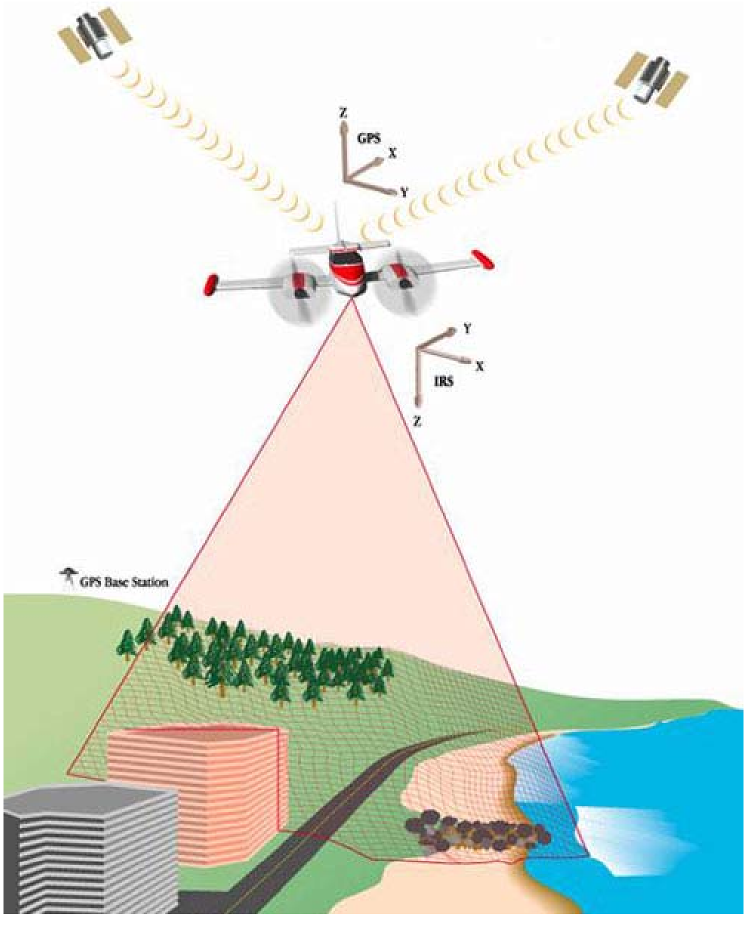
What is LIDAR?

OPG 2007

LIDAR is the acronym for Laser Imaging, Detection and Ranging. It uses a powerful laser sensor mounted on an aircraft comprised of a transmitter and receiver, a geodetic-quality Global Positioning System (GPS) receiver and an Inertial Navigation System (INS) unit. The laser sensor is precision mounted to the underside of an aircraft. Once airborne, the sensor emits rapid pulses of infrared laser light, which are used to determine ranges to points on the terrain below.

Most LIDAR systems use a scanning mirror to generate a swath of light pulses. Swath width depends on the mirror's angle of oscillation, and ground-point density depends on factors such as aircraft speed and mirror oscillation rate. Ranges are determined by computing the amount of time it takes light to leave an airplane, travel to the ground and return to the sensor. A sensing unit's precise position and attitude, instantaneous mirror angle and the collected ranges are used to calculate 3-D positions of terrain points. As many as 100,000 positions or "mass points" can be captured every second.

LIDAR technology offers fast, real-time collection of 3-D points that are accurately geo-referenced and can yield high levels of accuracy for vertical height. The parameters of flying height, swath angle, scanner rate, flight-strip side lap and aircraft velocity determine the point density as a system moves through the air, and these parameters are tailored to accommodate project requirements. An aircraft flies a regular pattern over a project area, for example, and a focused laser sends a variable number of pulses (10-100 KHz is common) to the ground in a fan array across the flight path.



Right: Schematic of a typical LIDAR system (courtesy of NOAA)

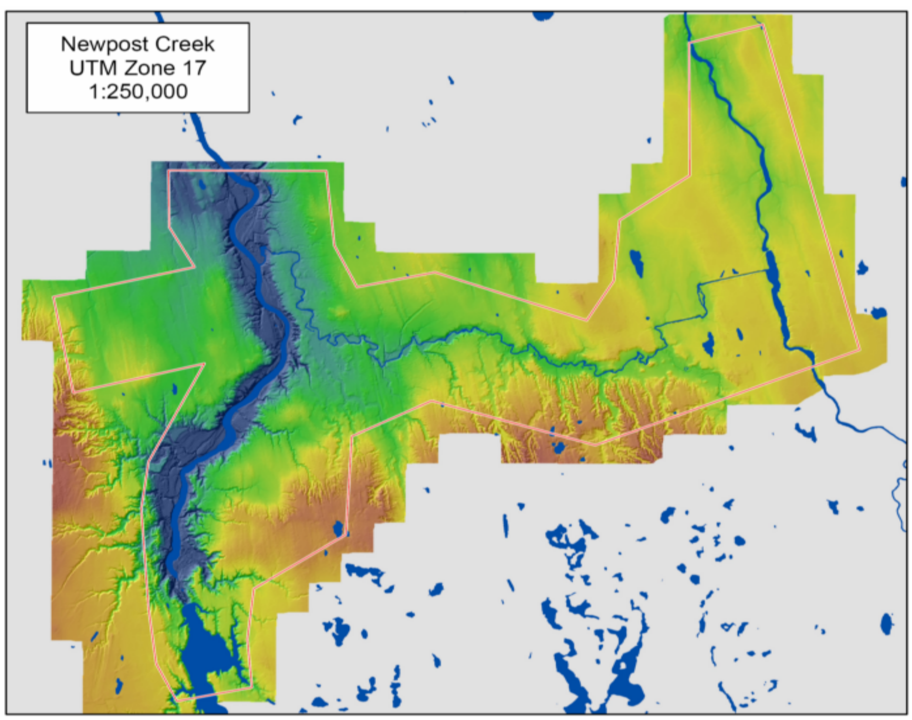
When a pulse hits the ground, the beam's footprint varies between .1 to .5 m, depending on altitude. The reflected light is collected by a receiver, and the interval between transmission and reception also is computed. A LIDAR system can discriminate among multiple returns from each pulse, simultaneously surveying the canopy top and terrain. Multiple returns also can be used to determine intermediate surfaces such as treetops and power lines. In a treed area, for example, the first return may locate the top of a tree, while the last return ideally locates the ground beneath the tree canopy. Multiple returns in between may represent branches, etc. All manmade and natural ground features are surveyed, including trees, buildings, cars, etc.

The LIDAR sensing instruments only collect elevation data. To make these data spatially relevant, the positions of the data points must be known. A high-precision differential Global Positioning System (GPS) using a base station and referenced by known ground control points provides high accuracy. Movement of the aircraft is also recorded by the inertial navigation system and is used to further correct each point returned. As the LIDAR sensor collects data points, the location of the data are simultaneously recorded by the GPS sensor. After the flight, the data are downloaded and processed using specially designed computer software. The end product is accurate, geographically registered longitude, latitude, and elevation (x ,y, z) positions for every data point. These "x, y, z" data points allow the generation of a digital elevation model (DEM) of the ground surface.

A flight over a large area such as New Post Creek (below) will generally last four hours. Weather conditions must be monitored. The flights cannot be flown during times of rain or fog as the water vapor in the air could cause the laser beams to scatter and give false readings. Additionally, the plane cannot fly during times of high winds or fire as the returned laser pulse will not be recorded correctly due to suspended particulates.

Collection and Production Of LIDAR and 0.5 m Contour Data

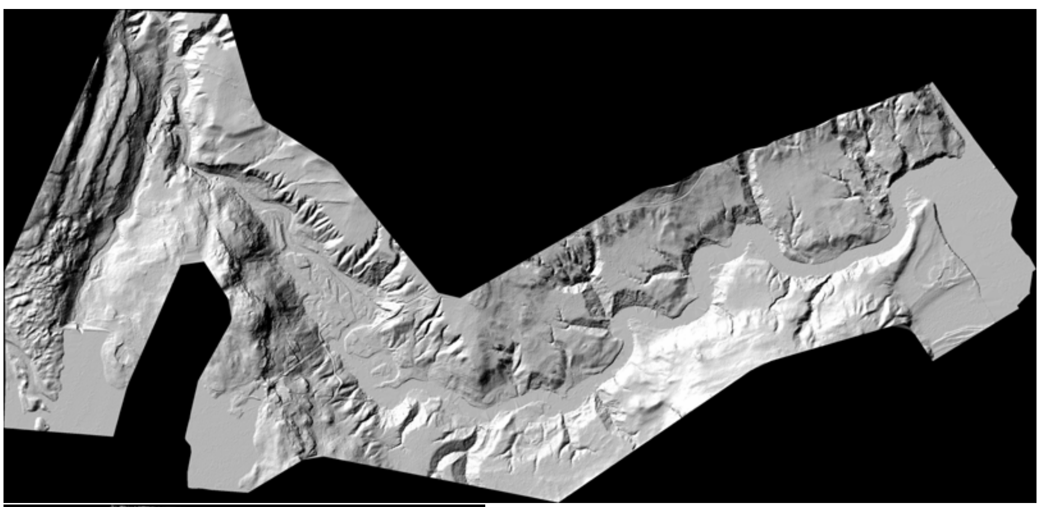
The terrain information used to generate the DEMs and contours is captured using an airborne Light Detection and Ranging (LIDAR). They are interpolated from the LIDAR data and interactively edited to create a seamless and consistent coverage. Image right is an example of a large area collection where data has been processed to render a contiguous dataset for a large site area – New Post Creek near the Abitibi River in northern Ontario.

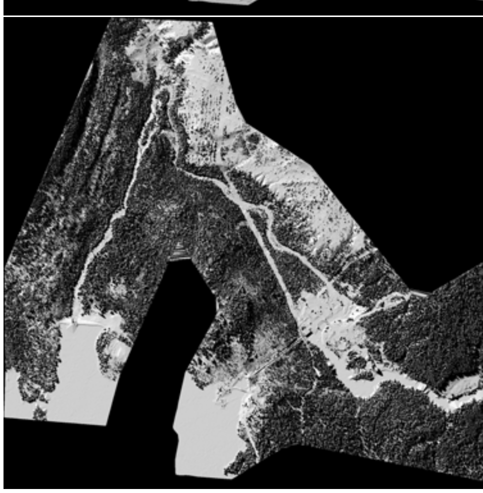


Two types of LIDAR Digital Elevation Models (DEMs)

Bare earth (Digital Elevation Model DEM)	Reflective (digital terrain model DTM)
Three Dimensional coordinate data which has been corrected for vegetation, buildings, and other obstructions	Three Dimensional coordinate data with buildings, roads and highways included in the digital elevation file
Reflects actual ground surface elevation	Reflects actual buildings elevations
Used as the base to display the buildings from the earth surface	Used to calculate the buildings heights
Delivered in ASCII format	Delivered in ASCII format

Below: Digital – Bare –Earth model of Matabichuan GS in Ontario

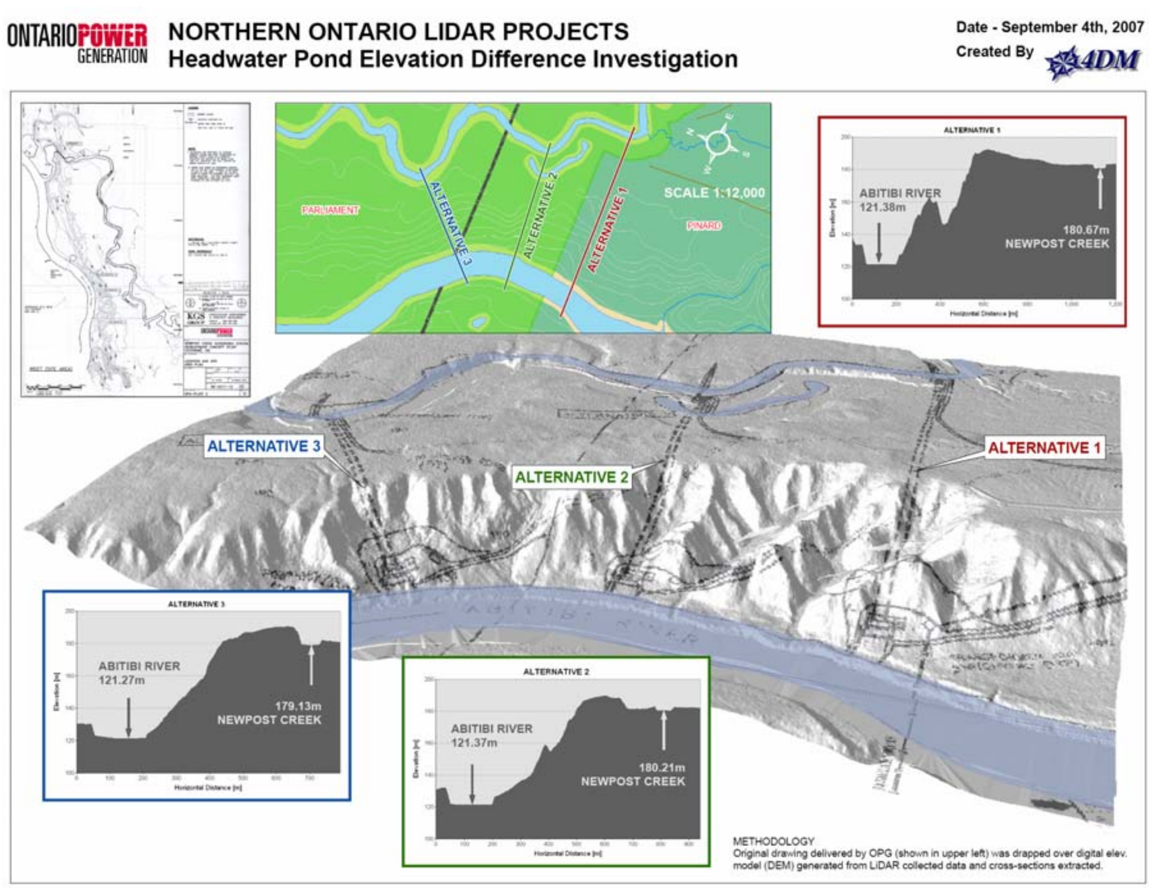




Left: Digital Terrain model showing vegetation and ground elevation.

Application of LIDAR Data to Hydroelectric Projects

When hydroelectric sites are evaluated for their potential and cost there are critical pieces of information that must be known in advance to provide a basis to justify the cost of building a new site. Head, flow duration, site configuration, geology, geomorphology, land tenure, land cover, detailed contour data, flood modeling. Using LIDAR much of this information can be easily collected. Below is an example of an application of LIDAR to evaluation of development options New Post Creek.



Orthorectified consultant drawings are draped over the bare earth elevation data for the site rendered as a hillshade model. Profile data is derived directly from the data and displayed as inset graphs showing absolute elevations as a function of distance. Head heights are known within centimeters of accuracy for each layout. Volumes can also be estimated for planned cut and fill and 3d drawings can be superimposed to provide detailed excavation and layout information. These maps and models can also be used to survey and map data for land tenure purposes and can serve a highly accurate baseline for erosion and environmental studies, modeling flood and surface area variations and in combination with digital aerial orthophotos[1] can create visualization graphics that can be valuable for public communications and aesthetic studies.

[1] An orthophoto is an aerial photograph which has been geometrically corrected. The scale of the orthophoto is uniform and can be used to measure true distances. In simple terms, it is an aerial photo which has control points (features in the photo such as a road intersection) which are used to move the photo to that coordinate position of the feature.