

Exelis Visual Information
Software Solutions for

TERRAIN ANALYSIS

EXELIS

Visual Information Solutions

Defense & Intelligence
SOLUTIONS GUIDE

MISSION SUCCESS

Software Solutions

Identify Landing Zones

Perform Viewshed Analysis

Develop Urban Maps

Monitor Development Sites

The U.S. Armed Forces has long acknowledged the connection between battlefield terrain and the military tactics employed by army commanders. Terrain features include natural and man-made obstacles, structures, and conditions that may favor the attacker, defender, or both. For a military operation to be successful, a thorough terrain analysis should be performed during the reconnaissance stage of planning. Terrain analysis is a vital part of successful deployments, maneuvers, and advancement of a military unit in the field. The formalized process of military terrain analysis is known by the acronym OAKOC (*see figure 1 at right.*)

- **O**bservation and Fields of Fire
- **A**venues of Approach
- **K**ey Terrain
- **O**bstacles
- **C**over and Concealment

Figure 1

The OAKOC terrain analysis process is based on the principle that “terrain has a direct impact on selecting objectives; location, movement, and control of forces; effectiveness of weapons and other systems; and protective measures.” As a military leader, your ability to quickly and efficiently analyze and tactically use the ground around you (and to know how your enemy can use the same ground) can transform terrain into a valuable ally.

With ENVI image analysis software from Exelis Visual Information Solutions, the ability to exploit the advantages of modern terrain analysis techniques is easier than ever before. ENVI allows you to ingest, read and extract useful information from virtually any form of remotely-sensed data - LiDAR, SAR, hyperspectral and multispectral imagery, panchromatic imagery, and more.

ENVI image analysis software provides the tools necessary to analyze imagery and other forms of remotely-sensed data to draw out the key features of interest to your operation. Using ENVI, three-dimensional data sources such as LiDAR data, Digital Elevation Models (DEMs), or Digital Surface Models (DSMs) can be used to produce highly-accurate three-dimensional representations of terrain. The ability to visualize terrain in three-dimensional space offers distinct advantages over standard two-dimensional mapping techniques. Two-dimensional maps can easily be misinterpreted or the size and shape of terrain features can be underestimated. Three dimensional terrain models enable a more natural interpretation of the landscape and can be used to derive the crucial information defined by the OAKOC process.

ENVI software provides more than intelligent solutions to get information from imagery; it makes it easy to put your analysis results into your GIS so decision makers can effectively plan operations. ENVI software is uniquely integrated with ArcGIS® from Esri and allows for single-click push of data layers to ArcMap. With customizable features available with ENVI, tools and workflows can easily be published across your organization through an enterprise solution. ENVI also has solutions to get valuable information to forward-deployed personnel via existing connections. It is even possible to provide tools to forward-deployed personnel for performing one-click analysis on mobile devices to gain an immediate understanding of their surroundings in time-sensitive situations. This type of rapid terrain analysis allows planners and units to modify their plans based on continuous evaluation of data and their situation.

SOFTWARE SOLUTIONS

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ENVI software solutions are the premier geospatial image analysis tools to pre-process and analyze remotely-sensed data so that you have the information you need to make more informed decisions. Whether your data is in the form of radar, LiDAR, SAR, panchromatic, multispectral, hyperspectral, stereo, or thermal, ENVI software has tools to quickly extract information that is of high value in the strategic planning of military operations. By leveraging the capabilities of ENVI, you can fuse multiple data modalities to get a complete picture of a geographic area.

Our Professional Services Group (PSG) can help you maximize your investment in ENVI by providing extensions, optimizations, and custom interfaces designed to meet your unique challenges. PSG provides custom software development, integration and consulting services to many DoD/INTEL organizations.

ENVI LiDAR

ENVI LiDAR is an interactive geospatial software environment that lets you create realistic 3D visualizations and easily extract important features and products from raw LiDAR point cloud data. The elevation data contained within LiDAR can be used to create DEMs, DSMs, or to extract features such as buildings, trees and power lines. The highly-accurate elevation data obtained from ENVI LiDAR can be used in your terrain analysis to determine line of sight information, determine best locations for cover and concealment, identify obstructions, and determine key terrain and avenues of approach.

IDL

IDL is a powerful programming language that is exposed in all ENVI products via an API. This unique feature means that you can easily customize your ENVI application to meet the unique needs of your mission. With IDL, you can extend ENVI with custom tools and plug-ins, programmatically automate your analysis process, update a GIS with valuable information from your terrain analysis, and collaborate and share results with others.

KEY SOFTWARE PRE-PROCESSING CAPABILITIES

Atmospheric Correction

Image analysts often need accurate and reliable imagery that is free of atmospheric interference. Removing the influence of the atmosphere is a critical pre-processing step in analyzing images of surface reflectance.

Image Registration

Use the image registration workflow to geometrically align two images with different viewing geometry and/or different terrain distortions into the same coordinate system so that corresponding pixels represent the same objects.

Orthorectification

Use ENVI orthorectification tools to orthorectify your imagery. An orthorectified image (or orthophoto) is one where each pixel represents a true ground location and all geometric, terrain, and sensor distortions have been removed to within a specified accuracy.

Customize Routines

Use IDL to extend and customize ENVI features and functionality to fit your specific terrain analysis requirements. IDL can be used to automate routines and to perform batch processing on your data.

Image Mosaicking

Use mosaicking to overlay two or more images that have overlapping areas or put together a variety of non-overlapping images. You can mosaic individual bands, entire files, and multi-resolution georeferenced images.

KEY SOFTWARE ANALYSIS TOOLS

Classification

Choose from a large selection of image classification algorithms to identify the features in your imagery based on spectral characteristics.

Feature Extraction

Identify and extract features from your imagery based on spatial, spectral, and textural characteristics. This method often produces more accurate results than standard classification methods that rely solely on the spectral characteristics of each pixel. With ENVI LiDAR, features such as buildings, trees and power lines can be extracted from your point cloud LiDAR data.

Anomaly Detection

Similar to target detection, the anomaly detection workflow employs an algorithm to identify the spectral or color differences between a region of interest and its neighboring pixels to identify targets that are spectrally distinct from the image background.

Target Detection

Use the Target Detection workflow to locate objects within an image that match the spectral signatures of known targets.

DEM Extraction

Extract highly-accurate DEMs from stereo pair imagery or from point cloud LiDAR data. The extracted DEM can be used for further terrain analysis and three-dimensional visualization of a scene.

Change Detection

Change detection analysis encompasses a broad range of methods used to identify, describe, and quantify differences between images of the same scene at different times or under different conditions. Change detection analysis offers an easy method for comparing multi-temporal images to determine where changes might have occurred. This is particularly useful for monitoring the movement of vehicles and equipment, as well as assessing changes to structures in the scene.

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EXAMPLE SCENARIO | 1



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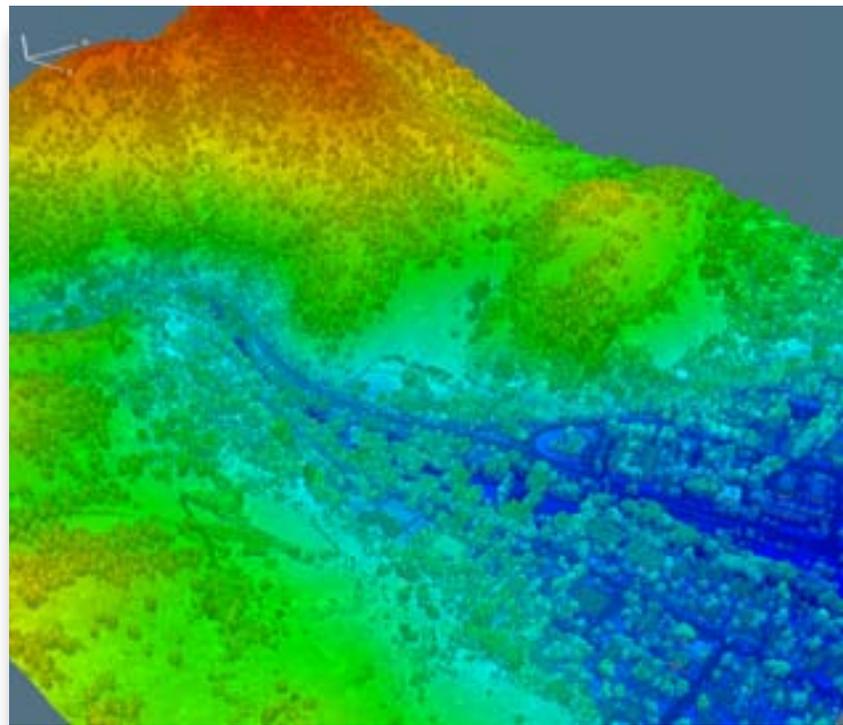
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ANALYSIS TASK IDENTIFY HELICOPTER LANDING ZONES

The following example demonstrates how ENVI software can be used to locate Helicopter Landing Zones in an Operational Area. This example uses point cloud LiDAR data to create highly-accurate DEM and DSM datasets, and to extract trees and buildings from the scene. ENVI LiDAR provides easy-to-use tools for visualizing your raw point cloud LiDAR data; including the ability to color points by elevation and view cross sections of your scene. With just a few clicks of a mouse you can create highly-accurate Digital Elevation Models and Digital Surface Models from your point cloud LiDAR data which can be used for further analysis and for visualization. When extracting DEM and DSM information from your LiDAR data, you can also choose to extract features such as trees, buildings and power lines in vector shapefile format. When processing is complete, ENVI LiDAR provides an easy-to-use 3D Viewer for visualizing and editing your extracted features.



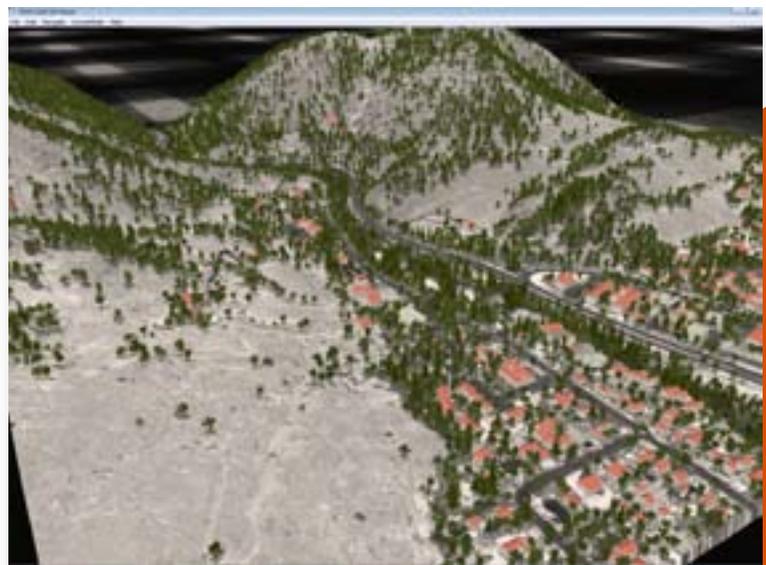
Rain point-cloud LiDAR data visualized in ENVI LiDAR



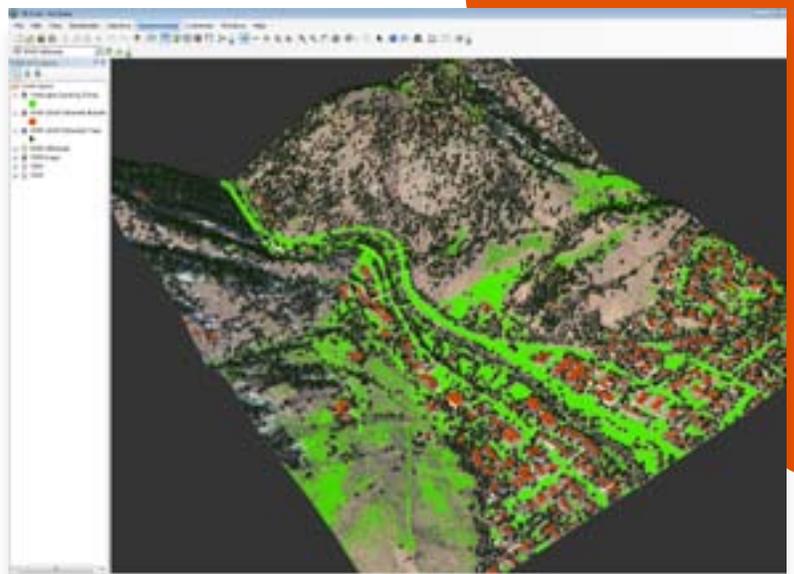
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ENVI LiDAR provides one-click push of your newly-created DEMs, DSMs, and vector shapefiles to ENVI and to ArcMap from Esri. You can also chip your view directly to Microsoft PowerPoint. When pushed to ENVI, your digital elevation data can be used to create a number of additional terrain products, including slope, aspect, and hill shade images. By taking advantage of the unique interoperability ENVI has with ArcGIS, this data can quickly be pushed to ArcMap to determine which areas of the scene meet the criteria for Helicopter Landing Zones. The following scene was created using only products extracted from the initial point cloud LiDAR data via the ENVI platform. Areas in bright green represent acceptable Helicopter Landing Zones based on acceptable slope characteristics and distance from trees and buildings. To achieve a three-dimensional representation, a multispectral image, along with the data create using the ENVI platform is draped over the DEM that was created using ENVI LiDAR.

QuickBird images courtesy of DigitalGlobe

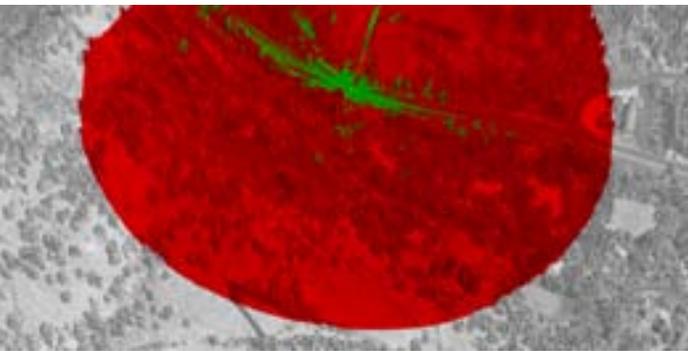


Three-dimensional features extracted from raw point-cloud LiDAR data using ENVI LiDAR



Areas in bright green represent acceptable helicopter landing zones based on slope characteristics and distance from trees and buildings

EXAMPLE SCENARIO | 2



Line-of-sight analysis for discrete observation point



Lines-of-site analysis along convoy route

ANALYSIS TASK PERFORM VIEWSHED ANALYSIS

Viewshed analysis can be used to determine the observation, fields of fire, and cover and concealment that the terrain provides to both you and the enemy. The ENVI platform offers several options for performing viewshed analysis. Viewshed analysis can be performed at discrete observation points, or you can use the tools in ENVI to determine lines-of-site along convoy routes. You can confine the search radius of your viewshed analysis, as well as adjust the observation height. The results of your viewshed analysis can be exported as vector shapefiles for further use in ArcGIS.

With cloud-based ENVI capabilities, viewshed analysis can even be performed by forward-deployed field personnel carrying mobile devices. Using existing communication links, field personnel can perform one-click line-of-sight analysis to gain immediate understanding of their surroundings in time-sensitive situations.

WorldView-2 images courtesy of DigitalGlobe

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EXAMPLE SCENARIO | 3

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ANALYSIS TASK

Develop an Urban Map of Al-Fallujah, Iraq

A key component of military terrain analysis is the ability to quickly generate an accurate land cover, or terrain categorization (TERCAT) map. TERCAT maps aid in determining avenues of approach, identifying key terrain, identifying obstacles and locating opportunities for cover and concealment. The robust set of image classification tools available within ENVI offer the ability to quickly generate a TERCAT map through automated processes that limit the need to rely on hand digitization.



Figure 2: Terrain Categorization (TERCAT) map generated from QuickBird image using ENVI classification tools



QuickBird images courtesy of DigitalGlobe

For this example, a TERCAT map was developed to define the urban landscape of Al-Fallujah, Iraq. The classification tools available in ENVI offer a variety of options for identifying terrain within a scene. Classification algorithms differ in the criteria used for defining decision boundaries between classes. With all classifiers, ENVI first computes a set of statistics for each region or class.

Then, using these statistics and user-defined thresholds, ENVI retrieves the spectral values for each pixel in the image and determines its placement in classification space. ENVI provides a wide variety of unsupervised and supervised classification algorithms. Unsupervised classification algorithms require minimal user-input and can be run with only a few clicks of a mouse. Supervised classification methods take into account user-input training data to define classes.

In addition to the classification tools available in ENVI, the ENVI Feature Extraction module gives you the ability to extract features based not only on spectral characteristics, but also spatial and textural characteristics. This object-based approach to identifying and defining features allows users to get accurate results even with a limited number of bands.

By taking advantage of the unique interoperability between ENVI and ArcGIS, terrain features created in ENVI can be pushed directly to ArcGIS. In figure two, an accurate TERCAT map of Al-Fallujah, Iraq, was created in a matter of minutes using the ENVI supervised classification workflow.

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EXAMPLE SCENARIO | 4

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ANALYSIS TASK

Monitor Development of Hardened Fuel Enrichment Complex, Natanz, Iran

ENVI change detection tools make it easy for military analysts to quickly extract important information from multiple images of the same scene taken at different times. ENVI change detection tools allow military analysts to monitor a scene for the appearance or disappearance of objects and structures, the motion of objects relative to the background, or changes to brightness or color of stationary objects. Data obtained using ENVI change detection tools can be saved in multiple formats and statistical information can be extracted, allowing military analysts to provide planners with accurate and quantifiable information about the current state of a scene without needing to spend countless hours manually pouring over imagery.



INITIAL QuickBird image of Hardened Fuel Enrichment Complex, Natanz, Iran



FINAL QuickBird image of Hardened Fuel Enrichment Complex, Natanz, Iran



*ENVI change detection analysis
result, Hardened Fuel Enrichment
Complex, Natanz, Iran*

QuickBird images courtesy of DigitalGlobe.

In this example, the SPEAR Change Detection tool was used to examine a pair of images captured over the Hardened Fuel Enrichment Complex in Natanz, Iran. In the resulting change detection image, areas in cyan represent structures and objects that are unique to the final image. This shows where additional buildings, roadways and concrete barriers have been constructed since the time the original image was captured. Areas in red represent structures and objects that are unique to the initial image. This shows where three large buildings, including two centrifuge cascade halls have been buried underground since the time the initial image was captured.

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