What is lidar mapping?

Light **d**etection **a**nd **r**anging (lidar) is a remote sensing technology used to acquire elevation data about the Earth's surface. A lidar system consisted of three main components: the laser ranging system, Global Positioning System (GPS) and Inertial Measurement Unit (IMU) (Figure 1). The laser ranging system transmits a laser pulse down to the Earth's surface, and the time delay between the transmission of the laser pulse and its return to the sensor is measured. This two-way travel time is then converted into a range or distance from the sensor to the target. The range has a time stamp based on the precise GPS time and is related to the lidar sensor scan angle and the aircraft position. The aircrafts' 3-D (x,y,z) position is maintained by the precise survey GPS and the IMU is used to measure the roll, pitch and heading of the aircraft so that the ranges measured by the lidar sensor can be converted to points and georeferenced (x,y,z coordinates) and represented as a lidar point cloud) (Figure 2). The point cloud is processed using software to detect points that represent the ground. This is known as lidar point classification (Figure 2).

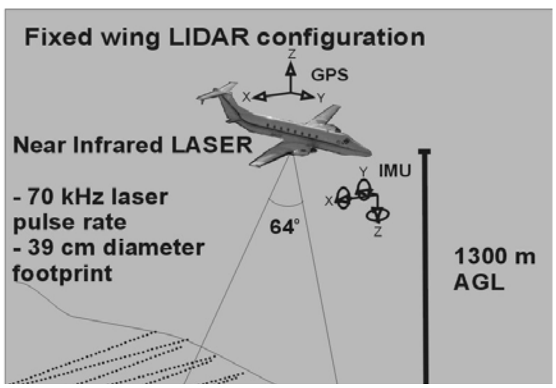

Figure 1- Typical lidar configuration used by AGRG for the topographic coastal surveys prior to 2014.

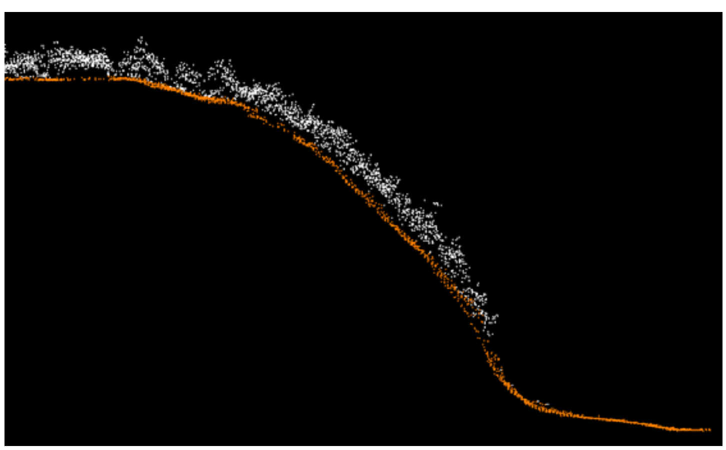

Figure 2- Example of lidar point cloud. Orange points represent ground points and white points represent non-ground points (trees).

How can we use lidar technologies for flood risk mapping?

The minimum lidar classification involves detecting the lidar points that represent the ground. More advanced classifications involve determining if the points represent vegetation, building or power lines for example. Once the lidar is classified, the points are converted into a continuous surface model that can be colourized and have artificial sun shading applied to enhance the relief. If only the ground lidar points are used to produce the continuous surface we call that a "bare earth" Digital Elevation Model (DEM) (Figure 3 A).or a Digital Terrain Model (DTM). If all of the valid lidar points are used to build the model it is knows as a Digital Surface Model (DSM) (Figure 3 B).. Since the DSM represents the tops of the building and trees, it can be subtracted from the DEM to produce a Normalized Height Model (NHM), or if forest only a Canopy height Model (CHM). These models are stored in a raster format as grid cell or pixels where the value of each cell represents the elevation of the feature (eg. Ground or building etc.). The surface models constructed from the lidar have grid cells of 1-2 m in size because of the dense point spacing resulting from the lidar survey. The vertical accuracy of the lidar data is also very high and is typically within 15-30 cm in open flat terrain, thus making it the preferred data to use for flood risk mapping.

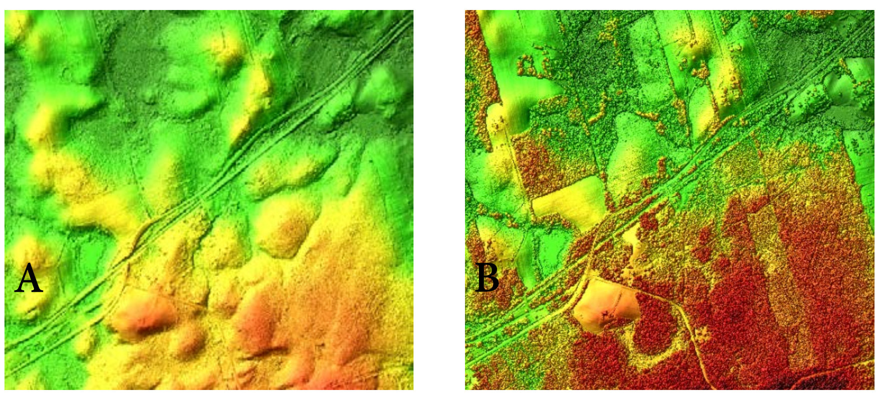

Figure 3 - Image A represents a bare earth Digital Elevation Model (DEM) while Image B represents a Digital Surface Model (DSM) including features such as buildings and trees.

The bare earth DEM's were used to generate the flood inundation layers for this project. By ensuring that the DEM's are hydraulically connected. Roads which have streams or rivers running under them most often contain a culvert or bridge to allow for the flow of water. The lidar is not able to measure below the earth and detect a culvert, therefore the road on the DEM does not represent the correct path for water to move. In these cases the DEM was modified and the values altered where culverts and bridges exist so that as the ocean water is raised, it can move to low lying areas correctly. Ensuring hydraulic connectivity allows flood inundation mapping to be as accurate as possible.

The latest lidar systems allow elevation to be surveyed above and below the water line

In 2014 the Applied Geomatics Research Group, NSCC acquired a topographic-bathymetric lidar system. The Chiroptera II System manufactured by Leica Geosystems is equipped with 4 different sensors: a near-infrared (NIR) laser that can fire at 500kHz (500,000 shots per second) for mapping topography, a green laser (35kHz) for mapping bathymetry (Figure 4), and 60 megapixel camera that can acquire true colour (RGB) and near-infrared (NIR) images as well as a 5 megapixel quality assurance (QA) camera. The green laser is able to penetrate through the water column to reach the bottom of the seabed, enabling the bathymetry to captured. This allows a continuous DEM to be constructed that seamlessly measures the elevation from land to under the sea or fresh water. The ability to survey the near-shore environments instead of just the land improves our ability to use hydrodynamic models to circulate the water during storm surges. The nearshore topography, water level and wind are the dominant factor controlling how waves behave near the shoreline. As more data is collected using this system, eventually wave runup can be modelled and incorporated into this flood risk mapping tool.

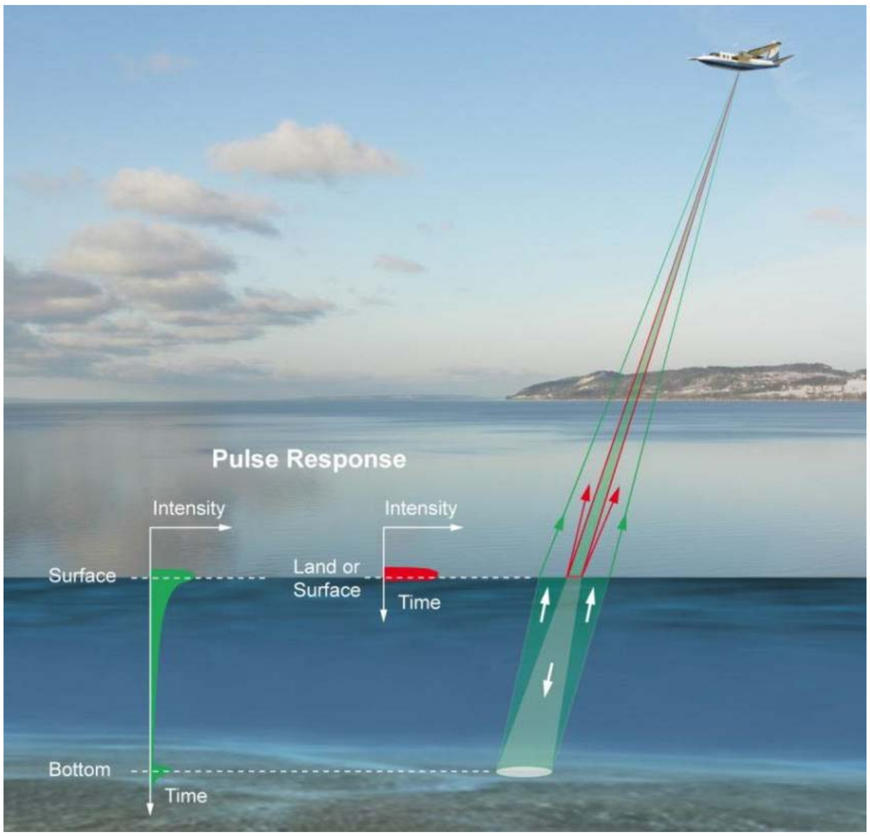

Figure 4- Example of how a topo-bathymetric lidar system works.

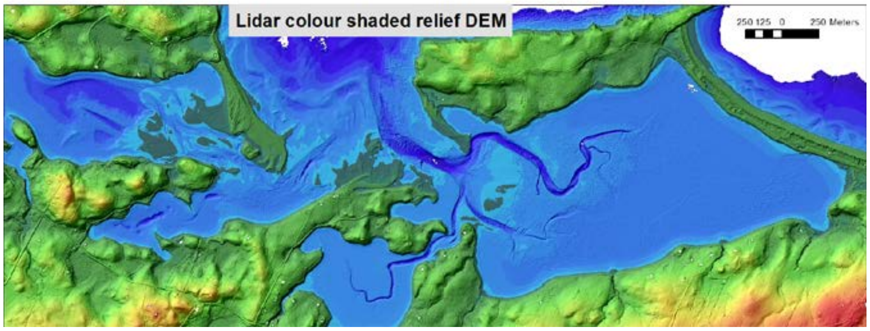

Figure 5 Example of a seamless DEM from a topo-bathymetric lidar sensor.