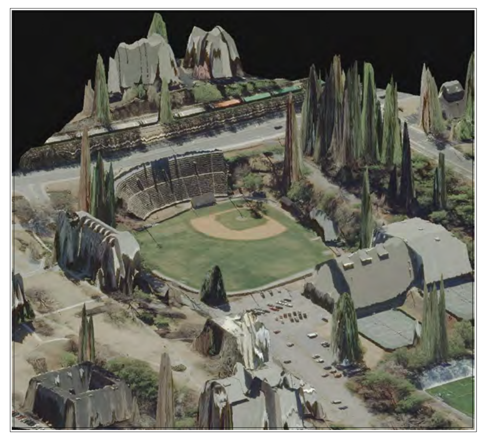
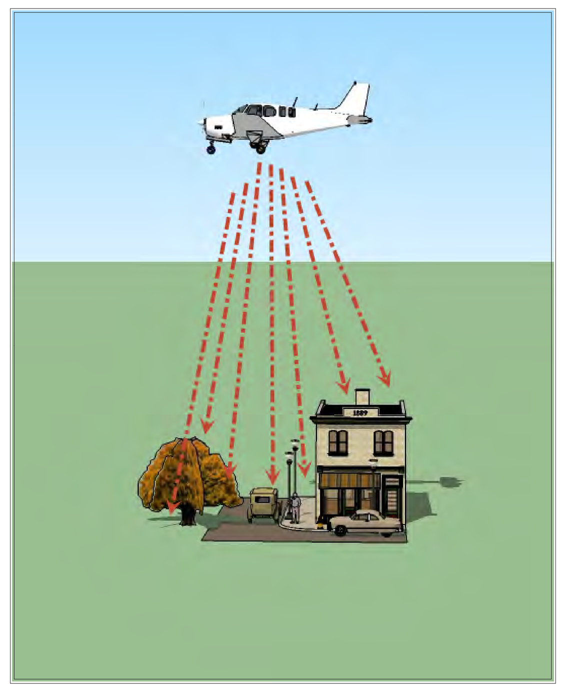
A "30,000 Foot Overview" of LiDAR (Light Detection and Ranging)

LiDAR provides low-cost capabilities to acquire detailed three-dimensional data over a large area in a relatively short period of time.

Hermance Stadium Built 1920
Listed on the National Register of Historic Places
Oglethorpe University Brookhaven, Georgia



Data Collection Methods



Airborne Collection Method
In order to collect data the LiDAR sensor is mounted below an aircraft where it emits short infrared laser pulses towards the earth's surface. Each pulse results in multiple echoes or 'returns'. The first return will usually be received from the tops of trees and vegetation, but as the laser penetrates the canopy further returns are received from low vegetation or buildings, or water surfaces. Typically, the last return is received from the ground surface. As the airplane moves forward the position of each return, or point, can be calculated using global positioning systems (GPS) in tandem with a fixed ground-base system, while the pitch, roll and yaw of the aircraft is recorded by an inertial measurement unit to increase accuracy. Each point therefore has a set of x, y, and z coordinates to reflect its position and elevation.

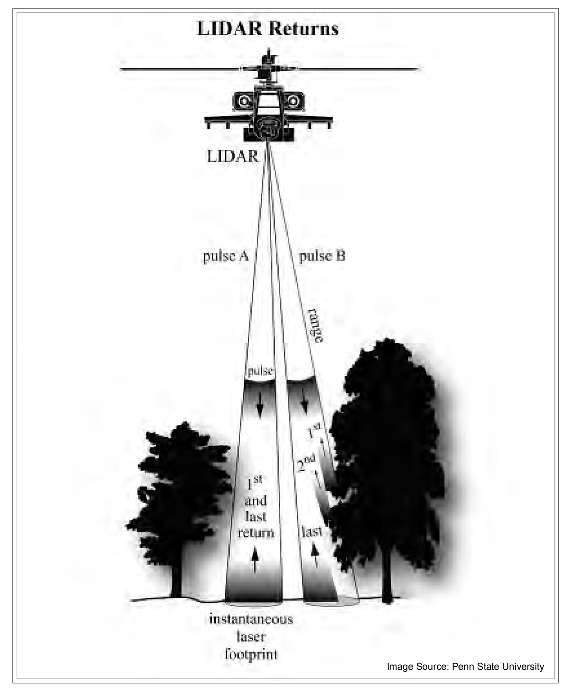
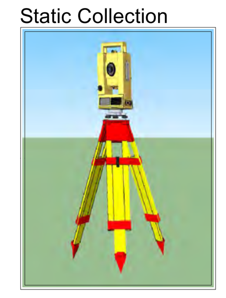


Image Source: Penn State University

Ground-Based Collection Method
There are two main types of ground-based or terrestrial lidar: mobile and static. In the case of mobile acquisition, the lidar system is mounted on a moving vehicle. In the case of static acquisition, the lidar system is typically mounted on a tripod or stationary device. Ground-based LiDAR collection uses the same same technology as the airborne collection method. Ground-based collection allows for detailed LiDAR collection at the ground level or inside buildings or natural feature such as caves.

Static Collection



Mobile Collection

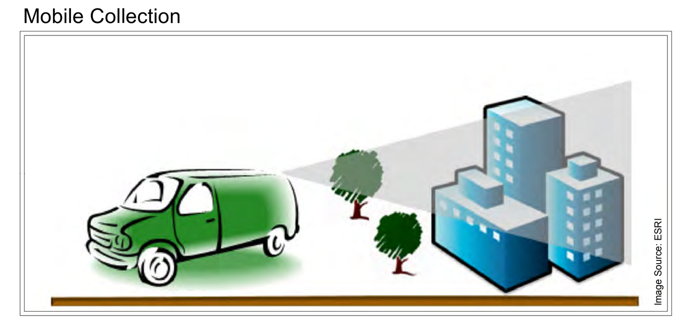
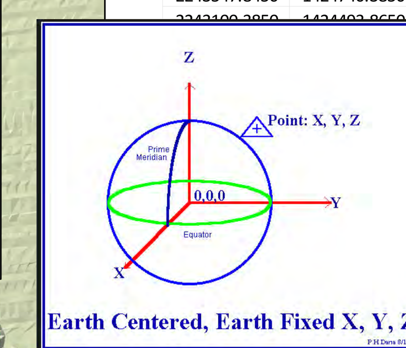


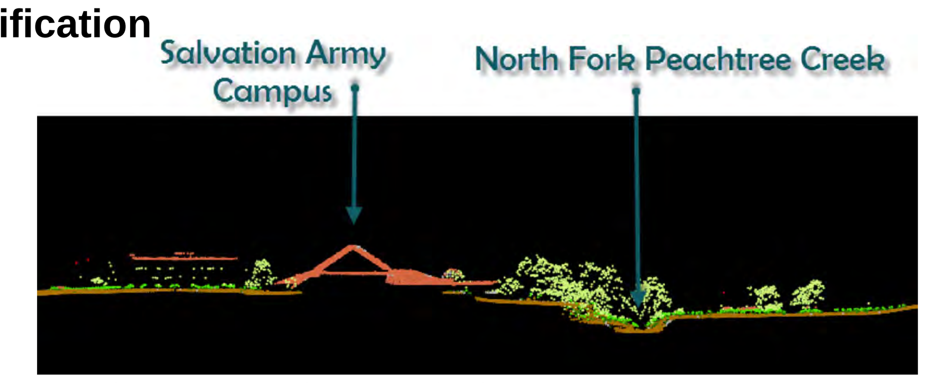
Image Source: ESRI

Data Processing and Classification

XYZ Coordinate Table
Raw data called XYZ Coordinates are processes then classified into ground, vegetations, buildings or other classifications such as elevation or return value.

X Coordinate	Y Coordinate	Elevation (Z)	Type
2242653.5550	1424905.8150	1042.69	Vegetation
2242877.1400	1424905.9300	993.56	Ground
2242653.4900	1424740.4400	1003.67	Building
2242653.4800	1424493.8850	984.67	Ground
2242877.1100	1424493.8550	976.90	Vegetation
2243100.7200	1424905.8050	996.14	Ground
2243324.3000	1424905.8250	998.53	Ground
2243547.8900	1424905.8500	972.88	Vegetation
2243100.7100	1424699.8350	965.63	Building
2243324.3250	1424740.4350	989.22	Ground
2243547.8450	1424740.3850	992.81	Ground
[illegible]	[illegible]	981.20	Vegetation
[illegible]	[illegible]	992.09	Ground
[illegible]	[illegible]	1132.57	Building
[illegible]	[illegible]	1001.38	Vegetation
[illegible]	[illegible]	993.94	Ground
[illegible]	[illegible]	1005.10	Vegetation
[illegible]	[illegible]	1021.33	Building
[illegible]	[illegible]	1032.00	Vegetation





Above: Cross-section view of LiDAR data classified by type. Buildings in red, vegetation is yellow and ground surfaces are orange.


Above: Cross-section view of LiDAR data classified by elevation. Yellow is high elevation,green is medium elevation, and white is low elevation.

Uses and Analysis

Forestry Management and Planning
LiDAR is unique in its ability to measure the vertical structure of forest canopies, as well as mapping the ground beneath the forest. LiDAR is able to predict, amongst other things, canopy fuel capacity for use in fire behaviour models.

Biology and conservation
LIDAR has also found many applications in forestry. Canopy heights, biomass measurements, and leaf area can all be studied using airborne LIDAR systems. LIDAR allows research scientists to not only measure the height of previously unmapped trees but to determine the biodiversity of the forest. This technology will be useful in directing future efforts to preserve and protect ancient trees.

Mapping and Cartography
LiDAR can assist in road, building and vegetation mapping. The 3D aspect of LiDAR makes it especially suitable for mapping terrain models, including complex mountain topography.

Cellular Network Planning
LiDAR provides detailed information that can be incorporated into statistical or GIS software and used to provide accurate analysis for determining line of sight and view shed for proposed cellular antenna.

Quarries and Minerals (Volumetrics and Exploration)
LiDAR can also be useful for existing quarry sites. Its high accuracy means that a quick survey can be undertaken that will give precise volumetric measurements within a few centimeters.

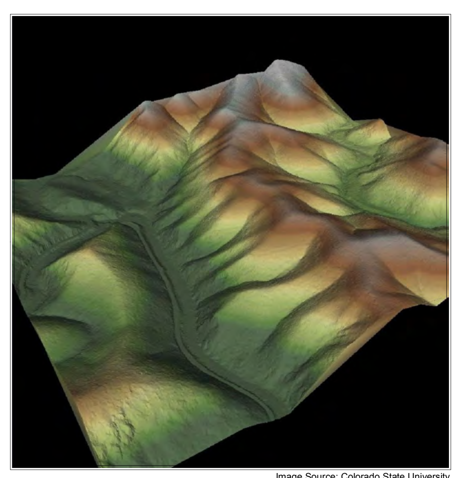


Image Source: Colorado State University

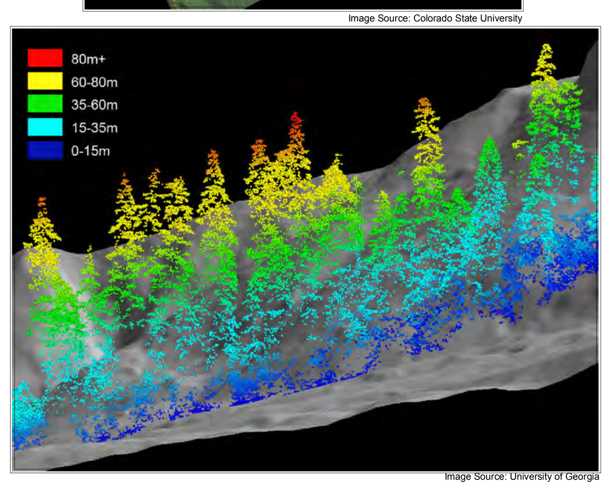


Image Source: University of Georgia

Gaming
LiDAR allows any physical object to be re-created in a computer environment. In the gaming industry LiDAR allows the quick and precise creation of whole cities, sport complexes or natural features.


Image Source: OpTech Inc.

Meteorology
The first LiDARs were used for studies of atmospheric composition, structure, clouds, and aerosols.
Elastic backscatter LIDAR is the simplest type of LiDAR and is typically used for studies of aerosolsand clouds.
Differential Absorption LIDAR (DIAL) is used for range-resolved measurements of a particular gas in the atmosphere, such as ozone, carbon dioxide, or water vapour.
Raman LIDAR is also used for measuring the concentration of atmospheric gases, but can also be used to retrieve aerosol parameters as well.
Doppler LIDAR is used to measure wind speed along the beam by measuring the frequency shift of the backscattered light.

Navigation
LiDAR is becoming more popular as a guidance system for self-driving vehicles. The speed and accuracy of a scanner means that data can be passed to a system to process the return in more or less real-time. This allows the device controlling the vehicle to detect obstacles and to achieve the smoothest and safest ride.

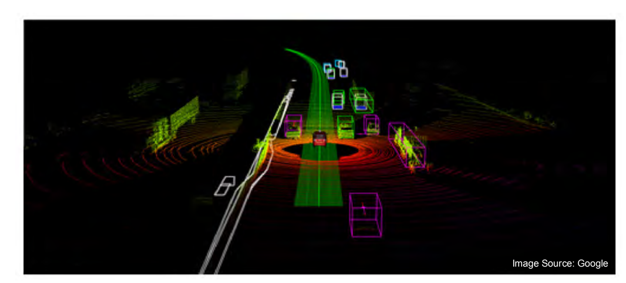


Image Source: Google

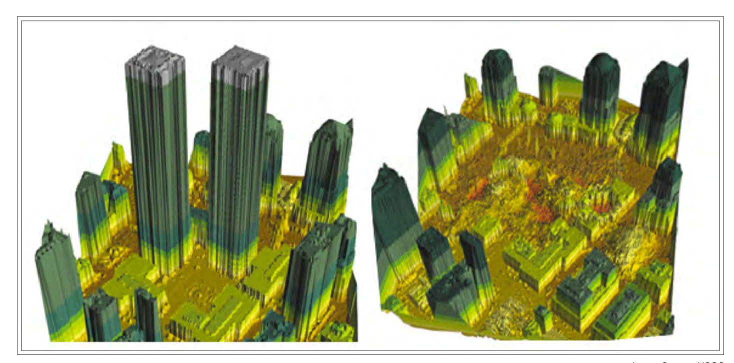
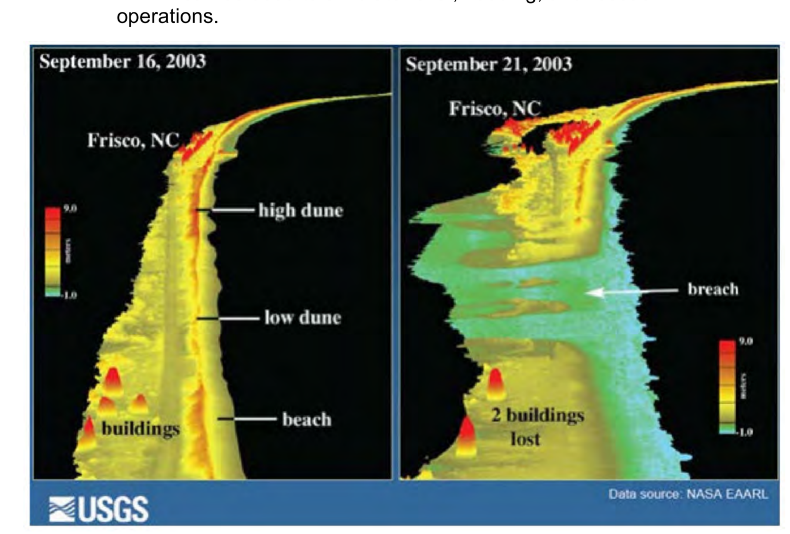


Image Source: USGS

Scene of Accident/Crime
By using a ground based LiDAR system it is possible to record the scene of a car accident within a few minutes, enabling the emergency services to clear the scene and then to reproduce it later on in the digital realm. This reduces traffic jams as well as preserving the evidence before anything is compromised.

Flood Modeling
Flood Modeling is a major use of LiDAR technology. LiDAR is used to predict the extents of different magnitudes of flooding. LiDAR can be used to simulate relief, flooding, and rescue operations.



Sewer and Manhole Maintenance
LiDAR data can also be obtained by sensors mounted on remotely controlled vehicles. A robotic vehicle can be sent down sewers and take detailed surveys of the interior of the system. It is also possible for the airborne pollutants to be measured at the same time.

Geology
In geology and seismology a combination of aircraft-based LIDAR and GPS have evolved into an important tool for detecting faults and measuring uplift. NASA's Airborne Topographic Mapper is also used extensively to monitor glaciers changes.

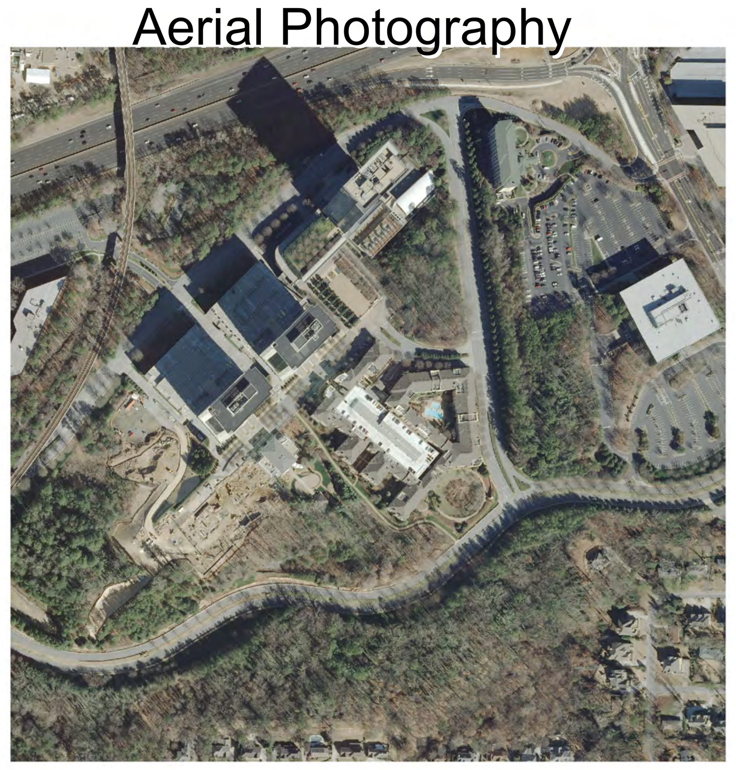

Image Source: SamsInc-Austraila

Building Restoration
Using a ground based LiDAR survey it is possible to capture minute details in building facades. This detail is a valuable record of the current condition of a building and can be used as the basis for a digital restoration before any work takes place.

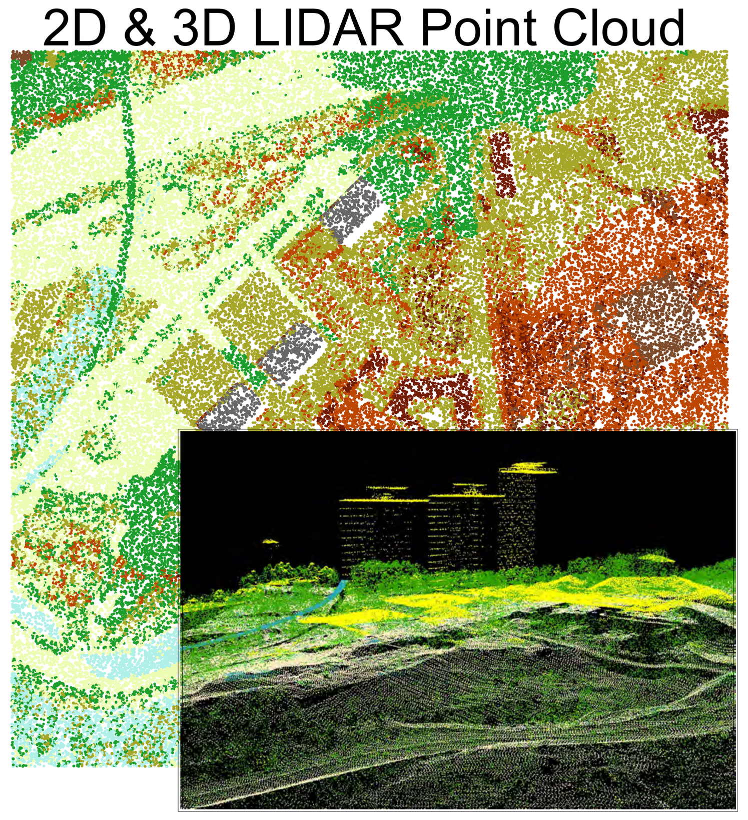
Text Source: LIDAR-UK.com

Creating 3D Models using LiDAR & Aerial Photography

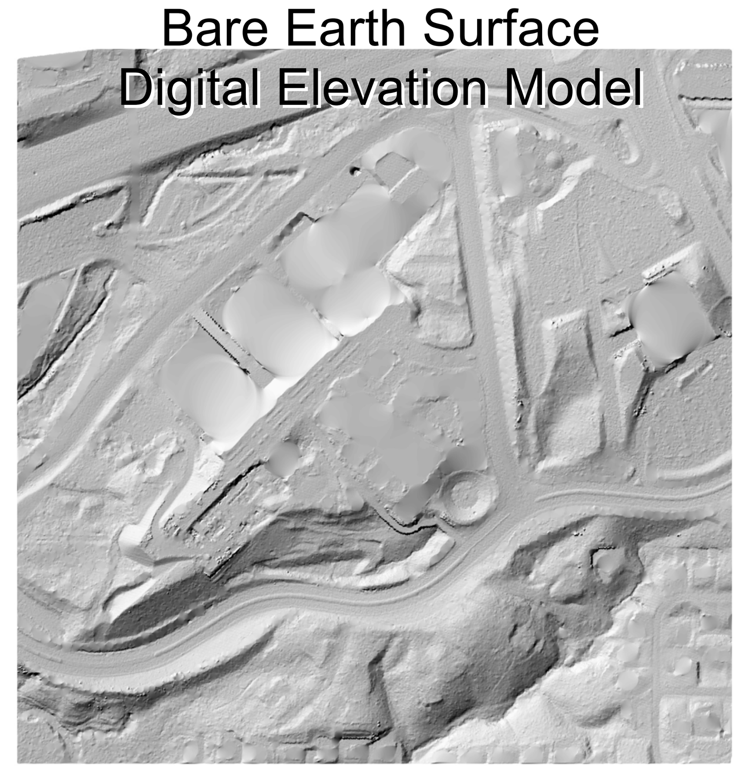
Aerial Photography



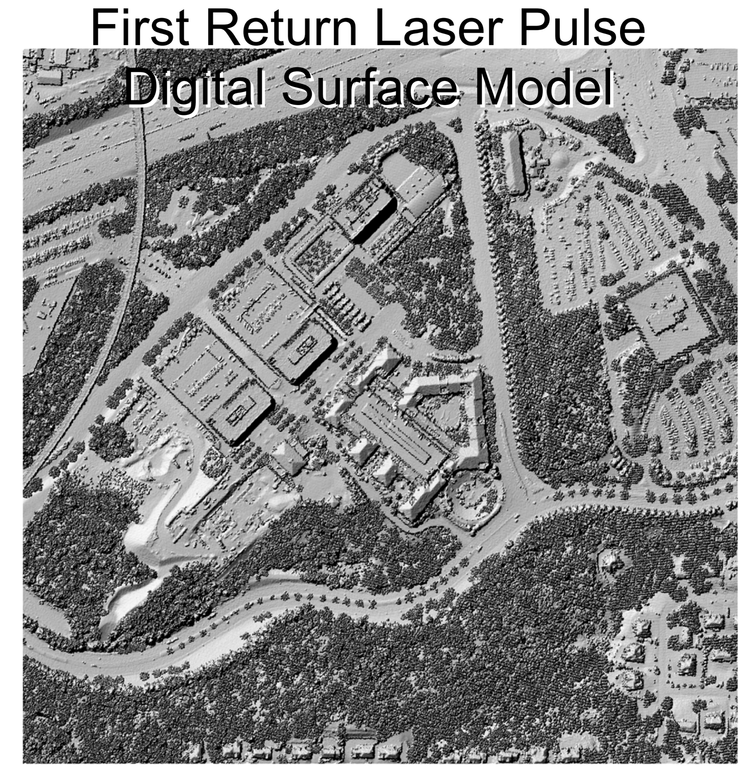
2D & 3D LIDAR Point Cloud



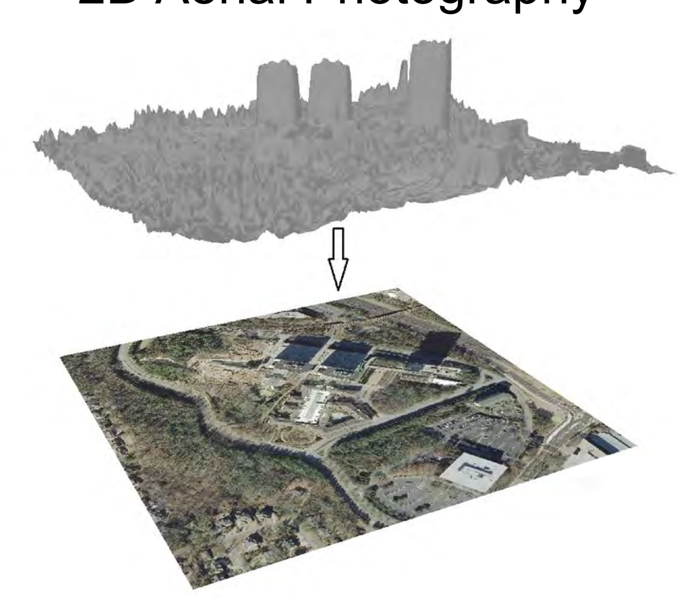
Bare Earth Surface Digital Elevation Model



First Return Laser Pulse Digital Surface Model



3D Digitial Surface Model & 2D Aerial Photography



3D Digitial Surface Models