# LASERS

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# LIDAR

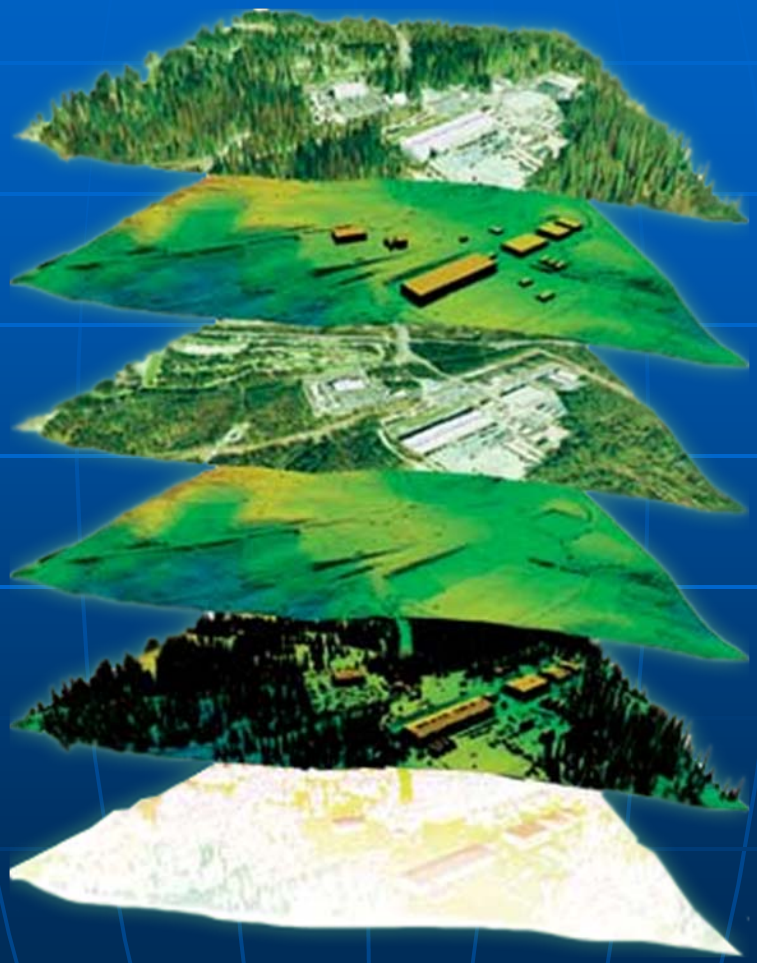
# LIDAR/LADAR

- Light/Laser Detection and Ranging
- Similar to Radar (Radio Detection and Ranging)
  - Transmits radio pulses and waits for the reflection, then uses data (time until return) to calculate the distance of an object.
- Uses in archaeology, geology, geomorphology, atmospheric physics, etc.

# Applications

- LIDAR can be applied as a tool for capturing data on:
  - Distance
  - Chemical composition
  - Speed

# Terrain Mapping



# Terrain Mapping

- Airborne laser mapping technology
- A LIDAR system aboard an airplane scans the surface and the data acquired is used to generate 3D renderings of the terrain.
- Data used for geographic surveys and planning.

# Terrain Mapping

- For more information:
  - http://lidar.cr.usgs.gov/
  - http://www.sbgmaps.com/lidar.htm
  - http://www.youtube.com/watch?v=JvauCmPAjuI

# LASERS AND ATMOSPHERIC READINGS

# LIDAR Atmospheric Mapping

- Combinations of lasers allow for mapping of atmospheric contents
  - Accomplished by examining wavelength-dependent changes in the intensity of the returned signal

# System

- High powered (as opposed to micropulse) LIDAR systems are typically used for atmospheric research
  - Used for measuring atmospheric parameters
    - height/layering/density of clouds, cloud particle properties, temperature, pressure, wind, humidity, trace gas concentration

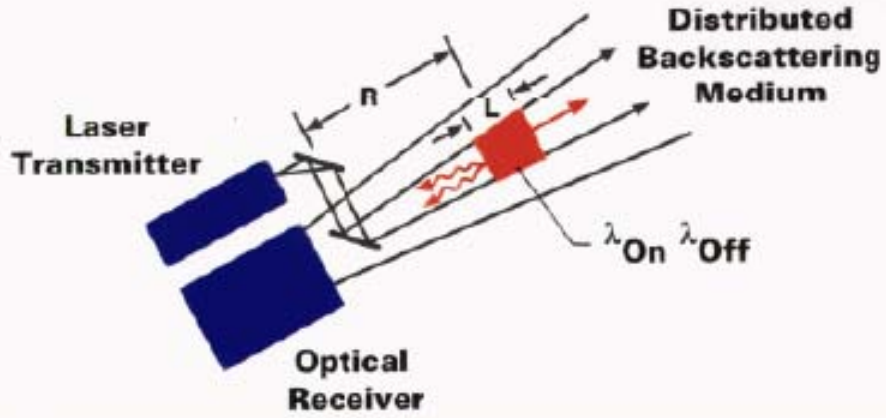
# Youtube Video

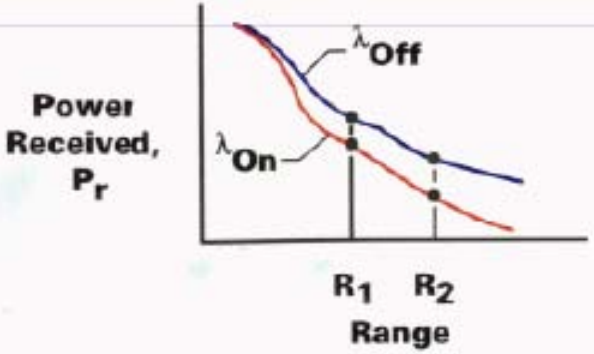
- http://youtube.com/watch?v=34AXOmshQbw
  - 5:05

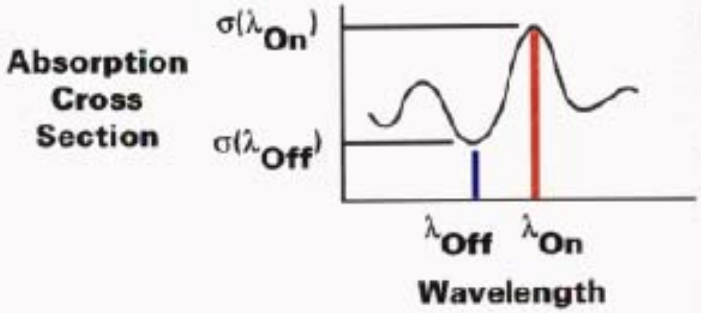
# DIAL

- Ultraviolet Differential Absorption LIDAR
- Measures ozone as well as aerosols and clouds simultaneously
  - Location and amount can be determined through calculations based on five laser wavelengths
- Used for readings in the troposphere & stratosphere

# Differential Absorption Lidar (DIAL) Concept




$$N_A = \frac{1}{2(R_2-R_1)\,[\sigma_A(\lambda_{On})-\sigma_A(\lambda_{Off})]}\ \ln\left[\frac{P_{r_{On}}(R_1)\times P_{r_{Off}}(R_2)}{P_{r_{Off}}(R_1)\times P_{r_{On}}(R_2)}\right]$$

# LIDAR Atmospheric Sensing Experiment (LASE)

- Previous DIAL system experiments consisted of tunable lasers requiring real-time experimenter control
- The LASE program is working on autonomous DIAL systems

# Future of LASE

- Being reconfigured to fly on NASA DC-8, P-3 aircraft & the ER-2
- Considered the first step toward developing a spaceborne LIDAR instrument

# MEASURING SPEED

## Speed Guns

# Laser Guns

- Police lidar laser guns use a pulsed infrared laser invisible to the human eye
- The gun shoots anywhere from 100-600 pulses per second
- The beam itself can travel up to 2000 feet one way
- From 1000 feet, the beam itself forms a 3 foot square on the target

# Functionality

- Using *Distance = (Speed of Light x Time of Flight) / 2* the gun can determine the speed of the object, as well as the distance between two objects.
- Although the laser moves about 1 foot per nanosecond, it is more difficult to use since you must focus on one point and remain very still. Radar, on the other hand, uses a much broader electromagnetic pulse, but moves at a much slower speed.

# Getting the Best Data

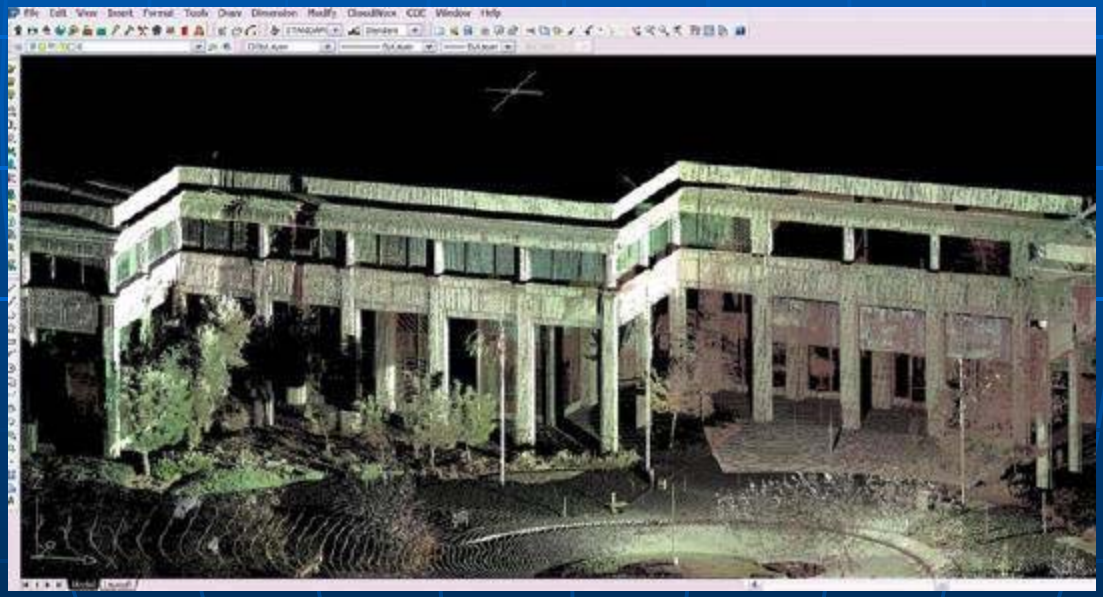
- License plates
- Headlights, taillights and fog lights
- Sections of chrome
- Frontal shape of the vehicle
- Color and type of paint

# Video

- http://youtube.com/watch?v=lBbrLWETQT8

# 3D LASER SCANNING

## The Next Breakthrough Technology?



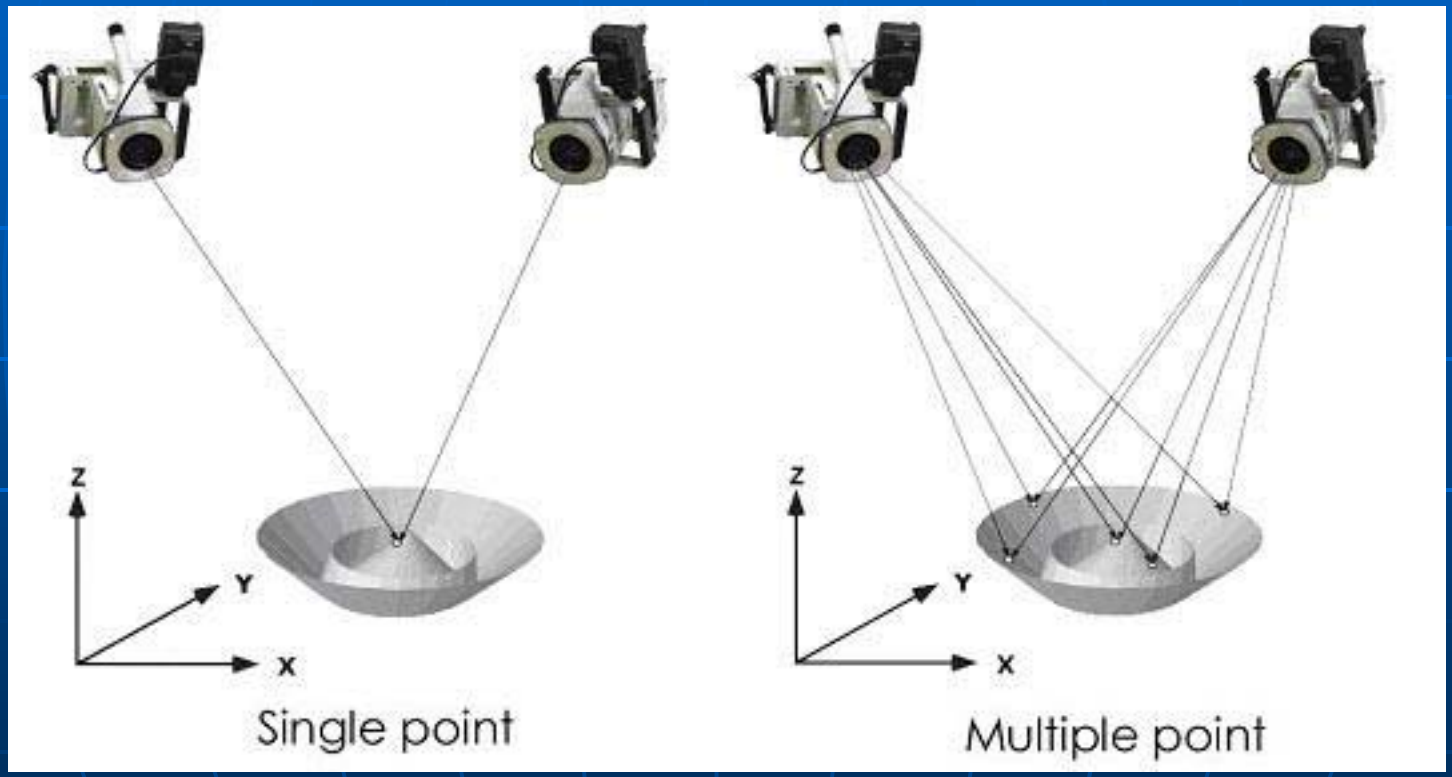
# Types of 3D Scanning

- Two types of 3D scanners
  - Contact
  - Non-Contact.
    - Active Scanners
    - Passive Scanners

# 3D Scanning Without the Laser

- Contact
  - Contact 3D scanners probe the subject through physical touch.
  - For example, a coordinate measuring machine (CMM)
- Non-Contact
  - Passive scanners do not emit any kind of radiation themselves, but instead rely on detecting reflected ambient radiation.
  - For example, photogrammetry

# Photogrammetry



# 3D Active Laser Scanning

- Active scanners emit some kind of radiation or light and detect its reflection in order to probe an object or environment. Possible types of emissions used include light, ultrasound or x-ray.
- Laser scanners are usually based on one of three general types of scanning:
  - Modulation, Time of Flight, Triangulation

# Modulation

- Modulated light 3D scanners shine a continually changing light at the subject.
- Usually the light source simply cycles its amplitude in a sin wave pattern.
- A camera detects the reflected light and the amount the pattern is shifted by determines the distance the light traveled.

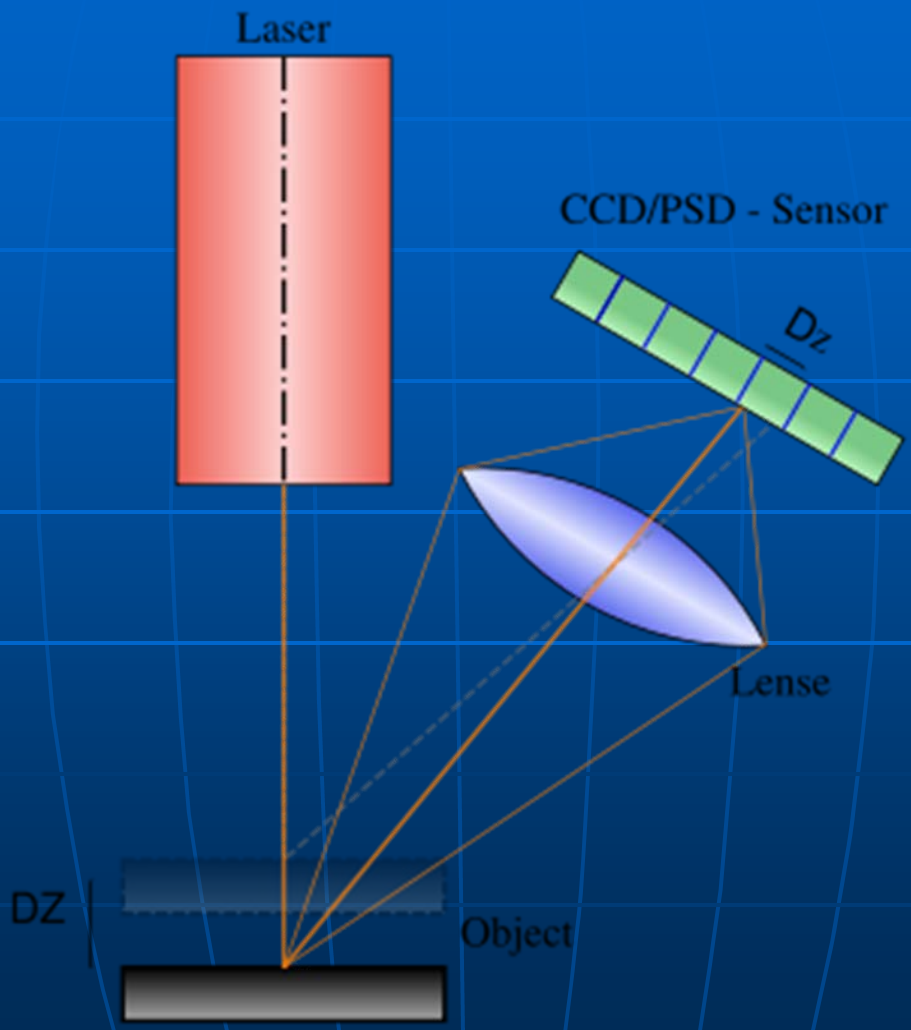
# Time of Flight

- The time-of-flight 3D laser scanner is an active scanner that uses laser light to probe the subject.
- Relies on the use of a laser range-finder.
- Advantages include the capability of operating over very long distances.
  - Good for buildings or geographic features.
- The disadvantages involve its accuracy.
  - Due to the high speed of light.

# Triangulation

- Triangulation laser scanners shoot a laser at the surface from one end of the scanner and receive the reflected laser along the other end of the scanner.
- By measuring the angle, the distance can be calculated.
- They have a limited range, but their accuracy is relatively high.

# Triangulation

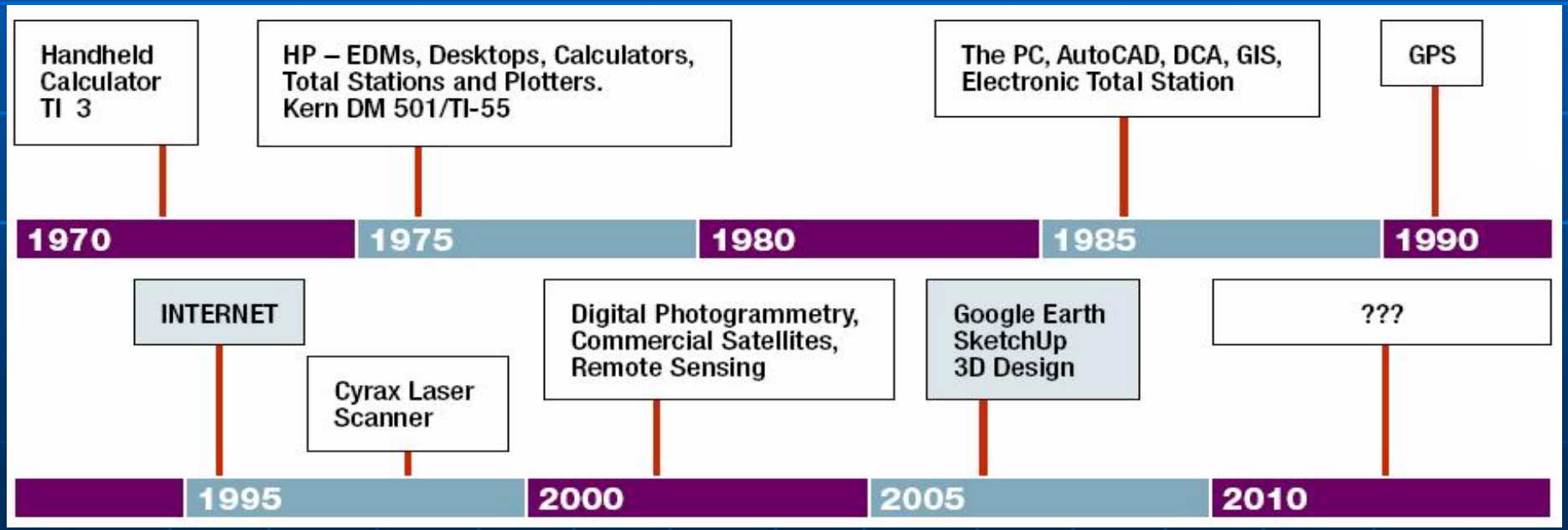


# Applications

- Material Processing and Production
  - Laser engraving, welding, and cutting
  - Laser sintering and rapid prototyping
- Entertainment
  - Movies and videogames
- Engineering
  - Construction and civil engineering
  - Reverse engineering
- Cultural Heritage
  - Historical sites and artifacts

# Implications

- 3D laser scanning as a surveying innovation.
- Entrepreneurship & Disruptive Technology
  - Gene Roe PhD, PE, LS – *The American Surveyor*




http://www.youtube.com/watch?v=Bh7bYNAHXxw