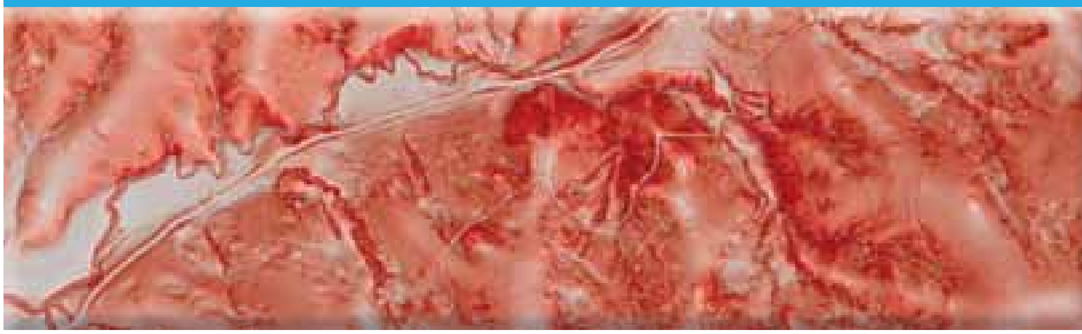
Automated Landslide Detection

with high-resolution LiDAR



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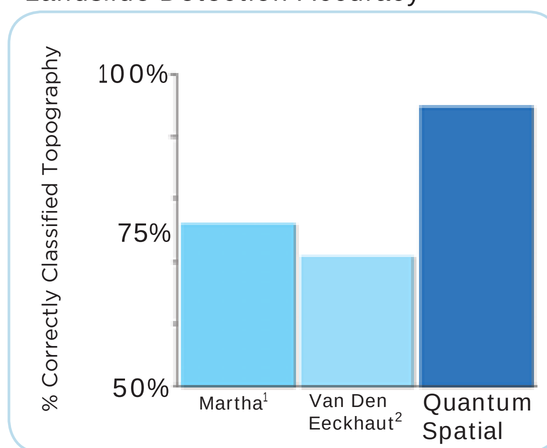
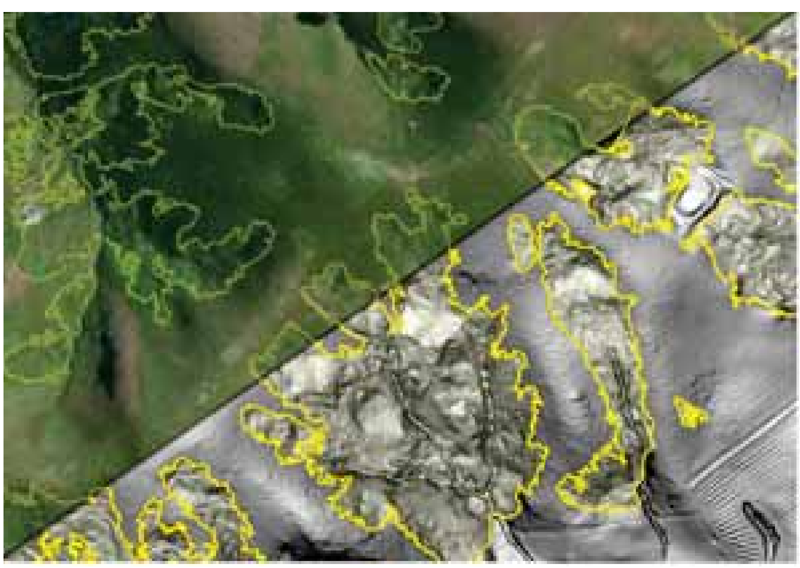
Comprehension of geologic processes is of great concern to many modern industries such as infrastructure planning, energy distribution, forestry management, and emergency response. Utilizing an automated approach, Quantum Spatial has developed an accurate and efficient methodology, which detects areas of failed terrain using high-resolution LiDAR data (15 pts/m^2). The result is a robust, efficient, cost-effective dataset that indicates the presence of landslides, fault lines and other forms of failed terrain.

LiDAR modeling reveals subtle surface features that are undetectable via aerial photographs or field observation, which leads to unparalleled richness in topographic models. Quantum Spatial LiDAR accuracies ($RMSE_Z$ 3-5 cm) are second to none, providing the necessary foundation for assessing terrain attributes associated with landslides.

Landslide Detection Accuracy



Quantum Spatial classification accuracy compared to results from two notable, published studies



Aerial imagery (top left) and Quantum Spatial enhanced relief DEM (bottom right) with classified landslide areas (yellow).

Quantum Spatial achieved a 95% accuracy for landslide detection

Quantum Spatial has developed a unique methodology that incorporates existing techniques from published literature and adheres to the rigors of the scientific method. Statistical analysis indicates terrain classification accuracy of 95%, a vast improvement compared to existing detection methods.

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1. Martha, T.R., et al, 2013. *Landslide hazard and risk assessment using semi-automatically created landslide inventories.* Geomorphology 184, 139–150.
2. Van Den Eeckhaut, M., et al, 2012. *Object-oriented identification of forested landslides with derivatives of single pulse LiDAR data.* Geomorphology 30–42.

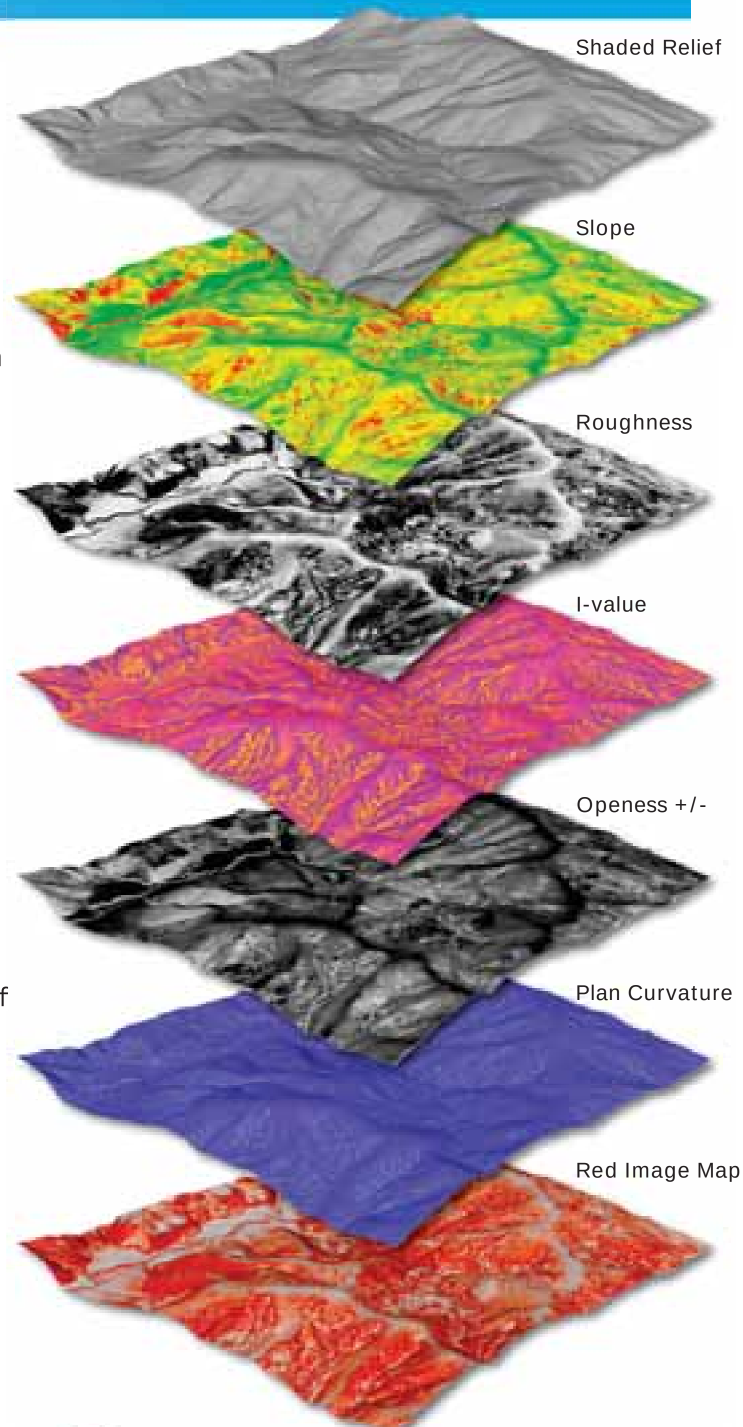
Quantum Spatial's landslide detection relies on a detailed bare-earth DEM derived from a LiDAR ground model. Ground-classified LiDAR points are first processed to create a variety of raster images (≤ 1-meter cell size), which reveal different landform features unique to landslides and faults. These images are then used as inputs for a series of semi-automated classification steps. The various algorithms include a combination of iso-clustering, principal component analysis, and support vector machines, which result in an initial landslide classification.

A step-wise procedure systematically pares the model, excluding non-landslide and non-fault areas from the analysis (*e.g.*, cultivated fields, roads, lakes) that may appear in the initial processing steps.

Iso-Clustering is used to separate the survey region into several distinct classes. This classification technique is an iterative optimization procedure that repeatedly assigns cluster centers, based on the multi-dimensional, topographic characteristics of each input raster image. After each classification step, the algorithm evaluates the results by measuring the minimum distances within each cluster. Each iteration of the procedure causes unique morphological clusters to migrate together. Due to the distinctive morphological signature of these hazardous areas, high-risk landslide features are gradually separated from non-landslide areas. The process is finalized when the most stable arrangement of classified clusters is found and hazard regions are built. Employing zonal statistics, these regions are simplified and condensed down until a dataset outlining potential landslide areas is created.

Once the automated detection is completed, manual editing is performed to eliminate false-positives and to refine the geometry of landslide delineations and fault lines. Upon completing landslide delineation, the landslide areas are automatically assigned respective slope angle, aspect, mean annual precipitation, vegetation cover, and soil attributes.

Continued refinement and corroboration promises enhancement in the automation process, further increasing productivity and reducing cost.



Potential Landslide Areas (yellow) atop DEM with orthoimagery overlay

For more information about automated landslide detection, related literature, or statistical findings referenced in the report, contact Quantum Spatial.