Name	Description
MAK Earth Air and Space (online).mtf	US Sectional Air Charts for IFR (Instrument Flight Rules) with base imagery. This terrain is designed for airspace simulation using the 2D projection (plan view).
MAK Earth Base (online).mtf	VR-TheWorld MAK Earth terrain with high resolution insets for Honolulu, Hawaii, and Boston, Massachusetts. Includes streaming feature data.
MAK Earth Bing Maps (online).mtf	A procedurally generated earth merged with high-resolution imagery and elevation. Imagery data is cached locally for 24 hours before it expires and VR-Forces queries the Bing Maps API for updated data. To use the Bing imagery services, you must create a Bing Maps Key at https://www.bingmapsportal.com and then add it to *./SharedData/##/latest/TerrainData/TerrainConfiguration/imagery.worldwide.BingMaps.online.xml*.
MAK Proving Ground.mtf	A non-realistic terrain with buildings, trees, roads, a runway, different types of soil, slopes, and other environments. It is designed specifically for testing.
NTC (online).mtf	A high-resolution area of the National Training Center at Fort Irwin in California, U.S.A.
Sadr City.mtf	An urban geotypical Middle Eastern terrain in Sadr City, Iraq, a suburb of Baghdad. Ideal for urban scenarios.
Test terrains	Multiple terrains used for testing models and different terrain database capabilities. Not all test terrains are suitable for VR-Forces scenarios, for example, Test-WorldFlatEarthNoElevation.
Truman Carrier.mtf	A model in VR-Forces of an aircraft carrier as a terrain object rather than a simulation object.
VR-Village.mtf	GDB. Feature data. OpenFlight terrain. VR-Village is a fictional database created by MAK. It has a highly detailed small town in a larger, sparsely detailed desert environment. The town includes multilevel buildings, underground tunnels, and a road that tunnels through a mountain. The coordinates place it off the west coast of Africa.

2. Introduction to Terrain Usage in VR-Forces

This chapter provides introductory information about terrain usage, including supported file formats, coordinate systems supported, and use of large terrain databases.

2.1. Composing Terrains (and Creating MTF Files)

VR-Forces lets you compose terrains from a variety of supported data formats. You can combine elevation data (terrain patches), imagery, and feature data to create terrains.

VR-Forces offers some basic methods for creating terrains:

- Compose a terrain by loading individual elevation, image, and feature data files. This method is best for relatively small terrains that do not require paging. It supports all of the coordinate systems that VR-Forces supports. For more information, see "Creating a Composed Terrain" in the *Adding Content to MAK ONE Applications Reference Manual*.
- Specify a set of files to load using an osgEarth format earth file. Use this method to stream terrain data from local or remote sources. This method is best for terrains with large amounts of elevation or image data, which would benefit from paging. For more information, see the topic "Connecting to Terrain Servers" and also the chapter *Loading Data Using Earth Files*, both in the *Adding Content to MAK ONE Applications Reference Manual*.

When you compose a terrain, you can save it as a MAK terrain file (MTF), which is essentially a description of all of the data used to visualize the simulated 2D and 3D environment. Saving a terrain lets you automatically load all of the data that you loaded manually when you first created it.

You can save terrains in a cached format that loads terrain data more quickly than if the terrain is created from the source data. For details, see "Configuring File Caching" in the *Adding Content to MAK ONE Applications Reference Manual*.

2.2. Supported File Formats

VR-Forces can import elevation, terrain, images, models, and feature data. Some types of files can contain more than one type of information. For example, GeoTIFF files can have elevation data or only image data. The following sections list the supported formats.

> ⓘ In theory, VR-Forces can load any format supported by osgEarth if you use the earth file format to load them. However, VR-Forces does not include drivers for all of the formats supported by osgEarth. Furthermore, when using osgEarth, VR-Forces only supports geocentric terrains. If you are uncertain about support for a particular format, please contact support at https://www.mak.com/mak-one/support/portal.

Terrain Data

VR-Forces imports terrain data directly as terrain patches. It supports these formats:

- MAK encrypted data format (*.medf*)
- OpenFlight (*.flt*)
- MetaFlight (*.mft*)
- Shape terrain data (*.shp*)
- TerraPage (*.txp*)
- CDB (using an earth file)
- FBX

VR-Forces provides limited support for data in these formats. If you have problems loading data in these formats, MAK will try to assist you, but cannot guarantee that it will be possible to use your data.

- 3DS
- OSG

Elevation Data

VR-Forces supports these types of elevation data:

- DTED (*.dt0*, *.dt1*, *.dt2*, *.dted*)
- GeoTIFF
- DEM
- Arc/Info Binary Data (*.adf*)
- Other formats supported by osgEarth

Supported Image Formats

You can import images in these formats:

- GeoTIFF (*.tif*, *.tiff*)
- JPEG (*.jpg*, *.jpeg*)
- PNG
- RGB
- Windows bitmap (*.bmp*)
- GIF
- ECW (Windows only)
- Other formats supported by osgEarth using the GDAL driver. For a list of formats supported by GDAL, go to https://gdal.org and select the Supported Formats link. If you have problems loading an image format that is not in this list, please ask on the Support Portal at https://www.mak.com/mak-one/support/portal.

We cannot guarantee that unlisted formats are fully supported. For more information about earth files, see "Connecting to Terrain Servers" and the chapter on *Loading Data Using Earth Files* in the *Adding Content to MAK ONE Applications Reference Manual*.

Supported Feature Data Formats in the GUI

VR-Forces supports these feature data formats in the GUI:

- Shape files
- S-57
- OGR vector formats referenced in earth files

2.3. Feature Layers and Props

A terrain can have objects such as buildings and trees embedded in it. These objects cannot be manipulated in this format. However, VR-Forces lets you extract these types of objects from the terrain and render them independently as props. Props are terrain elements that you can manipulate as separate objects.

You can add props to a terrain by extracting them from an external reference in a terrain patch or from a feature layer. You can also add props directly from the Props Palette.

A feature layer is a file that contains feature data such as point features, linear features, and areal features. You can extract point features as props. You can extract props from MAK Terrain Format (GDB) files, shapefiles (SHP), or DFAD data (DFD).

For more information, see "Adding Props to a Terrain" in the *Adding Content to MAK ONE Applications Reference Manual*.

2.3.1 Geometric Representation of Point Feature Data

There are differences between how the GUI and sim. engine process feature data. This is because the information needed to simulate simulation object interaction with features is different from the information needed to render the scene.

The GUI renders point features such as buildings or trees based on the data provided in the feature layer. These objects could have been extracted as props, in which case they are represented as geometric objects in the terrain.

If you are streaming features using an earth file, you can configure the earth file to extrude buildings into 3D geometry. This capability is demonstrated in some of the insets in *MAK Earth (online).mtf*, for example the Boston and Honolulu insets.

The simulation engine's representation of point features depends on how they are used. Collision avoidance treats them as bounding volumes with infinite height. Line-of-sight calculations treat them as bounding volumes with a defined height. If you extract features as props, the sim. engine treats them as geometry where that is appropriate and as features otherwise.

The sim. engine does not recognize extruded geometry.

2.3.2 Feature Data Types Supported by the Simulation Engine

The sim. engine supports the following types of feature data files:

- MAK terrain database (*.gdb*)
- Shape terrain data (*.shp*)
- S-57
- WFS
- OGR vector formats referenced in earth files
- VMAP

The preferred format for adding features is shapefiles. You can extract feature data from GDB, DFD, and VMAP into shapefiles with the vectorNetworkToShapeFiles utility. For details, see "Extracting Feature Data from GDB to Shapefiles" in the *Adding Content to MAK ONE Applications Reference Manual*. You can extract feature data from S-57 files into shapefiles with the ogr2ogr tool. For details, see "Converting S-57 Feature Data to Shapefiles" in the *Adding Content to MAK ONE Applications Reference Manual*.

2.4. Coordinate Systems

VR-Forces supports UTM, geocentric, flat earth, and Lambert Conformal Conic coordinate systems. There is no presumption that a particular database format, such as OpenFlight or DTED, will use a particular coordinate system.

2.4.1 The UTM Coordinate System

VR-Forces includes several databases that use Universal Transverse Mercator (UTM) coordinates. UTM databases are well-suited to two-dimensional views and simulations on a relatively small geographic area. However, their accuracy decreases as you move away from the origin, so they are not well-suited for exercises that need to simulate over areas greater than one UTM zone.

There are several types of UTM systems. In general, the earth is divided into 60 zones generally 6 degrees wide in longitude. These zones may be further subdivided into quadrangles by using letter designations from south to north. This complicates references to UTM. For example, standard offset could be used with or without the quadrangles (which affects the northing portion of the coordinate), non-offset does not use the quadrangles, and Milgrid requires the quadrangles.

More specifically, UTM coordinates define two dimensional, horizontal, positions. UTM zone numbers designate 6 degree longitudinal strips extending from 80 degrees South latitude to 84 degrees North latitude. UTM zone characters designate eight degree zones extending north and south from the equator. There are special UTM zones between 0 degrees and 36 degrees longitude above 72 degrees latitude and a special zone 32 between 56 degrees and 64 degrees north latitude.

VR-Forces uses this definition:

A non-Cartesian coordinate system in which the X, Y, and Z correspond to easting (nearly east), northing (nearly north), and height above an ellipsoid that approximates the surface of the earth. When in UTM mode (the default), VR-Forces uses an offset UTM coordinate

system, one in which coordinates are expressed with respect to an origin located at the latitude and longitude specified in a configuration file. Typically, this will be the location of the origin of your terrain database.

2.4.2 Geocentric Terrain Databases

To support large play areas, simulations can use geocentric coordinates. In the geocentric coordinate system, the origin is at the center of the earth. The positive X-axis passes through the prime meridian at the equator; the positive Y-axis passes through 90 degrees east longitude at the equator; and the positive Z-axis passes though the North Pole.

2.5. Loading Supported Databases

MTF files reference elevation, image, and feature files that VR-Forces processes and loads when you load a scenario. However, you can also load terrain databases directly into VR-Forces. They will be converted to the VR-Forces internal format using default values. This process is less efficient than loading MTF terrains, may take more time, and must be repeated each time you load the terrain as part of a scenario or in the GUI.

When you create a scenario, you can choose a terrain in any supported format. If you want to open a terrain using the **File > Open Terrain** menu option, you can only choose MTF files. To load a non-MTF terrain out of the context of creating a scenario, you must load it as a terrain patch.

If you load a terrain directly, you can still save it to MTF.

2.6. Using Large Terrain Databases

VR-Forces can support large databases, where large might mean a high polygon count, a large geographic area, or both. VR-Forces supports two methods for dealing with large databases – terrain paging and streaming terrain. Both approaches have a common goal – providing access to large amounts of data without loading all of that data into memory at any one time.

VR-Forces cannot arbitrarily page or stream terrains. It can page terrains that have been designed for paging and can stream terrains that are accessed through a terrain server, such as VR-TheWorld. For details about support for paged terrains, see "Loading MetaFlight Terrains" in the *Adding Content to MAK ONE Applications Reference Manual*. For details about connecting to terrain servers, see "Connecting to Terrain Servers" and "Creating an Earth File to Load Terrain Data", also in the *Adding Content to MAK ONE Applications Reference Manual*.

> ⓘ Even if you use terrain paging or streaming terrain, it is still possible that a large terrain could exceed the memory limitations of your operating system.

2.6.1 Terrain Paging

Terrain paging breaks up a database into multiple cells that can be loaded independently. By comparison, a non-pageable terrain must be loaded in its entirety. When VR-Forces loads a paged terrain, the GUI loads the terrain at whatever level of detail is required by the zoom level. The simulation engine always loads terrain at the highest level of detail.

Therefore, if you rapidly zoom into a section of the terrain in the GUI, there may be a delay in correlation between simulation objects and the terrain until the GUI catches up to the proper level of detail.

In general, the simulation engine does not load terrain until it needs the terrain to support the objects in the scenario. (Some terrain data is always loaded immediately, such as terrain data in OpenFlight format.) For example, if you create a new scenario and specify a paged terrain, the simulation engine does not load terrain until you create a simulation object. Then it only loads the terrain page required for the object.

When you run a scenario, as simulation objects move, the simulation engine tries to predict which terrain pages it will need to support the simulation objects and tries to page them in before the simulation objects need them. If the total polygon count required to page in required terrain exceeds the maximum polygon count configured, VR-Forces pages out (removes) unused pages. The simulation engine pages out the least recently used data.

> Predictive terrain paging is done in real time, not just when a scenario is running. For example, when you load a scenario, all required terrain is paged in and when you add objects during scenario creation, terrain is paged in.

You can also manually page in terrain using terrain page-in areas. For details, see "Manually Paging-In Terrain in VR-Forces" in the *Adding Content to MAK ONE Applications Reference Manual*.

Paging is done based on these priorities:

- If a simulation object is moving, paging in terrain that it needs is a higher priority than predictive paging.
- Blocking terrain calls have a higher priority than non-blocking calls. (A blocking call is one that prevents the simulation from progressing until the call is completed. For more information, see the **assertOnBlockingTerrainCalls** parameter in Table 1, in "The vrfSim.mtl Configuration File".)
- Paging out terrain to recover memory is a higher priority than paging in terrain. The need to page out is calculated based on the polygon count of the terrain, not on its memory usage.

2.6.2 Terrain Streaming

The term terrain paging is used in reference to static, local terrains. Another way to load terrain data for a large area is to stream it from a terrain server. The idea is similar to terrain paging. Only the data you need at a particular location is loaded. The difference is that a terrain server can serve many computers at a time and normally holds much more data than a static local terrain. It can stream elevation data, imagery, map data, and feature data. It may have data at multiple levels of resolution for a particular portion of the terrain. VR-Forces supports connection configurations to terrain servers, including MAK's VR-TheWorld Server.

2.7. Using Ground Clamping

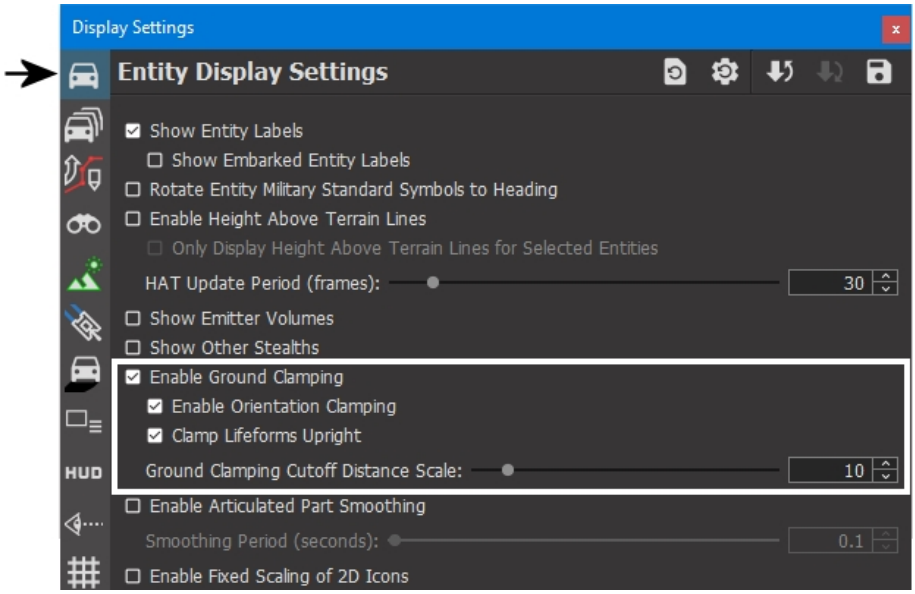
Because of differences in terrain databases among exercise participants, entities can sometimes appear to be underground or hovering above the terrain surface. To compensate, VR-Forces can clamp land and sea entities to the terrain surface. When ground clamping is enabled, VR-Forces keeps an entity anchored to the terrain surface regardless of the altitude data contained in its state update.

- Use of ground clamping can reduce your frame rate. If you correlate the simulation and visualization terrain databases, you can eliminate the need to use ground clamping.
- Although ground clamping controls are available in aggregate-level scenarios, since aggregate-level scenarios do not use 3D models, they are not useful.

➤ **To enable or disable ground clamping:**

1. Choose **Settings > Display**. The Display Settings dialog box opens.
2. Select the Entity Display Settings page (Figure 1).

Figure 1. Ground clamping settings



3. Select or clear the Enable Ground Clamping check box.

You can also enable and disable ground clamping by choosing **Settings > Ground Clamping**.

2.7.1 Configuring Ground Clamping

You can configure aspects of ground clamping:

- Enable or disable ground clamping.
- Enable or disable orientation clamping.
- Force lifeforms to remain upright relative to the plane of their location when moving up slopes or steps, rather than being perpendicular to the terrain.
- The distance from the terrain within which entities are clamped.

➤ **To configure ground clamping:**

1. Choose **Settings > Display**. The Display Settings dialog box opens.
2. Select the Entity Display Settings page (Figure 1 on the previous page).
3. To enable or disable a ground clamping option, select or clear its check box.
4. To specify the distance from the terrain in which entities are ground clamped, adjust the Ground Clamping Cutoff Distance Scale slider or type a value, in meters, in the box.

ⓘ The setting for the Ground Clamping Cutoff Distance Scale maximizes at 100 meters. If you set it to the maximum, the distance is infinite and all entities are ground-clamped.

3. Displaying Terrain Information

This chapter describes how to change the display of terrain to provide different types of useful terrain information.

3.1. Introduction

As you create and view simulations, you may need information about the terrain. By changing how terrain is displayed, you can get some of this information. If your terrain does not have texture data or an image overlay, features such as elevation coloring can provide a more realistic look to the terrain.

For information about how to compose terrains, see the chapter *Composing Terrains* in the *Adding Content to MAK ONE Applications Reference Manual*.

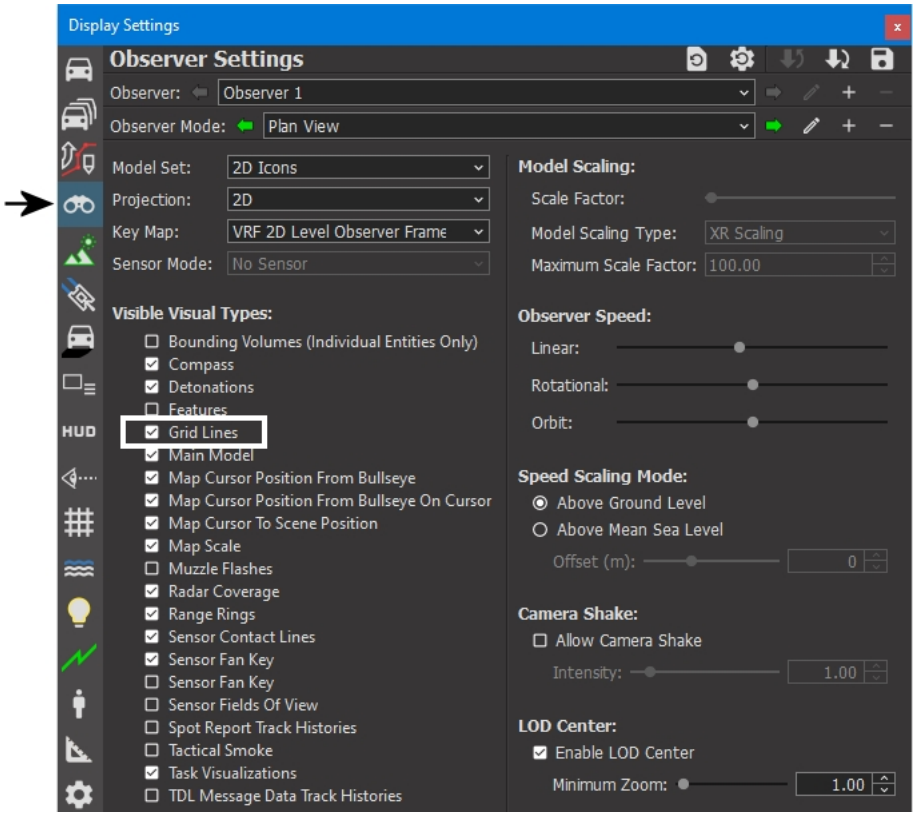
3.2. Displaying Grid Lines

VR-Forces can display grid lines in the 2D view. Grid lines are an observer-specific setting. They are configurable, as described in "3.2.1 Configuring Grid Lines" on the facing page.

To enable or disable grid lines:

1. Choose **Settings > Display**. The Display Settings dialog box opens.
2. Select the Observer Settings page (Figure 2).

Figure 2. Observer Settings page



3. Select Plan View mode (or a locally created 2D observer mode).
4. Select or clear the Grid Lines check box.

> ⓘ You can also enable or disable grid lines by choosing **Observer > Grid Lines**.

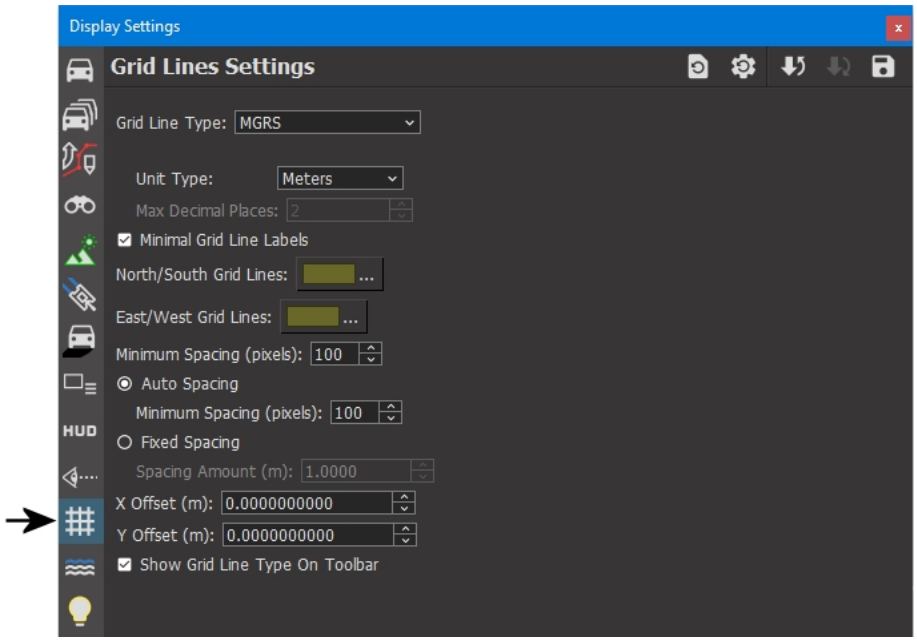
3.2.1 Configuring Grid Lines

You can configure the coordinate system used for grid lines, the precision, and the spacing. Spacing can be fixed, in meters, or determined by VR-Forces using a specified number of screen pixels. Fixed spacing can result in a very tight grid and unreadable labels as you zoom out. Auto spacing does not have this problem. However, the grid lines constantly recalculate as you zoom in and out.

➤ **To configure grid lines:**

1. Choose **Settings > Display**. The Display Settings dialog box opens.
2. Select the Grid Lines Settings page (Figure 3).

Figure 3. Grid Lines Settings page



3. To change the coordinate system used for grid lines, select an option in the Grid Line Type list. The list displays grid line types that are appropriate for the type of database loaded. (Until a database is loaded, the settings are blank.)

> ⓘ You can also select the grid line coordinate system using the Grid Line Selector Toolbar.

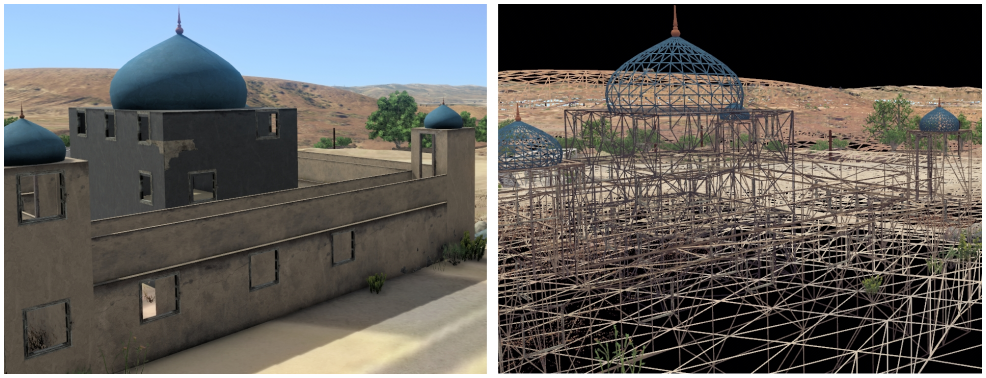
4. To specify the unit type for the grid line labels, select an option on the Unit Type list.
5. To specify the precision of the grid line labels, enter a value in the Max Decimal Places box.

6. To show more or less information at each grid line, clear or select the Minimal Grid Line Labels check box, respectively.
7. To use different colors for the north/south or east/west grid lines, choose a color for the lines.
8. To change the spacing type, select AutoSpacing or Fixed Spacing and specify a value for the chosen spacing type.
9. To specify an offset from the origin, change the values for X Offset and Y Offset.
10. Specify the altitude at which VR-Forces should stop putting latitude and longitude coordinate labels on the sides of the window and instead place them in the center of the world. The default is when the observer viewpoint moves into low earth orbit.
11. To include the coordinate system on the Grid Line Selector toolbar, select the Show Grid Line Type On Toolbar check box.

3.3. Displaying Models and Terrain in Wireframe Mode

In wireframe mode, VR-Forces displays the polygons that make up the terrain and objects (Figure 4).

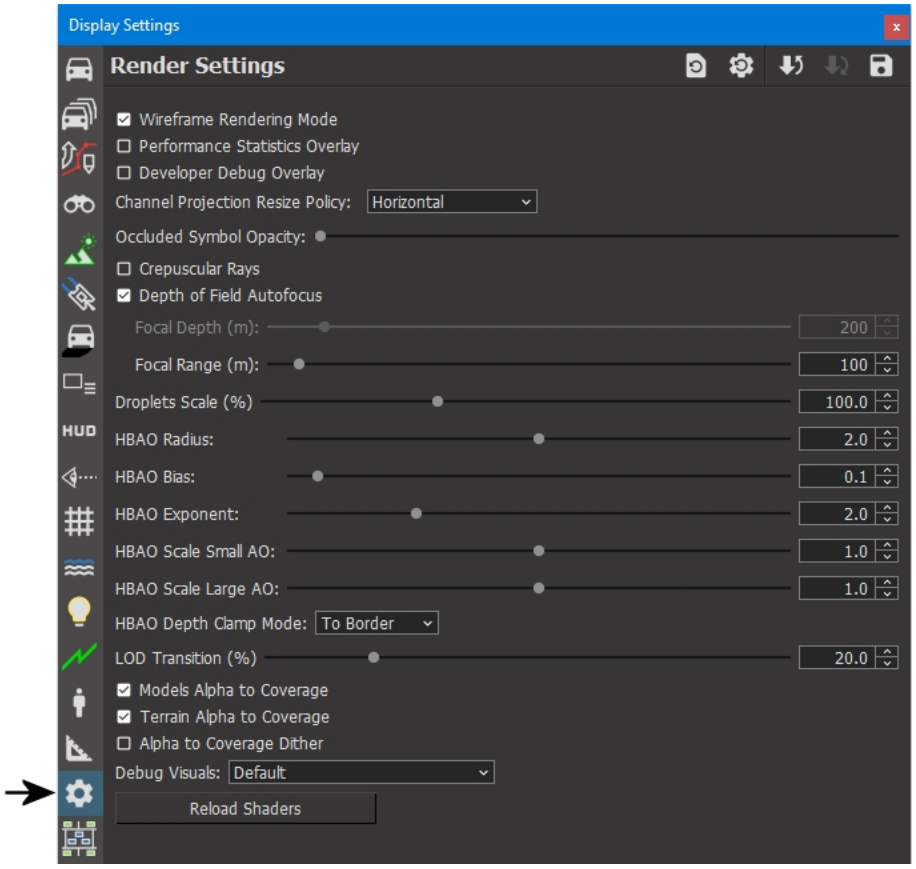
Figure 4. Wireframe off and on



➤ **To enable or disable wireframe mode:**

1. Choose **Settings > Display**. The Display Settings dialog box opens.
2. Select the Render Settings page (Figure 5).

Figure 5. Render Settings page



3. Select or clear the Wireframe Rendering Mode check box.

> You can also enable and disable wireframe mode by choosing **Settings > Wireframe Rendering**.

3.4. Filtering Earth File Layers

When you load a terrain using an earth file, imagery and feature data is specified in image elements and model elements. You can load multiple instances of these types of data, resulting in a rich, complex terrain. However, if you are only interested in certain types of terrain features, such as roads or rivers, displaying all of the terrain data can obscure the data that you are most interested in. To help declutter the map, you can filter out image and model layers globally or by observer mode.

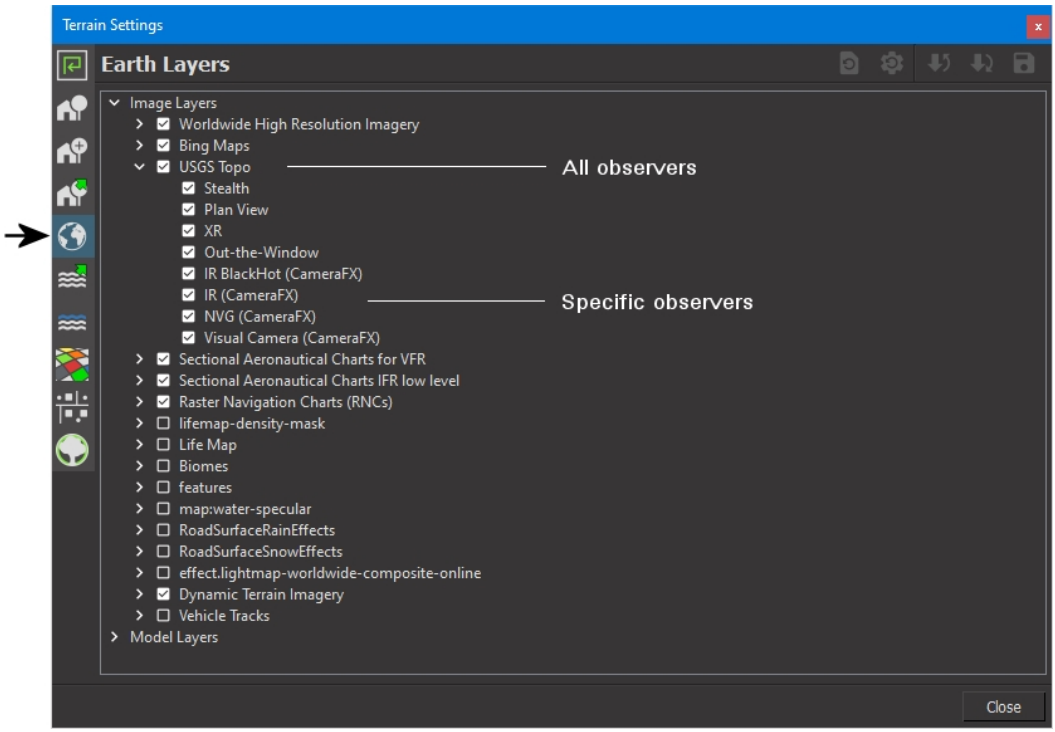
This feature is particularly useful if you want to show some layers in the PVD observer mode and others in one of the 3D observer modes. Settings are saved to the MTF file so that they are in effect in all scenarios that use the terrain.

- Filtering an earth file layer affects all open windows. You cannot hide a layer in one window and leave it open in a different one.
- Filtering only affects the GUI. All layers are loaded in the sim. engine.

➤ **To filter out earth file layers:**

1. Choose **Settings > Terrain**. The Terrain Settings dialog box opens.
2. Select the Earth Layers page (Figure 6).

Figure 6. Earth Layers page



3. To display or hide an image or model layer for all observer modes, select or clear its check box.
4. To display or hide an image or model layer for a particular observer mode, expand the entry for the layer you want to change and select or clear the check box for the observer mode you want to change.

3.5. Displaying Feature Data (2D)

If a terrain contains feature data imported from GDB files or shapefiles, you can display it in the 2D view observer mode. Figure 7 shows a section of the Little Pond terrain with features disabled and enabled.

Figure 7. Feature data

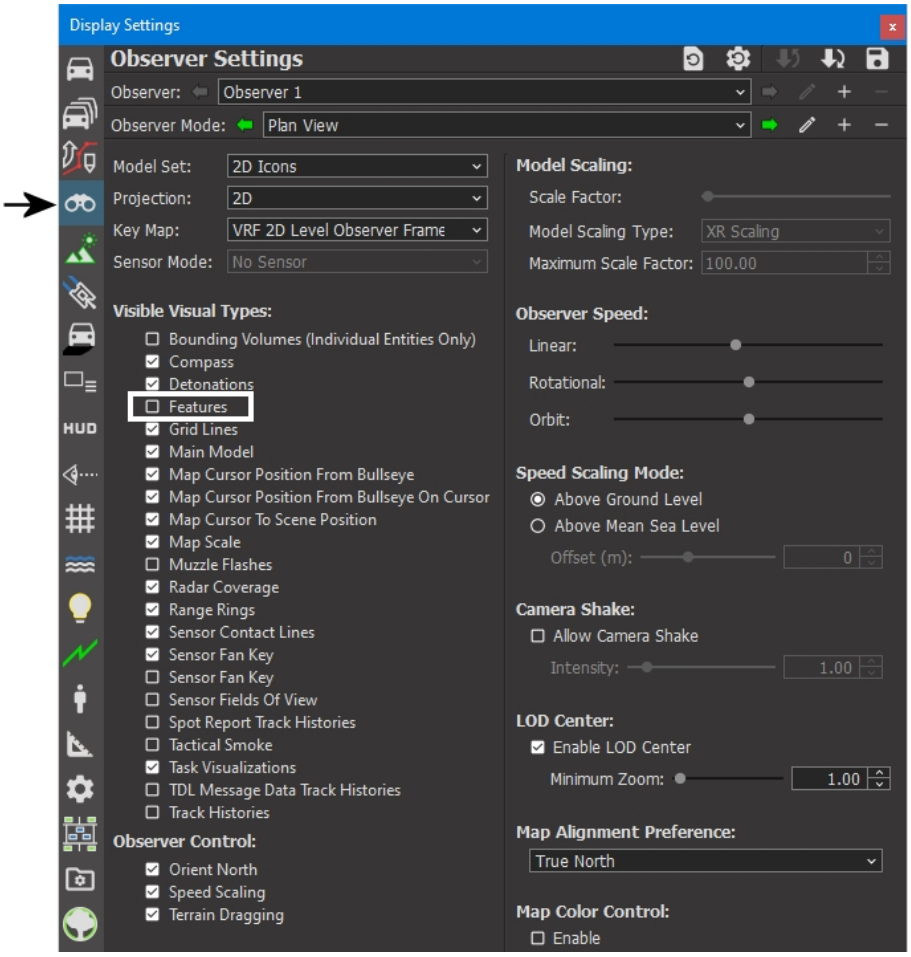
This setting only displays features imported from GDB files or shapefiles. It does not display features streamed from a terrain server. If you load features using an earth file, they are drawn (or not drawn) based on the configuration information in the file.

ⓘ If your terrain has many features, displaying them can take a long time.

➤ **To show or hide feature data:**

1. Choose **Settings > Display**. The Display Settings dialog box opens.
2. Select the Observer Settings page.
3. In the Observer Mode list, select Plan View (Figure 8).

Figure 8. Observer Settings page, Plan View observer mode



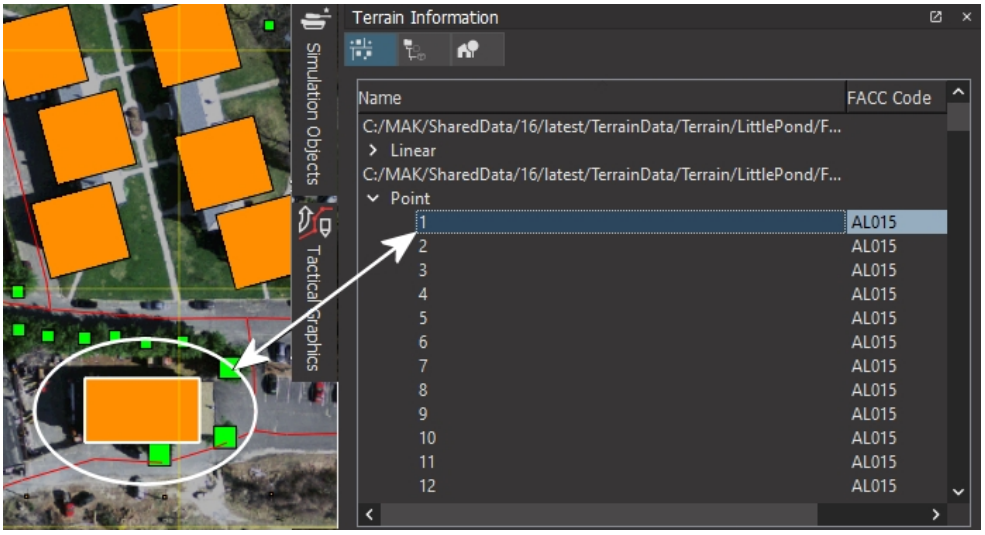
4. Select or clear the Features check box.

> You can also enable or disable display of feature data by choosing **Observer > Features**.

3.5.1 Displaying a List of Vector Features

If a terrain has vector features, they are listed on the Vector Network tab of the Terrain Information Panel. If you select a feature in the list, it is highlighted in the display, and the other way around (Figure 9).

Figure 9. Vector feature selected



➤ **To display the feature list:**

1. Choose **View > Terrain Information Panel**. The Terrain Information Panel opens.
2. Select the Vector Network tab (Figure 9).
3. Expand the top-level categories to see the lists of individual features.

3.5.2 Changing the Colors Used for Feature Data

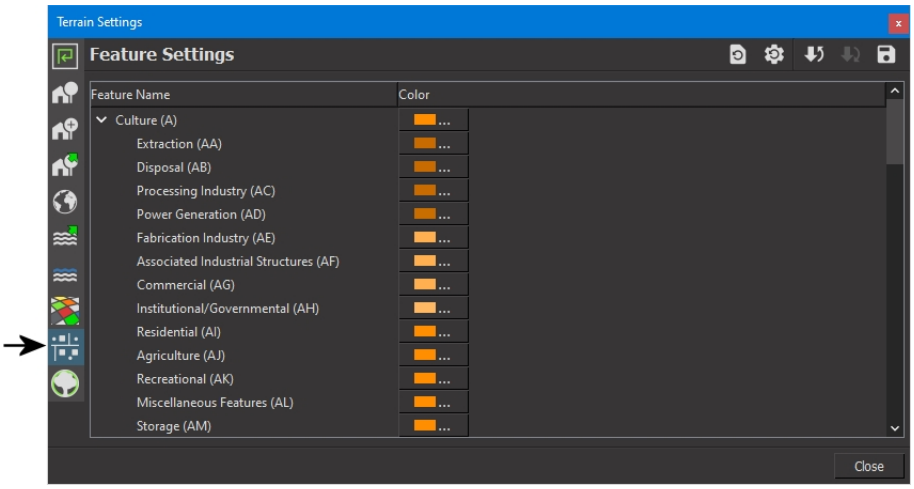
If a terrain database contains feature data, you can change the colors used to display it. In Figure 10, the Woodland feature in the Little Pond terrain was changed to pink. Compare it to the default color (Figure 7 on page 21).

Figure 10. Feature data with color change

➤ **To change the color of feature data:**

1. Choose **Settings > Terrain**. The Terrain Settings dialog box opens.
2. Select the Feature Settings page (Figure 11).

Figure 11. Feature Settings page

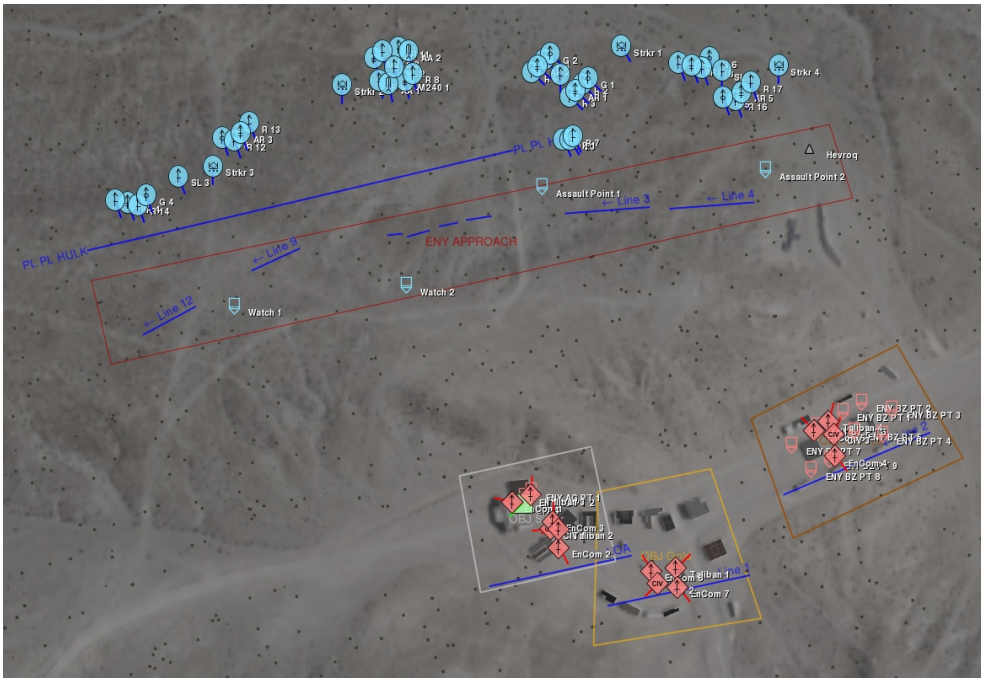


3. Click the color swatch for the feature that you want to change. A color picker dialog box opens.
4. Select the color that you want to use.
5. Click OK.

3.6. Adjusting Map Colors

In the 2D view, you can change how the colors are displayed. You can adjust the contrast, brightness, and color mix. You can also invert the grayscale. This allows you to view the scenario without the colors of the terrain distracting from what you want to see.

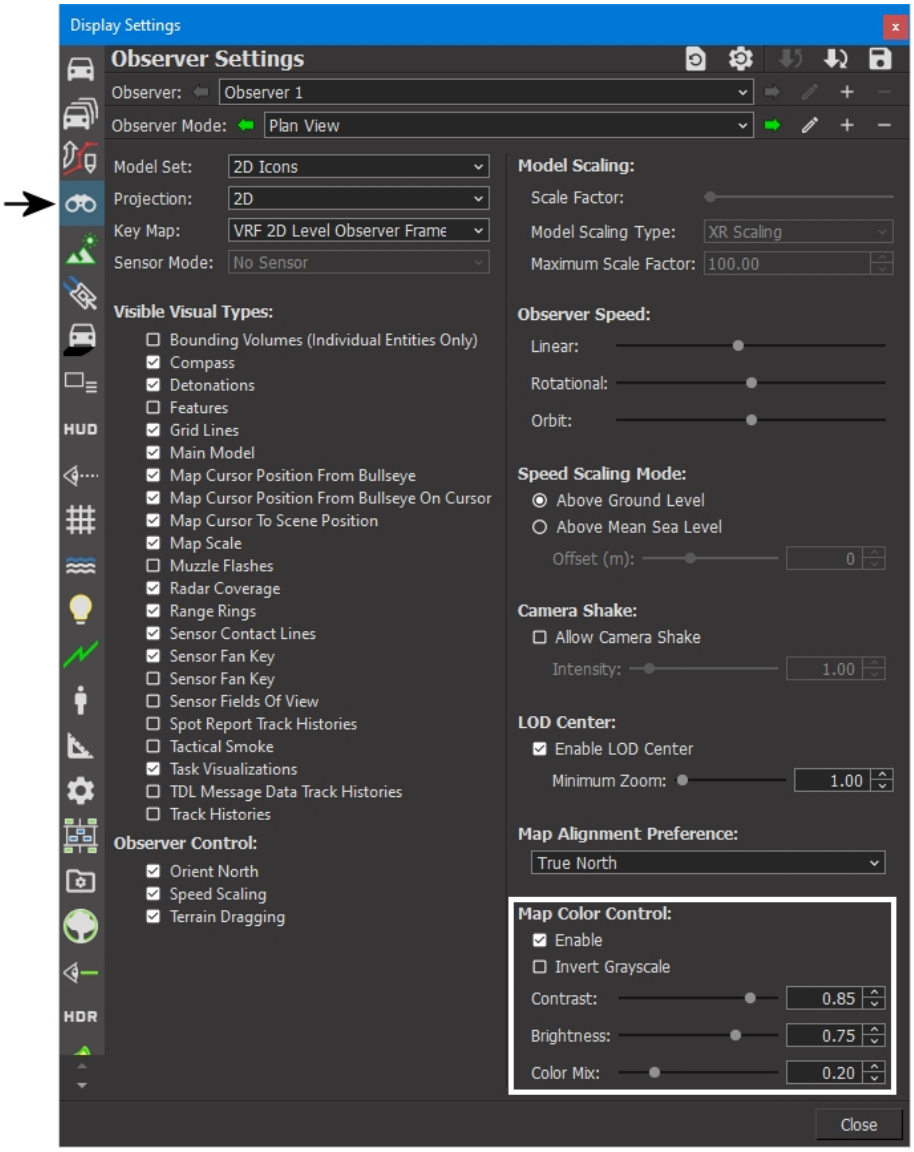
Figure 12. Map color set to grayscale



➤ **To adjust the terrain colors:**

1. Choose **Settings > Display**. The Display Settings dialog box opens.
2. Select the Observer Settings page (Figure 13).

Figure 13. Map Color Control Settings



3. Under Map Color Control, select the Enable check box. The terrain colors are changed to reflect the settings.
4. Optionally, select or clear the Invert Grayscale check box.
5. Adjust the Contrast, Brightness, or Color Mix values as desired.

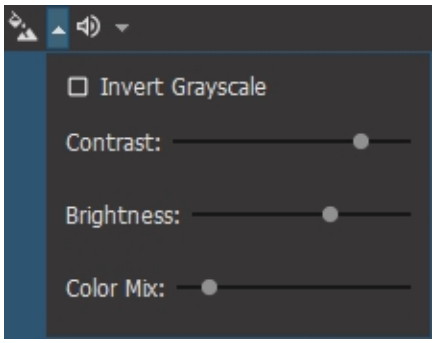
3.6.1 Adjusting Map Colors on the Display Settings Toolbar

You can also manage the Map Color Control using the button on the Display Settings toolbar.

➤ **To enable or disable map color control on the Display Settings toolbar:**

1. Click the Map Color Control button ( ) to enable or disable the settings.
2. Click the arrow to display a small panel with the available settings (Figure 14). It is a persistent window.

Figure 14. Enter Caption Here



3. Set the values as desired.
4. To hide the panel, click the arrow on the Map Color Control button.

3.7. Selecting a 2D View Layer

osgEarth terrains can have different visible layers to display in the 2D view. These can be layers defined specifically to display contour lines, annotations, and so on.

➤ To select a 2D View Layer, choose the layer from the 2D View Layer toolbar.

3.8. Displaying Coordinates and Soil Type for a Location

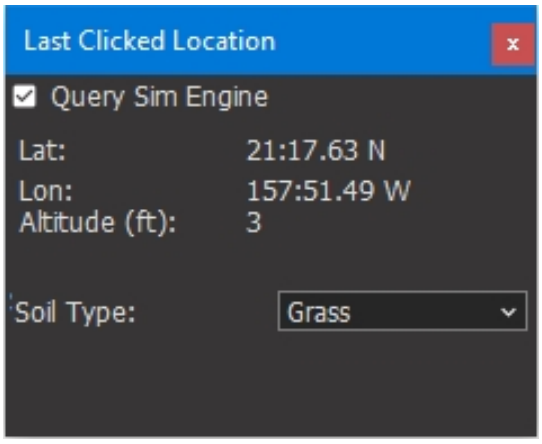
You can display the coordinates and soil type (if defined) of features and any point in the terrain. Soil type must be provided by the simulation engine. If you do not choose to query the simulation engine, the Last Clicked Location Panel just displays coordinates using data from the GUI.

The Last Clicked Location Panel becomes unavailable if you query the simulation engine and it takes more than 1/2 second for a response.

➤ **To check the coordinates and soil type of a feature or location:**

1. If the Last Clicked Location Panel is not open, choose **View > Last Clicked Location**.

Figure 15. Last Clicked Location Panel



2. If you want soil type information, select Query Sim Engine.
3. Click a point on the terrain or click a feature. Information appears in the Last Clicked Location Panel.

3.9. The Map Scale Overlay

In Plan View Observer mode, you can display a map scale overlay on the terrain.

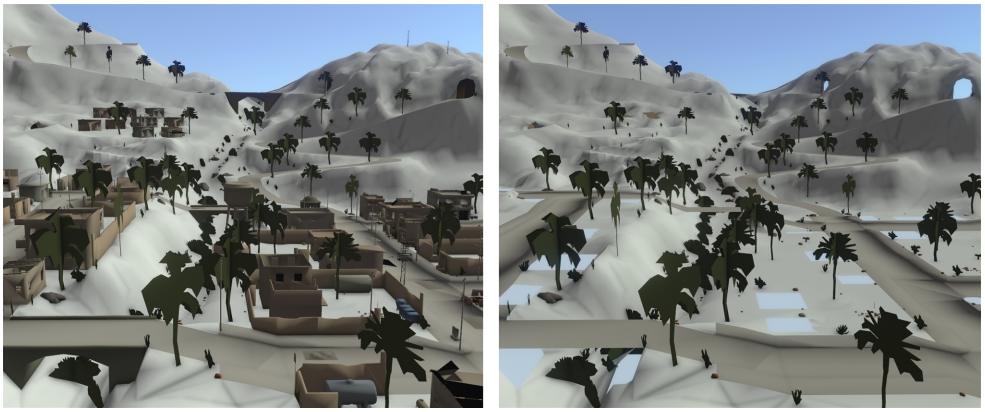
Figure 16. Map scale overlay

➤ To view or hide the map scale overlay, choose **Observer > Map Scale**.

3.10. Configuring Visible Surfaces (GDB Soil Types)

If a terrain patch was loaded from a GDB file, you can display or hide GDB soil types. Figure 17 shows the *VR-Village.gdb* terrain file. The view on the left shows all soil types. The view on the right has Building, Grass, and Rock surfaces hidden.

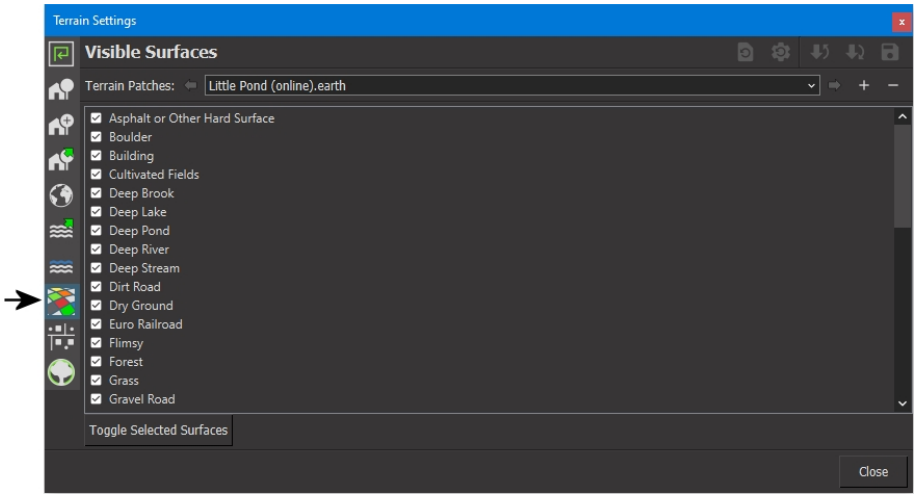
Figure 17. Visible surfaces toggled off



➤ **To display or hide GDB soil types:**

1. Choose **Settings > Terrain**. The Terrain Settings dialog box opens.
2. Select the Visible Surfaces page (Figure 18).

Figure 18. Visible Surfaces page



3. In the Terrain Patches list, select the terrain patch that you want to configure.
4. Select the check box for each soil type that you want to be visible.
5. Clear the check box for each soil type that you want to hide.
6. To change the state of multiple soil types at one time:
    a. Select (highlight) the names (not the check boxes) of the soil types whose state you want to change.
    b. Click Toggle Selected Surfaces.

4. Using Terrain Profiles

This chapter explains what terrain profiles are and how to display and configure them.

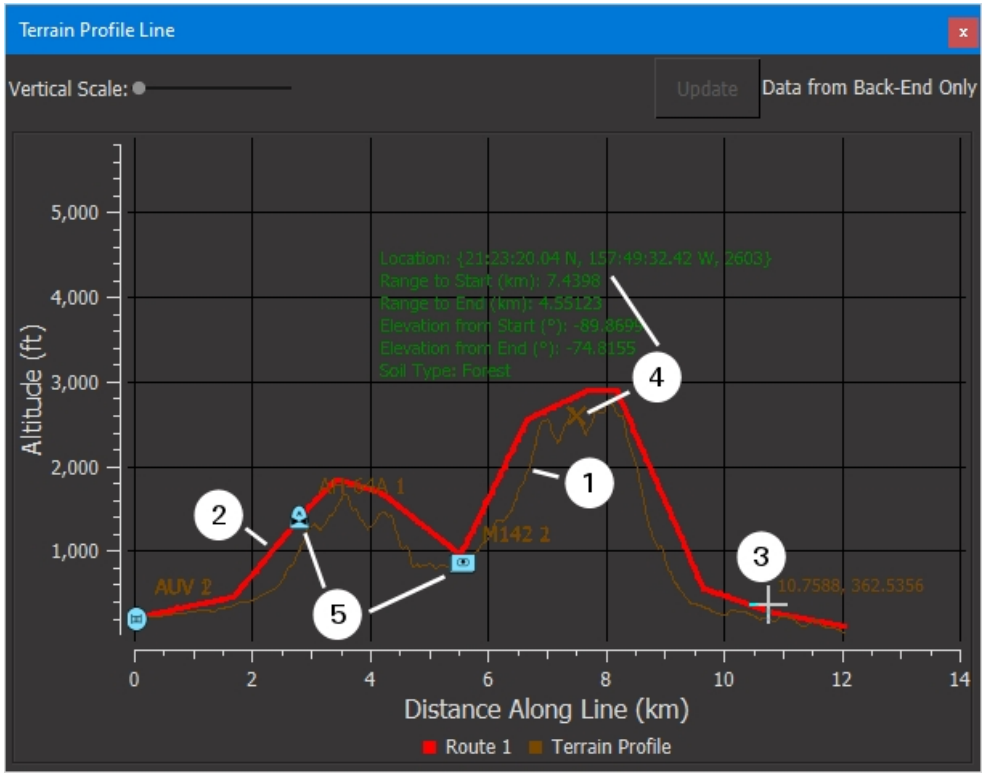
4.1. Terrain Profiles

You can display terrain profile windows for line objects that have height (in other words, routes and lines, but not phase lines), for intervisibility lines, and for a simulation object's track history. You can also create lines specifically for the purpose of showing the terrain profile. A terrain profile displays:

- A graph of the line against the terrain.
- Simulation objects within a specified distance of the line or track.
- Location of any one point along the line.
- The location on the grid of the cursor. This helps you estimate distances between the grid lines.

In Figure 19, the brown line (1) represents the terrain and the red line (2) shows a route. The location of the cursor in grid coordinates displays (3) and the location of one point along the terrain is displayed (4). Several entities are close to the route and they are shown as well (5).

Figure 19. Terrain profile



4.1.1 Displaying a Line's Terrain Profile

You can display a terrain profile for routes, intervisibility lines, and terrain profile lines.

➤ **To view a line's terrain profile, use one of the following methods:**

- Right-click a line and choose **Terrain Profile** from the shortcut menu.
- Open the Edit dialog box for a line and click Terrain Profile. (You can configure terrain profiles to open automatically when you open an Edit dialog box.)

To display the terrain profile for a track history, follow the procedure in "Displaying a Terrain Profile for a Track History".

4.1.2 Configuring Terrain Profiles

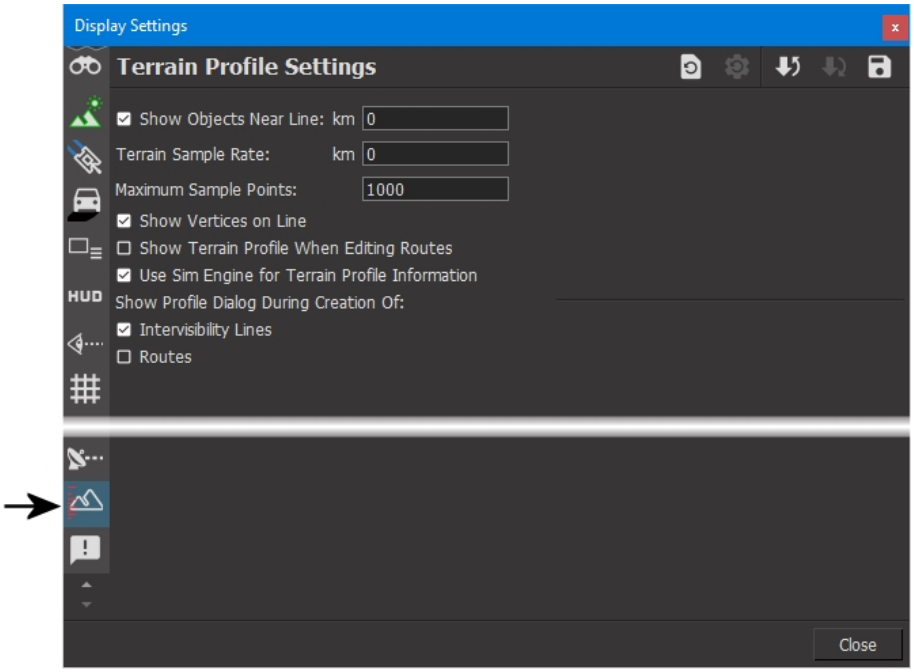
You can configure these aspects of a terrain profile:

- The frequency, in distance, at which terrain height is sampled to create the graph in the Terrain Profile window.
- Whether to use the sim. engine for the terrain's height data when displaying the terrain profile line.
- The maximum number of points to sample along a line.
- Whether to show simulation objects that are close to the line and how close to the line simulation objects need to be to be shown.
- Whether to show the vertices of the line.
- Whether terrain profiles should be displayed automatically when a line is created or edited.

➤ **To configure terrain profiles:**

1. Choose **Settings > Display**. The Display Settings dialog box opens.
2. Select the Terrain Profile Settings page (Figure 20).

Figure 20. Terrain Profile Settings page



3. Change settings as desired. Table 2 describes the configuration options:

Table 2. Terrain profile parameters

Option	Description
Show Objects Near Line	If enabled, displays icons for simulation objects near the line. The text box specifies the distance from the line within which simulation objects are displayed.
Terrain Sample Rate	Specifies the frequency at which the terrain is sampled along the line.
Maximum Sample Points	Specifies the maximum number of sample points for a line.
Show Vertices On Line	If enabled, the vertices of the line are displayed.
Show Terrain Profile When Editing Routes	If enabled, a terrain profile window opens when you edit a route.

Table 2. Terrain profile parameters (continued)

Option	Description
Use Sim. Engine for Terrain Profile Information	If enabled, the height data of the terrain for the Terrain Profile Line comes from the sim. engine. While you create the line, the profile uses GUI data. When you finish creating the line, the height information comes from the sim. engine. The Terrain Profile Line indicates whether the data is coming from the GUI or sim. engine.
Show Profile During Creation	If enabled, a terrain profile window opens while intervisibility lines, routes, or both are created.

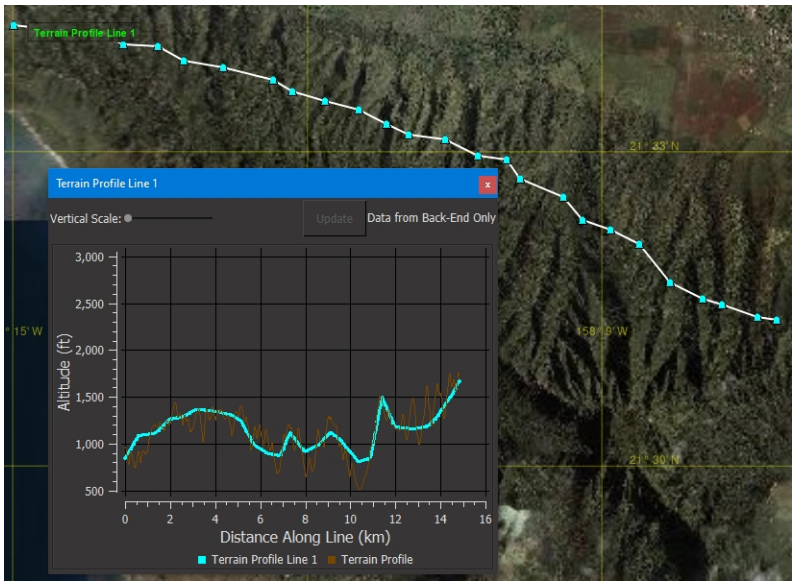
4.2. Analyzing Terrain Using a Terrain Profile Line

A terrain profile line is a special line used to analyze the terrain. It is more versatile than a point-to-point intervisibility line because it can have multiple points, which allows a finer analysis of the terrain. Unlike a route (for which you can also view terrain profiles), a terrain profile line is not published, so it has less overhead and does not clutter up object lists.

➤ **To create a terrain profile line:**

1. Choose **Intervisibility > Create Terrain Profile Line**. A Terrain Profile window opens and the cursor changes to draw mode.
2. Click on the terrain to place the vertices of the line. As you add vertices, the Terrain Profile window updates to show the profile of the line (Figure 21).

Figure 21. Terrain profile line



3. Double-click to finish the line.

After you create a terrain profile line, you can edit it just like any other line. For details, see "Editing Vertices".

5. Generating Navigation Data

This chapter explains how to generate navigation data for use with VR-Forces.

5.1. Introduction

To use advanced navigation, you must use a terrain that has navigation data generated for the areas in which you want to navigate. You generate navigation data in the VR-Forces GUI.

When you generate navigation data, the VR-Forces creates separate sets of navigation data, at various levels of detail, for specified profiles. VR-Forces includes profiles for lifeforms and ground vehicles. You can modify the profiles and add new ones. The navigation data is stored in separate directories where it can be accessed by multiple terrains, if needed.

The general procedure for generating navigation data is:

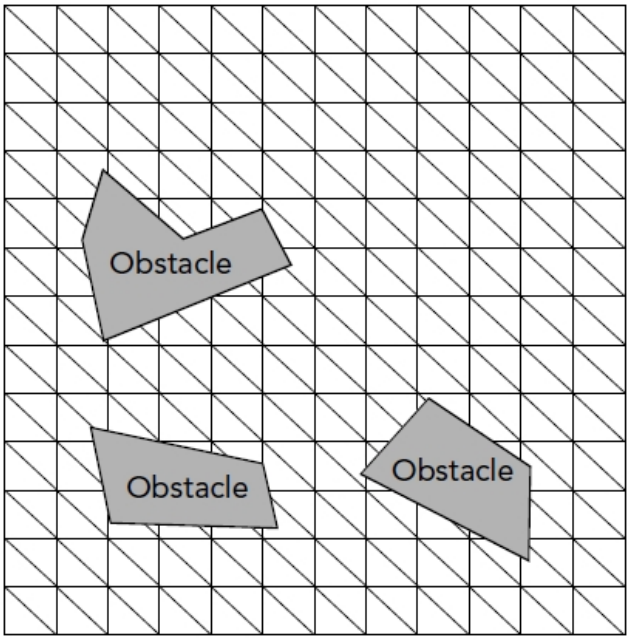
1. Load the terrain on which you want to generate navigation data or load a scenario that uses that terrain.
2. Create a navigation area.
3. Generate the navigation data.
4. Save the terrain.
5. Start a new scenario or save and reload the existing scenario.

5.1.1 How Navigation Data is Generated

Navigation data is generated from the GUI. Before you can use newly generated navigation data, you must close your scenario and reopen it. (This is so it can be loaded by the sim. engine.) If the terrain is modified, the navigation data must be generated again.

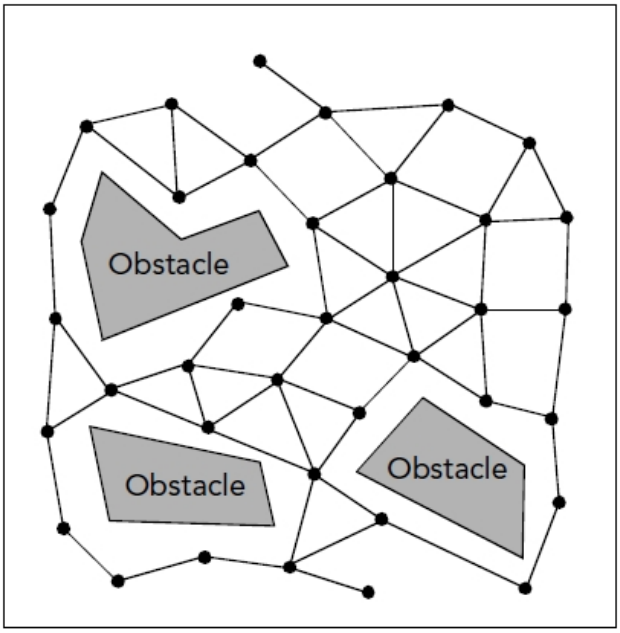
VR-Forces analyzes the terrain and creates a navigation mesh (NavMesh) of the terrain. The NavMesh defines areas in which an entity can move, given its dimensions. A lifeform can move in spaces that a ground vehicle cannot move in. Figure 22 shows a NavMesh for a terrain that has several areas in which entities cannot move.

Figure 22. NavMesh



Based on the NavMesh, VR-Forces generates a graph of locations in the terrain that the entity type can move to. Each location can be accessed from at least one other location. Figure 23 shows a hypothetical graph of the paths that an entity can follow in the NavMesh shown in Figure 22.

Figure 23. Graph



For details about generating navigation data, see "5.3. Generation of Navigation Data" on page 47.

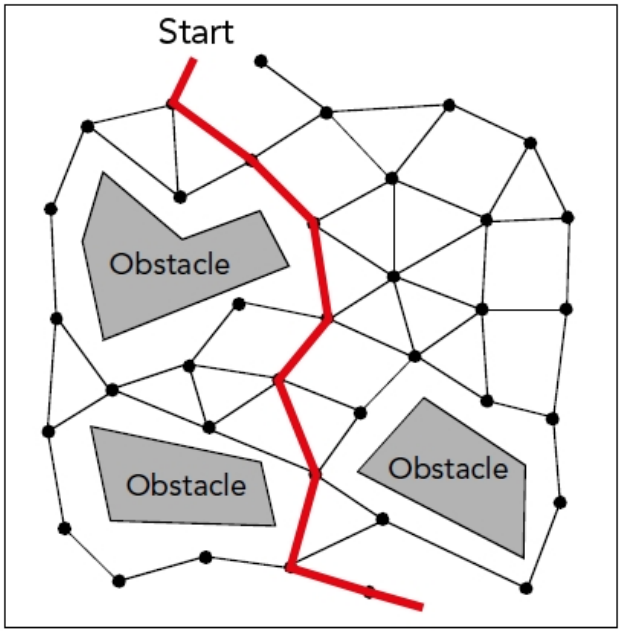
5.1.2 Path Finding

Path finding is the process by which an entity plans a path, follows the path, and avoids obstacles along the path.

Planning a Path

Every time an entity decides to move (either through an autonomous decision or a task assignment), it computes its path. Path computation, or path planning, consists of running an A* algorithm, with a given heuristic, on the navigation data.

Figure 24. Planning a path



A path finding heuristic is a cost estimate for the shortest path to reach a target. This cost can be measured according to various criteria, such as distance, time, and danger. The path finding heuristic is critical for the performance of the A* algorithm used by VR-Forces.

The standard path finding heuristic is the Euclidian Heuristic. In this heuristic, the cost of moving from one vertex to another vertex is the Euclidian length of the connecting edge.

Path Following

Once a path is determined for an entity, it can start moving to its final goal. As illustrated in Figure 24, a path is a set of vertices and edges. However, entities do not necessarily follow the exact path. VR-Forces smooths the entity's movement.

The first intermediary destination (or subgoal) of the entity is the nearest vertex. Before moving towards this point, the entity checks to see if it can move directly to the next vertex in its path. This test is performed against the AI mesh. If the next vertex is reachable, it becomes the new subgoal. The entity continues testing successive vertices until it finds a vertex that it cannot reach directly. The final trajectory is a smooth line that connects the various subgoals.

Figure 25 and Figure 26 illustrate this process. Using the prospective path defined in Figure 24, the entity computes its actual path. In Figure 25, view 1, it tests the first three vertices (dashed lines) and finds that it can reach all of them directly. In Figure 25, view 2, it tests the fourth vertex and finds that it can reach it. It then tests the fifth vertex and finds it cannot reach it directly. Therefore, the fourth vertex becomes the subgoal for this portion of the path. Figure 26 shows the final calculated path (dashed line). Notice how the path to the fourth vertex is much smoother than a path that strictly follows the vertices and edges would be, because the entity determined that it could move directly to that vertex.

Figure 25. Checking next vertex

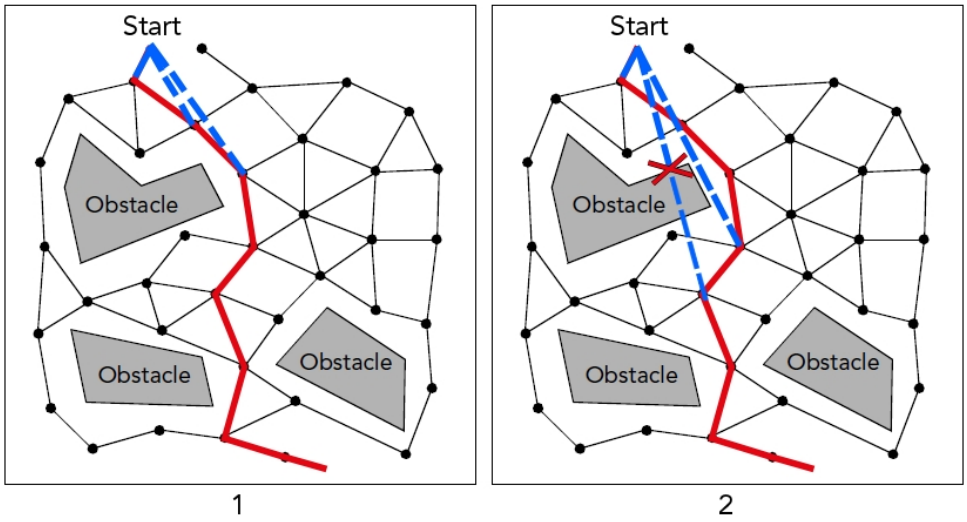
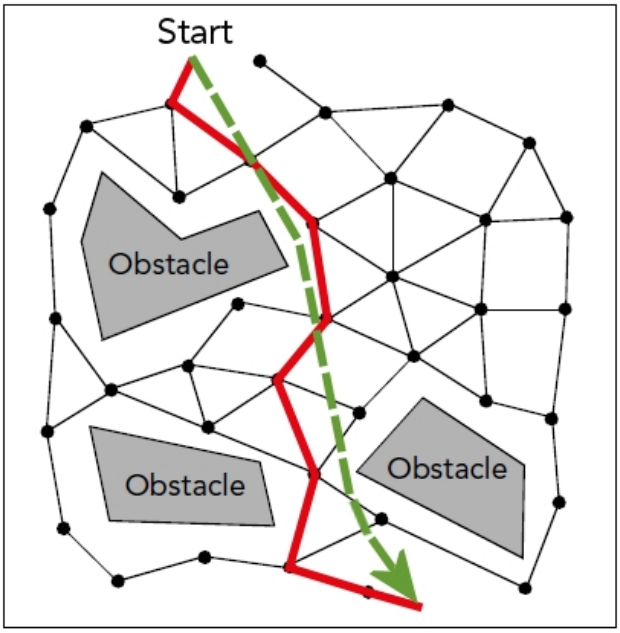


Figure 26. Final calculated path

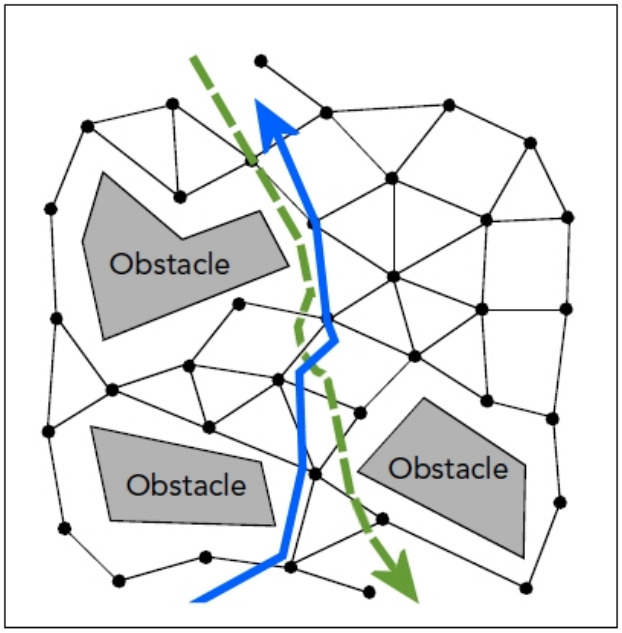


Dynamic Avoidance

While following its path, an entity may encounter other entities. VR-Forces models include collision avoidance. However in complex scenarios, the scenario developer may have to spend a considerable amount of time creating routes and coordinating entities to minimize collisions among entities and obstacles.

Advanced navigation uses a dynamic avoidance algorithm to make entities behave realistically when they are about to collide. Entities detect potential collisions in advance and adjust their trajectories smoothly using the navigation data.

Figure 27. Collision avoidance



In Figure 27, two entities traveling in opposite directions avoid each other, then resume their routes. Compare the track of the dashed line to that in Figure 26.

5.2. Navigation Areas

Navigation areas define areas on the terrain for which you can generate navigation data. Navigation areas are rectangular areas that are aligned to the North/South axis. The maximum size of the area on which you can generate navigation data depends on the raster precision value used to generate it. If you reduce the precision of navigation data, creating a sparser graph, the size of the maximum area increases. The maximum size for a navigation area using the default values is 20 km by 20 km. (Raster precision is configured in *./appData/settings/vrfSim/navigationProfiles.mtl*.)

You can create multiple navigation areas on a terrain.

5.2.1 Sectorizing Navigation Areas

You can generate navigation data for a navigation area as a whole or you can divide the navigation area into sectors and generate navigation data for each sector. VR-Forces can regenerate navigation data at runtime in response to changes in the terrain (dynamic

terrain damage and placement of buildings). If you sectorize the navigation area, regeneration is much quicker because VR-Forces can restrict regeneration to the sector that is affected rather than the entire navigation area.

The disadvantages of using sectors are:

- Increasing the number of sectors slows down generation of navigation data.
- The navigation data generation process can fail if any single sector is too large, too complex, or both. However, this is also true if you generate navigation data for a very large terrain without using sectors.
- Path planning over long distances may be slower.

To generate a maximum size navigation area, you must use multiple sectors.

5.2.2 Creating a Navigation Area

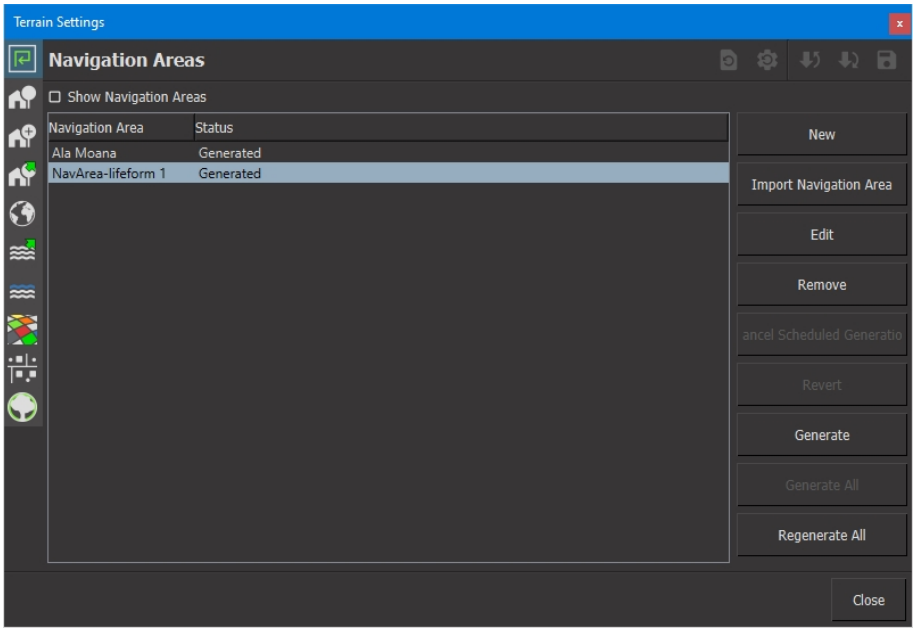
Navigation areas are created on the terrain used by the simulation engine. In most cases, scenarios use the same terrain for the GUI and simulation engine and there is no need to think about where navigation areas are created. However, sometimes scenarios use different terrains for the GUI and simulation engine. In those cases, note:

- The GUI only displays the navigation areas that are in the simulation terrain. If the GUI terrain has navigation areas they are not displayed.
- When you create a navigation area, it displays in the coordinate system used by the GUI terrain. Any data entry is in the GUI's coordinate system. However, the navigation area configuration files are saved in the coordinate system of the simulation terrain.
- The simulation terrain must be available to the GUI. If the GUI and simulation engine are running on different machines, it is possible that the files for the terrain used by the simulation engine are not on the computer that is running the GUI. However, for navigation areas to be created, the GUI must have access to the simulation terrain.
- Props are created on the GUI terrain. If you want props to be part of the navigation data, you must add them in a scenario that has the same terrain for the GUI and simulation engine.

➤ **To create a navigation area:**

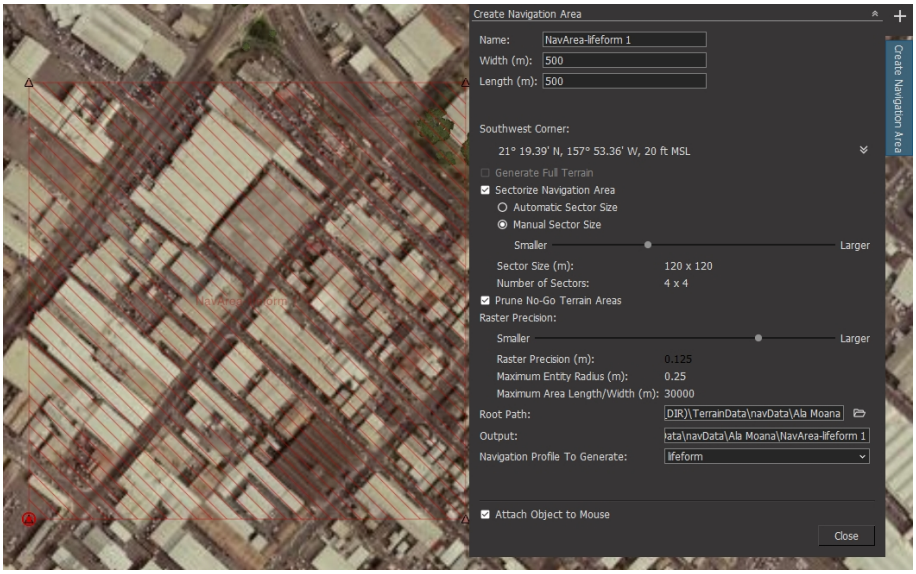
1. Open a scenario or a terrain on which you want to generate navigation data.
2. Choose **Settings > Terrain**. The Terrain Settings dialog box opens.
3. Select the Navigation Areas page (Figure 28).

Figure 28. Navigation Areas page



4. Click New. The cursor changes to create mode and shows a box that represents the navigation area. The default size is 500 m by 500 m. The Create Navigation Area tab is added to the window.
5. Click to place the lower left corner of the navigation area (Figure 29).

Figure 29. New navigation area



6. In the Create Navigation Area dialog box, edit the properties of the navigation area. Table 3 describes the fields in the dialog box.

Table 3. Navigation area properties

Property	Description
Name	The name of the navigation area. You cannot change the name after you create the navigation area.
Width Length	The length and width of the navigation area. Do not try to create an area larger than 20 km by 20 km unless you have changed the raster precision to support a larger area.
Southwest Corner	The coordinates of the southwest corner of the navigation area. (The altitude value is not used.)
Generate Full Terrain	Generate navigation data for the entire terrain. If the terrain is too large for this option, it is disabled.
Sectorize Navigation Area	Generate navigation data for sectors, rather than one large area.
⚠ If you are creating a large navigation area, we recommend that you always sectorize it. Generation of large unsectorized navigation areas sometimes fails.	
Automatic Sector Size	If selected, VR-Forces chooses a sector size based on the size of the navigation area. The sector size and number of sectors is shown below the manual sector size slider.
Manual Sector Size	Allows you to choose a sector size using the slider. As you move the slider, the sector size and number of sectors is shown below the slider.
Prune No-Go Terrain Areas	Do not calculate navigation data for areas in which simulation objects cannot move.
Raster Precision	Determines the density of the navigation graph.
Root Path	The root path of the data for this terrain.
Output (Path)	The location to save navigation data to.
Navigation Profile to Generate	Select the platform type for which you want to generate navigation data.
ⓘ Navigation areas created before VR-Forces 4.8 allowed more than one navigation profile. This is supported for backward compatibility only. For faster navigation generation, we recommend one profile per navigation area.	

7. Click Create.

5.2.3 Editing a Navigation Area

After you create a navigation area, you can edit any of its attributes except its name.

➤ **To edit a navigation area:**

1. Open a scenario or a terrain that has the navigation area you want to edit.
2. Choose **Settings > Terrain**. The Terrain Settings dialog box opens.
3. Select the Navigation Areas page (Figure 28).
4. Select the navigation area you want to edit.
5. Click Edit. The Edit Navigation Area dialog box opens.
6. Make the change you want to make.
7. Click OK.

5.2.4 Reverting Edits to a Navigation Area

If you edit a navigation area, you can revert to the previous version of the area.

➤ **To revert an edited navigation area:**

1. Choose **Settings > Terrain**. The Terrain Settings dialog box opens.
2. Select the Navigation Areas page (Figure 28).
3. Select the navigation area you want to revert.
4. Click Revert.

5.2.5 Displaying Navigation Areas

➤ To display navigation areas, choose **Settings > Navigation Areas**, click the Navigation Area button on the Display Settings toolbar, or select the Show Navigation Areas check box on the Terrain Settings dialog box, Navigation Areas page.

5.2.6 Removing a Navigation Area

➤ **To remove a navigation area:**

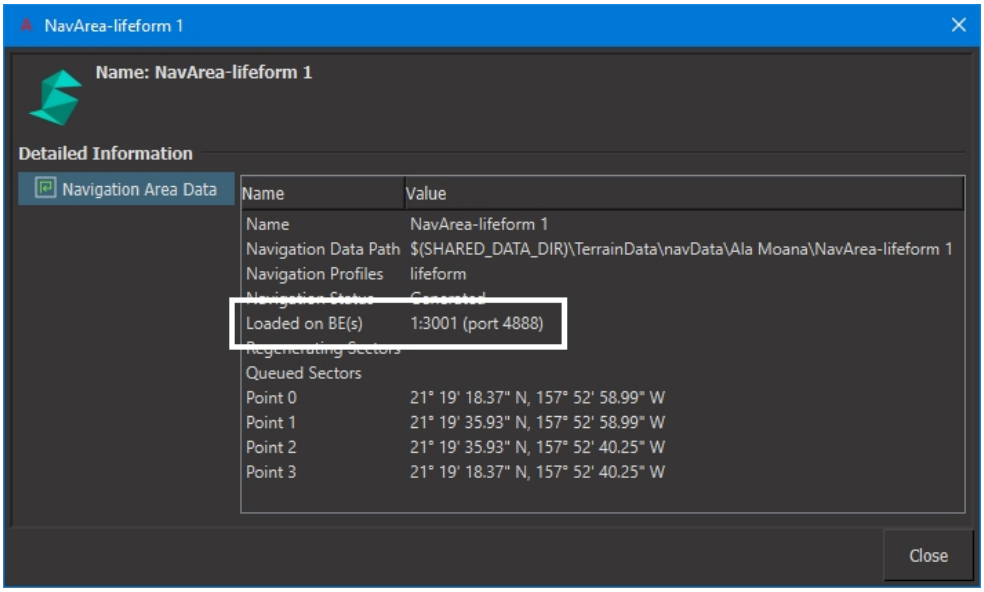
1. Choose **Settings > Terrain**. The Terrain Settings dialog box opens.
2. Select the Navigation Areas page (Figure 28).
3. Select the navigation area you want to remove.
4. Click Remove.

5.2.7 Displaying Information about a Navigation Area

You can display an Information dialog box that has information about the selected navigation area (Figure 30). By default, the dialog box does not display the port used by the navigation area. It is marked (Disabled). To display the port, in *./appData/settings/vrfSim/vrfSim.mtl*, set **enableNavigationLabDebugging** to 1.

For performance reasons, navigation data does not load until you place a simulation object that will use it. When you enable Navigation Lab debugging and look at the terrain's navigation areas before a simulation object uses it, the information dialog box shows that the data has not been loaded.

Figure 30. Navigation area information



5.3. Generation of Navigation Data

To generate navigation data, you create navigation areas and then generate navigation data for them. A terrain can have more than one navigation area. Entities use advanced navigation within the areas and standard navigation if they move between them.

Generating navigation data can last from a few minutes to hours to days depending on the terrain complexity, the level of detail, and your computer's processing power. Navigation data is saved to *./userData/navData* in a directory that matches the name of the terrain on which it was generated. In addition to using sectors ("5.2.1 Sectorizing Navigation Areas" on page 42), generating cover points can significantly affect the amount of time it takes to generate navigation data.

By default, when you generate navigation data for lifeforms, VR-Forces calculates cover points. For large and complex terrains, this process can be very slow. MAK has recorded this taking one week to finish on a maximum size navigation area. You can disable calculation of cover points in the navigation profile. However, if you disable calculation of cover points, tasks that use cover points will not work in the navigation area.

5.3.1 Navigation Profiles

VR-Forces generates navigation data based on parameters in a profile. VR-Forces includes profiles for lifeforms and ground entities. They provide default values for generating navigation data that should work for most terrains. You can change the profiles. You can also add profiles. Profiles are configured in *./appData/settings/vrfSim/navigationProfiles.mtl*. The configuration parameters are explained in the file.

Navigation profiles include parameters that control the priority of navigation data regeneration in response to terrain changes and the types of changes that trigger regeneration. For more information about regenerating navigation data, see "5.3.4 Automatic Regeneration of Navigation Data" on page 50.

You can use the `nav-edges` block in a navigation profile to connect points in the terrain that would not normally be connected by the navigation data generation process. This feature, for example, allows a human entity to walk up to a door, open the door, walk through the door, and then close the door. This is an advanced feature. For details, see the comments in *navigationProfiles.mtl* or contact support at https://www.mak.com/mak-one/support/portal.

> ⓘ You can dynamically add nav edges to a navigation area using nav edge tactical graphics. For details, see "Creating Nav Edges".

The profile that an entity uses for advanced navigation is specified in its OPE file. For example, *Human.ope* specifies use of the lifeform profile:

```
(navigation-parameters
  (DtRwString navigation-profile  "lifeform")
  (DtRwString navigation-method  "shortcut")
)
```

Another advanced feature that you can use is `min-navigable-surface`, which indicates the minimum size, in meters squared, of the surface area a section of the terrain must have before the generator will generate navigation data for it. The default is 10 meters squared, which is reasonable for many terrains but can omit small rooms that are connected by dynamic doors to the larger terrain. By specifying smaller sizes, you can include areas such as those.

5.3.2 Generating Navigation Data for a Navigation Area

The Navigation Areas page (Figure 28) displays the status for each navigation area:

- Generated. Data has been generated.
- Needs Generation. The navigation area needs to have navigation data generated.
- Scheduled Generation. VR-Forces is generating navigation data for multiple navigation areas. This area is in the queue for generation.

You can generate navigation data for:

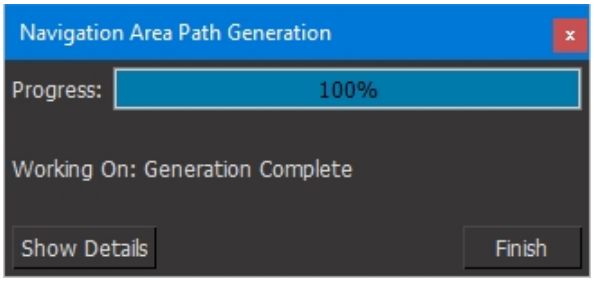
- Selected navigation areas.
- For all navigation areas that need to have navigation data generated.
- For all navigation areas, including those that already have navigation data.

> ⓘ When you generate navigation data, the generator does not use the version of the terrain that is loaded into the simulation engine or GUI. It uses a separate version. Therefore, if you have made any changes to the terrain, for example by adding props, and you want them to be part of the updated terrain, you must save the terrain before you generate navigation data.

➤ **To generate navigation data:**

1. Open a scenario or a terrain on which you want to generate navigation data.
2. Choose **Settings > Terrain**. The Terrain Settings dialog box opens.
3. Select the Navigation Areas page (Figure 28 on page 44).
4. Select the navigation areas for which you want to generate navigation data.
5. Click Generate.
6. You are prompted to save the terrain before navigation data is generated.
7. Click Yes. The Navigation Area Path Generation dialog box opens (Figure 31). You can optionally view details of the generation process or cancel the process. When the navigation data is generated, the dialog box buttons redisplay. You are prompted to reload the scenario.

Figure 31. Navigation Area Path Generation dialog box



8. Click OK.
9. Click Finish.
10. Save the terrain. (**File > Terrain > Save Terrain**.)
11. To use the navigation data, reload the scenario.

Removing a Navigation Area from the Generation Queue

If you schedule multiple navigation areas for navigation data generation by clicking Generate All or Regenerate All, you can remove areas from the generation queue. If you remove a navigation area for which you had already generated navigation data, its status returns to Generated. If you remove a navigation area that has not had navigation data generated, its status returns to Need Generation.

➤ **To remove a navigation area from the generation queue:**

1. Select the navigation area in the Navigation Areas list.
2. Click Cancel Scheduled Generation.

Canceling Generation of Navigation Data

You can cancel generation of navigation data while it is being generated for a navigation area. If you cancel generation of navigation data, the status for the navigation area changes to Needs Generation, even if you previously generated navigation data for this area.

➤ **To cancel generation of navigation data while it is being generated, do one of the following:**

- Select the navigation area in the Navigation Areas window and click Cancel Scheduled Generation.
- In the Navigation Area Path Generation dialog box, click Cancel NavArea *n*, where *n* is the number of the area currently being generated.

5.3.3 Using Newly Generated Navigation Data

To use newly generated navigation data, create a scenario that uses the terrain or open a scenario that uses that terrain. If you generate navigation data while a scenario is open, you must close the scenario, then open it again before you can use the navigation data.

5.3.4 Automatic Regeneration of Navigation Data

By default, VR-Forces automatically generates navigation data if a dynamic terrain change occurs in a navigation area. Unless your navigation area is quite small, regenerating navigation data will be much quicker if you create the navigation area with sectors.

The speed at which navigation data is regenerated depends on different factors (most notably sector size, number of affected sectors, and the complexity of the terrain), but in all cases it is not instantaneous. It takes at least several seconds, and possibly considerably longer. It is not abnormal for regeneration to take up to 20-30 seconds even in a well sectorized terrain. Therefore it is normal for entities to continue navigating using the original navigation data for a brief period until navigation data is updated.

Regeneration of navigation data is configured in *./appData/settings/vrfSim/navigationProfiles.mtl*.

You can specify the types of dynamic terrain change that trigger regeneration of navigation data and a priority for how quickly regeneration takes place relative to other profiles. The following code configures regeneration of navigation data for the lifeform profile. Please see the file for explanatory comments.

```
(regeneration-priority 1)
(regenerate-for-dynamic-terrain-types
  (dynamic-terrain-type  "entity")
  (dynamic-terrain-type  "damage")
  (dynamic-terrain-type  "damage_structure")
)
```

ⓘ Regeneration of navigation data in response to terrain changes does not require an additional license. Therefore, terrains that have navigation areas (which require an extra cost license to generate) can be distributed to VR-Forces users and regeneration of navigation data will work even if those users do not have a license for creating navigation areas.

5.4. Generating Navigation Data for Entities

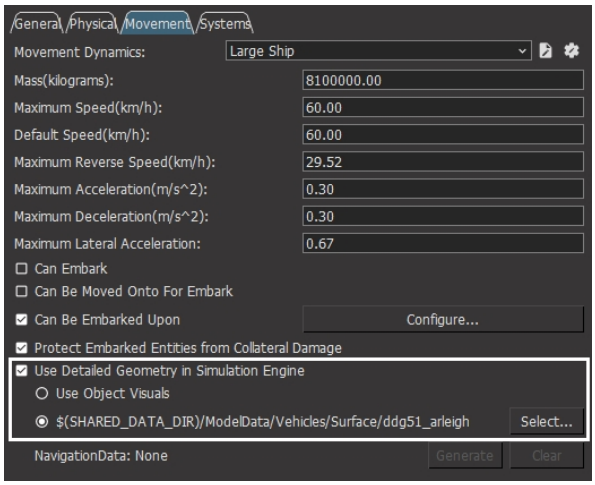
You can generate navigation data for entities that have object geometry. This allows human and ground entities to move around on the deck of an aircraft carrier or some other surface entity. Navigation data is generated for any surface on the entity that is accessible for the profile. For example, lifeforms can move on steeper surfaces than ground platforms. You generate navigation data for entities in the Simulation Object Editor. For complete details about using the Simulation Object Editor, see "Creating and Editing Simulation Models".

When you generate navigation data for an entity, it is saved in the *vrfSim/navData* directory for the SMS (*./data/simulationModelSets/<model_set>*). It saves immediately, regardless of whether you save changes to the SMS.

➤ **To generate navigation data for an entity:**

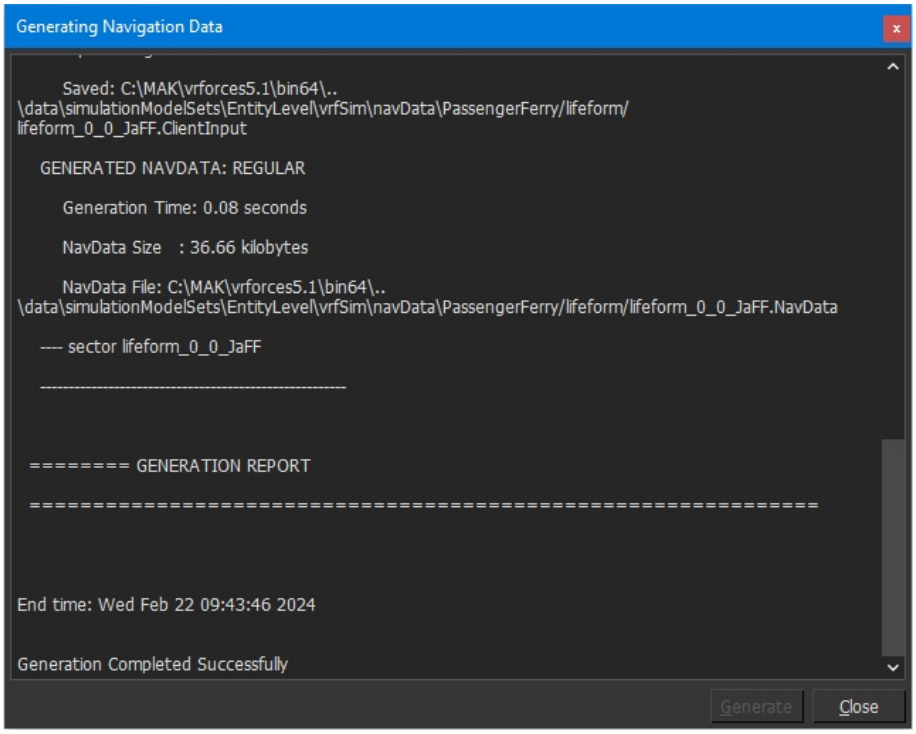
1. Start the Simulation Object Editor, as described in "Starting the Simulation Object Editor".
2. Load the SMS for the entity you want to edit, for example *EntityLevel.sms*.
3. In the object list, select the entity for which you want to generate navigation data.
4. Select the Movement tab.
5. Select the Use Detailed Geometry in Simulation Engine check box (Figure 32).

Figure 32. Object geometry



6. If you have not specified geometry for this entity, click Select and select the appropriate geometry file. (For complete details, see "Adding Object Geometry to a Simulation Object".)
7. Click Generate. The Generating Navigation Data dialog box opens.
8. Specify the platform types for which you want to generate navigation data.
9. Click Generate. VR-Forces generates navigation data (Figure 33). When the process finishes, the Cancel button changes to read Close.

Figure 33. Generating Navigation Data dialog box



10. Click Close.

5.5. Importing Navigation Areas and Navigation Data

When you generate navigation data for a navigation area, navigation area configuration files and the navigation data itself are saved to *./userData/navData*. For example, the configuration files for the Ala Moana navigation area provided with VR-Forces are *Ala Moana.navGenConfig* and *Ala Moana.navRuntimeConfig*.

You can import the navigation area and navigation data into other terrains that have the same coordinate systems and cover the same area of the earth. When you import a navigation area, it is imported with the status Generated.

➤ **To import a navigation area and its associated navigation data:**

1. Choose **Settings > Terrain**. The Terrain Settings dialog box opens.
2. Select the Navigation Areas page (Figure 28 on page 44).
3. Click Import Navigation Area. A file browser window opens.
4. Navigate to the directory for the navigation area that you want to import and select the *.navRuntimeConfig* configuration file for the navigation area.
5. Click Open. The navigation area is added to the terrain.
6. Save the terrain.

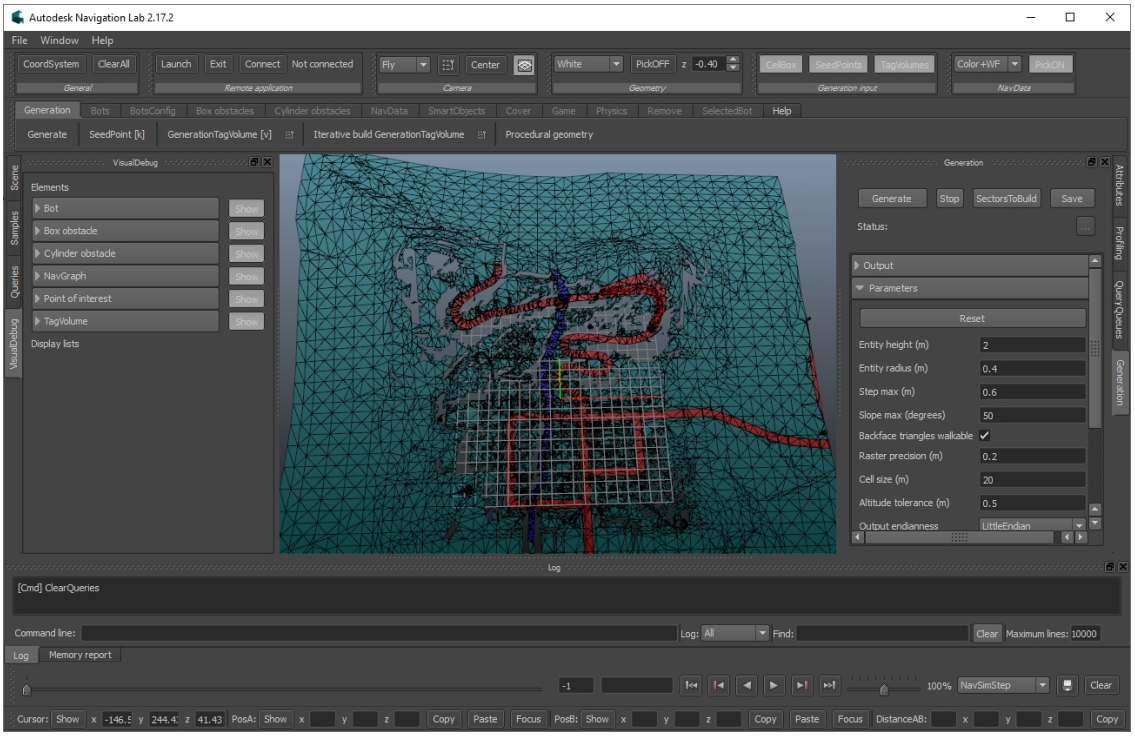
5.6. Displaying Navigation Data

VR-Forces includes Autodesk® Gameware Navigation Lab software (Navigation Lab), a tool that lets you view navigation data. It also lets you connect to a simulation and watch entities move about on the terrain.

You can view navigation data for navigation areas and for the object geometry on entities. You can open Navigation Lab and use its menus to select the navigation data to view or you can open it directly from an Information dialog box.

Figure 34 displays the navigation data for VR-Village.

Figure 34. Navigation data display



Autodesk® Gameware Navigation Lab is not supported on Linux.

➤ **To display navigation data by opening it in Navigation Lab:**

1. On the Start menu, choose **MAK Technologies > VR-Forces 5.2 Tools**. In the Tools folder, double-click the Navigation Lab shortcut. Navigation Lab opens.
2. Choose **File > Open**. A file browser opens.
3. To view navigation data for a terrain, navigate to a terrain under *./userData/navData*. To view navigation data for an entity, navigate to a directory in *./data/simulationModelSets/EntityLevel/vrfSim/navData*.
4. Select a file with the *.NavData* extension. The navigation data is displayed in the Navigation Lab window.

5.6.1 Opening Navigation Lab from an Information Dialog Box

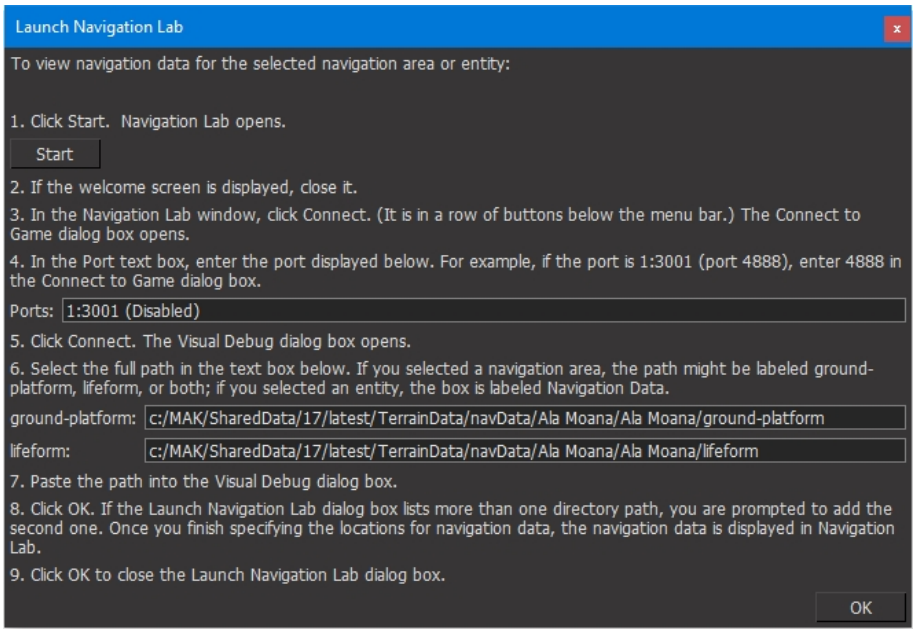
Navigation areas and entities that have object geometry and navigation data have a button on their Information dialog box that you can use to quickly display their navigation data in Navigation Lab.

> ⓘ Navigation data does not load until it is needed, such as when an entity is placed in the area. Until navigation data is loaded, clicking the Navigation Lab button displays a message informing you that you can use the Navigation Lab once the navigation data is loaded in the sim. engine.

➤ **To open Navigation Lab from an Information dialog box:**

1. Open the Information dialog box for the navigation area or entity for which you want to view navigation data.
2. Click the Navigation Lab button ( ). The Launch Navigation Lab dialog box opens (Figure 35).

Figure 35. Launch Navigation Lab dialog box



3. Follow the directions on the dialog box.

5.6.2 Showing Simulation Object Movement in Navigation Lab

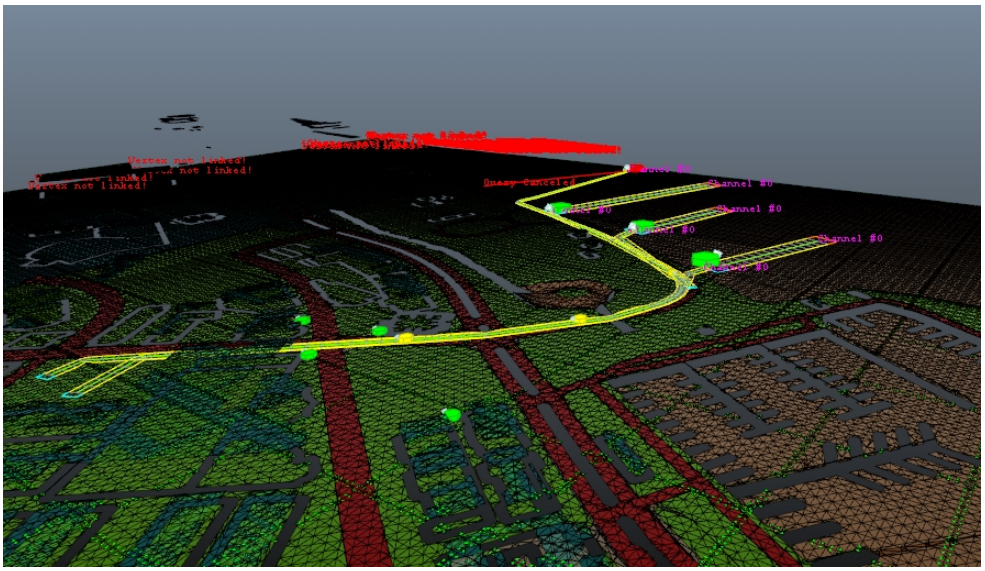
You can view simulation objects in Navigation Lab. This can help you analyze problems in navigation data, such as the inability of an entity to plan a path.

➤ **To view simulation objects in Navigation Lab:**

1. Connect to Navigation Lab as described in "5.6.1 Opening Navigation Lab from an Information Dialog Box" above.
2. Run the scenario.

3. In Navigation Lab, look for volumetric objects that represent the simulation objects (Figure 36).

Figure 36. Simulation objects represented in Navigation Lab



6. Aerodromes

Aerodromes allow you to give aircraft realistic places to take off and land. You can also control managed aerodromes' settings either manually or as part of a plan. This chapter describes how to work with aerodromes that are in a terrain and their functionality.

6.1. Overview of Aerodromes

Aerodromes are representations of airports and airbases using data is contained in a shape file. Some of the terrains in the MAK data package include aerodrome data, and you can also use your own terrains if they have aerodrome data.

When aerodromes simply exist in the terrain, you can have aircraft take off and land from aerodromes' runways. You can also have aircraft take off and land on route tactical graphics instead of using aerodromes.

If you want to manage an aerodrome's features, such as lighting and runway conditions, you must promote it. You can select specific aerodromes to promote individually, or you can promote aerodromes in an area. After promoting aerodromes, you can manage them as needed for your scenario. You can control the aerodrome lights as well as the runway lighting and conditions, either as a set data request or part of a plan. The changes you make are reflected in any simulation connected to the exercise.

For entities to take off from and land on runways at managed aerodromes, the runways must be set to active.

> ⓘ The aerodromes included in MAK terrains do not include helipads or water landing sites. They are primarily intended for fixed-wing aircraft that take off from and land on runways.

Aerodromes are a layer in MAK Earth and streaming terrains. The features are part of the vector files that are distributed with VR-Forces. These files are originally from X-Plane and, while they are good for many of the airports in the world, they may not be entirely accurate. You can use GIS tools to edit the files and change, add, or remove aerodrome features as needed.

6.1.1 Checking a Terrain for Aerodromes

It's simple to check whether a terrain includes aerodromes. After loading a terrain in VR-Forces, check the list in the Aerodromes toolbar. If there are values in it, then those aerodromes have been defined in the terrain. If the list is empty, then there are no aerodromes.

➤ To open the Aerodromes toolbar, choose **View > Toolbars > Aerodromes Toolbar**.

6.2. Managed Aerodromes and Runways

You can use either the Create Selected Aerodrome or Promote Aerodrome feature in terrains that include aerodrome shape files to promote aerodromes and their runways to be managed. This allows you to use set data requests to control the lighting and runway conditions.

6.2.1 Promoting a Specific Aerodrome

You can quickly promote an aerodrome from the Aerodromes Toolbar. This makes it a managed aerodrome in the neutral force, and one runway is set to Active.

➤ **To promote a specific aerodrome:**

1. If the Aerodromes Toolbar is not visible, choose **View > Toolbars > Aerodromes Toolbar**.
2. In the Aerodrome list, select the aerodrome to generate. You can filter the list by entering part of the name or code.
3. Click Create Selected Aerodrome ().

6.2.2 Promoting Aerodromes in a Terrain

Using Promote Aerodrome, you can promote a specific aerodrome, or some or all of the aerodromes that exist in an area of the terrain. You also specify the force for the aerodromes. When you promote aerodromes, VR-Forces uses the terrain data to get the information about the aerodrome and runway objects. One runway is also set to Active for the aerodromes when you promote them.

➤ **To promote a specific aerodrome:**

1. Choose **Create > Promote Aerodrome**. The Promote Aerodrome dialog box opens.
2. Select the force for the aerodrome.
3. Select the ICAO Code option.
4. In the Aerodrome list, select the aerodrome to generate. You can filter the list by entering part of the name or code.
5. Click Create. The aerodrome and its associated runways are created.

➤ **To promote some or all of the aerodromes in an area:**

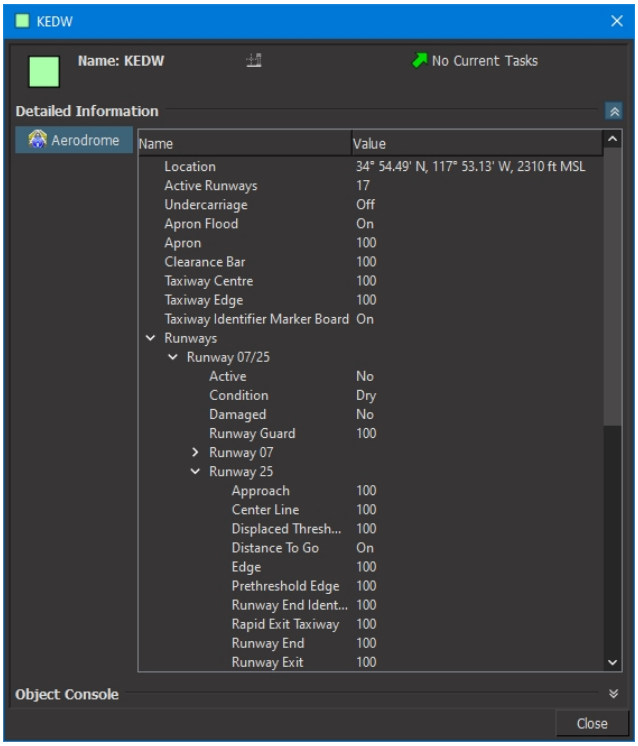
1. Adjust your view of the terrain in the main window to include the aerodromes you want to promote.
2. Choose **Create > Promote Aerodrome**. The Promote Aerodrome dialog box opens.
3. Select the force for the aerodromes.
4. Select the Area Selection option.
5. Click the Select button. The cursor changes.
6. On the terrain where the aerodromes are located, draw an area as you would any areal tactical graphic.

   When you finish the area, you return to the Promote Aerodrome dialog box and the Aerodromes list populates with the aerodromes defined in that area of the terrain. Depending on the number of aerodromes in the area, this can take a little while.
7. If desired, select or unselect aerodromes to limit the list to only the aerodromes you want to promote. You can use **Ctrl**+click or **Shift**+click.
8. Click Promote. The selected aerodromes are added to the Objects List as managed aerodromes. This can also take some time if you selected many aerodromes.

6.2.3 Viewing Aerodrome Information

The Information dialog box for managed aerodromes includes information on the lighting and conditions for the aerodrome and its runways.

Figure 37. Information dialog box for Aerodrome



6.2.4 Centering on an Aerodrome

There are a number of ways that you can center on an aerodrome.

➤ To center on a managed aerodrome from the Last Selected Object Panel or the Information dialog box, click Center on Aerodrome ( ).

➤ **To center on an aerodrome from the Aerodromes Toolbar:**

1. If the Aerodromes Toolbar is not visible, choose **View > Toolbars > Aerodromes Toolbar**.
2. In the Aerodrome list, select the aerodrome to center on. You can filter the list by entering part of the name or ICAO code.
3. Click Center on Aerodrome ( ). Your window focuses on the selected aerodrome.

ⓘ As with other simulation objects, you can also double-click on an aerodrome in a list to center on it.

6.3. Aerodrome and Runway Set Data Requests

You can control the settings for managed aerodromes and their runways using set data requests, including in global or individual plans.

> Not all aerodromes in the terrains included with VR-Forces are configured for all supported lights. The Edwards Air Force Base (KEDW) has been fully configured as an example. Other aerodromes include some lights, but require terrain file changes to display others. See the *Procedural Airports* chapter in the *Adding Content to MAK ONE Applications Reference Manual* for more information.

6.3.1 Aerodrome Light Conditions

You can set the light conditions for all of the lights at an aerodrome, including the runway lights. The lighting changes are visible in Stealth observer mode (where configured), and your changes set the state on the managed objects and publish the information to the network. You can also see the lighting information in the aerodrome's Information dialog box.

➤ **To set the light conditions for an entire aerodrome:**

1. In the Objects List, select a managed aerodrome.
2. Choose **Set > Aerodrome Light Conditions**. The Aerodrome Light Conditions parameter displays.
3. From the list, select the desired light condition.
4. Click OK.

6.3.2 Aerodrome Undercarriage Inspection System

The Aerodrome Undercarriage Inspection System set data request allows you to set the undercarriage inspection system at an aerodrome to either on or off. There is no simulation effect associated with this setting. The information is only published to the network. You can also see the system's state in the aerodrome's Information dialog box.

➤ **To set the state of an aerodrome's undercarriage inspection system:**

1. In the Objects List, select a managed aerodrome.
2. Choose **Set > Aerodrome Undercarriage Inspection System**. The Undercarriage Inspection System parameter displays.
3. From the list, select whether the system is on or off.
4. Click OK.

6.3.3 Lights (Advanced)

Using the Lights (Advanced) set data request, you can set the intensity of the lights for a managed aerodrome as well as its associated runways. The lighting changes are visible in Stealth observer mode, and your changes set the state on the managed objects and publish the information to the network. You can also see the light settings in the aerodrome's Information dialog box.

Lights you can control the state of include:

- Aerodrome
  - Apron
  - Apron Flood
  - Clearance Bar
  - Taxiway Centre
  - Taxiway Edge
  - Taxiway Identified Marker Board
- Runways
  - Approach
  - Center Line
  - Displaced Threshold
  - Distance To Go
  - Edge
  - Prethreshold Edge
  - Rapid Exit Taxiway
  - Runway End
  - Runway End Identifier
  - Runway Exit
  - Runway Guard
  - Taxiway Lead On
  - Taxiway Stop Bar
  - Threshold
  - Touch Down Zone
  - VSGI

You can use Edwards Air Force Base (KEDW) to visualize the lights. Other aerodromes can publish the information but might not be configured to display all of them.

➤ **To set the aerodrome or runway lights:**

1. In the Objects List, select a managed aerodrome.
2. Choose **Set > Lights (Advanced)**. The Aerodrome Lights parameters display.
3. Select the lights that you want to change. You can specify them for all of the lights in the aerodrome or all runways, or you can expand the list underneath any of them to choose specific lights.
4. Set the intensity using the slider or by entering a value in the box. The intensity is a percentage, from 0 (off) to 100%.
5. Click OK.

6.3.4 Runway Active

The Runway Active set data request allows you to specify whether the runway is active. When one direction of the runway is active, the other direction is inactive. There is no simulation effect associated with this setting. The information is only published to the network. You can also see the runway's active state in the associated aerodrome's Information dialog box.

➤ **To set the active state of runways:**

1. In the Objects List, select a managed aerodrome.
2. Choose **Set > Runway Active**. The Runway Active parameters display.
3. You can specify the active state for all of the runways, or you can expand the list underneath these to choose specific runways. For each runway or a collection of runways, specify the active state.
4. Click OK.

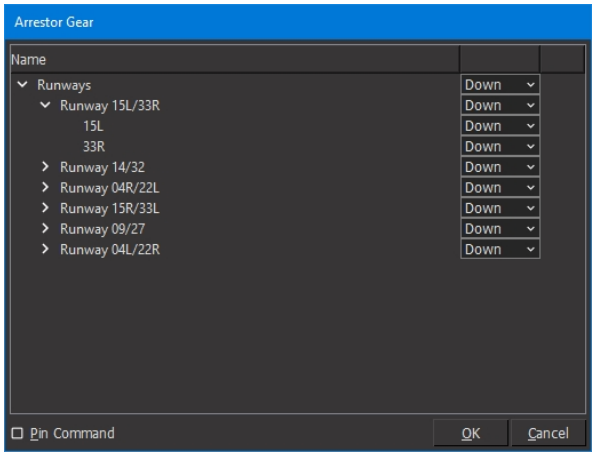
6.3.5 Runway Arrestor Gear

The Runway Arrestor Gear set data request allows you to set the arrestor gear on a runway to either up or down for one or more runways. There is no simulation effect associated with this setting. The information is only published to the network.

➤ **To set the state of runway arrestor gear at an aerodrome:**

1. In the Objects List, select a managed aerodrome.
2. Choose **Set > Runway Arrestor Gear**. The Arrestor Gear parameters display (Figure 38).

Figure 38. Arrestor Gear dialog box



3. You can specify the arrestor gear state for all of the runways, or you can expand the list underneath these to choose specific runways. For each runway or a collection of runways, specify whether the arrestor gear is up or down.
4. Click OK.

6.3.6 Runway Condition

The Runway Condition set data request allows you to specify the conditions on one or more runways at an aerodrome. The runway conditions are not visible in any views of the exercise, but your changes set the state on the managed objects and publish the information to the network. You can also see the runway condition in the associated aerodrome's Information dialog box.

If you set the runway condition to Snow, for example, there is no visualization of snow. If you want to see snow, you could add a local weather zone and set the desired environmental condition, such as Blowing Snow or Snowy. See "Setting Environment Conditions". Likewise, adding simulated weather does not affect a runway's condition setting.

➤ **To set runway conditions:**

1. In the Objects List, select a managed aerodrome.
2. Choose **Set > Runway Condition**. The Runway Surface Conditions parameters display.
3. Specify the runway surface condition for the desired runways.
4. Click OK.

6.3.7 Runway Damaged

The Runway Damaged set data request allows you to specify whether one or more runways at an aerodrome are damaged. The damage is not visible in any views of the exercise, but your changes set the state on the managed objects and publish the information to the network. You can also see the state of the runway in the associated aerodrome's Information dialog box.

➤ **To set runway conditions:**

1. In the Objects List, select a managed aerodrome.
2. Choose **Set > Runway Damaged**. The Runway Damaged parameters display.
3. Specify the damaged state for the desired runways.
4. Click OK.

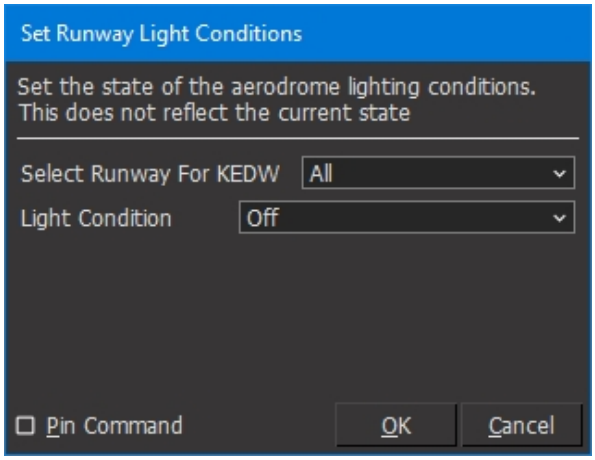
6.3.8 Runway Light Conditions

The Runway Light Conditions set data request allows you to set the lights for one or all runways at the aerodrome. The lighting changes are visible in Stealth observer mode, and your changes set the state on the managed objects and publish the information to the network. You can also see the light settings in the associated aerodrome's Information dialog box.

➤ **To set the light conditions for runways:**

1. In the Objects List, select a managed aerodrome.
2. Choose **Set > Runway Light Conditions**. The Runway Light Conditions parameters display (Figure 39).

Figure 39. Runway Light Conditions dialog box



3. From the Select Runway list, choose whether you want to set the light conditions for all of the runways at the aerodrome or select a specific runway.
4. Select the desired light condition from the list.
5. Click OK.