

## The Basics: Laser Radar - LIDAR

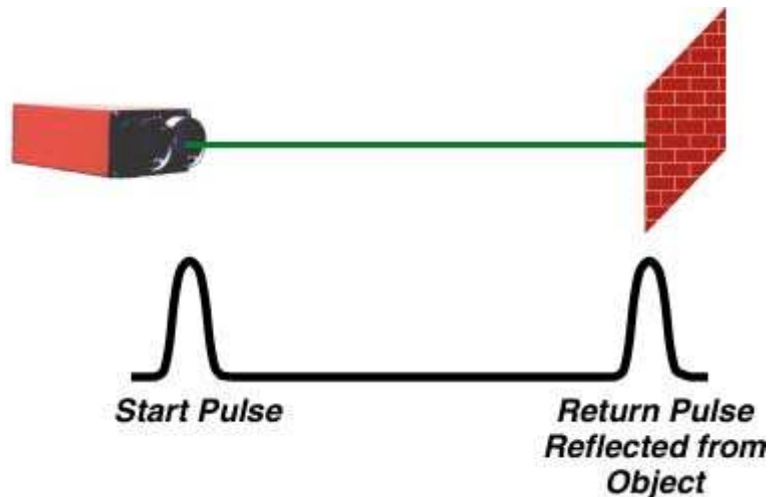
Almost all Optech products are based on the same technology: laser radar, or lidar. It works a lot like ordinary radar, except that our systems send out narrow pulses or beams of light rather than broad radio waves. A receiver system times, counts and processes the returning light.

**Laser + Receiver System = Lidar (Light Detection and Ranging)**

Laser radar depends on knowing the speed of light, approximately 0.3 metres per nanosecond. Using that, we can calculate how far a returning light photon has travelled to and from an object:

$$\text{Distance} = (\text{Speed of Light} \times \text{Time of Flight}) / 2$$

1. Laser generates an optical pulse.
2. Pulse is reflected off an object and returns to the system receiver.
3. High-speed counter measures the time of flight from the start pulse to the return pulse.
4. Time measurement is converted to a distance by using the formula above.



### 1. First/Last-Pulse Measurements

Our counting electronics can operate in two modes:

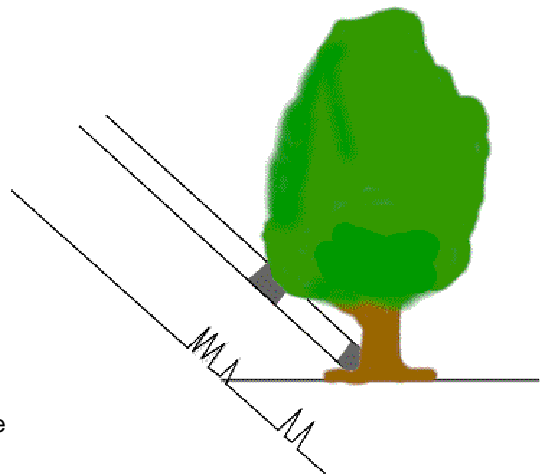
#### First-pulse

Measures the range to the first object encountered - in this illustration, the tree foliage.

#### Last-pulse

Measures the range to the last object - in this case, the ground.

By acquiring first- and last-pulse data simultaneously, Optech's ALTMs can measure both tree-heights and the topography of the ground beneath in a single pass.



## **2. Are Measurements Affected By ...**

### **Reflectivity of the Object**

Not usually. Highly reflective objects may saturate some laser detectors, while the return signal from low-reflectivity objects may occasionally be too weak to register as valid.

### **Day or Night**

No. Laser radar is an "active illumination" technique that, unlike photography, does not depend on ambient illumination. It works during the day or at night.

### **Sunlight and Reflections/Angle of Measurement**

Sometimes. A strong sunlight reflection off a highly reflective target may "saturate" a receiver, producing an invalid or less accurate reading. However, laser measurements are not usually affected by other reflections.

Optech's scanning laser instruments scan laser pulses within a preferred range of angles. Instruments are designed to operate in daylight.

### **Dust and Vapour**

Yes. Laser measurements can be weakened by interacting with dust and vapour particles, which scatter the laser beam and the signal returning from the target. However, using last-pulse measurements can reduce or eliminate this interference.

Optech systems that are expected to work in such conditions regularly can be optimized for these environments.

### **Target's Angle of Repose**

Laser measurements can be made to targets at any angle.

### **Background Noise and Radiation**

The laser is not affected by background noise. Optech products determine baseline radiation levels to ensure that it does not interfere with measurements.

### **Temperature and Temperature Variations**

Laser measurements are based on the speed of light and are unaffected by temperature variations. Optech products have a defined operating temperature range, which varies by product.

### **Vessel Pressure and Off-Gas Layers**

The laser is unaffected by pressure or vacuum variations, or off-gas layers.

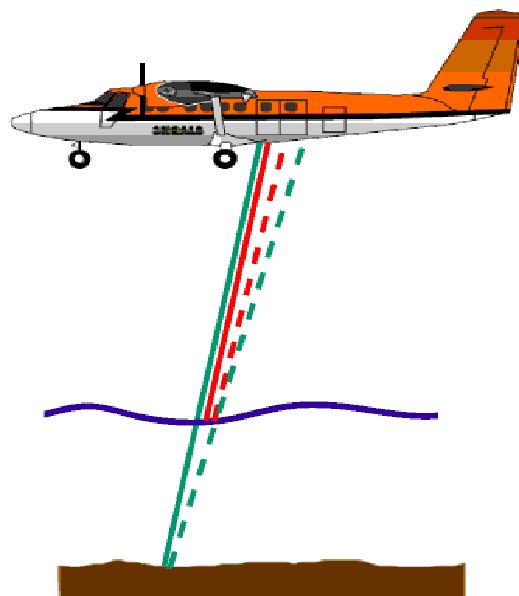
### 3. Lidar for Hydrographic Measurements (Bathymeters)

The DIAL principle described in the previous section also lies behind lidar bathymetry, a technique that uses two laser wavelengths to measure the depth of coastal waters down to about 50 m, as well as shoreline topography. It works like sonar, but uses light instead of sound.

As shown on the right, a lidar bathymeter fires co-aligned laser pulses at the water: the **red wavelength** is reflected by the water surface and detected by the receiver, while the **blue-green wavelength** penetrates the water surface and is reflected from the bottom.

The **time difference** between the two signals, after accounting for a range of system and environmental factors, determines the water depth.

We can also use this technique to locate objects on the ocean floor, from **sunken ships** to **small targets**.



### 4. Differential Absorption Lidar (DIAL) for Atmospheric Measurements

Optech designs and builds laser radar systems that measure the concentration of certain gases or atmospheric constituents in the atmosphere - ozone, for instance, or aerosols. These systems, called DIALs, work by exploiting the fact that a gas will absorb light emitted at a certain laser wavelength while transmitting light at most others.

So if we send two selected wavelengths at the same time in the same direction, a gas will absorb light at one wavelength. When the light returns to our detection electronics, the signal will be stronger for one wavelength than for the other. By comparing the two, we can determine the concentration of the gas at that particular region of the atmosphere - hence differential absorption.

Optech has installed systems that use this technique to measure ozone concentrations in the Canadian Arctic, in Norway, and at York University in Toronto, Canada.

### 5. Intensity Measurements (ALTM, ILRIS-3D, Vision & Imaging)

Our data processing software can categorize detected laser pulses according to the reflectivity of the target surface. The output has the detail of high-resolution photographs, yet images can be taken at night and the data are already in digital form.

**Highly reflective materials = Strong (intense) return signal**

#### High Reflectivity:

- Light surfaces
- Grass
- Trees
- Water (wavy conditions)

#### Low Reflectivity:

- Dark surfaces
- Asphalt
- Coal, iron oxide
- Wet surfaces, mud
- Still water

#### Factors Affecting Reflectivity:

- Elevation
- Composition
- Density
- Orientation to the sensor

## 6. Glossary:

<b>DIAL</b>	Differential Absorption Lidar
<b>Laser</b>	Light Amplification by the Stimulated Emission of Radiation
<b>Lidar</b>	Light Detection and Ranging
<b>Lidar Bathymetry</b>	Using Lidar technology to measure water depths

## 7. Links

[www.rli.com](http://www.rli.com) Rockwell Laser Industries, Inc. operates an informative site about laser instrument classes, laser safety, and U.S. government laser regulations. Includes many links to laser safety-related sites.

## 8. Hardware

**Each ALTM system includes the following hardware:**

- Pilot display
- Vibration-isolated control rack with ruggedized removable hard drive
- Sensor head; fits standard camera mounts or mounts directly to floor of aircraft and features adjustable tilt angle (up to 18°)



Pictures from first ATML 3100 installation and flight-testing in January 2005



Optech ATML 3100 Scanner Head installed in PC-6 MSN 935 (HB-FMP)