



GIS Point Cloud Integration

The Next Dimension in Asset Management

The Power Portfolio from Hexagon's Geospatial division combines the best photogrammetry, remote sensing, GIS and cartography technologies available. Flowing seamlessly from the desktop to server-based solutions, these technologies specialize in data organization, automated geoprocessing, spatial data infrastructure, workflow optimization, web editing, and web mapping. The Producer Suite enables you to intelligently author, analyze, process, and map multiple sources of data.

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Introduction

The generation of point cloud datasets is growing as technologies become less expensive and easier to deploy; as such, point clouds are quickly becoming an integral part of the geospatial processing market. There is a marked increase in the demand to use these data sources, and one example of this demand is within the field of Asset Management.

This paper discusses how the most efficient use of point cloud data in Asset Management starts with having the point cloud data well integrated within your Geographic Information System (GIS). An integrated environment enables users to see their point cloud data in the context of their GIS so that interactive feature updates can take place.

Problem Statement

Maintaining up-to-date information on the status and location of assets within large organizations, such as Public Works departments or Transportation agencies is an enormous task. Without current information on assets, decisions can be made incorrectly or go unmade altogether; as a result, citizen service and safety can be jeopardized.



Point Cloud Data Sources

The ability to procure accurate and current 3D information about any environment is the best it has ever been. As sensing technologies continue to develop, more techniques for generating point clouds emerge. Nowadays, point clouds can be generated from a multitude of sources, including but not limited to: airborne platforms, terrestrial platforms (mobile and stationary), and even large collections of aerial photographs and satellite images using Semi-Global Matching (SGM) algorithms.

LIDAR (Light Detection And Ranging)

LiDAR (**L**ight **D**etection **A**nd **R**anging) is a remote sensing technique that is used to calculate distance based on the time it takes a laser pulse to strike an object and return to the source device¹. This time figure is then converted to geo-referenced data (in close to real-time) and written to files.

LiDAR is an active sensor technology, which allows for data acquisition during both day and night (as long as the atmosphere is clear). Conventional sensors can transmit and receive anywhere from 10 to 100 thousand pulses of laser light per second. However, some state-of-the-art devices are now capable of transmitting and receiving over 500 thousand pulses of laser light per second. This advancement grants users access to three-dimensional data sources that are extremely dense and highly accurate².

Airborne Point Clouds

Airborne point clouds are typically collected using a laser scanner that is mounted on a platform such as an airplane or unmanned aerial vehicle (UAV).

¹ LiDAR Definition: <https://oceanservice.noaa.gov/facts/lidar.html>

² Aerial LiDAR: <http://www.nrcan.gc.ca/forests/inventory/13425>

The LiDAR sensor sends thousands of laser pulses to the ground every second. The pulses are directed from the aircraft using an oscillating mirror. The exact location of the platform is tracked using GPS satellites and the LiDAR distance measurements are converted to map coordinates and elevations. This process results in a relatively dense set of data points arranged in a swath determined by the flight line of the aircraft (Figure 1). After each mission, the data is downloaded and post-processed.

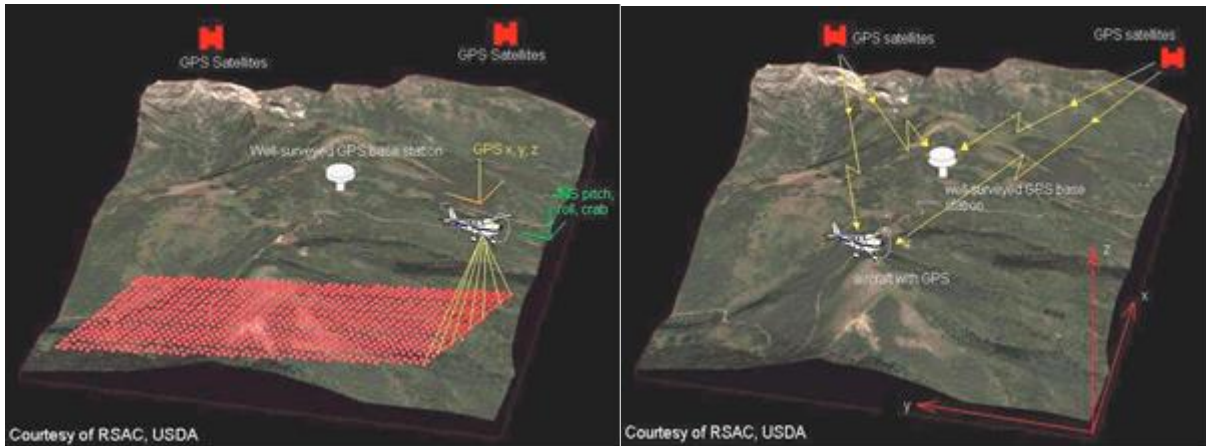


Figure 1

Part of this post-processing is the classification of the point returns. This classification procedure can produce a dataset that includes point qualifiers, a collection of attributes that reflect the source of return. More specifically, the post-processing can create classification values such as those presented by the American Society for Photogrammetry and Remote Sensing (ASPRS) in Figure 2 below³.

Classification Value	Meaning
0	Created, never classified
1	Unclassified
2	Ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building
7	Low Point (noise)
8	Model Key-point (mass point)
9	Water
10	Overlap Points

Figure 2

³ American Society for Photogrammetry and Remote Sensing (ASPRS) LAS File Definitions:
http://www.asprs.org/a/society/committees/lidar/lidar_format.html

These classifications can be used to create a legend with each of the point return classification values represented. Figure 3 illustrates an airborne point cloud presented with a legend that represents the source classification of each point.



Figure 3

Terrestrial Point Clouds

Terrestrial LiDAR systems are used for close-range, high-accuracy applications. These systems generate three-dimensional datasets similar to those provided by airborne LiDAR systems, but they use a laser to map objects from distances of 1 to 100 meters on the ground rather than from an airplane (Figure 4). The resultant data set can be accurate within centimeters or even millimeters⁴.

⁴ Terrestrial LiDAR: <http://www.nrcan.gc.ca/forests/inventory/13427>

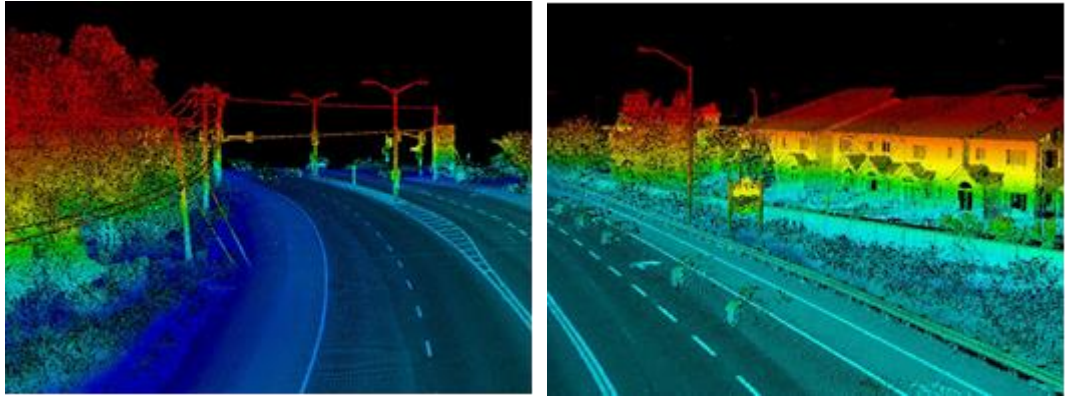


Figure 4

Terrestrial LiDAR systems can be dynamic (on a moving vehicle) or static (on a stationary platform such as a tripod or mast). These systems can also rotate 360 degrees horizontally and scan vertically as well to produce a hemispherical “snapshot” of their surrounding environment.

Image-derived Point Clouds

Orthophotographs have long been a good source of GIS data. The underlying science has proven to be extremely accurate and it produces results that can benefit a wide variety of GIS consumers. Hexagon’s Geospatial division provides ImageStation Automatic Elevations – Extended (ISAE-Ext) for the ImageStation product line and IMAGINE Auto DTM for the IMAGINE Photogrammetry product line for creating point clouds from imagery.

ISAE-Ext employs the pixel-level image correlation technique of Semi-Global Matching (SGM) to produce extremely accurate point clouds⁵.

⁵ ISAE-Ext: <http://hexagongeospatial.com/products/photogrammetry/imagestation>



Figure 5

The procedures associated with the point cloud generation workflow are highly automated, allowing users to complete county-wide projects in a matter of weeks instead of years.

ISAE-Ext supports a broad variety of digital aerial source images including those from UAS/UAV-type sensors. ISAE-Ext also supports a broad variety of output options such as:

- Full-resolution point cloud
- Point cloud compressed format
- Panchromatic encoding
- RGB encoding
- CIR encoding
- RGB plus CIR encoding
- Multi-band TIF plus Z, i.e. RGBN-Z

IMAGINE Auto DTM supports both aerial and satellite sensors. It also provides a broad variety of output options. In short, ISAE-Ext and IMAGINE Auto DTM produce Dense Surface Models (DSMs) in the form of point clouds and raster files from digital stereo aerial frame and satellite source images.

Point Cloud Viewing Technologies

Point cloud viewing continues to progress and has undergone a transformation in recent years. Consumers in this market are increasingly moving away from standalone point cloud viewers and towards solutions that feature seamlessly integrated point cloud data with GIS software.

Stand-Alone Point Cloud Viewers

Stand-alone point cloud viewers have been a standard solution for many years now. Over time, a variety of these applications have been produced, some of which are available for free download. These viewers are typically capable of viewing individual files and often include several tools that allow users to change colour attributes and to measure distances within 3D space. In this type of application, dedicated windows are used to display point clouds. In the two examples in Figure 6, PointVue LE was used to open and display an airborne point cloud (left) and a terrestrial point cloud (right).

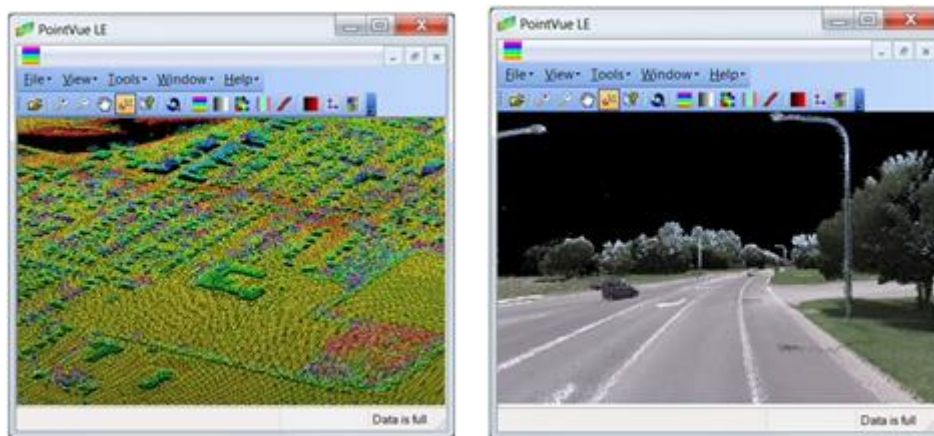


Figure 6

These stand-alone products tend to be excellent at viewing files individually and provide great value to the point cloud viewing community.

Point Cloud Viewers within GIS Systems

Point cloud viewing continues to evolve and the GIS industry is now starting to see point cloud viewers integrated as separate windows within GIS products (Figure 7).

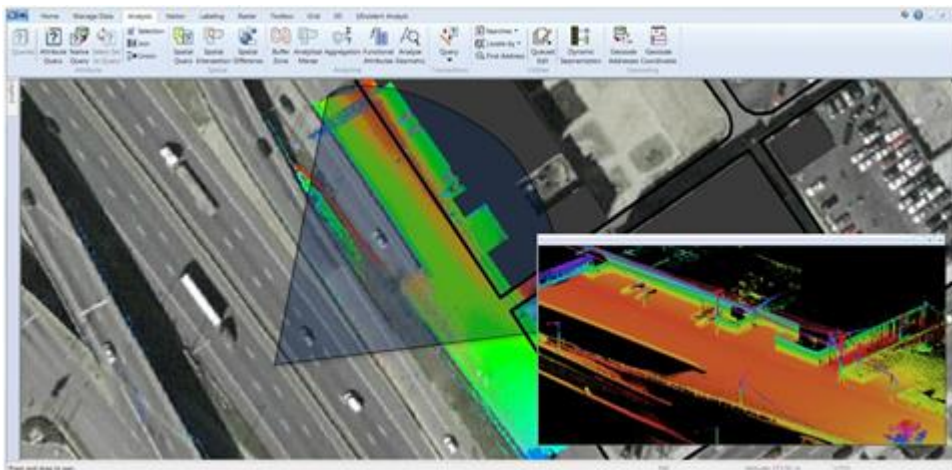


Figure 7

In the example in Figure 7, a 2D map window is used to drive the contents of the point cloud viewer window. The user can essentially use the 2D map window to display associated point cloud files in a separate window. These separate windows sometimes include simple measurement tools. While this is a nice first step towards integration, it lacks a true sense of data context and the use of a separate window is limiting in that it does not easily allow for interactive updates.

Seamless Point Cloud Integrated Within GIS Systems

A natural improvement on this technique is to fully integrate point cloud data directly within a GIS. Starting with the release of GeoMedia 2015.1, point clouds are treated as first-class citizens. The user can seamlessly connect to these data sources and view, measure, stylize, and interact with them directly in the context of other GIS data sources.



Figure 8

Figure 8 shows a screenshot that illustrates the level of integration in GeoMedia. Specifically, it shows a 3D view that includes GIS features (street lamps, curb lines, building footprints), 3D models, and terrestrial point cloud data all in a single, unified window.

GeoMedia Desktop – Data Connectivity with Dynamic Analysis

GeoMedia Desktop is a powerful, flexible GIS management platform that lets you aggregate data from a variety of sources and analyze them in unison to extract clear, actionable information. It provides simultaneous access to geospatial data in almost any form, uniting them in a single map view for efficient processing, analysis, presentation, and sharing. In addition, GeoMedia Desktop has specialized functionality that makes it ideal for extracting information from an array of ever-changing data and supporting smarter decisions.

Data Servers

GeoMedia Desktop gives you the freedom to spend less time trying to connect to your data so you can focus on what you want to achieve with it. GeoMedia Desktop is a leading GIS choice among users who want to connect directly to the spatially-enabled databases they already use—such as Oracle, SQL Server, and PostgreSQL—without using importers, converters, or any other proprietary technology.

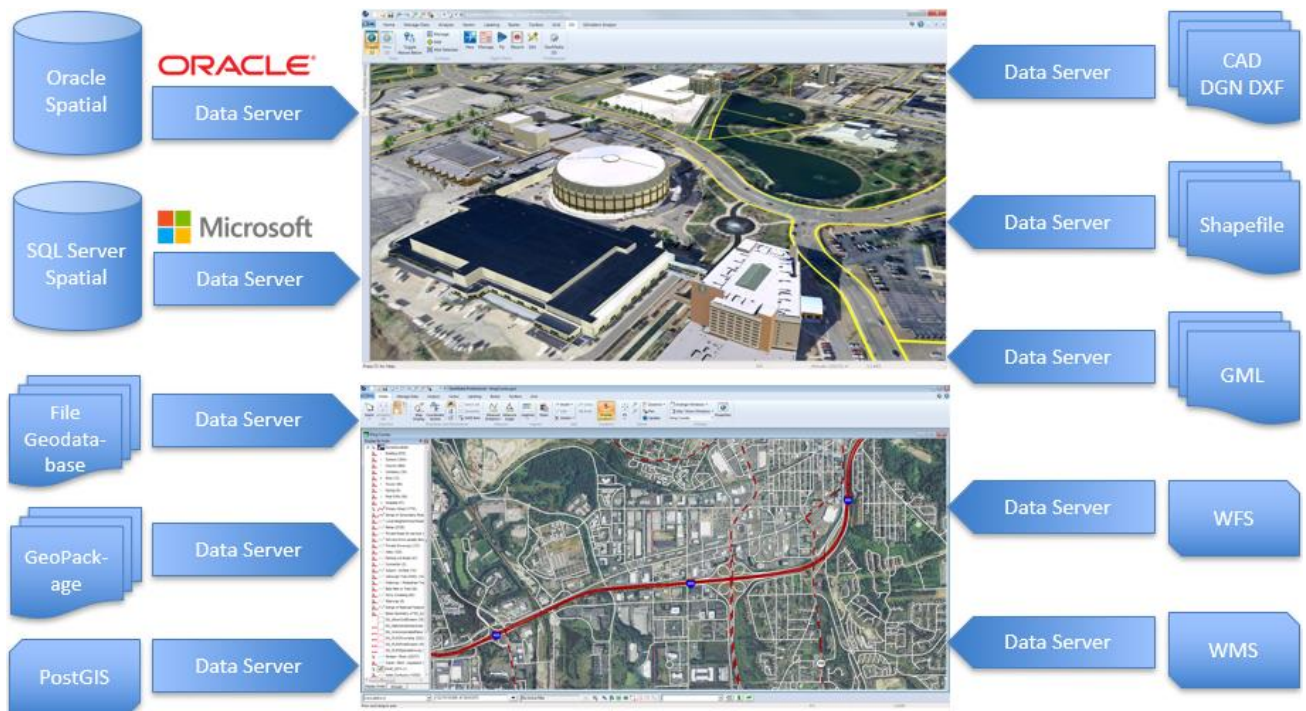


Figure 9



Additionally, GeoMedia Desktop can access many common geospatial file formats including:

- Most CAD formats (MicroStation and AutoCAD)
- Esri's Shapefile and File Geodatabase
- MapInfo
- PostGIS
- GeoPackage
- GML and KML
- Simple text files
- OGC web services such as WCS, WMS, WMTS, WFS, and WFS-T

GeoMedia Desktop also provides the ERDAS APOLLO catalog explorer to display unstructured image data directly in the map window.

Data Integrity

Any GIS is only as accurate or useful as the data it contains. GeoMedia Desktop offers a multitude of options to ensure the data you add to your GIS is high-quality and that it remains that way during its entire lifespan.

GeoMedia Desktop streamlines and improves the addition of large volumes of data to your enterprise databases so you can make sure the data meets your standards for completeness (attributes are populated and checked that they are within allowable range and geometry is validated) and matches the data model your organization uses. GeoMedia Desktop lets you ingest and integrate multiple data sources with differing schemas into a single, high-quality source. In addition, GeoMedia Desktop ensures the integrity of the database by examining the geometric quality, content, and completeness of data before it accepts it.

Databases and Notification

GeoMedia Desktop gives you the power to perform sophisticated investigations to extract information from data stored in multiple databases on different platforms and a variety of different files, all at once. It also enables you to create queries of unlimited intricacy, creating and stringing queries together so that the results of one feed into another.

Most notably, GeoMedia Desktop uses change notification technology making spatial data processing dynamic and hence ideal for extracting timely information from an array of ever-changing data.



GeoMedia 3D – Point Cloud Integration

When GeoMedia Desktop is used in tandem with GeoMedia 3D, point cloud data sources, like all connections to spatial data, are treated as a first-class citizen. You can connect to these data sources and then view, measure, stylize, and interact with them directly in the context of your other data sources. The two case studies below are presented to illustrate how having your point cloud data integrated with your GIS data can benefit typical GIS workflows, and more notably, how this integration can benefit the Asset Management process.

Airborne Integration – a Case Study in Visualization

In this case study an airborne point cloud data set is used to demonstrate how navigation commands native to GeoMedia Desktop are used to visualize a point cloud data set in the context of GIS data for a transportation department.

Data Sources

This case study makes use of data that is courtesy of the Ohio Department of Transportation. It consists of a large collection of vector data (railways, interstates, US highways, state roads, non-state roads, rivers, and lakes) and 457 LAS-formatted LiDAR files, collectively containing an excess of 430 million individual points. This data was collected using an aircraft-based LiDAR sensor and therefore is an airborne point cloud. This data includes intensity values and has been classified using the ASPRS classifications noted earlier.

Workflow – an Overview

This case study aims to illustrate how GeoMedia Desktop can connect to a variety of sources and then use a collection of standard GeoMedia Desktop navigation commands to explore the point cloud data in the context of a single, unified GIS map window.

Use connections to create base map

As noted previously, GeoMedia can connect to a wide variety of data sources and then display them in a single map window. In the following example, connections and styles were used to create a comprehensive base map of transportation-related features.



Figure 10

Use Toggle 3D Map Window to Create a 3D Map Window

GeoMedia 3D allows users to toggle an existing 2D map window to a 3D map window or alternatively create a new 3D map window. If a new 3D map window is created, users can have two or more map windows open simultaneously and then use these in tandem to make use of data within GeoMedia Desktop.

In Figure 11, all the features in all the connections are carried forward and presented within the 3D map window. In particular, the point cloud data is also now part of the equation; namely, it is part of the overall dataset and is displayed in the context of all the other data sources.

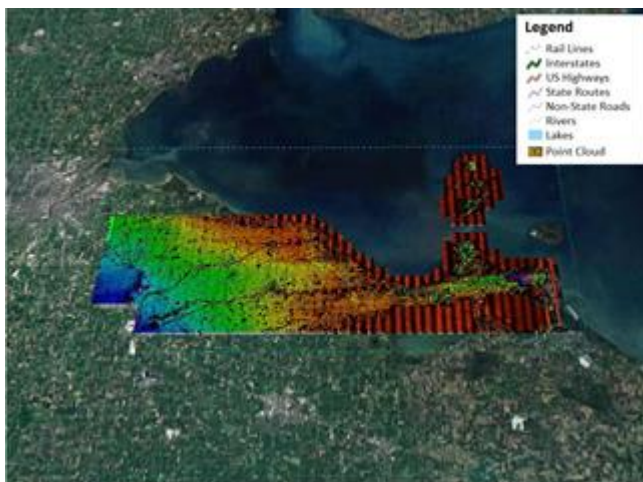


Figure 11



Use Named Location Command to go to a Predefined Place

GeoMedia Desktop includes a set of Named Locations commands. These commands allow users to define, manage, and quickly access specific locations. Individual Named Locations include not only X and Y information, but they also include camera (viewpoint) location and metadata. Hence, they can be used within GeoMedia 3D to automatically go to a specific place and view orientation.

In Figure 12, a Named Location called “Railway” was used to immediately place the user at a specific location in anticipation of flying a route along a segment of a railway feature.

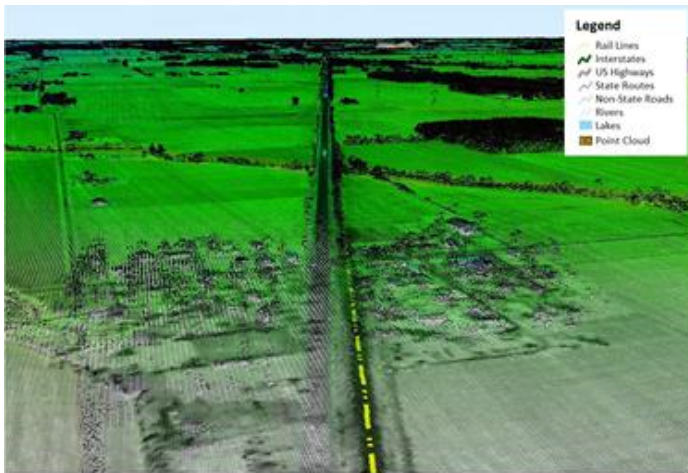


Figure 12

In this use case, the point cloud dataset has been colorized using a blending approach. Specifically, the data intensity values have been assigned a colour sequence blending blue through green through red to represent elevation.

Use Flight Path Commands to Fly-through Environment

GeoMedia 3D includes a rich set of Flight Path commands. These commands allow users to define, manage, and fly routes.

The ability to fly a predefined route within a 3D environment can prove extremely useful. For instance, urban planners can evaluate proposed utility corridors or review the aesthetic effects of introducing new buildings into an environment. Intelligence public safety officers may also want to visually inspect an area of interest. With flight paths, users can fly the exact same path repeatedly and consistently. The ability to fly the same path repeatedly allows users to make iterative modifications to objects that fall within the view of the flight path (e.g., modify terrain, add/remove buildings and/or vegetation) between each run. Each run can be recorded and these recordings can subsequently be used to evaluate each proposal or scenario.

In Figure 13, a segment of the railway feature is selected. This selection guides the flight path process (i.e., the flight path follows this feature based upon a set of predefined flight parameters such as altitude, speed, and view angle).

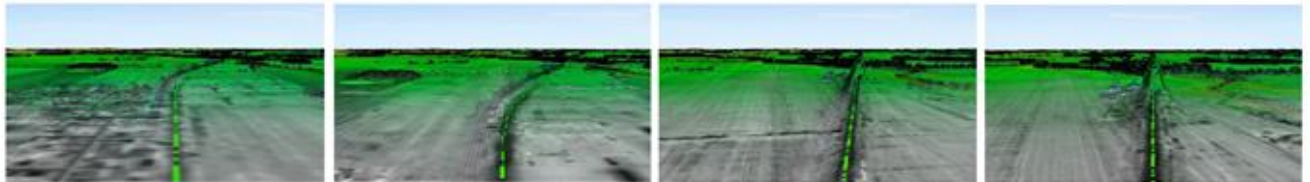


Figure 13

The screen shots from left to right in the figure show the progression as the system flies through the data while following the selected segment of railway.

Terrestrial Integration – a Case Study in Asset Management

In this case study, a terrestrial point cloud data set is used to demonstrate how the GeoMedia Desktop Move command can be used to first update an existing asset. It will then show how the Insert Feature command can be used to add a new feature. In both cases, the point cloud data is used as the source of truth, and thus it helps guide the editing process.

Data Sources

This case study makes use of data that is courtesy of the Tennessee Department of Transportation. The dataset consists of a collection of vector data (building footprints, street lamps, and curb lines) and one LAS formatted LiDAR file containing approximately 100 million individual points. This data was collected using a ground-based stationary platform and is therefore considered a terrestrial point cloud. This data also includes intensity values.

Workflow – an Overview

The intent of this case study is to illustrate how GeoMedia Desktop can be used to stylize point symbols for better visual interpretation. It is important to understand that integrating point cloud data with a GIS not only allows users to see their point cloud data in the context of their GIS, but it also allows them to make use of all standard GeoMedia Desktop vector commands. These commands can be used to perform interactive updates of features and thereby easily perform tasks such as: locate assets that are not in your GIS; locate assets that have incorrect location values in a database; and locate assets that may be in need of repair.

Use Toggle 3D Map Window to Create a 3D Map Window

As noted above, GeoMedia 3D allows users to toggle an existing 2D map window to a 3D map window. In this case, 3D styles were used to extrude the building footprint features to accurately represent their height in the real world and to assign a representative 3D model to the street lamps feature class.



Figure 14

In Figure 14, the terrestrial point cloud has also been added using a default purple through red color sequence. This color sequence does not illustrate the point cloud very well, but GeoMedia Desktop styling capabilities are available to modify this aspect of the point cloud.

Stylize the Point Cloud Color Sequence

Point clouds can carry attributes including Red, Green, and Blue (RGB) values and intensity values. The ability to make use of these attributes helps in the display of these data. In Figure 15, the points within the point cloud are displayed by intensity (left) then by a blue through green through red color sequence to show both intensity and relative elevation (right).



Figure 15

If you examine the data in the figure closely, you can see features such as windows and doors on each of the facades. This information provides a better understanding of the underlying source data (especially when used in conjunction with the color sequence).

Update an Asset Feature

GeoMedia Desktop contains a number of vector-editing tools. In Figure 16, the Move command is used to interactively move an asset that is in the wrong location (left) to the correct location (right). It is extremely powerful that standard GeoMedia Desktop commands can be used in tandem with GeoMedia 3D to perform these types of edits.

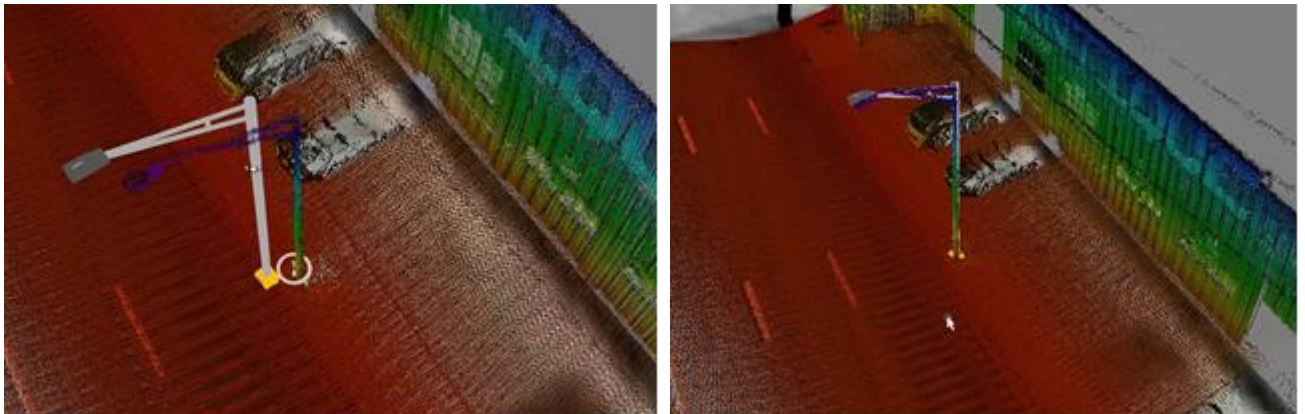


Figure 16

Add an Asset Feature

In instances where an asset feature is missing (left), the GeoMedia Desktop Insert Feature command can be used to interactively add an asset feature to the GIS database (right) (Figure 17).

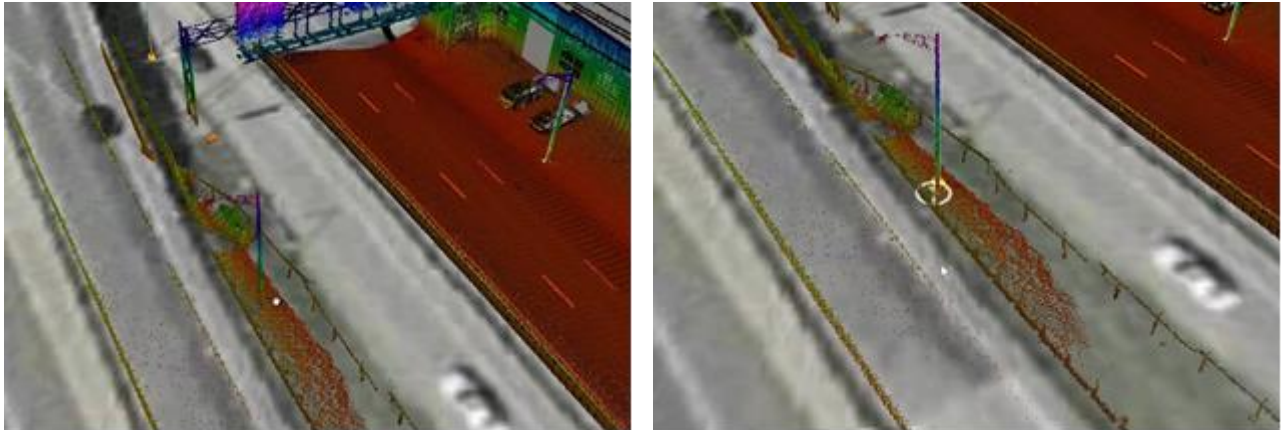


Figure 17

Another interesting note in this example is that if you look closely at either of the images, you will notice that the guard rail is in need of repair.

Conclusion

The ease with which high-fidelity point cloud (source of truth) datasets can be generated or purchased offers a momentous opportunity for many organizations to increase the accuracy of their Asset Management systems.

When point cloud information is effectively integrated geographically with corresponding GIS vector and imagery data representing assets, it is straightforward to correct GIS asset data to match newly acquired point cloud data.


Most notably, the time and costs required to maintain an accurate GIS containing asset information can be significantly reduced by minimizing physical field inspection operations.



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About Hexagon

Hexagon is a global leader in sensor, software and autonomous solutions. We are putting data to work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications.

Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous — ensuring a scalable, sustainable future.

Hexagon's Geospatial division creates solutions that deliver a 5D smart digital reality with insight into what was, what is, what could be, what should be, and ultimately, what will be.

Hexagon (Nasdaq Stockholm: HEXA B) has approximately 20,000 employees in 50 countries and net sales of approximately 4.3bn USD. Learn more at hexagon.com and follow us @HexagonAB.

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