Never before in the history of mankind has there ever been more geospatial data collected from sensors deployed all over the globe, from the deep ocean seafloor to more than 22,000 miles above earth. Data sets larger than several terabytes are generated daily from oceanographic and meteorological satellite systems alone. The U.S. Department of Defense estimates that the amount of data collected over the next two years will exceed all the history's recorded data up to the present time. Collecting massive amounts of geospatial data has created new problems in how to efficiently manage, store, analyze and visualize these data. Makai Ocean Engineering, Inc. has created an advanced visualization tool to solve the analytical and visualization problems. This whitepaper discusses Makai's software in context with the leading geospatial visualization tool, Google Earth.

GOOGLE EARTH

In June 2005 Google Inc. announced the launch of Google Earth, Google's new satellite imagery-based mapping product that combines 3D buildings and terrain with mapping capability. Google Earth, using web-streaming technology, was the first software to efficiently manage the terabytes of satellite imagery covering the globe. The software quickly became popular among anyone wishing to view their world from space. It was the first time that the general public, using a desktop PC, could easily travel the world to far-away places.

Google Earth excels at efficiently displaying high resolution satellite terrain imagery with global coverage. In addition, the software can display 3D buildings, terrain (mountains and valleys), and can overlay GIS information such as highways, parks, and local businesses.

Google Earth is limited in its ability to analyze and visualize certain types of geo-spatial data and it does not allow users to process their own imagery. It has no charting or graphing capabilities. It cannot display LIDAR data which is used extensively for atmospheric research and meteorology, surveying and mapping. It cannot display true volumetric data which is used in oceanographic, meteorological, and medical fields. And, it cannot display data changing dynamically over time (e.g., an animation of a hurricane's track).

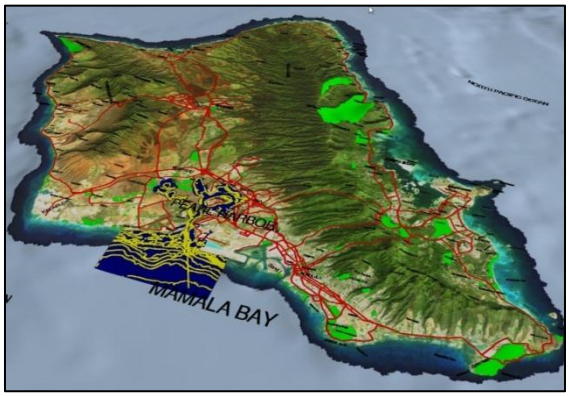
MAKAI VOYAGER

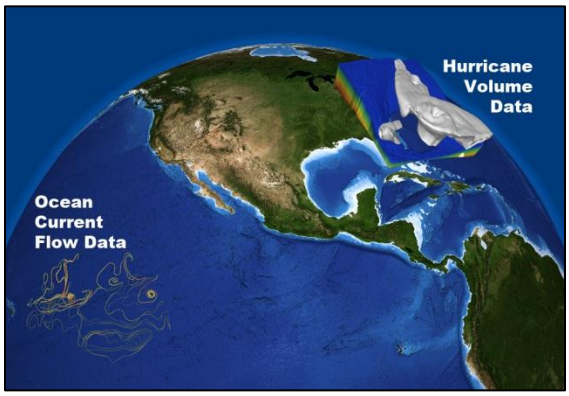
Makai Voyager™ is the result of a multi-million dollar development effort to create an innovative software tool that provides a global geospatial framework, similar to Google Earth, from which to view and analyze large amounts of scientific data. While Google Earth is designed for the general public, Makai Voyager is designed for the private, education, and military sectors needing to process, view and analyze massive amounts of 3D data. Makai Voyager operates on a standard PC and supports multiple operating systems (Windows, Mac and Linux).

FEATURES

- View global geospatial imagery (e.g., images you typically see in Google Earth).
- View geospatial elevation data above and below the ocean surface.
- View meteorological data from a 3D/4D perspective (e.g., tools to slicing through a cloud or hurricane and view animation of a weather pattern changing over time).
- View geospatial wind and ocean currents (e.g., flow data).
- View tsunami inundation zone animation.
- View data from soil contamination models.
- Incorporate third-party GIS data (e.g., roads, parks, maps).
- Process and view LIDAR data.
- Import and view 3D buildings.
- Generate charts for data analysis.
- Create movies.

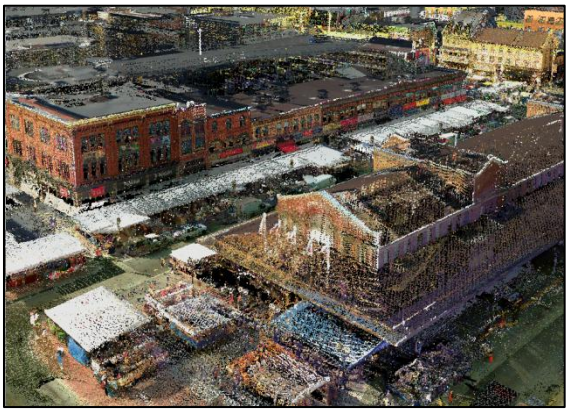
GIS capabilities: Makai Voyager provides native support for 18 different GIS formats with the option to expand support for over 140 different spatial data formats. The process of importing imagery, elevation, or 3D data is simple regardless of the type or complexity of the data. The figure to the right shows an S-57 nautical chart (yellow lines), Oahu roads (red lines) and parks (green polygons) overlaid on top of elevation and high resolution imagery. Lower resolution bathymetry surrounds the island.

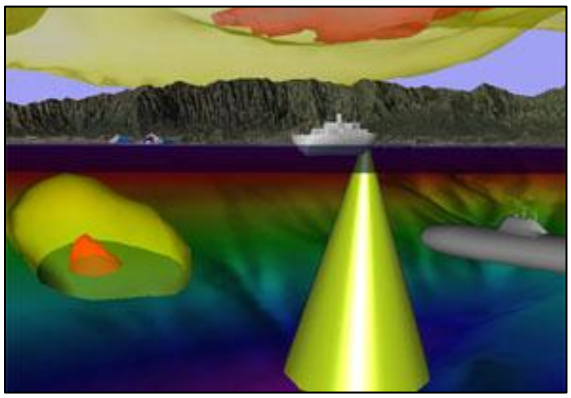




Oceanographic and atmospheric volumetric data: Volumetric data is fundamentally different than standard images. Google Earth is composed of 2-dimensional "pixels". Although scenes or building may look 3D, they are really only 2D images overlaid on top of a mesh or elevation data. In Makai Voyager users have the ability to view true 3D volumetric data which consist of "voxels" instead of pixels. Volumetric data is important to meteorologists, oceanographers, the medical industry (e.g., viewing CAT scans), and environmental chemistry (e.g., viewing ground water flow and contamination). The figure above shows a simulation of Hurricane Isabel in 2003 to the right, and ocean current flow data to the left. Tools are available to slice through the volumes, graph variables, and animate the changes to the data over time.

LIDAR Data: LIDAR (light detection and ranging), sometimes referred to as "laser radar" is commonly used in archaeology, conservation, geology and soil science, meteorology, the military, physics and astronomy, and surveying. The challenge to displaying LIDAR data is the size of the dataset that needs to be displayed. The figure to the right shows a screenshot of downtown Ottawa, Canada taken from a dataset consisting of nearly 1 billion 3D points. Makai Voyager excels at managing and visualizing massive amounts of data while maintaining high animation frame rates.

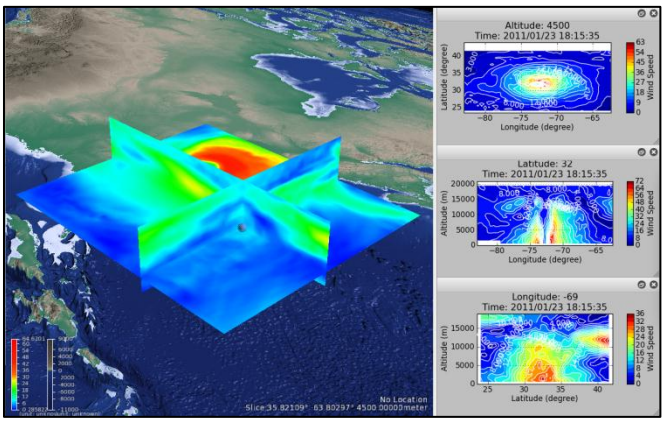


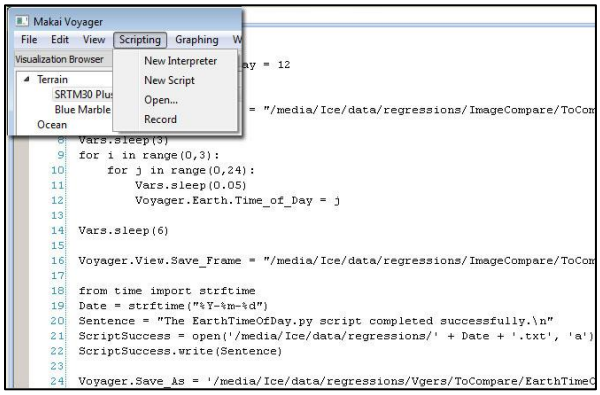


Data Streaming: Makai Voyager uses data streaming technology to deliver sensor data from a central server to Makai Voyager clients over the network. As long as the clients have a network connection, they can receive up-to-the-minute data from oceanographic and atmospheric sensors. The figure to the left shows the detection cone of a surface vessel's instrument, a fresh water underground plume to the left, and atmospheric conditions.

Makai Voyager

Data Graphing and Analysis: Makai Voyager is designed for the researcher in mind. While Google Earth is a powerful platform to view imagery and GIS data, it has no data graphing and analysis abilities. Users of Makai Voyager can interactively create plots of selected data sets, including single and multiple time series plots, scattered plots for points in space or of variable dependence, 2D plots along arbitrary planes, and horizontal and vertical plots of variable gradients. The figure to the right is a screenshot of Makai Voyager's 3-slice graphing capability through a volumetric dataset.





Enhanced Scripting Capabilities: Makai Voyager has powerful Python language scripting functionality to allow users to manipulate the internal state of the software. Any action performed via the GUI can be recorded and duplicated via the command line (e.g., creation of macros). Python scripting can also be used to configure network serial data transfers (e.g., sensor data) and to automate image preprocessing.

Feature Comparison			
Features	**Google Earth**	**Google Earth Pro**	**Makai Voyager**
Worldwide satellite coverage	X	X	X
3D buildings and objects	X	X	X
Terrain imagery	X	X	X
Elevation data	X	X	X
Bathymetry data	X	X	X
Network data streaming	X	X	X
Animation of time-dependent data	X	X	X
Web Map Services	X	X	X
Cross-platform (PC, Mac, Linux)	X		X
Movie making		X	X
Import custom GIS data		X	X
LIDAR point data			X
Meteorology volume data			X
Oceanography volume data			X
Wind and ocean current/flow data			X
Data processing and fusion			X
Scriptable with Python			X
Data analysis - graphing and measurements			X