

TerraExplorer® Pro

Version 7.4

Datasheet

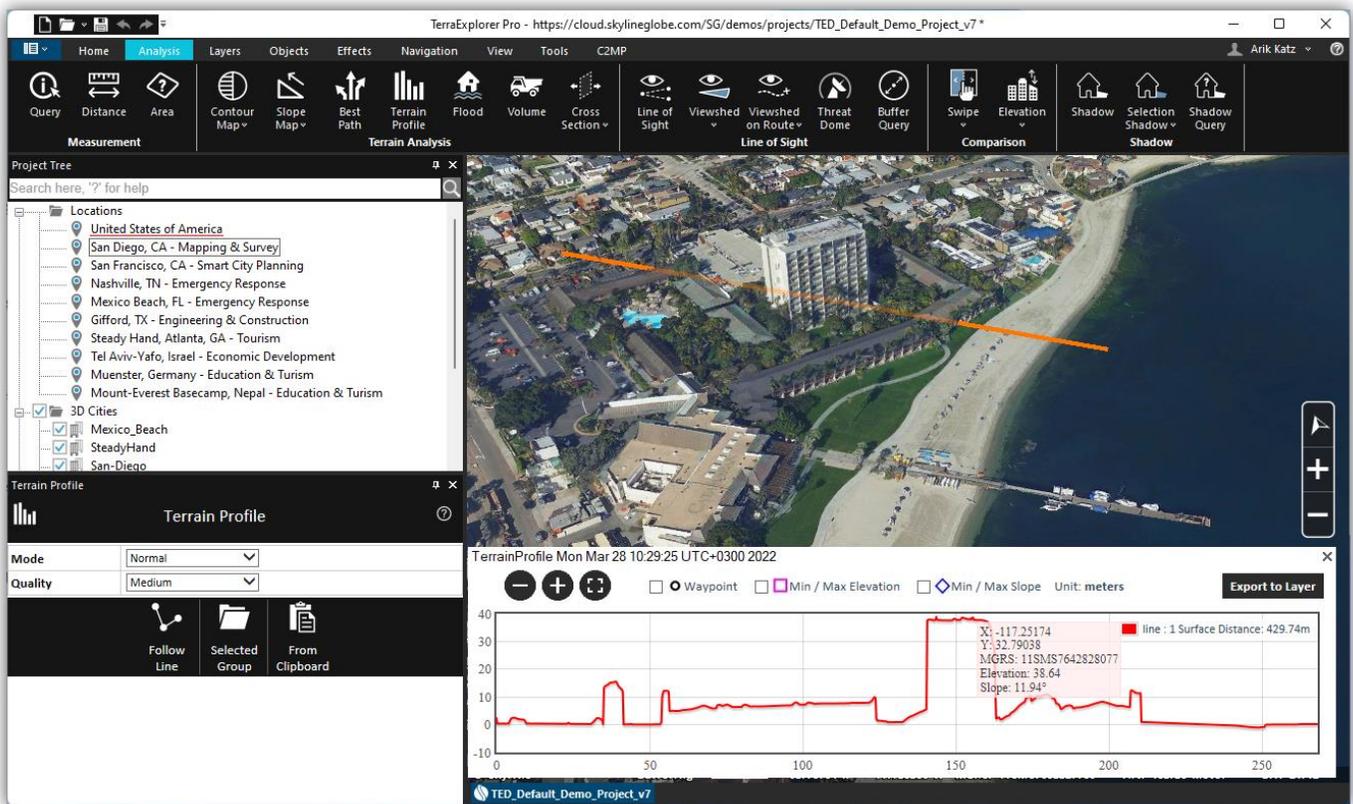


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OVERVIEW

TerraExplorer Pro is a cutting-edge 3D GIS desktop viewer and creator that provides powerful, easy-to-use tools and a high resolution 3D environment in which to view, query, analyze, edit, present, and publish geospatial data. With TerraExplorer's robust and extensive capabilities, realistic 3D visualizations can be created by overlaying the terrain with unlimited data layers, 3D models, virtual objects and more.

Analysis

In addition to basic measurement and analysis tools for distance, slope, and volume measurements, TerraExplorer features advanced capabilities, including 3D plane area measurement, imagery comparison, and dynamic 3D viewshed.

Display

Imagery and elevation layers of unlimited size and resolution in a wide range of formats can be overlaid on the terrain and seamlessly integrated with feature layers and multi-resolution, stream-optimized 3D mesh model layers for easy visualization, access, and analysis of 3D geospatial data. If a new layer is based on a source that uses a different coordinate system, the layer can be reprojected to the project's coordinate system.

Point, line and polygon features can be displayed and used to display advanced layer information based on their attribute data. TerraExplorer also includes an extensive set of objects: 2D and 3D, dynamic, buildings, models, point cloud models and video, that can be displayed on the terrain, as well as advanced terrain objects that allow terrain modification within TerraExplorer Pro. A flexible clipboard mechanism and sophisticated duplication tools make it easy to copy, paste, and position objects on the terrain.

Realism is enhanced with environment settings that include lighting effects, horizon distance, fog color, sky texture, cloud display, and shadow color.

Spatial Queries

TerraExplorer provides advanced capabilities for manipulating feature and 3DML data and analyzing spatial relationships. Various spatial operations can be performed on a layer's features, including merging features into a single feature, clipping one polygon from another, exploding a multi-part feature into its individual component features, and exporting selected features to a new file.

Complex spatial and attribute queries are supported. Features can be filtered based on attribute value or based on their spatial relationship with a specified polygon, line point or object. A buffer zone can be defined to include features within a certain radius of the selection.

Sharing and Presenting Data

SkylineGlobe Server streamlines the TerraExplorer workflow, enabling complete projects and layers to be optimized and published directly from TerraExplorer Pro to the cloud server. Through a single publishing operation, the data is made available to all TerraExplorer clients: Desktop, Mobile, and TE for Web, as well as standard geospatial clients such as WFS/WFS-T/WMS/WMTS/3D Tiles (Cesium).

TerraExplorer's presentation tools enable you to create a presentation, in which you communicate a specific view of the 3D World, by combining a customized flight route with a particular display of the project. Presentations can be easily converted into a movie in AVI format and played using any standard AVI Viewer.

Optimization

Advanced tools allow conversion of model files and of point cloud data from various formats to a stream-optimized Skyline-proprietary format for improved display performance as well as download rate. The Extract Terrain tool extracts and creates a subset of a local or remote terrain database for easy distribution.

PRODUCT HIGHLIGHTS

- Efficient streaming of raster, feature, and 3D mesh layer (3DML) data over standard networks.
- Interactive drawing tools to create and add 2D and 3D objects, labels, modify terrain objects, and buildings on a 3D terrain model.
- Loads 3D models, video, and geo-referenced information layers
- Supports editing and saving of layers to GIS standard file formats.
- Communicates with external local and web applications using standard COM interface. Controls all static and dynamic objects, information layers and application content.
- Robust set of tools for measurement and terrain analysis.
- Hyperlink feature links specific areas, or objects, to web pages, applications and databases.
- Integrates text and web content messages.
- Presentation tool enables sharing of geographical information through dynamic presentations.
- Creates movies, as AVI, from any presentation.
- Takes snapshots of the 3D Window and saves them to external files.
- Powerful tool for creating 3DML data sets from point layers with individually referenced 3D models.
- Users can easily share, post, find, and load necessary geographic data for a TerraExplorer project by connecting to SkylineGlobe Server.
- Publishing tool to create project directory ready for distribution to external local users, or for publishing to a web server. Additional publishing options enable extraction and publishing of a geographic subset of the project for offline and mobile users.
- Provides improved level of security for local and remote users.
- Advanced Ribbon customization options allow external developers to integrate new custom tools into the TerraExplorer Ribbon.
- Export the 3D Window, Project Tree and Navigation Map as ActiveX controls.

LAYERS

TerraExplorer Pro features the following layer types:

- [Feature Layers](#)
- [Complex Layers](#)
- [Point Cloud Layers](#)
- [Imagery Layers](#)
- [Elevation Layers](#)
- [3D Mesh Layers \(3DML\)](#)

Feature Layers

A feature layer is a visual representation of a geographic data set like roads, national parks, political boundaries, and rivers using geographic objects such as points, lines, and polygons.

Streaming: TerraExplorer Pro can load the entire content of the feature layer or stream the data directly from a server or local file. Information from the remote layer server or file is retrieved, added to the terrain, and then removed dynamically based on the camera's position. This option enables you to explore the area without waiting for the entire layer to load.

Styling: TerraExplorer Pro can perform layer level operations. On this level, the Properties Sheet can be set for appearance and behaviors of the geographic objects contained within the layer with various other layer parameters. For a loaded feature layer with a set of attributes containing object level data, advanced layer information can be displayed in the 3D Window.

Spatial Queries: Perform a spatial query by selecting all features spatially related to a polygon, line, or point, or to an existing object. You choose whether to include only features that entirely overlap with your selected or drawn geometry, or whether to include also those that partially intersect. You also can define a buffer zone to include features within a certain radius of the selection.

Spatial Operations: You can perform various spatial operations on the layer's features, including deleting selected features, merging features into a single feature, creating a multipart feature, clipping one polygon from another, exploding a multi-part feature into its individual component features, and exporting selected features to a new file. Using the Attribute Table Tool, you can search and filter the data in a map layer to obtain and display only the features and information you require. You can then display only the filtered data on the map or create a new layer that includes only this data. The original layer is not modified. Attribute values can be edited from the Attribute table, so that multiple feature attributes can be easily modified without opening separate property sheets for each feature.

Saving: Since you are always connected to the data source (local or remote), you can easily get the latest source updates by refreshing the layer. For .shp files and WFS-T (A WFS service with read-write access by enabling transactions), all changes can be saved directly to the original source file. Data source updating is also allowed for streaming layers.

Creating New Feature Layers: You can define a layer type and attribute fields and create a feature layer directly from TerraExplorer. The layer is saved to a local data source in shapefile or SQLite format.

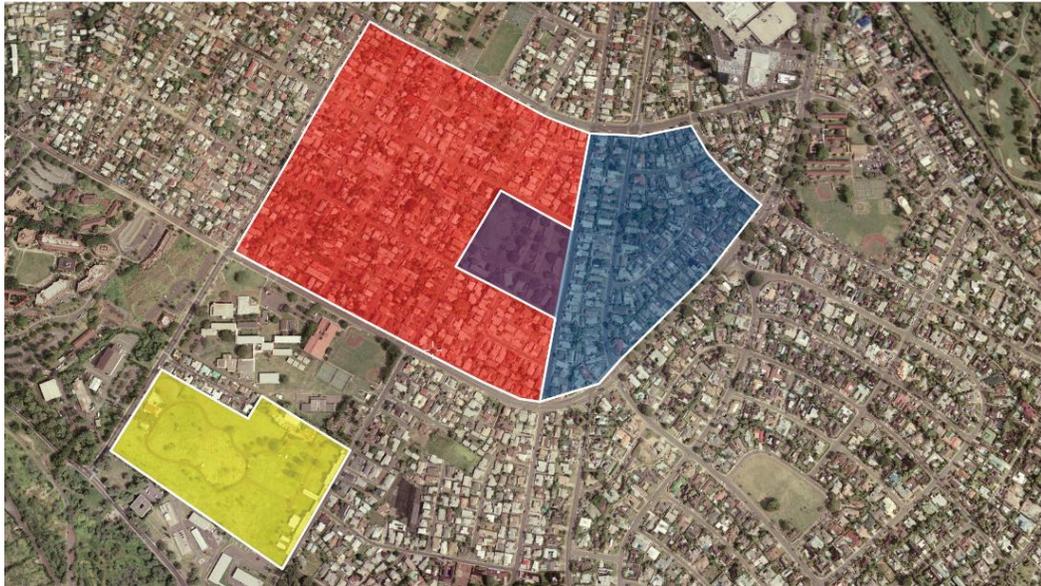


Figure 1: Feature Layers

Layers can be loaded from the following feature files:

- ESRI Shapefile: .shp
- Excel: .xls, .xlsx
- Text: free format
- File Geodatabase: *.gdb
- MapInfo: Tab, Mif, Mid
- Microstation DGN
- AutoCAD DXF: .dxf
- SQLite: *.sqlite, *.db
- GeoPackage
- Virtual Datasource (VRT)
- Geospatial PDF
- S-57
- GeoJson

Layers can be loaded from the following servers:

- SkylineGlobe Server
- Web Feature Server (WFS)

- TerraGate SFS (legacy support)
- ESRI ArcSDE Server
- Oracle Spatial Server
- SQL Spatial Database
- PostgreSQL with PostGIS
- ESRI REST (GeoJSON) Server

TerraExplorer Pro can **save** groups of objects to the following file formats:

- ESRI Shapefile: .shp
- TerraExplorer FLY Projects: .fly
- KML or KMZ

Complex Layers

In addition to feature layer data sources which are composed entirely of homogeneous or heterogeneous geometries (points, lines, and polygons) representing geographic features, TerraExplorer Pro also supports the import of several types of complex feature layers, which combine different data types in one layer. These include:

- **FLY** –Skyline's proprietary compressed binary file that includes pointers to feature and raster data, objects, and models.
- **OGC KML/KMZ** - OGC standard, publically defined layer, which can be composed of feature and raster elements. For more information, **see:** <http://www.opengeospatial.org/standards/kml>)

Point Cloud Layers

The Point Cloud model allows you to add a pre-processed point cloud model at any point in the 3D Terrain. These models are created from a list of points in a 3D area that are collected by various sources including 3D scanners. The load Point Cloud feature supports Skyline's proprietary Point Cloud files (CPT).

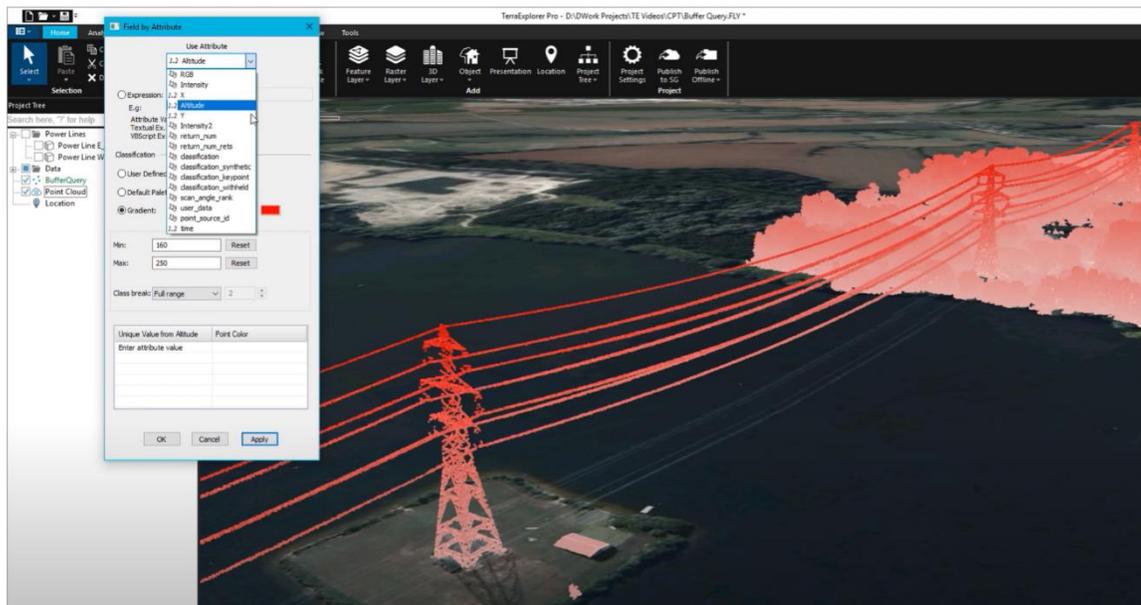


Figure 2: Load Point Cloud Layer

Imagery Layers

An imagery layer is a geo-referenced, satellite or aerial image that overlays the terrain imagery. The Imagery Layer feature enables the user to add **unlimited size**, geo-referenced, satellite and aerial images directly to a TerraExplorer project. A source file that has multiple resolution levels (e.g., Skyline MPU, MrSID, etc.) is visible from any altitude. The layer can be of better resolution than the area on which it is placed. Automatic morphing between the terrain imagery and the Imagery Layer is performed.

Projection: If the source file is not rectified to the same coordinate system as the Terrain Coordinate system that the TerraExplorer uses, the user can reproject it on-the-fly using the built in mechanism.

Clip Polygon: A subsection of a raster file can be displayed by loading a shapefile containing the required clip polygon.

Imagery layers from the following files can be loaded:

- Window Bitmap (.bmp)
- Gdal Gif (.gif)
- Gdal Ntiff (.ntf)
- Gdal Jpeg (.jpg)
- Gdal Jpeg2000 (.jp2, .j2k, .jpc)
- Gdal Tiff (.tif)

- Gdal Img (.img)
- Gdal GeoPackage (.gpkg)
- Gdal Webp (.webp)
- Gdal Cib (*.*)
- Skyline Image MPU (.li.mpu)
- ER-Mapper (.ecw, .jp2, .jpc, .j2k)
- Erdas Imagine (.img)
- Image files (.bmp, .gif, .Jpeg)
- NGA formats (CIB, CADRG, ADRG)
- Tile Text file (.tlt)
- Mip Terrain (.mpt)
- HTC Raster file (.htc)

Imagery layers from the following servers can be loaded:

- SkylineGlobe Server
- Web Map Server (WMS)
- Web Map Tile Service (WMTS)
- Oracle Spatial Database
- ECW Image Web Server
- TerraGate Server (legacy support)
- ArcSDE Raster Server
- Google Earth Enterprise (GEE) Server

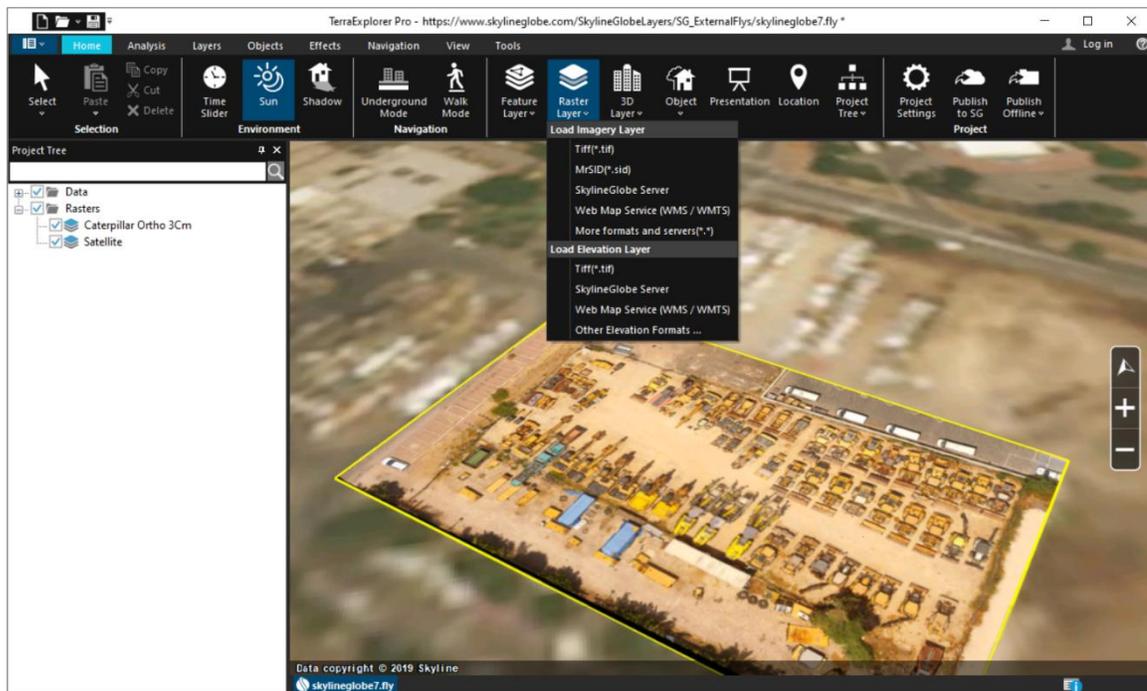


Figure 3: Loading a Raster Layer

Elevation Layers

An elevation layer is a geo-referenced elevation raster that replaces the elevation data of the terrain database. The Elevation Layer feature enables the user to add **unlimited size**, geo-referenced elevation data directly to a TerraExplorer project. The file can be of better resolution than the area on which it is placed. Automatic morphing between the terrain imagery and the Imagery Layer is performed. A source file that has multiple resolution levels (e.g., Skyline MPU, WMS etc.) is visible from higher altitudes.

Projection: If the source file is not rectified to the same coordinate system as the Terrain Coordinate system that the TerraExplorer uses, the user can reproject it on-the-fly using the built in mechanism.

Elevation Layers from the following files can be loaded:

- Window Bitmap (.bmp)
- ER-Mapper (.ecw)
- Gdal Dted (dt?)
- Gdal USGS Ascii Dem (.dem)
- Gdal USGS SDTS Dem (.ddf)
- Gdal Arc/Info Binary Grid (.adf)
- Gdal Img (.img)
- Gdal Tiff (.tif)
- Gdal GeoPackage (.gpkg)

- Mip Terrain (.mpt)
- Elevation MPU (.Ei.mpu)
- Erdas Imagine (img)
- NGA DTED (DMED)
- Tiff Format (tif)
- Projection Text File (prj)
- Local MPT (MPT)
- TiLe Text file (.tlt)
- Triangle Elevation (.tri)
- No Stream Bitmap (.bmp)
- No Stream Jpeg (.jpg)
- No Stream Gif (.gif)

Elevation Layers from the following servers can be loaded:

- SkylineGlobe Server
- Web Map Server (WMS)
- Web Map Tile Service (WMTS)
- Oracle Spatial Database
- ECW Image Web Server
- TerraGate Server (legacy support)
- ArcSDE Raster Server

3D Mesh Layers (3DML)

Mesh layers are multi-resolution, textured mesh models that are created through automatic reconstruction methods, manual modeling, or building information modeling (BIM). Mesh layers can be loaded into TerraExplorer from files or from SkylineGlobe or 3D Tile servers, and displayed on the terrain, as well as measured and analyzed. If a mesh layer is classified, you can also access its attribute data and perform feature layer operations on the layer, including spatial and attribute queries.

TerraExplorer Pro loads a 3D mesh layer as a layer object, which is then displayed in the Project Tree. After loading the layer from file or server, you can set its appearance and parameters in the layer's property sheet. You can load 3D mesh layers in either of the following formats:

- Skyline's proprietary, stream-optimized 3DML format - from a file or from SkylineGlobe Server
- OGC 3D Tiles (B3DM) format - from a server or from Cesium ion

Mesh layers can also be added to TerraExplorer by importing Building Information Modeling - BIM (IFC/FBX) layers, Cesium 3D Tiles, DAE (LODTreeExport.xml) and OSGB layers. TerraExplorer automatically converts these layers upon import to the stream optimized, 3DML mesh layer format. This

enables them to be streamed with SkylineGlobe Server and merged with classification information so that you can access attribute data and perform feature layer operations on the mesh layer. Selected sections of the 3DML can be imported using clip polygons.



Figure 4: Mesh Layer

The following mesh layer operations are supported:

- **Set Display Style** – Select a mesh model display style, e.g., texture, wireframe, or x-ray.
- **Classify** – Create a feature layer with classification polygons containing attribute data relevant to the mesh layer. Classification enables you to visually distinguish different areas of the mesh layer and perform spatial and attribute queries on the feature layer that is classifying the mesh layer.

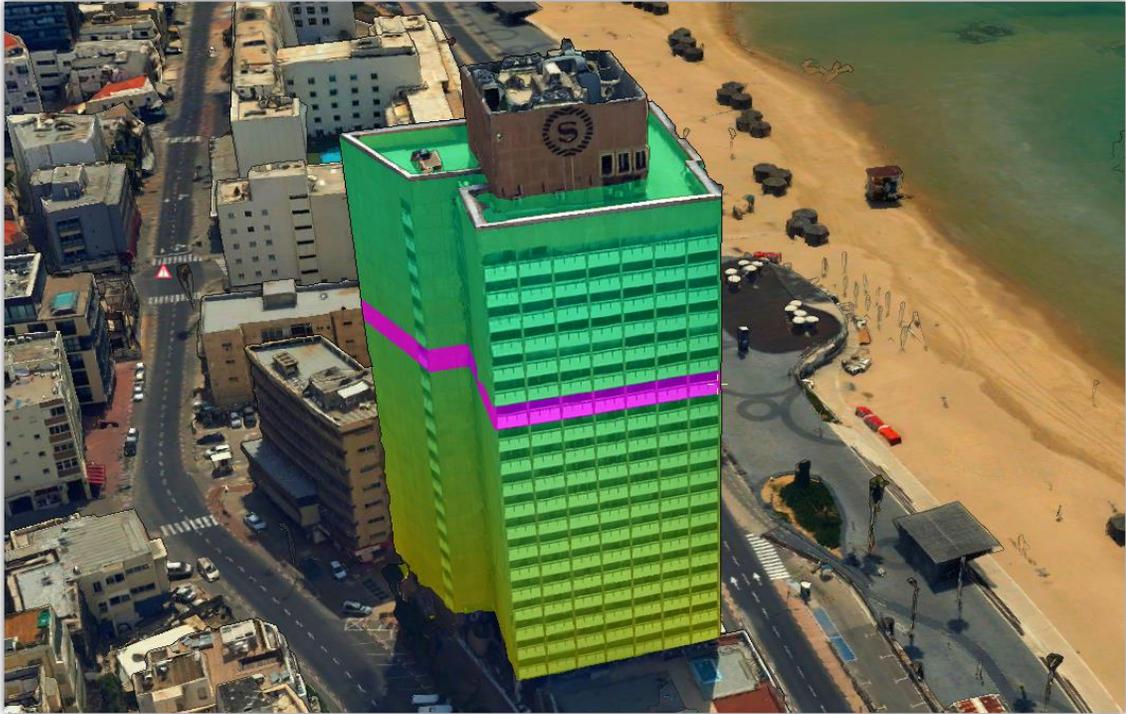


Figure 5: Classified Mesh Layer

- **Modify** – Modify the elevation values in a designated area of a 3DML using a modify mesh layer object.
- **Mark for Retouch** – Edit mesh imperfections, such as bumps, irregular surfaces, or floating artifacts.
- **Scale and Rotate** – Correct inaccuracies in mesh layers' scale, rotation and positioning.
- **Export to Models** – Export polygonal areas of a 3DML, e.g., buildings, to individual OBJ models.
- **Export to Mesh** – Export 3DML to 3D Tiles (tileset.json) or I3S/SLPK formats.

Some operations are only available for mesh layers with associated feature layers (i.e., mesh created from point feature layers with individually referenced 3D model files, imported BIM layers, or mesh layers classified using the legacy Classify Mesh Layer tools):

- **Spatial Queries** - Select features based on their spatial relationship with a polygon, line or point that you draw, or with an existing object.
- **Search by Attribute** - Search the layer attribute database files to easily edit the attribute values of multiple features and to create a new shapefile based on the filtered data.
- **Display by Attribute** - Display only selected areas of the mesh model that match a specific attribute value.
- **Colorize by Attribute** - Colorize the mesh model based on attribute value, with a different color assigned to each attribute value.

OBJECTS

The TerraExplorer Pro provides a set of tools to manually add 2D, 3D, dynamic, and terrain objects to the project. The user can create new objects, edit single or multiple objects' parameters using the properties sheet, edit objects directly in the 3D window, and copy /move/delete objects in the 3D window. The objects are organized in the Project Window's tree structure.

2D Objects

A set of 2D primitives and labels can be placed in the 3D World:

- Text Labels
- Image Labels
- Polylines
- Polygons
- Rectangles
- Regular Polygons
- 2D Arrows
- Circles
- Ellipses
- Arcs

3D Objects

A set of 3D objects can be placed in the 3D World:

- 3D models
- Buildings
- 3D shapes

3D Models

The 3D model feature allows you to place a pre-prepared 3D object at any point in the 3D terrain. These models can be created using external design tools. Models can be loaded in any of the following formats:

- **COLLADA** (DAE), e.g., DAE models created in PhotoMesh or Sketchup
- **OBJ** – Wavefront simple data-format for storing 3D model surface geometry, color and texture information.
- **Direct X** (X) and its compressed version (XPC)
- **3DS** – 3D studio format for exchanging 3D data models
- **OpenFlight** (FLT) – Multigen format for exchanging 3D data models and its compressed version (FPC)

- **XPL** and **XPL2**, which provide better performance for the Direct X model (A set of XPL files is created from a single X file where each file contains data for one Level of Detail (LOD) only)
- **GLB** – Binary file format representation of 3D mesh models saved in the GL Transmission Format (gITF).

All model formats support BMP, JPG, DDS, and PNG texture formats. FLT also supports Silicon Graphics popular texture formats (RGB, RGBA, INT, INTA, BW).

All loaded models can be optimized by conversion to XPL2, either by using the Convert Models to XPL tool or automatically during the publishing process.

When a model file is converted to XPL, a set of XPL files is created from a single X file where each file contains data for one Level of Detail (LOD) only. TerraExplorer displays the best LOD file based on the viewer position in relation to the object. When downloaded from a web server, each file is also downloaded independently. This results in an improvement in overall model display performance as well as download rate.



Figure 6: 3D Models

Buildings

The Building feature allows you to add 3D models to the project by manually defining the geometry of the building rooftop and stretching it above the basic terrain, or by importing the rooftop geometry from external feature layers. You can define the shape of the roof as a flat surface, or as an angular surface. After defining the building geometry, you can assign fill color and texture from external files, or apply texture from the terrain to the roof and side walls.

3D Shapes

A set of 3D primitives and models can be placed in the 3D World:

- 3D Polygons
- Boxes

- Cylinders
- Spheres
- Cones
- Pyramids
- 3D Arrows

Dynamic Objects

Dynamic objects provide an easy-to-use way to add movement to 3D objects as well as text and image labels. You can also create a virtual dynamic object that is a dynamic route with no object assigned to it. You can then attach any object to the virtual dynamic object, and it follows the route you have set for it.

You set the route of a dynamic object by manually placing waypoints in the 3D Window. The object's speed is set either by setting a specific speed for the object in the object's property sheet, or by setting the object to Move by Time and then defining a Start and End time. TerraExplorer Pro features a set of ground and air vehicles that you can add to your project.

There are two types of dynamic objects:

- **Ground Vehicle:** Get pitch and roll angles according to the terrain surface under the object while it moves.
- **Air Vehicle:** Get pitch and roll angles according to the altitude differences between the waypoints, regardless of the terrain surface.



Figure 7: Dynamic Object

Terrain Objects

TerraExplorer provides two objects that affect the terrain itself.

- **Modify Terrain Tool:** Changes the elevation values of the terrain based on a polygon. The surface of

the terrain is raised or lowered according to the elevation values of the polygon's points. Different elevation behaviors allow replacing or cropping above/ below the original values of the terrain. The interior of the polygon can be flat or irregular in shape.



Figure 8: Modify Terrain Tool

- **Hole on Terrain:** Cuts holes in the terrain based on a polygon that exposes the other side of the terrain through the opening.

Video on Terrain and Video Billboard

The Video on Terrain/Video Billboard commands play a video file either on a selected area of the terrain (Video On Terrain), or on a floating billboard (Video Billboard). Both these commands open the same property sheet and can be converted one to the other by changing the default properties. The primary difference between the two is the distance from the projector at which the video should be displayed (Maximum Projection Distance property set in the property sheet). When this distance is set to zero, the video is projected on the terrain.

The positioning of the projector and the projected video can also be determined using telemetry data that holds positioning information for the camera based on time stamps. The telemetry data can either be embedded in the video file or contained in a separate telemetry file.

Supported video file formats are determined by the codecs that are installed and registered on your computer. Most files that Windows Media Player can play (e.g., *.avi, *.mpg, .mov, etc.), including streaming Microsoft Media Server (MMS) content, can be draped on the terrain.

TerraExplorer supports the KLV (Key Length Value) format for videos with telemetry information (MISB 0601 standard). TerraExplorer can parse this data and place the video correctly on the terrain.



Figure 9: Display Live Video on Terrain

Timespans

Timespans can be set for groups and objects, limiting the display of the object or group on the terrain to the specified start and end time values integrated in the object or group's property sheet. The project's time and date are adjusted using the time slider.

NAVIGATION

TerraExplorer offers a wide range of navigation options:

- [Free flight](#)
- [Searching for an Address or Location](#)
- [Presentations with predefined flight paths](#)
- [Locations](#)
- [Oculus rift and quest controls](#)
- [GPS tracking](#)
- [GPX reader](#)
- [Navigation map](#)
- [Underground navigation](#)
- [Walk mode](#)
- [Target tool](#)
- [Look around tool](#)
- [Multiple coordinate systems](#)

Free Flight

In the 3D Window, use the mouse, keyboard, Ribbon commands, navigation controls, joystick, 3DConnexion SpaceNavigator™, and Oculus Rift and Quest controllers to navigate freely in the 3D World. For touch screens, TerraExplorer Pro supports several gestures for 3D Window navigation and simplified navigation controls.

Searching for an Address or Location

You can search for a specific address or location or obtain address information for any point on the terrain. The search provider is dependent on the SkylineGlobe Server that TerraExplorer is currently connected to.

Presentations with Predefined Flight Paths

Presentation capabilities enable you to record a presentation in which you navigate through the 3D World, showing or hiding objects on the terrain, following dynamic objects, displaying messages and performing different operations. You can create a route either by flying through the terrain recording an exact route or by adding each waypoint separately. For each step in the presentation, you display the map in the state you want:

- Current camera position and extent.
- Visibility of raster layers.
- Visibility of feature layers.

- Visibility of map items (objects, groups).
- Popup messages and captions.
- Set environment variables such as underground mode and system time.

An easy to use editor enables you to set step timings and transitions and modify step sequence.

Presentations can be played back according to the transitions set in the Presentation Editor or in Auto-play, advancing from step to step automatically.

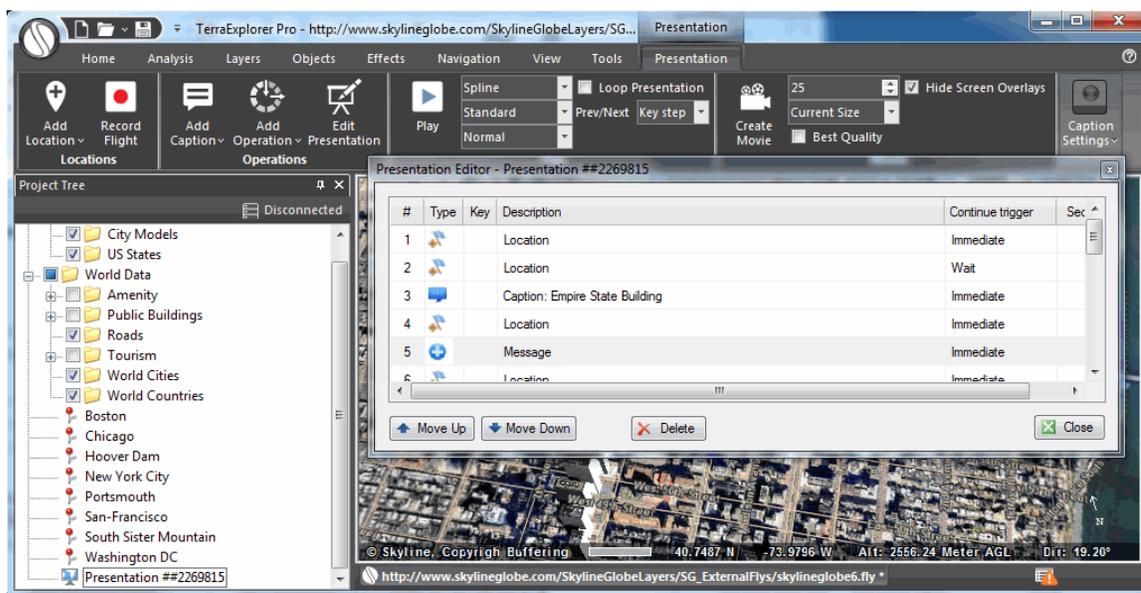


Figure 10: Editing a Presentation

Locations

A location defines the geographical coordinates of a point on the terrain as well as the position from which the point is to be viewed. By double-clicking on a location name in the Project Tree the camera can perform a flight, jump to the location or play one of the predefined patterns (circle, oval, line or arc).

Oculus Rift and Quest Controls

Navigate intuitively through Skyline's 3D World and perform most TerraExplorer commands using the Oculus Rift S and Quest 2 controllers. TerraExplorer is compatible with the Oculus Rift S and Quest 2 virtual reality systems, which enable you to use slight, natural head movements to easily fly through the 3D world.



GPS Tracking

The GPS Tracking tool creates 2D or 3D objects and moves them according to position information, in NMEA format, it reads directly from a GPS or communication device through a USB or COM port or from a local or remote file.

The GPS tool supports multiple entities in a single device and allows fast forwarding capabilities when reading the information from files.

You can display the GPS-moving objects in a variety of 2D or 3D graphic representations, and add trace lines trailing the object routes.

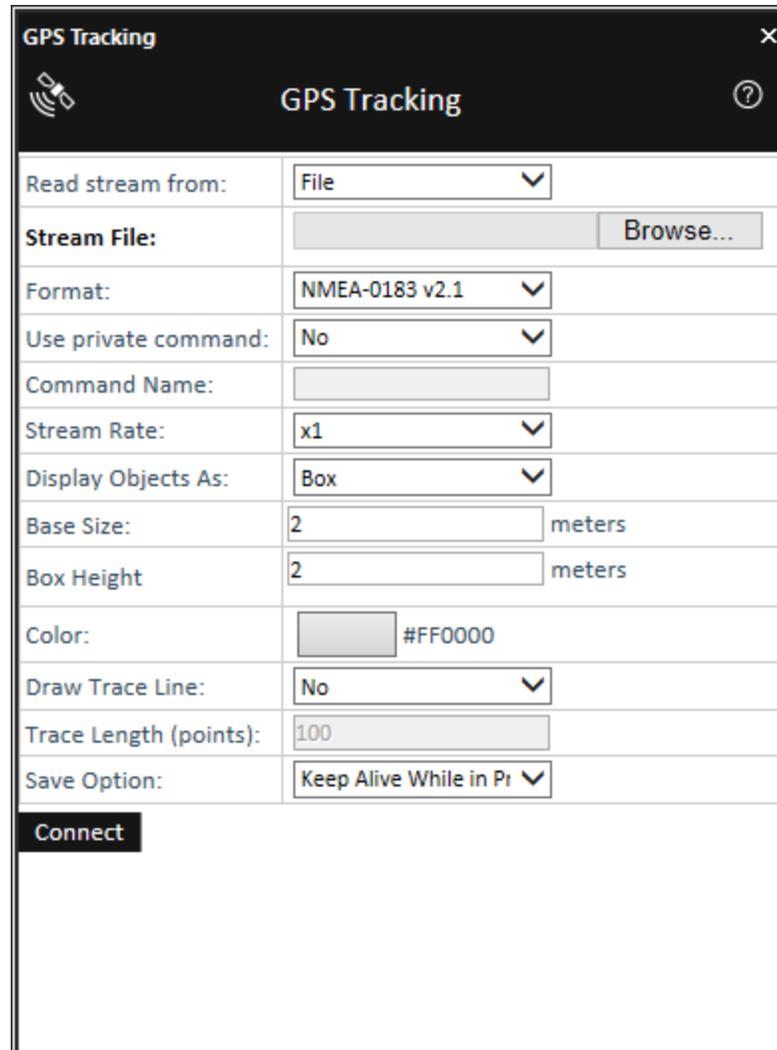


Figure 11: GPS Tracking

GPX Reader

GPX is an XML schema designed as a common GPS data format to describe waypoints, tracks, and routes. The GPX Reader reads GPX files and displays their waypoint and track data in the 3D Window, storing the GPX data in the project either as groups of point objects or as feature layers.

Navigation Map

The two-dimensional Navigation Map window provides quick and easy navigation through the entire terrain. It shows a raster-based map and the location and direction of the camera view on the map. The Navigation Map window offers a simple mechanism to integrate file or server-based maps into the application.

Underground Navigation

The underground navigation mode allows you to explore the subsurface of the terrain. You can navigate under the terrain's surface and through buildings. A subsurface grid navigation aid appears when you navigate below the terrain, allowing you to navigate the same way as above ground.

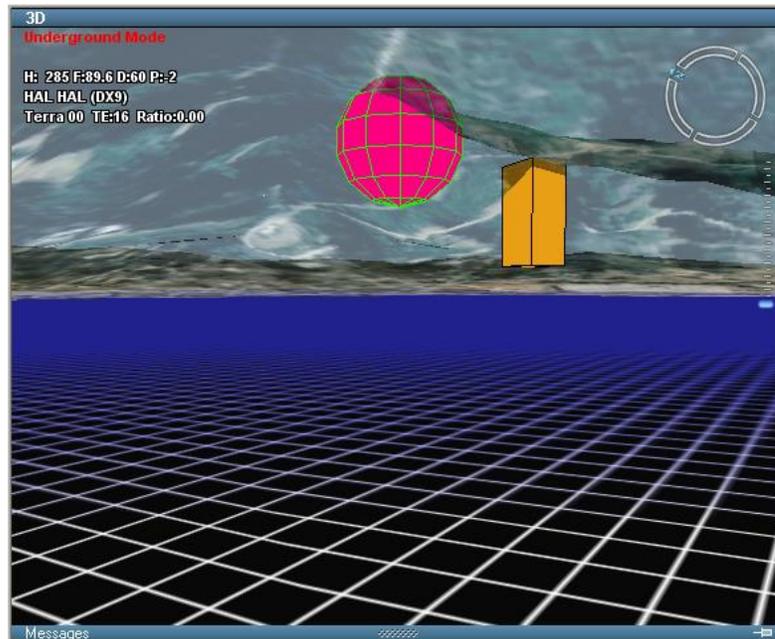


Figure 12: Underground Navigation

Walk Mode

The Walk Mode Navigation controls enable easier navigation within confined spaces, x-ray vision and collision detection. Direction control buttons provide for greater control and finer adjustments to movement.



Figure 13: Walk Mode Navigation Controls

Target

The Target tool continuously tracks the distance and direction to a specific target.

Look Around

The Look Around tool serves as a virtual stationary observation deck, enabling you to analyze the view from a specific position. Intuitive controls enable you to easily adjust your yaw and tilt and zoom in and out.



Figure 14: Look Around Controls

Multiple Coordinate Systems

The Multiple Coordinate Systems tool projects the current camera/cursor coordinates to a user-selectable coordinate system. The tools always display the Lat-Long and MGRS coordinate systems.

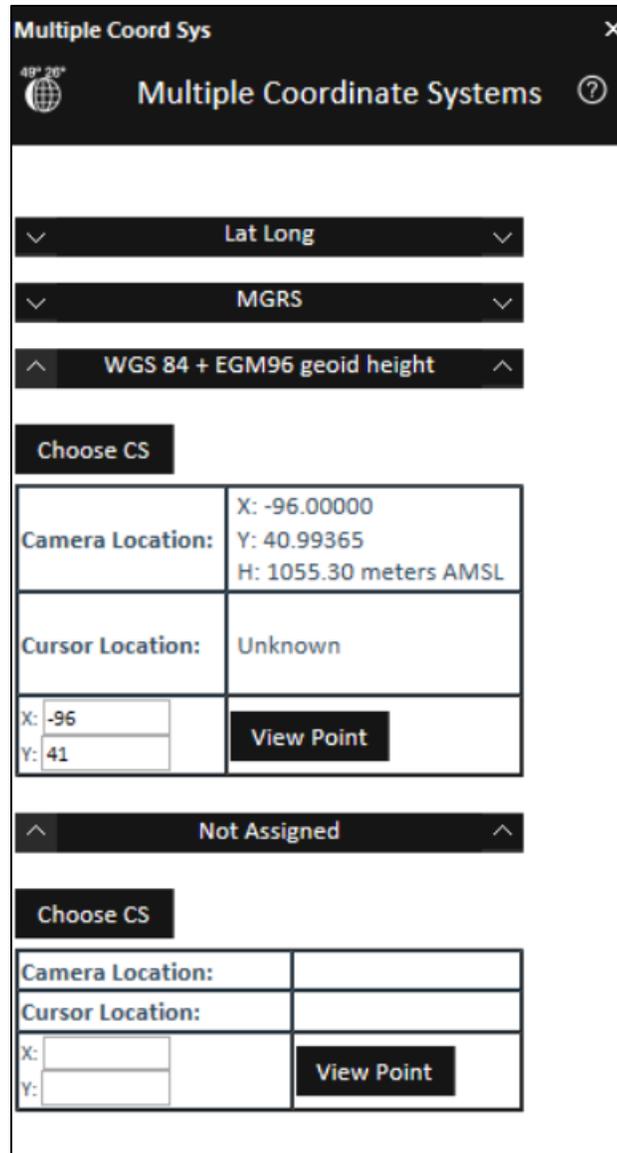


Figure 15: Multiple Coordinate Systems Tool

MEASUREMENT AND ANALYSIS

TerraExplorer Pro provides a robust set of tools for measurement and terrain analysis.

Measurement Tools

Measurements can display dynamically or be created as measurement objects that are listed in the Project Tree and can be exported to FLY, KML/KMZ, or shapefiles.

- **Information Query Tool:** Displays the exact location and elevation of any point in the 3D World, and additional information about objects.
- **Horizontal Distance Tool:** Measures the horizontal distance, elevation difference and slope angle between two or more points in the 3D View.
- **Aerial Distance Tool:** Measures the aerial distance, elevation difference and slope angle between two or more points in the 3D View.
- **Vertical Distance Tool:** Measures the elevation difference between two points in the 3D View.
- **Terrain Area Tool:** Measures the horizontal projection or the surface area (taking into account terrain contours) of an area on the terrain.
- **3D Plane Area Tool:** Measures the area of a polygon on an arbitrary surface.

Terrain Analysis Tools

- **Contour Map Tools:** Topographic map that portrays differences in terrain elevation by connecting points of equal elevation with contour lines or by coloring terrain according to varying altitudes. The contour lines are rendered on the terrain textures as well as on the 3DML layers. The elevation labels, however, appear only on the terrain and not on the 3DML. The following options are available:
 - Global Contour Map - Applies contour colors to the entire terrain and 3DML with dynamically placed contour lines that provide coarse contours when zoomed out and detailed contours when zoomed in.
 - Custom Contour Map - An advanced map in which parameters such as coverage area (specified rectangular area or entire terrain), contour palette, and contour line interval can be customized and a contour map object is added to the Project Tree. Contour colors and lines are only applied to the terrain, and not to 3DML layers.

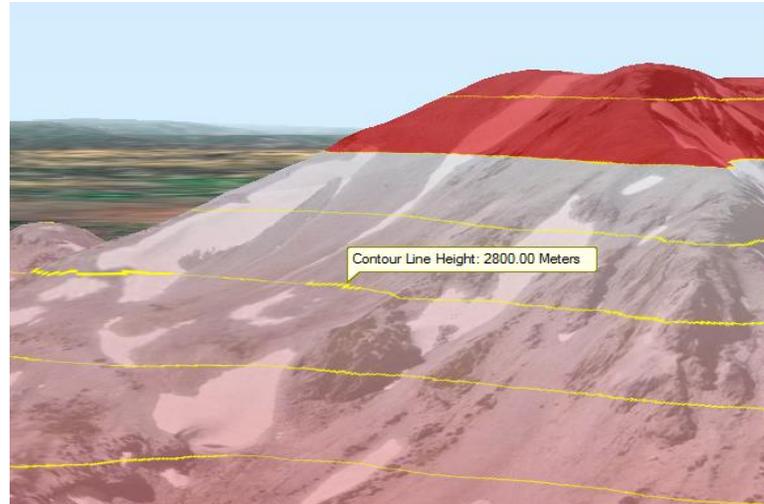


Figure 16: Contour Map

- **Slope Map Tools:** Provide slope information for a specified area or the entire terrain. The following options are available:
 - Global Slope Map - Applies default palette colors and direction arrows to entire terrain according to slope degree and aspect. Slope map colors are rendered on terrain textures as well as on 3DML layers.
 - Custom Slope Map - An advanced slope map in which parameters such as coverage area (specified rectangular area or entire terrain), slope palette, and arrow color can be customized and a slope map object is added to the Project Tree. The custom slope map can show degree and/or aspect (direction). Slope colors and arrows are only applied to the terrain, and not to 3DML layers.
 - Slope Map Query – Graphically represents slope values in a specified area, outputting a highly-accurate color coded point feature layer that is listed in the Project Tree and can be exported to a shapefile or SQLite layer.

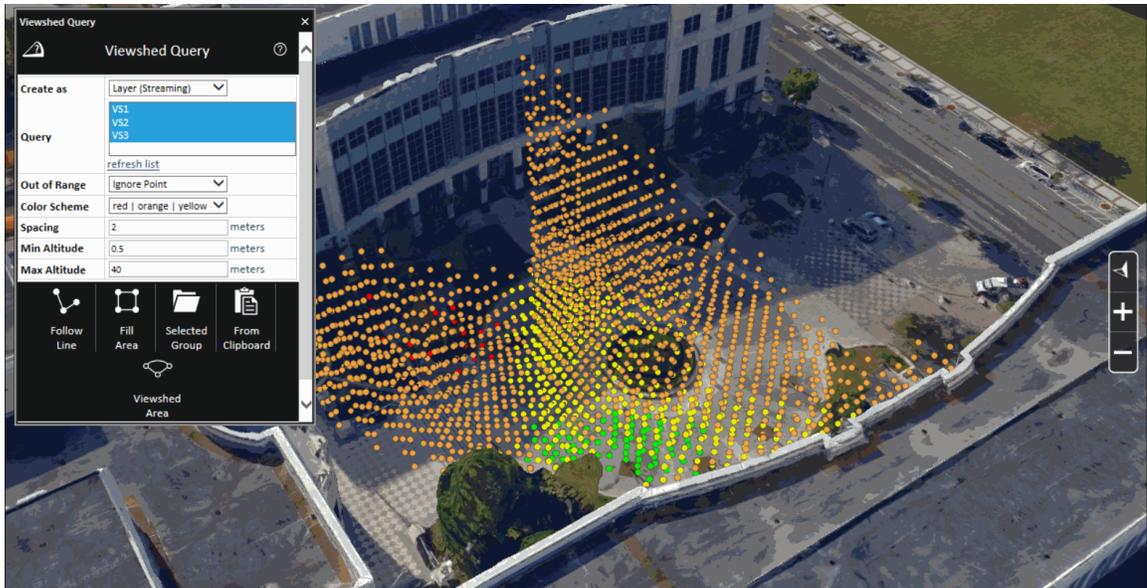


Figure 17: Slope Query

- Slope Cursor - Displays slope information in a specified radius around a selected point.



Figure 18: Slope Map

- **Flood Tool:** Assesses the land area covered by water in different water flooding scenarios. The result of the flood analysis process is a set of polygons showing the flooded areas.

- **Volume Analysis Tool:** Analyzes the volume of the terrain or model removed or added by Modify Terrain/Modify 3DML objects.
- **Terrain Profile Tool:** Displays the terrain elevation profile along a path, and related information on this profile such as maximum and minimum elevation values and slope. The terrain profile can also compare between the base terrain and an elevation layer.
- **Best Path Tool:** Calculates the best path between two locations on the terrain without exceeding definable climb and descent slope limits. The tool creates a line object marked on the ground representing the calculated path. The calculation takes into account the elevation values of the terrain and implements a heuristic algorithm. The parameters available for the search determine the time and probability of finding the best path.
- **Cross Section Tool:** Makes a horizontal or vertical straight cut to expose obscured sections of the 3D View. The cross section slider increments are based on the Plane Size set and the distance between the camera and the plane when creating the cross section box, i.e., the narrower the plane and the closer the camera, the smaller the increments.
- **Clip Box Tool:** Clips everything except labels that are outside or inside of a selected box to help you focus on specific elements in your 3D project.

Line of Sight Tools

- **Line of Sight:** Provides a visual indication of whether specific locations in the 3D World can be seen from a selected position. The tool displays a visual marker for the existence of a line of sight from a single observer position to multiple positions in the world..
- **Viewshed** – Viewshed tools calculate the view from a selected observer point or multiple observer viewpoints:
 - 3D Viewshed – Calculates and marks all areas on the terrain and on 3D models and objects that are visible from a selected point on the terrain.
 - 2D Viewshed - Calculates and marks all areas on the terrain that are visible from a selected point on the terrain.
 - Viewshed Query - Analyzes the visibility of a selected area from multiple viewshed observer viewpoints.
- **Viewshed on Route** - The Viewshed on Route tools provide a graphical representation of the view on the terrain from a series of points (route):
 - 3D Viewshed on Route By Speed – Provides an animated representation of the terrain and objects that are visible as a dynamic object progresses along a defined route according to a set speed.
 - 3D Viewshed on Route By Time – Provides an animated representation of the terrain and objects that are visible as a dynamic object progresses along a defined route over a defined time frame.
 - 3D Viewshed on Route Query– Analyzes the visibility of a selected area from multiple viewshed observer viewpoints along a route.
 - 2D Viewshed on Route - Provides an animated representation of the terrain that is visible as a dynamic object progresses along a defined route.
- **Threat Dome Tool:** Displays the visible volume from a given point on the terrain with a specified scan field and elevation angle. Several display options for the threat dome are available so that the

particular information required can be easily visualized (i.e., sphere that defines the outer boundaries of the volume that is visible from the viewpoint, dome base that divides between visible and non-visible areas, or skyline that highlights obstructions to the field of view).

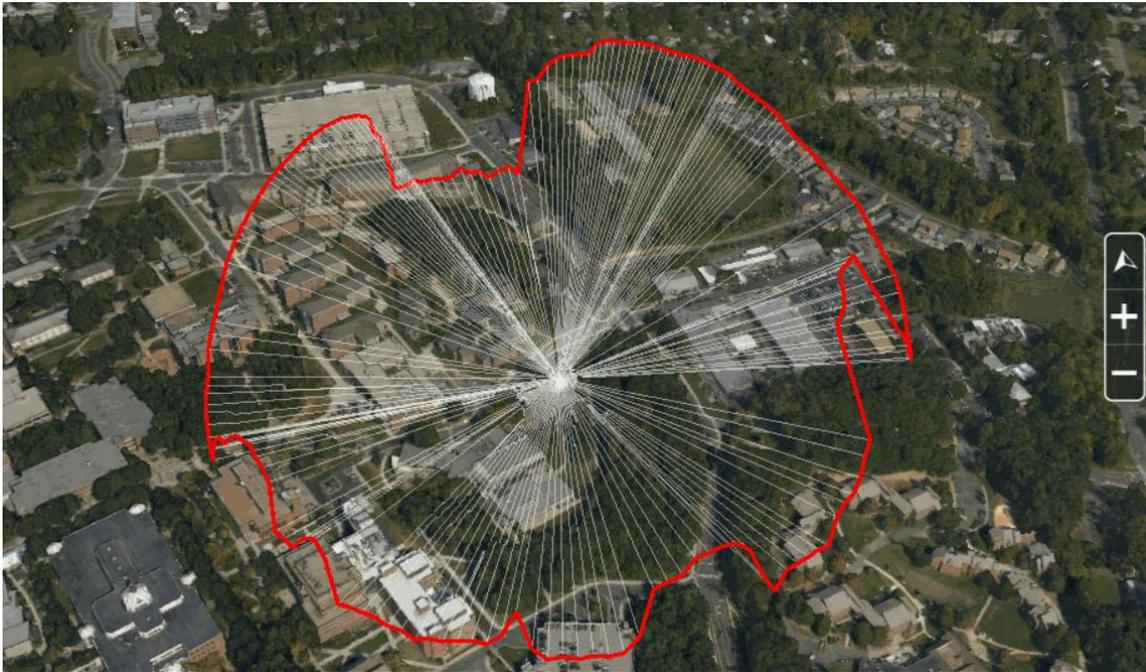


Figure 19: Threat Dome

- **Buffer Query Tool:** Detects all penetrations by 3D elements (e.g., 3D object or 3DML) to a set buffer zone of a selected polyline. This can be used, for example, in implementing safety requirements related to safe distances from a power line. The tool scans the buffer zone of each of the polyline's query points, and colors in red all query points with breached buffer zones. Clicking this query point highlights in red the 3D element that was found.

Shadow Tools

- **Global Shadow:** Displays a shadow effect for an entire scene (including terrain and all 3D models, objects, and buildings) based on the sun's position. Shadows dynamically update when the system date and time is changed.
- **Selection Shadow:** Casts shadows for selected objects based on the sun's position, enabling visualization of the shadow effect of a particular object on surrounding buildings and terrain. Shadows dynamically update when the system date and time is changed.

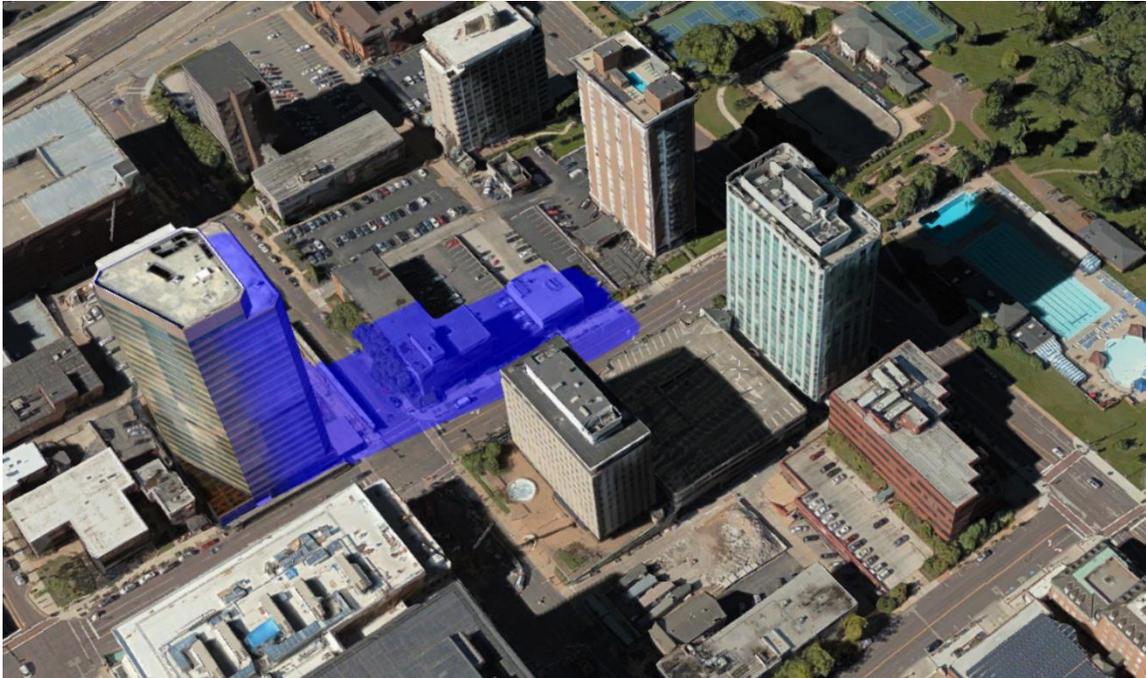


Figure 20: Selection Shadow

- **Shadow Query:** Calculates the sun-shadow ratio in a specified area, over a selected time span. The area is defined by a drawn line or polygon, or by a selection of points, lines or polygons. Shadow analysis can be based on the shadow effect of selected objects (Selection Shadow) or of all the project's objects.

Comparison Tools

- **Swipe Snapshots:** Helps you create and compare snapshots showing different versions of the area in view in the 3D Window by showing or hiding objects in the Project Tree.
- **Swipe Mesh, Point Cloud, and Imagery Layers:** Helps you detect the changes between two layers in the same location of any of the following types: mesh, point cloud, or imagery, or between one of these layer types and the base terrain. Using the tool, you can horizontally swipe between them, dynamically revealing and hiding parts of each layer.
- **Elevation Difference – 3D Mesh Layers:** Analyzes the elevation difference between two mesh layers in a defined polygonal area. This allows you to carefully compare between two layers and identify where there have been changes, e.g., for use in urban development to monitor compliance with building zone regulations and detect illegal construction.



Figure 21: Swipe 3D Mesh

- **Elevation Difference – Elevation Layers:** Analyzes the elevation difference between two elevation layers or between an elevation layer and base terrain in a defined polygonal area. This allows you to carefully compare between two layers to contrast between the state of an area before and after a landslide or volcano, or to evaluate restorative efforts following mining activity.

SKYLINEGLOBE SERVER

SkylineGlobe Server is a private cloud solution that provides a comprehensive set of web services for publishing, storing, managing and streaming 3D spatial data. The complete 3D geospatial data lifecycle is controlled and managed from a unified, centralized server technology and management interface.

- **Searching and streaming** - Remote TerraExplorer clients can access all spatial data types including terrain (MPT/TBP), map (raster-WMS/WMTS), feature (WFS/WFS-T), 3D Mesh (3DML, OGC 3D Tiles, I3S/SLPK), and point cloud (CPT, OGC 3D Tiles) using SkylineGlobe Server's streaming services. All data on your server is cataloged and referenced so you can easily find the specific published layer required.
- **User permissions** – The SkylineGlobe Server permissions mechanism allows you to set viewing/editing access rights to your published layers and projects.
- **Publishing** – SkylineGlobe Server streamlines the TerraExplorer workflow. All publishing and uploading of layers and projects to the server can be done directly from TerraExplorer eliminating the need to copy project kit folders to a web server or upload MPT, raster, and feature layers to TerraGate server. Through a single publishing operation, data is made available to all TerraExplorer clients: Desktop, Mobile, and TE for Web, as well as standard geospatial clients such as WFS/WFS-T/WMS/WMTS/3D Tiles (Cesium).

The screenshot shows the 'Load Layers' interface in the SkylineGlobe application. At the top right, the user is identified as 'User: arik'. The interface includes a search form with the following fields:

- Search String:
- And: ID: =:
- Type:
- Owner:
- Map:

A 'Search' button is located below the form. To the right of the form is a world map. Below the search form, the 'Search Result' section displays a table with 4 results (showing 1-100 of 587). The table has the following columns: Catalog, Type, Name, Data Source, Created at, Created by, Read Permission, Write Permission, and Size.

Catalog	Type	Name	Data Source	Created at	Created by	Read Permission	Write Permission	Size
haiti-vectors-split_raster_feature.ii.247148	Imagery	haiti-vectors-split_raster_feature.ii.mpt	upload	24/01/2017 12:27	mauro	Private	None	107.8
haiti-vectors-split_raster_feature.ii.247147	Imagery	haiti-vectors-split_raster_feature.ii.mpt	upload	24/01/2017 12:16	mauro	Private	None	105.2
PublishTest.243827	TerraExplorerProjectWeb	PublishTest.kml	upload	22/01/2017 14:19	arik	Private	None	2.6 KB
PublishTest.243826	TerraExplorerProjectDesktop	PublishTest.fly	upload	22/01/2017 14:19	arik	Private	None	2.2 KB

At the bottom of the interface, there are 'Close' and 'Load' buttons.

Figure 22: Loading Layers from SkylineGlobe Server

PUBLISHING

A TerraExplorer Kit is a directory that contains the project and all relevant files. This directory is ready to be distributed to external users using any external storage device or uploaded to SkylineGlobe Server or a different server over the Intranet or the Internet. The Publish TerraExplorer Kit process collects all the files that are used in the project and stores them in the target directory.

When publishing a TerraExplorer project, two .FLY files are automatically created: one for use on a desktop and one for mobile.

The following publishing options are available:

- **Publish Project as Local Kit** - Gather local files and objects to a kit folder, maintaining references to all network resources. When required, a TerraExplorer installation setup can be included in the kit.
- **Extract and Publish Area as Offline Kit** - Extract a geographic subset of the project and copy all of its local and network resources to local files, for use in a disconnected environment.
- **Publish Project as KMZ** - Export a TerraExplorer project to an OGC KML/KMZ file.

USER INTERFACE

TerraExplorer uses a Ribbon interface that organizes all commands in easily-accessible, intuitive groups, which are collected together under tabs. A customizable Quick Access toolbar makes the commands you most frequently use always available to you.

At any time during a TerraExplorer session, the Navigation Map, Project Tree or any of the TerraExplorer Tools can be repositioned on the screen so that you can create the application layout that is most convenient for you.



Figure 23: TerraExplorer Ribbon - Home Tab

PROGRAMMING WITH TERRAEXPLORER PRO

TerraExplorer API

The TerraExplorer Application Programming Interface (API) provides a powerful tool for integrating TerraExplorer, TerraExplorer Pro and custom applications. It also provides a way to create extensions that can access external information sources such as databases or Geospatial files. All of the interfaces, based on the **COM** protocol, can be managed through a scripting language (e.g., JavaScript) as well as non-scripting languages (e.g., C++ or C#).

The following main issues are addressed by the TerraExplorer API:

- Navigating in the 3D world.
- Project management.
- Feature and raster layers.
- Objects management.
- Terrain analysis.
- Events notifications.
- Embedding TerraExplorer ActiveX controls in web pages and windows applications.

In addition, TerraExplorer's API allows a variety of other operations such as controlling the content of the containers, querying the terrain for height information, taking snapshots, controlling the mouse and more.

Embedded Mode

TerraExplorer can run as an embedded **ActiveX control** in any **Windows application** or **Web page**. Using the power of the TerraExplorer API, developers can interact between the application or the Web page and the TerraExplorer controls.

TerraExplorer has three ActiveX controls:

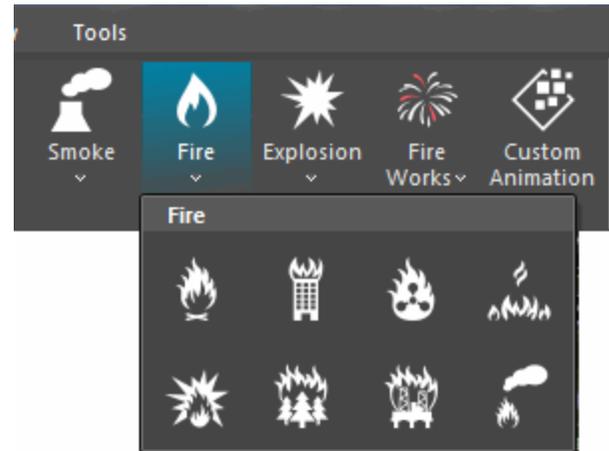
- 3D Window
- Project Tree
- Navigation Map Window

TerraExplorer embedded mode is an integrated feature in all TerraExplorer products.

VISUALIZATION EFFECTS

TerraExplorer offers three categories of visualization effects to enhance realism of the 3D visualization.

- **Weather Effects** – Simulation of meteorological phenomena such as clouds, wind, sky, sun, rain, snow, and fog.
- **Animation Effects** - Simulation of natural phenomena such as fire, smoke, and explosions, or fireworks, by modeling the underlying physical processes of these phenomena.
- **Water Effects** – Simulation of naturally or artificially flowing water such as rivers, oceans, waterfalls, and pools.



The latter two categories are rendered in TerraExplorer using a powerful and robust particle system. Particle system effects are based on very small graphic objects that fade out quickly and are then re-emitted from the effect's source to simulate certain kinds of "fuzzy" phenomena, such as fire, explosions, smoke, moving water, fog, and snow. Each particle effect is composed of one or more emitters (each of which can use a distinct graphic object with distinct emitter properties).

When selecting an animation effect, you can use the default properties that are specific to the particular effect, or you can modify these properties using the Particle Editor. This editor gives you the ability to customize nearly all particle properties including: base image, color, size, rotation, speed, and lifetime. Changes made in the editor take effect immediately



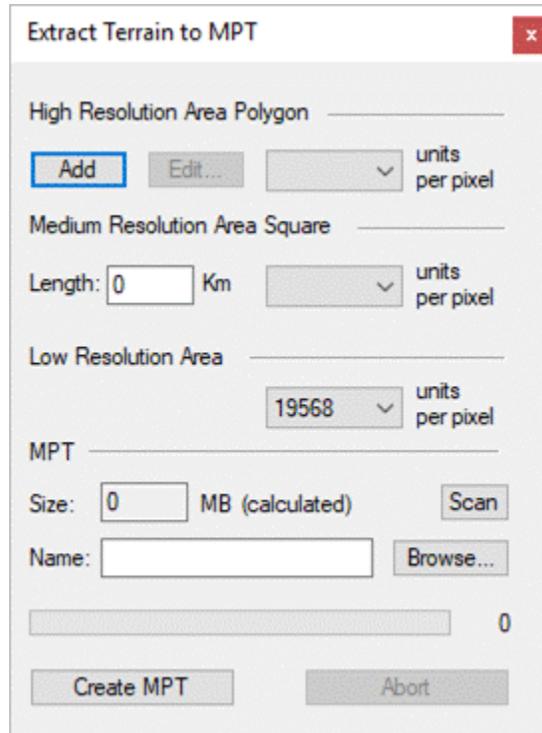
Figure 24: Snow Effect

TOOLS

TerraExplorer Pro provides a set of tools that extend the editing and interoperability functionality. The TerraExplorer Pro Tools use an advanced API to provide an extended set of features to the user.

Extract Terrain to MPT

The Extract Terrain tool extracts and creates a subset of a local or remote MPT database for distribution on CD/DVD. The Extract Terrain tool can even create a local MPT from a DirectConnect project.



Extract Terrain to MPT

High Resolution Area Polygon

Add Edit... units per pixel

Medium Resolution Area Square

Length: 0 Km units per pixel

Low Resolution Area

19568 units per pixel

MPT

Size: 0 MB (calculated) Scan

Name: Browse...

0

Create MPT Abort

Extract Terrain to VRML

The Extract Terrain tool extracts and creates a VRML model from a local or remote terrain database that can be displayed in VRML viewers, 3D printing etc.

Extract Terrain to Zebra

The Extract Terrain tool extracts and creates a Zebra Imaging model from a local or remote terrain database, which you can use for producing 3D hologram images.

Extract MPT to Zebra ✕

Project Name:

Location:

Area _____

Add Area

Left X: Right X:

Upper Y: Lower Y:

Output Format _____

Dimensions: ▾

Elevation Quality: ▾

Image Quality: ▾ dpi

View Mode: ▾

Note: VRML includes only opaque objects of the following types: Buildings, 3D polygons, Boxes, Pyramids, Cylinders, Spheres, 3D arrows and FLT models.

Drawing Tools

Terra Explorer Pro provides a set of drawing tools to perform any of the following:

Urban Design

The Urban Design tool enables you to create an urban scenario with its own roads, junctions and traffic lights.

Duplicate Objects

The Duplicate Objects tool creates multiple instances of the same object along a broken line, or fills a closed polygon shape area. The tool allows the user to set the basic graphic representation of the object and the spacing between the instances.



Figure 25: Urban Simulation Tool

Build Power Lines

This tool creates a power line by placing power poles along a user-defined path and connecting them with power lines. The Build Power Line tool allows the user to define distance between poles, pole type and other pole parameters.

Build Pipe Lines

This tool creates 3D pipe lines along a user-defined path. The output of a build pipe line operation is either a group of TerraExplorer objects or two Points layers, one for the pipes and the second for the connectors.

Build Fences and Walls

This tool creates fences and walls in the precise dimensions, shape and texture you require. The output can be saved as a TerraExplorer group of objects or as a feature layer (shapefile).

Data Library

The Data Library has four primary sets of graphic elements (icons, 3D models, lights, and line animation) that you can add to your project. In addition to the local data objects, the Data Library also includes online models that can be accessed if there is an Internet connection.

Snapshot

The Snapshot Tool copies the current 3D Window to a floating window so you can edit it in a Paint program before saving to image file.

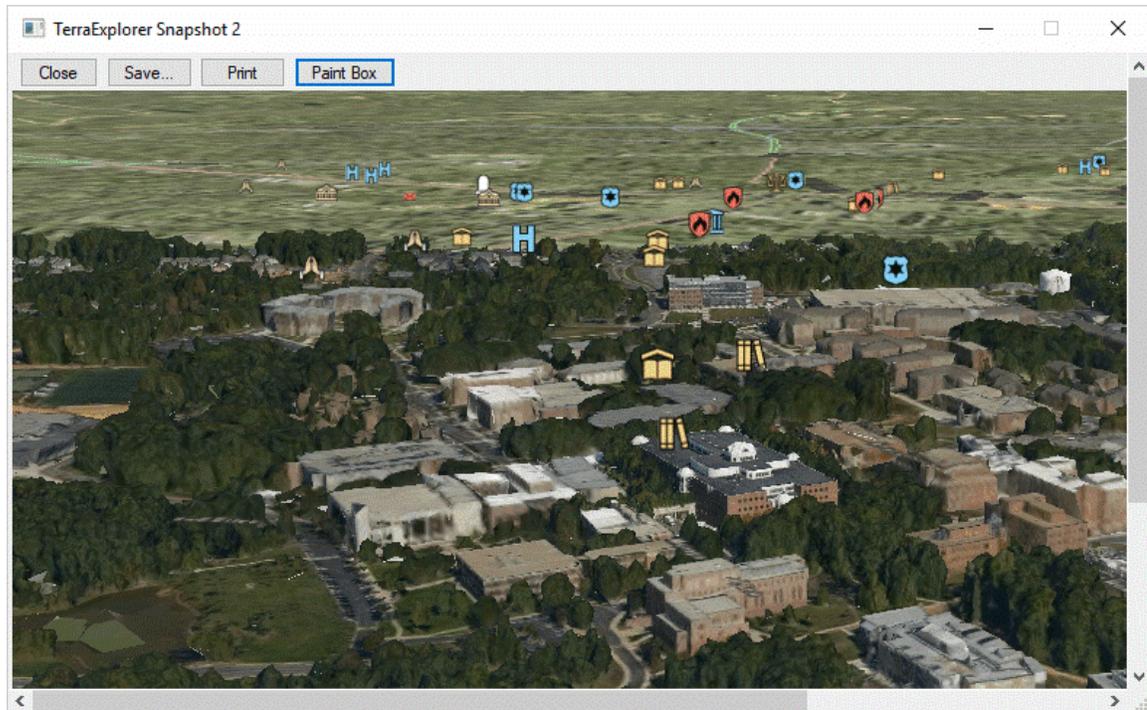


Figure 26: Snapshot

Manual Retouch

Mesh imperfections, such as bumps, irregular surfaces, or floating artifacts, can be edited in TerraExplorer using manual retouch layers, in which you mark surfaces for flattening and floating artifacts for removal. The implementation is then performed in PhotoMesh. The output of the Manual Retouch tool is a polygonal feature "retouch layer" with attribute information that defines what retouch action should be performed in each area: clean, flatten, and retexture. This "retouch layer" must then be reimported to PhotoMesh. When rebuilding the project, PhotoMesh uses the manual retouch layer to add a set of constraints to the reconstruction algorithms. Most of the constraints defined apply to the mesh **model**, and the modified model is then retextured using the project's photos. There is also an option in the Manual Retouch tool to set a specific file texture, e.g., water or grass, for a marked area, instead of basing texturing on the project's photos.



Figure 27: Manual Retouch

Photo Inspector

The Photo Inspector tool displays the photos used to generate a PhotoMesh 3D model so you can view and inspect any section of your model (tower, bridge, construction site, etc.) together with the source photos used to produce it. Photo Inspector makes it easy to navigate within the model and between the model and its associated photos, so you can find the best photos for each area of the model.

The Photo Inspector also provides a set of drawing and measurement tools to mark areas and locations on the model and generate a detailed report with all inspection details.

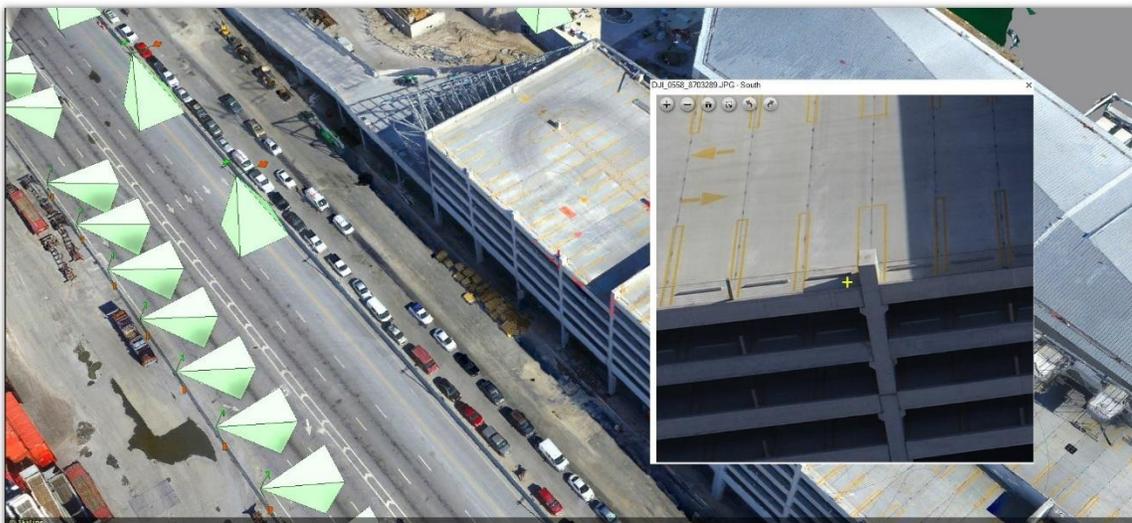


Figure 28: Photo Inspector

Timespan

Timespans restrict the visibility of data to a specific period of time. Timespans are usually used for data sets that appear in multiple locations (e.g., placemarks moving along a path). The data associated with a timespan is visible only when the time slider is showing the time interval defined in the timespan tag.

The timespan for an individual object, and likewise for a group can be set in its property sheet, when you want all objects in the group and all subgroup objects to have the same timespan. The Timespan Tool is necessary when you want to evenly split a timespan, either between a group's subgroups or between all the objects in all of a group's subgroups.

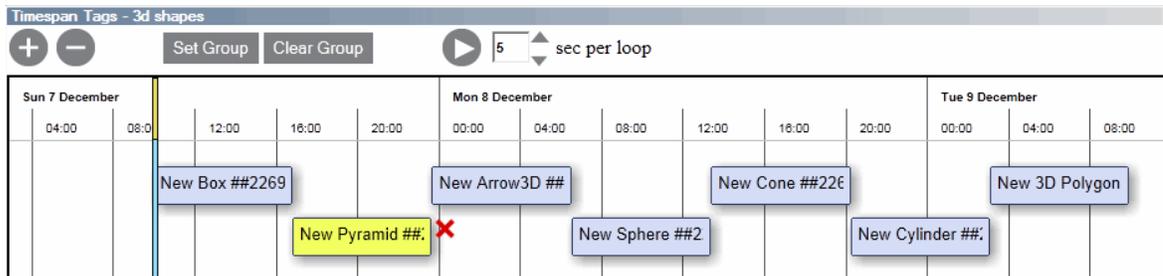


Figure 29: Timespan Timeline

Block Width

An appropriate block width is one of the most critical parameters used to stream a layer efficiently. If the block width is too big, it will take time to request for the data from the data source and it could take a lot longer to render it. If the block width is too small, TerraExplorer “wastes” many requests transmitting data it could have easily transmitted in one request. This also results in “bothering” the data source with many small requests.

The Block Width tool calculates an appropriate block width for efficient layer streaming. In some cases, setting the best block width for a layer is an iterative process. Two major factors influence the selection of the block width for a layer:

- **Layer’s Maximum Visibility Distance** – The higher you want to view the data, the bigger the block width should be.
- **Density and Precision Level** - The denser and precise the data, i.e., the mean points or vertices per area, the smaller the block width should be.

Sometimes, although the data is very dense and precise, you might want to view it from a high visibility distance. In this situation, it is advised to simplify the layer.

Convert Raster to MPT with Resolution Pyramid

To display a layer in different altitudes, TerraExplorer Pro requires a number of resolution levels per layer, which are also known as a resolution pyramid or a multi-resolution file. Without a resolution pyramid, the layer will not be displayed when attempting to zoom out from the original resolution level.

A layer source file may or may not include resolution levels or may have an insufficient number of them. In that case, TerraExplorer can generate a resolution pyramid for such sources. The resulting MPT file replaces the original layer source file and does not point to it.

It is good practice to convert all layers in the project to MPT with a resolution pyramid.

Convert Point Cloud Data to CPT

The Convert Point Cloud to CPT tool converts point cloud data from various formats to a unified, visualization and stream-optimized Skyline-proprietary Point Cloud file (CPT) format. Supported input formats include all of the following:

- LAS files containing Lidar point cloud data and their compressed version (LAZ)
- PTS text files
- Point cloud text files (.txt, .xyz)
- E57 files

Text point cloud files must be in space delimited format and in the order X Y Z R G B I or X Y Z I, where X, Y, and Z are coordinate data, R, G, and B are color values between 0 and 255, and I is the intensity value between 0 and 255.

Convert Models to XPL

The Convert Models to XPL tool converts 3D model files to the Skyline proprietary XPL2 file format, creating a set of XPL files where each file contains data for one Level of Detail (LOD). When displaying an XPL model, TerraExplorer dynamically selects and displays the best LOD file based on the viewer position in relation to the object. When downloaded from a web server, each file is also downloaded independently. This results in an improvement in overall model display performance as well as download rate.

The Convert Models to XPL tool offers the option to accelerate loading speed and consume less memory by using multi-resolution geometries in addition to multi-resolution textures. Performance can be further enhanced by combining models into streaming optimized groups and/or by using unified textures to dramatically reduce computer and graphic resource usage.

XPL files are optimized for TerraExplorer and Internet environments.



Geometry Level 1



Geometry Level 2



Geometry Level 3

The Convert Models to XPL tool supports the following formats:

- COLLADA (DAE)
- Direct X (X) and its compressed version (XPC)
- XPL – old format
- 3DS - 3D studio format for exchanging 3D data models
- OpenFlight (FLT) – Multigen format for exchanging 3D data models and its compressed version (FPC)

Convert Models to 3DML

The Convert Models to 3DML tool enables you to create a unified, stream optimized 3D Mesh Layer (3DML) database from a point feature layer with individually referenced 3D model files. This tool is only recommended for converting layers with many **small** models (each model should not exceed 100 MB), e.g., a city with individually modeled buildings. For larger model files, it is recommended to export the mesh models in a format that supported by TerraExplorer, and then to import them. Conversion to 3DML improves performance and provides better support for web and mobile devices, especially for large layers that reference many different models. If your point feature layer references multiple instances of only a few models, conversion to 3DML is not recommended.



Figure 30: Convert Models to 3DML

TERRAEXPLORER PRO EXTENSIONS

CityBuilder Extension

TerraExplorer's CityBuilder extension includes powerful mesh layer conversion tools that vastly increase TerraExplorer's compatibility with third party viewers and editors. With the CityBuilder extension, mesh layers in a range of formats can be imported and converted to Skyline's proprietary 3DML format, and 3DML's can be exported to other mesh layer formats or to individual OBJ models so you can easily extract precisely the area you need. For users with the CityBuilder extension, these capabilities are fully integrated in the TerraExplorer Pro GUI. Alternatively, they can be used from the standalone CityBuilder.exe application found in your installation folder.

Capabilities

The following capabilities are only supported in TerraExplorer with a CityBuilder extension:

- Export to Models – Export polygonal areas of a 3DML, e.g., buildings, to individual OBJ models.
- **Export to Mesh** – Export 3DML to OGC 3D Tiles (tileset.json) or I3S/SLPK formats.
- **Export Sections of Mesh** – Export sections of a mesh layer using clip polygons on the clipboard.
- **Import and Convert OpenScene Graph (OSGB) Layers** – Import and convert OSGB layers to the stream optimized, 3DML mesh layer format. This enables streaming with SkylineGlobe Server.
- **Import and Convert OGC 3D Tiles (tileset.json) Layers** – Import and convert 3D Tiles mesh layers to the stream optimized, 3DML mesh layer format. This enables them to be streamed with SkylineGlobe Server.

TerraExplorer C2MP Extension

The TerraExplorer family includes the C2MP extension (available in Viewer, Plus, and Pro versions) that provides a unique set of command & control and mission planning features for military and defense users. The extension includes the following tools:

- MultiTracking (Cursor-on-Target, Predator, GPS Tracking)
- FalconView Interface
- MIL-STD-2525C Annotator
- ACO Import
- GRG Creation
- Coordinate Marker
- Route Planner
- DAFIF Import
- Enhanced Data Library support (creation and import)
- Legend Creator

SYSTEM REQUIREMENTS

Requirement	Description
Operating System	Windows® 8 /10 /11 – 64 bit.
System Memory	2 GB of RAM (4 GB or more recommended). For 4K render mode - 4 GB of RAM (8 GB or more recommended).
Video Card	1 GB of video memory (2 GB or more recommended). Pixel and vertex shader v3.0. For 4K render mode - 2 GB of video memory (4 GB or more recommended).
Processor	4 cores (8 cores recommended).
Browser	Microsoft Internet Explorer 11 or higher.
Additional Software	.Net Framework 4.6.1 required.

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