Speed-Measuring Device Operator Training

Participant Manual

L. I. D. A. R.

NHTSA
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

TSI
Transportation Safety Institute

L.I.D.A.R. COURSE OVERVIEW

- Learning Objectives
  - Describe the origin of L.A.S.E.R. technology as related to speed measuring
  - Explain the scientific principles of L.A.S.E.R. technology
  - Identify the components and features of the specific L.I.D.A.R. device(s) used
  - Discuss L.I.D.A.R. speed measurement
  - Discuss the elements of tracking history
  - Discuss L.I.D.A.R. effects
  - Set up L.I.D.A.R.
  - Perform functions tests
  - Discuss legal considerations pertaining to L.I.D.A.R.
  - Discuss the requirements needed for citation documentation and/or courtroom testimony
  - Operate a L.I.D.A.R. speed-measuring device
- Section Review
- Written Posttest
- Practical/Proficiency Testing
- Course Evaluation

Materials

- Presentation slides
- Flipchart
- Markers
- Tape
- Copy of agenda/schedule

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INTRODUCTION/HISTORY

Estimated time for Chapter 1: 20 Minutes

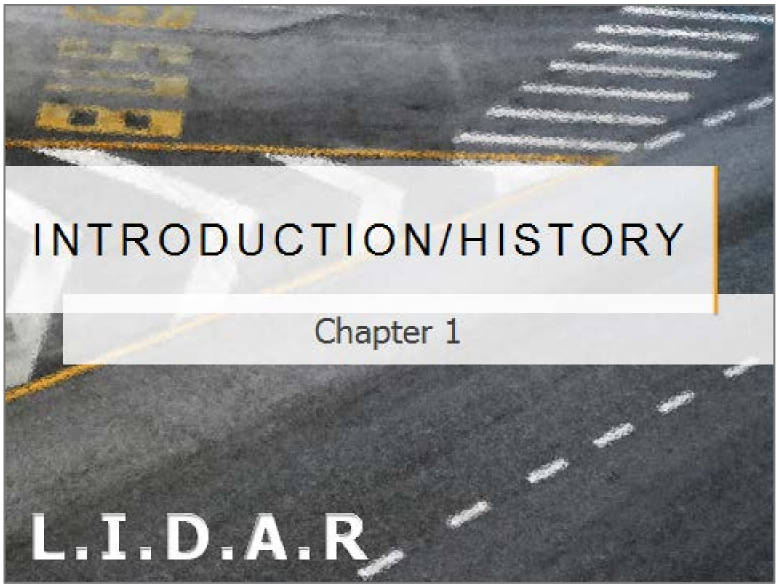
L. I. D. A. R.

Objectives

By the end of this chapter, you will be able to:

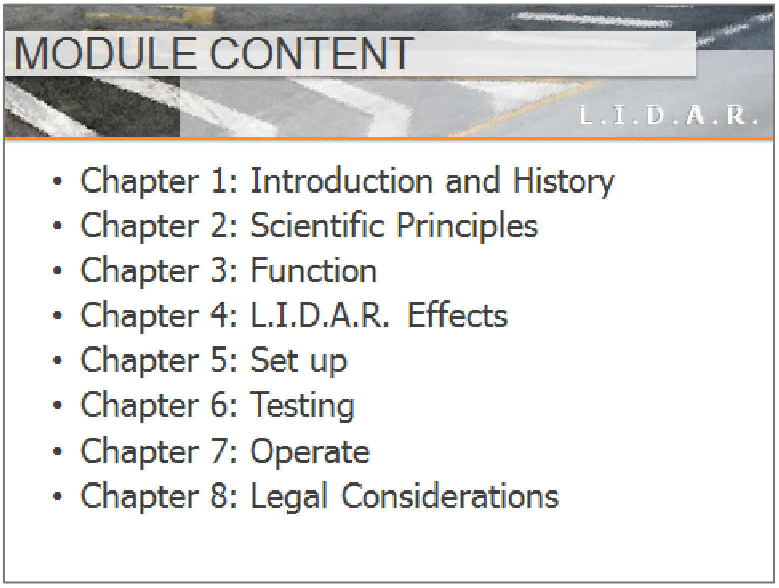
- Describe the origin of L.A.S.E.R. technology as related to speed measuring

Contents



Slide 1.

MODULE OVERVIEW



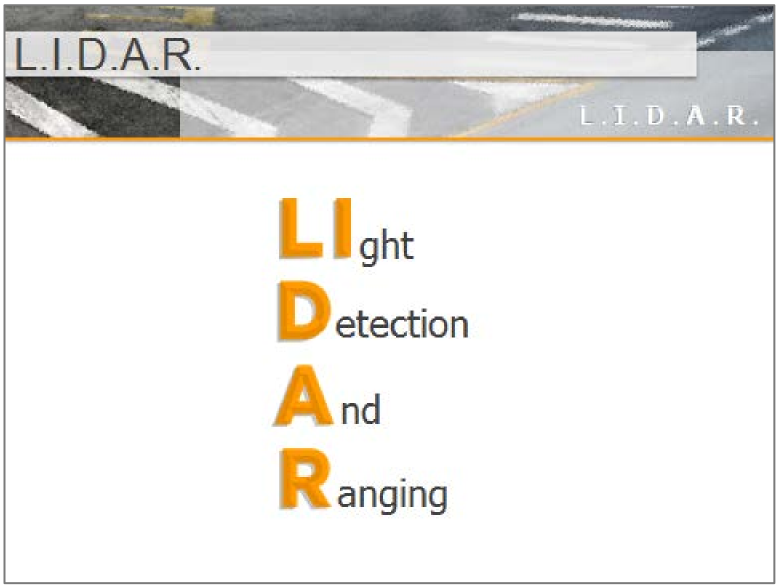
Slide 2.

The Speed-Measuring Device Operator Training course is designed to improve speed enforcement programs and enable agencies to better allocate their resources. The L.I.D.A.R. module is specifically designed to provide operators the knowledge and skills necessary to operate L.I.D.A.R. speed-measuring devices.

Students must understand how a L.I.D.A.R. device works and identify components, features, and functions before they can effectively operate the device.

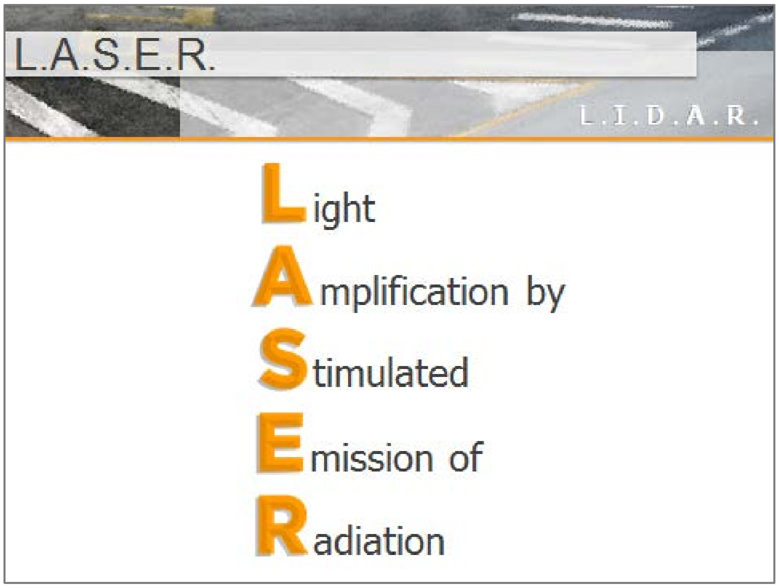
L.I.D.A.R., like any other law enforcement tool, must be used in compliance with laws, court's decisions, and department policy. Students must know the elements of the speeding offense before enforcement action can be taken. The officer's responsibility does not end with issuing a speeding citation. The charge must stand up in court. Officers must be prepared to present evidence and testify in court.

PRETEST (OPTIONAL)



Slide 3.

L.I.D.A.R. is an acronym for "Light Detection and Ranging." L.I.D.A.R.s measure a target vehicle's speed using light energy generated by a L.A.S.E.R. device. Light is an electromagnetic energy exhibiting the same properties as radio and microwave energies. L.I.D.A.R.s differ in method of generating light energy and resulting higher frequency.



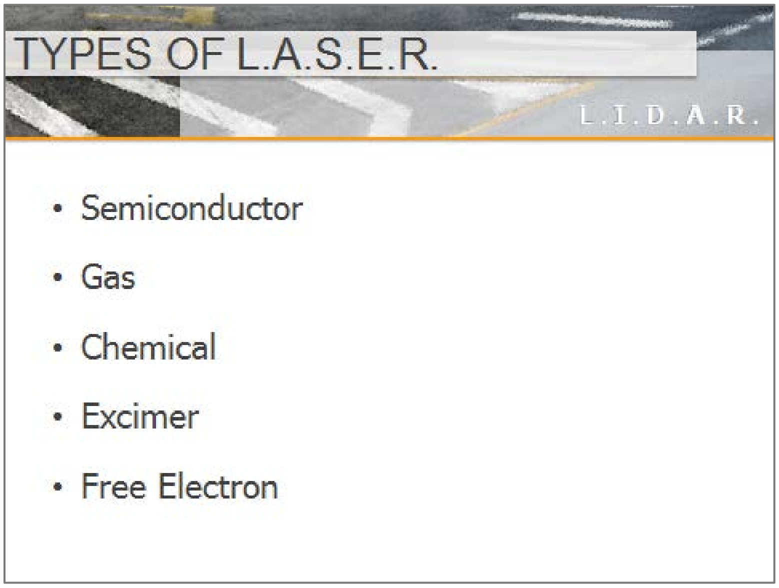
Slide 4.

The term L.A.S.E.R. is an acronym for “Light Amplification by Stimulated Emission of Radiation.”

L.I.D.A.R. is used when referring to speed-measuring devices that employ L.A.S.E.R. and pulse-timing technology for down-the-road speed measurements. L.I.D.A.R. is currently designed for stationary operations only.

Note that there is no such thing as “L.A.S.E.R. R.A.D.A.R.” The correct term is simply “L.I.D.A.R.”

TYPES OF L.A.S.E.R.



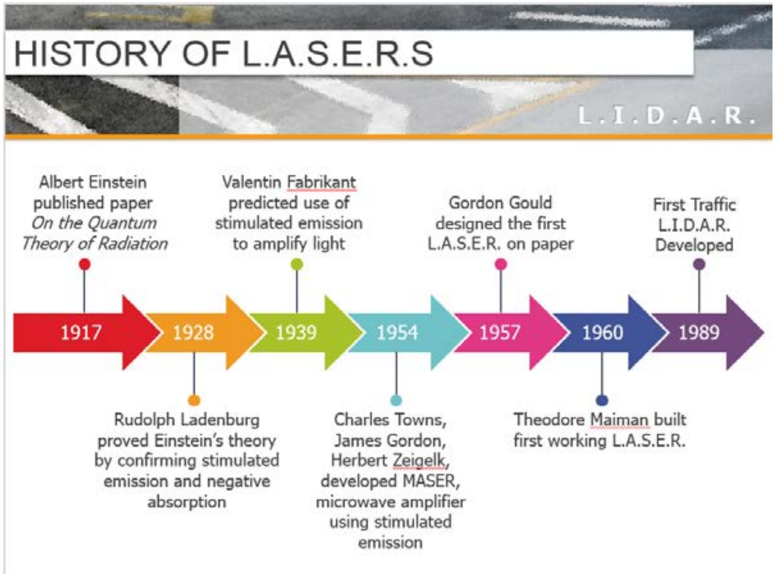
Slide 5.

L.A.S.E.R.s are produced from many different active materials (solids, liquids, and gases) and the design of the optical resonator and the method of exciting lasing mediums may vary. Whatever form the L.A.S.E.R. takes, the energy is generated by the same basic principle.

Typical Optical Resonator Device Types

- Semi-Conductor L.A.S.E.R.: uses are unlimited in high-technology applications such as fiber optic communications
- Gas L.A.S.E.R.: popular application is in the entertainment industry; light shows, movies, etc.
- Chemical L.A.S.E.R.: application are inertial confinement fusion and military applications
- Excimer L.A.S.E.R.: application within the medical field for surgical procedures
- Free Electron L.A.S.E.R.: these develop powerful light sources for strategic defense, industry, and basic research

HISTORY OF L.A.S.E.R.S



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In 1917, Albert Einstein published his paper *On the Quantum Theory of Radiation*. In the paper, he introduced probability coefficients, or absorption, spontaneous emission, and stimulated emission of electromagnetic radiation. This was the foundation for the L.A.S.E.R.

L.A.S.E.R.s are devices which transmit intense beams of light energy. Stimulated emission is the amplification of a single frequency of light.

The light from police L.I.D.A.R., as with R.A.D.A.R., is a form of electromagnetic radiation. The difference in R.A.D.A.R. and L.I.D.A.R. are the frequency and wavelength of this energy.

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SCIENTIFIC PRINCIPLES

Estimated time for Chapter 2: 60 Minutes

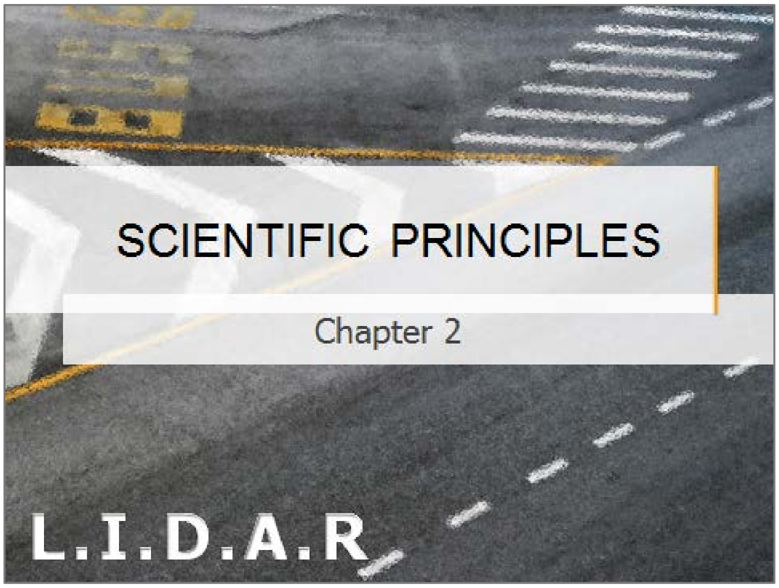
L. I. D. A. R.

Contents

Objectives

By the end of this chapter, you will be able to:

- Explain the scientific principles of L.A.S.E.R. technology



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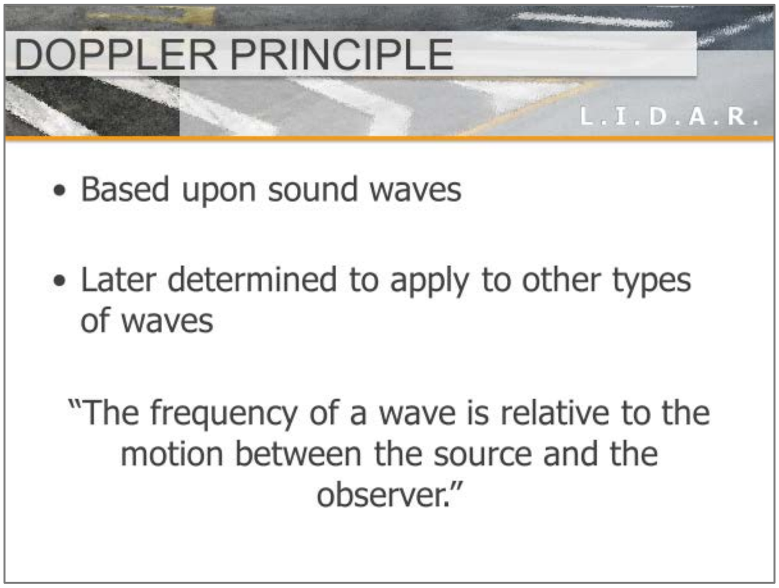
DOPPLER PRINCIPLE



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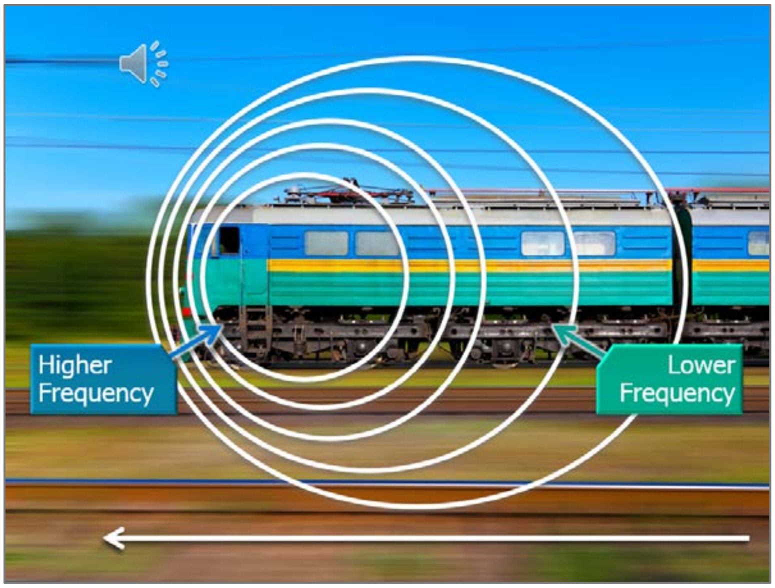
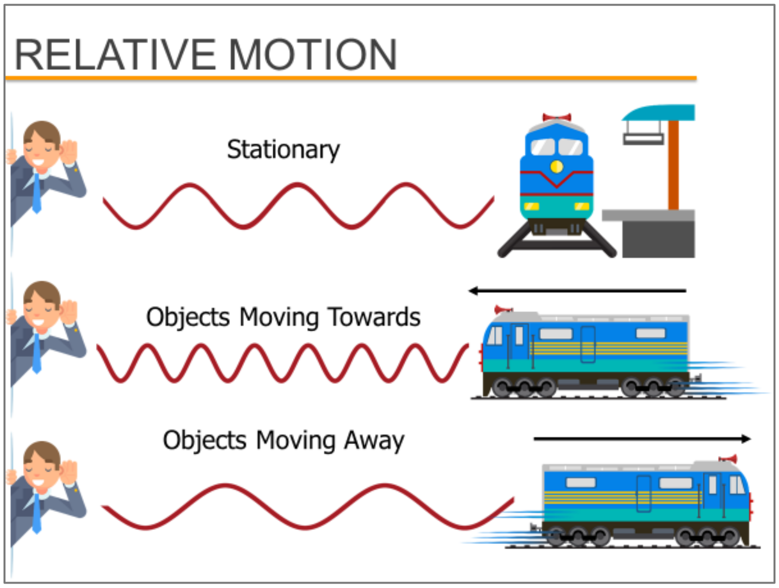
Doppler stated, "When there is relative motion between two objects, one of which is transmitting wave energy, the frequency of the signal as received by the other object changes due to that relative motion."



Slide 9.

Most know how the Doppler Principle applies to sound waves. When you stand near a railroad track the sound of an approaching train has a higher pitch and then lowers after the train passes. This frequency change is due to relative motion.

RELATIVE MOTION



Slide 10.

L.I.D.A.R. devices use specific characteristics of light energy to measure speed.

When the Doppler principle is applied to L.I.D.A.R., if there is relative motion (toward or away) between a L.I.D.A.R. and an object, the frequency of the reflected signal will be different from the frequency of the transmitted signal. This change, or shift, in frequency is known as the "Doppler shift." The greater the relative speed, the greater the frequency shift.

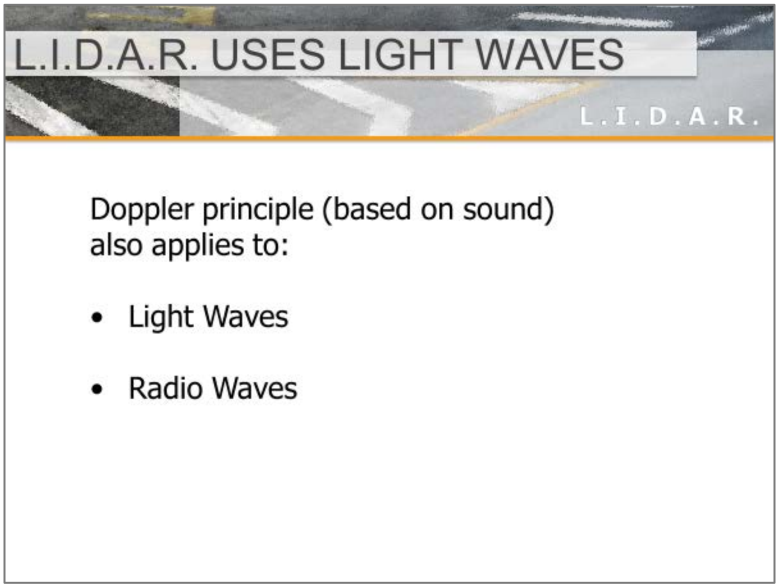
If the relative motion is bringing the object and the L.I.D.A.R. together, the reflected signal will have a higher frequency than the transmitted signal.

If the relative motion is moving the object and the L.I.D.A.R. apart, the reflected signal will have a lower frequency than the transmitted signal.

By measuring the amount of the frequency shift, the L.I.D.A.R. can calculate and display the target speed in miles per hour.

The point to remember about the Doppler Principle is that the frequency change only occurs when there is relative motion between the L.I.D.A.R. and the object.

LIGHT WAVES

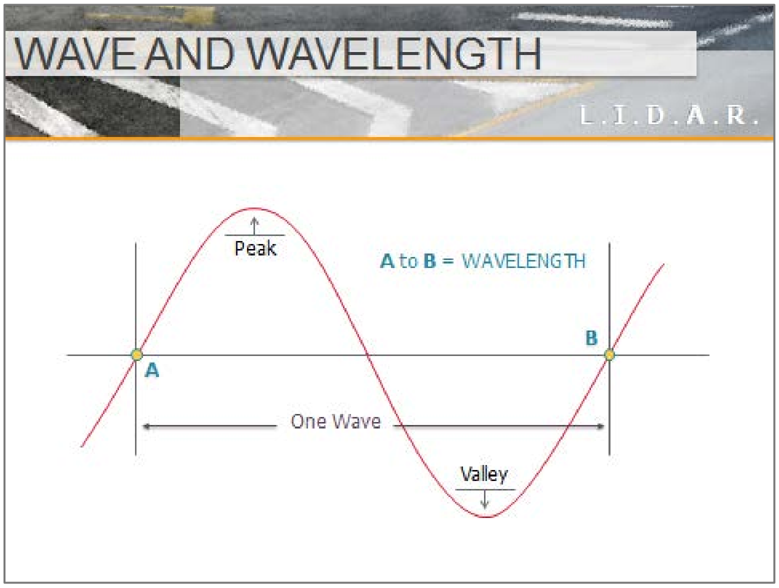


Slide 11.

Light waves are produced when rapid reversals of current in a conductor create coherent electromagnetic energy of a measurable wavelength and frequency.

Light waves spread out from the transmitter in a predictable manner at the speed of light. Given the time and location of transmission, frequency, wavelength, and speed of propagation, we can easily obtain useful information by calculating the difference between the original transmission and its reflection.

WAVE AND WAVELENGTH



Slide 12.

The L.I.D.A.R. signal possesses the same three distinguishable characteristics as other forms of electromagnetic wave energy:

- Signal Speed

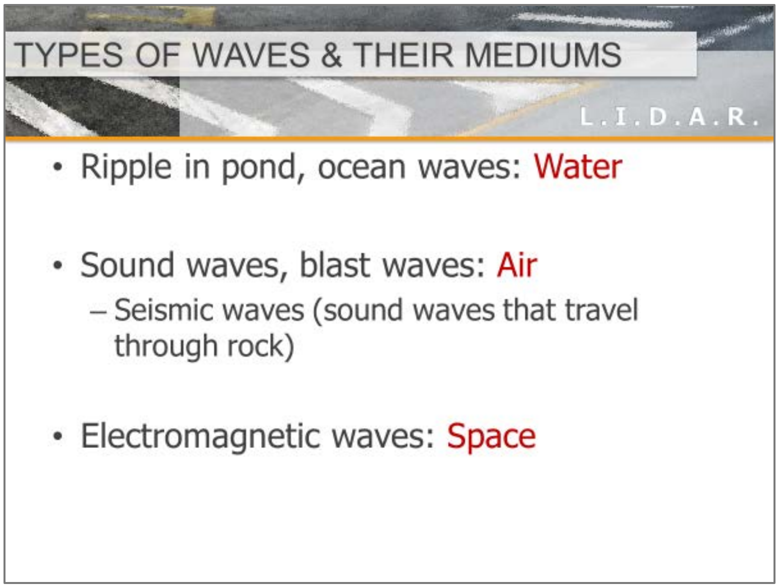
  The L.I.D.A.R. signal, as with all forms of electromagnetic energy, travels at the speed of light. This is generally accepted to be approximately 186,282 miles per second. Both the transmitted and reflected L.I.D.A.R. signal will travel at this constant speed.

- Wavelength

  The wavelength is defined as "the distance between two points in a periodic wave that has the same phase." Another way to describe wavelength is the distance from the beginning of the peak to the end of the valley.

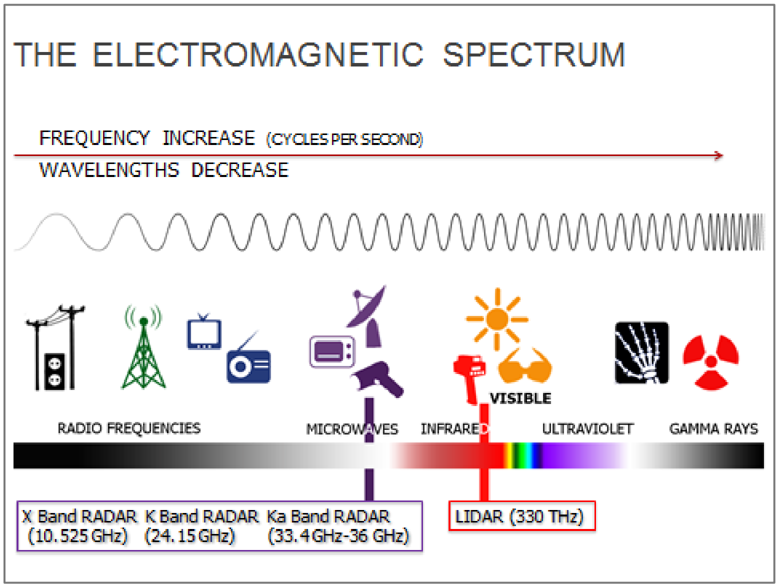
- Frequency

  Frequency is the number of signal recurrences during one second or the oscillation rate of a periodic signal.


TYPES OF WAVES & THEIR MEDIUMS
L.I.D.A.R.
• Ripple in pond, ocean waves: Water
• Sound waves, blast waves: Air
– Seismic waves (sound waves that travel through rock)
• Electromagnetic waves: Space

Slide 13.

ELECTROMAGNETIC SPECTRUM



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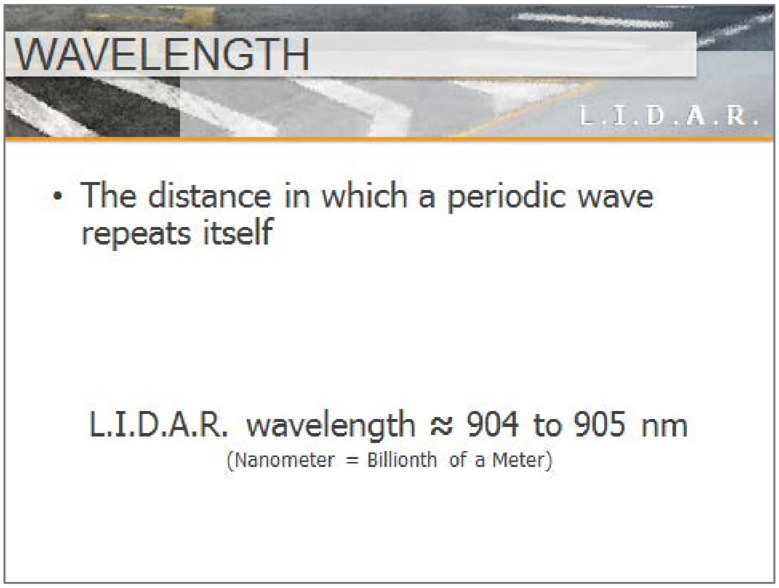
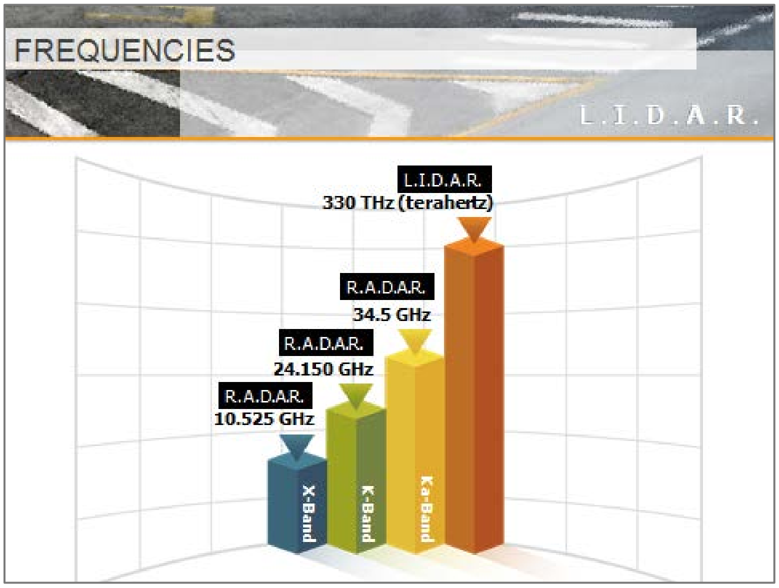
Frequency is measured in terms of cycles per second. Scientists and engineers use the term Hertz (abbreviated Hz) instead of cycles per second. All these terms have the same meaning: one Hertz = one cycle per second = one wave per second.



Slide 15.

The wavelength of the L.I.D.A.R. signal is approximately 904 - 905 nm (nm = nanometer or one billionth of a meter).

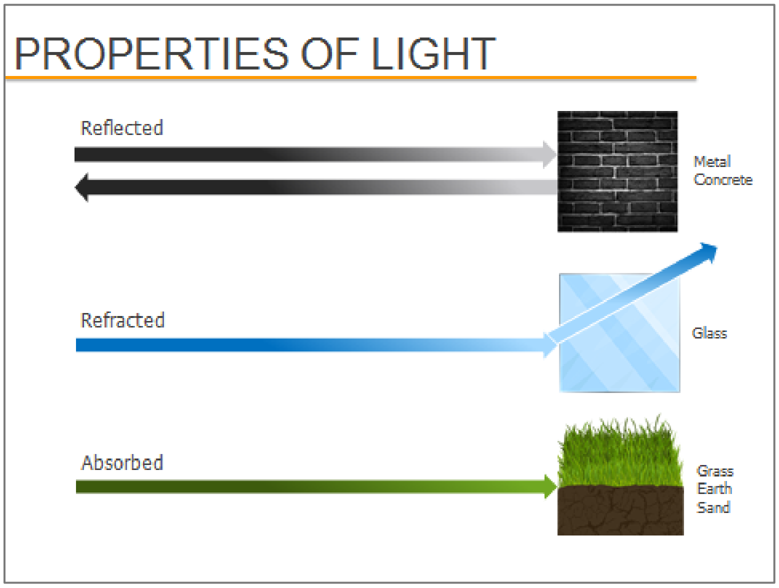
FREQUENCIES



Slide 16.

The frequency of the L.I.D.A.R. signal is approximately 330 terahertz (330,000,000,000,000 Hz), which is about 13,000 times higher than R.A.D.A.R. frequencies.

PROPERTIES OF LIGHT



Slide 17.

The L.I.D.A.R. signal, as with all electromagnetic energy, exhibits the following behaviors:

Reflected

The signal bounces back from the target vehicle.

The target vehicle's reflective capability may be influenced by its color and surface composition may affect the operational range. However, it will not affect the device's speed calculations once the reflected signal is detected.

The size of the target vehicle is not at issue. Ideally, the target vehicle should be as large, or larger, than the L.I.D.A.R. signal's cross section at the target's location. This condition is readily accomplished in speed measuring because the L.I.D.A.R. signal at 1,000 feet is approximately three feet wide and proportionately less at closer distances.

Refracted

The bending of a signal as it passes through transparent material. When the opposite faces of the material are parallel, it will result in only a slight displacement of the signal.

Absorbed

The L.I.D.A.R. signal's energy may be absorbed by some types of material, or surfaces, allowing less signal energy to be reflected from that object. The color of a target vehicle may affect the amount of energy absorption. While this may affect the operational range of the device, it in no way will affect the accuracy of the speed measurement. This is because the L.I.D.A.R. computes speed by the time-distance method.

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FUNCTION

Estimated time for Chapter 3: 40 Minutes

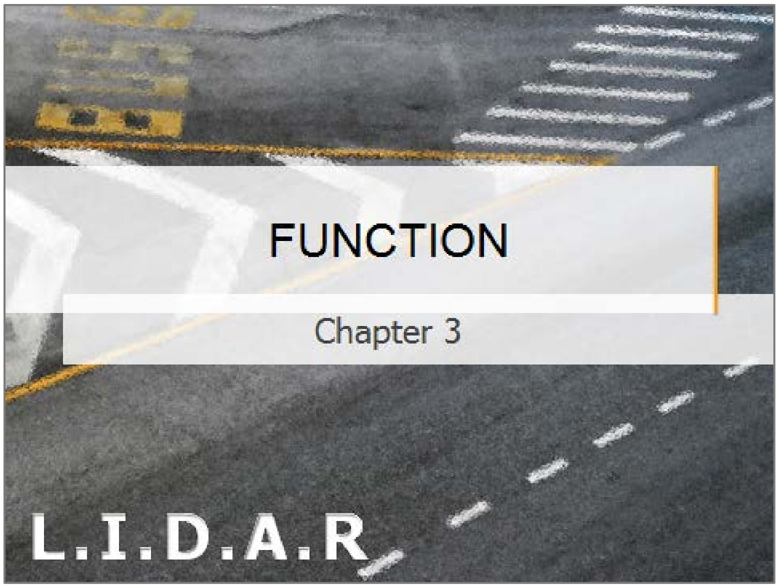
L. I. D. A. R.

Contents

Objectives

By the end of this chapter, you will be able to:

- Identify the components and features of the specific L.I.D.A.R. device(s) used
- Discuss L.I.D.A.R. speed measurement
- Discuss the elements of tracking history



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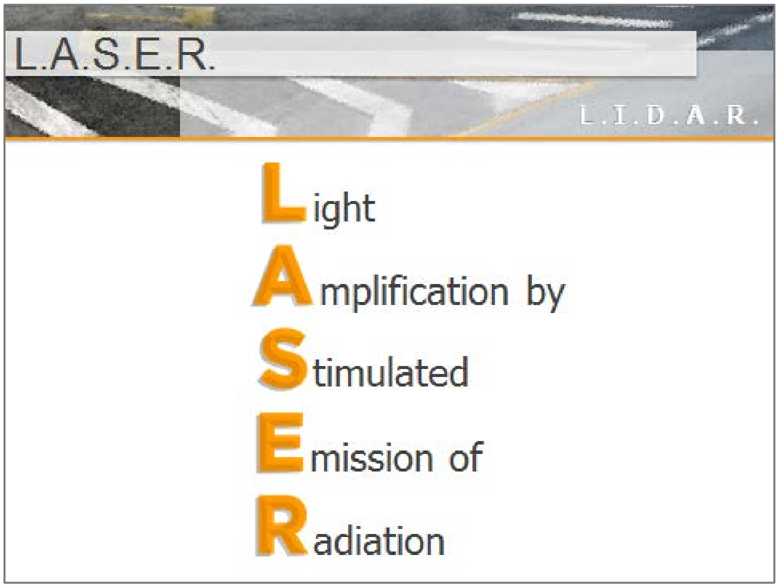
CREATING L.A.S.E.R. LIGHT



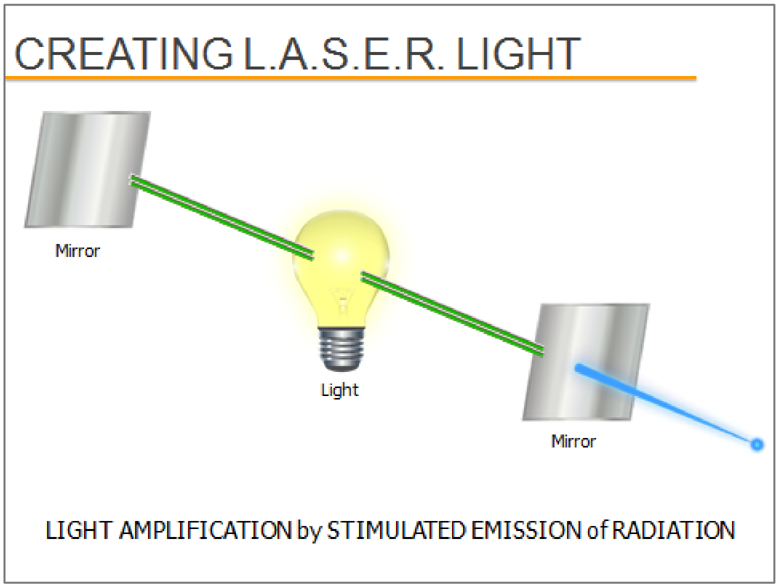
Slide 19.

What is a L.A.S.E.R.?

A device that utilizes the natural oscillations of atoms or molecules between energy levels for generating a beam of coherent electromagnetic radiation usually in the ultraviolet, visible, or infrared regions of the spectrum[1].

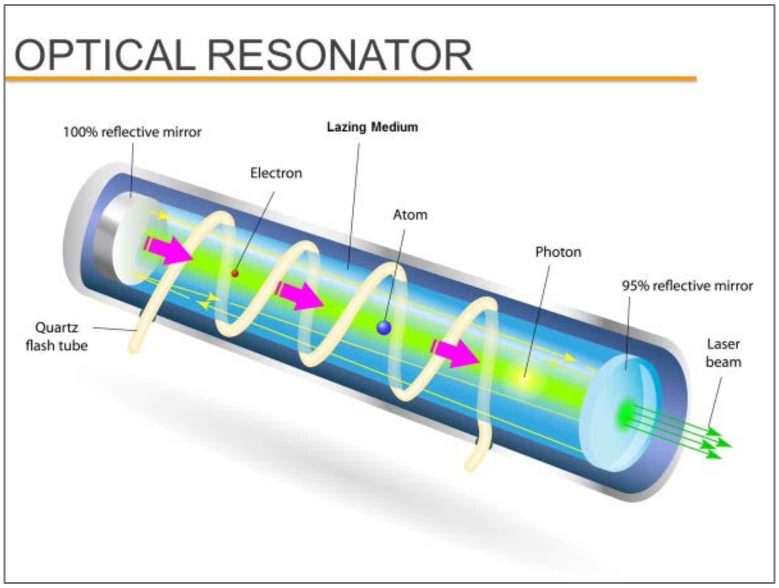
[1] "L.A.S.E.R." *Merriam-Webster.com*. Merriam-Webster, n.d. Web. 22 Feb. 2017.

HOW L.A.S.E.R. WORKS



Slide 20.

In its simplest form, L.A.S.E.R. energy is generated by energizing a piece of active material, known as the lasing medium, between two mirrors. These mirrors and the lasing medium form what is called an optical resonator.

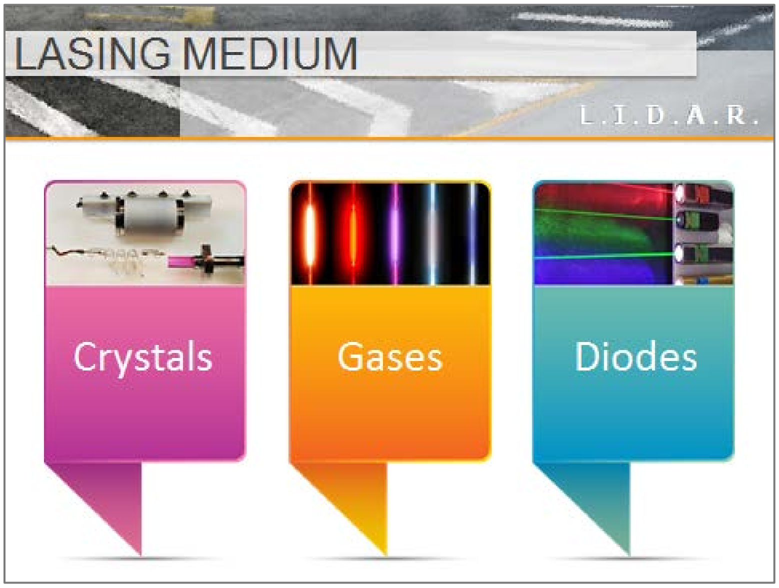


Slide 21.

The atoms of the lasing medium are put into an excited state by an external energy source (the atoms store some of that energy). These excited atoms can then be stimulated to release their stored energy as light energy resulting in an amplification of incoming light.

By positioning the two mirrors of the optical resonator exactly the right distance apart, a standing wave is formed by only those waves bouncing between the mirrors and having the proper wavelength. Under these conditions, the light waves emitted by the atoms of the lasing medium are aligned in the same direction and tuned in wavelength (frequency) to increase the strength of the standing wave. One of the mirrors is designed to allow some of this amplified light to “escape” and pass from the optical resonator as a L.A.S.E.R. beam.

LASING MEDIUM



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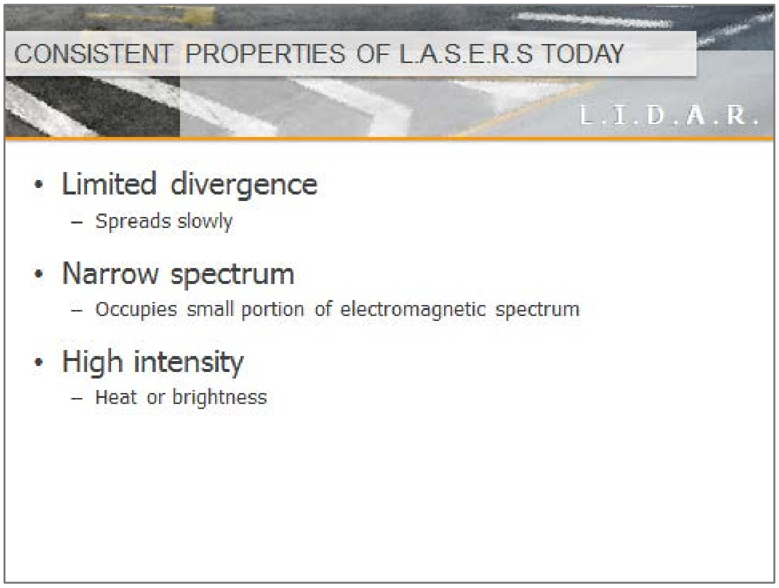
L.A.S.E.R.S TODAY

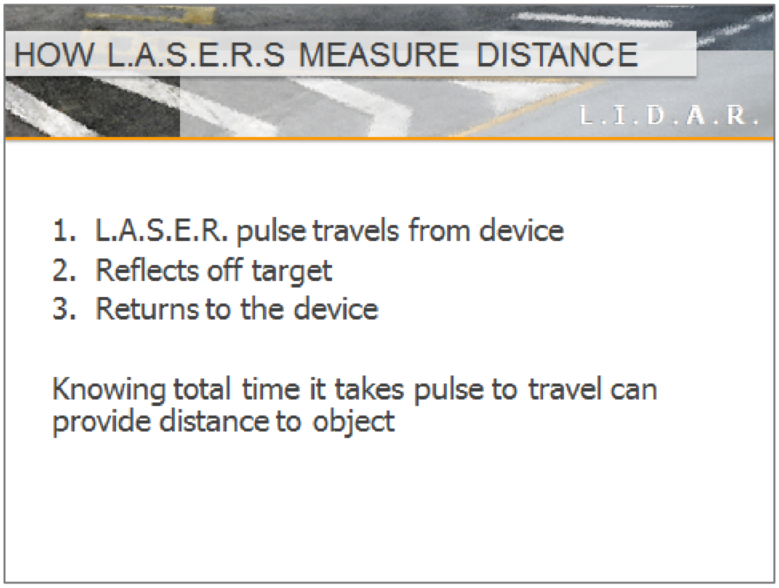


Slide 23.

Limited Divergence

- Coherent: refers to the synchronized phase of the light waves
- Collimated: refers to the parallel nature of the L.A.S.E.R. beam
- Monochromatic: refers to the single (wavelength) color of a L.A.S.E.R. beam

HOW L.A.S.E.R.S MEASURE DISTANCE



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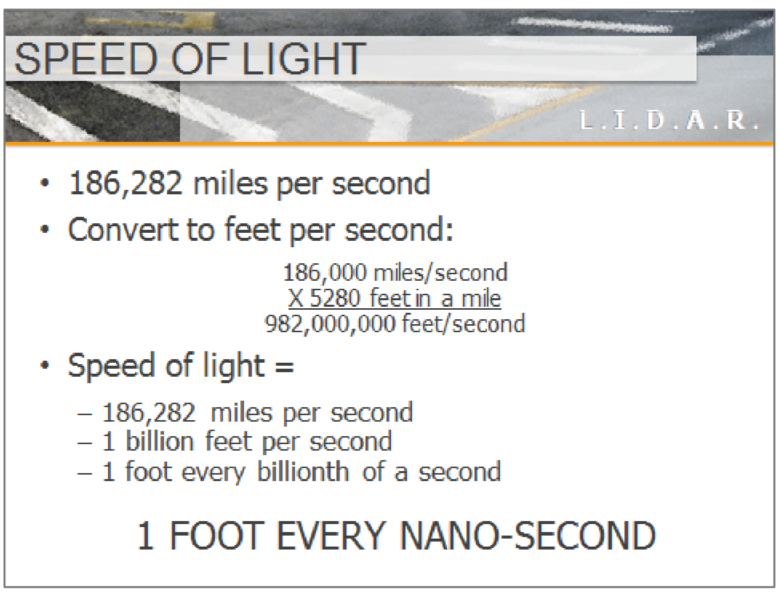
SPEED OF LIGHT



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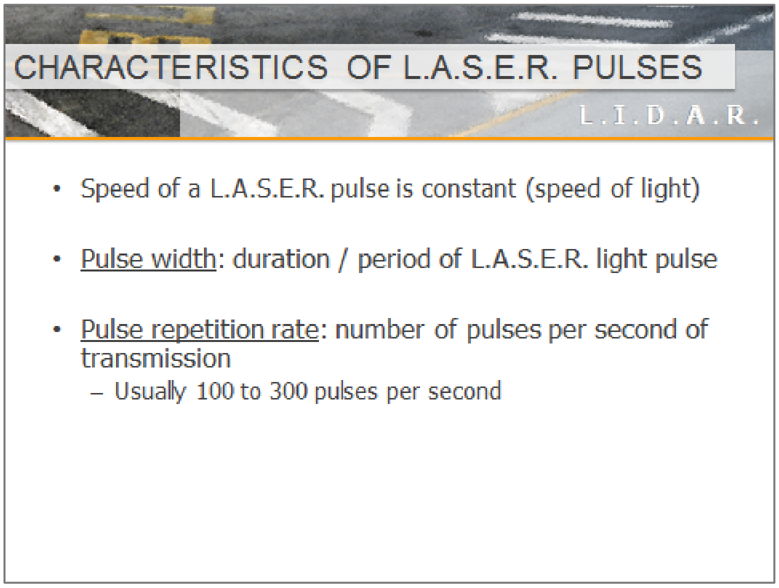
L.A.S.E.R. PULSES



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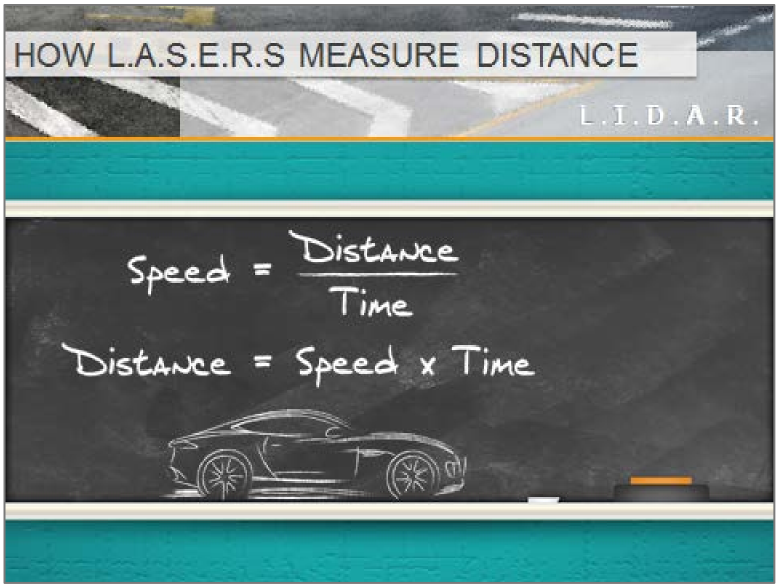


Slide 27.

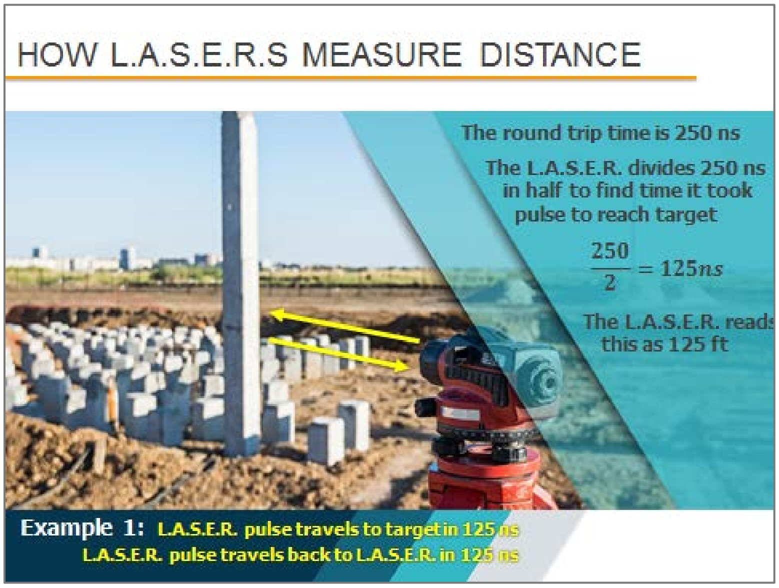
Recall the basic formula for a time/distance calculation is:

$$Speed = \frac{Distance}{Time}$$

If we know time and speed, we can change this formula using algebra to find a distance.

$$Distance = Speed\ x\ Time$$

EXAMPLE 1: MEASURING DISTANCE



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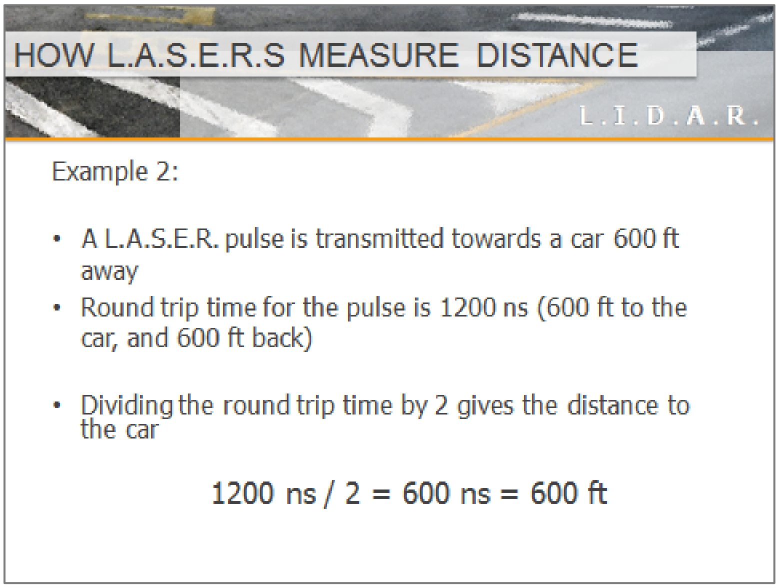
EXAMPLE 2: MEASURING DISTANCE



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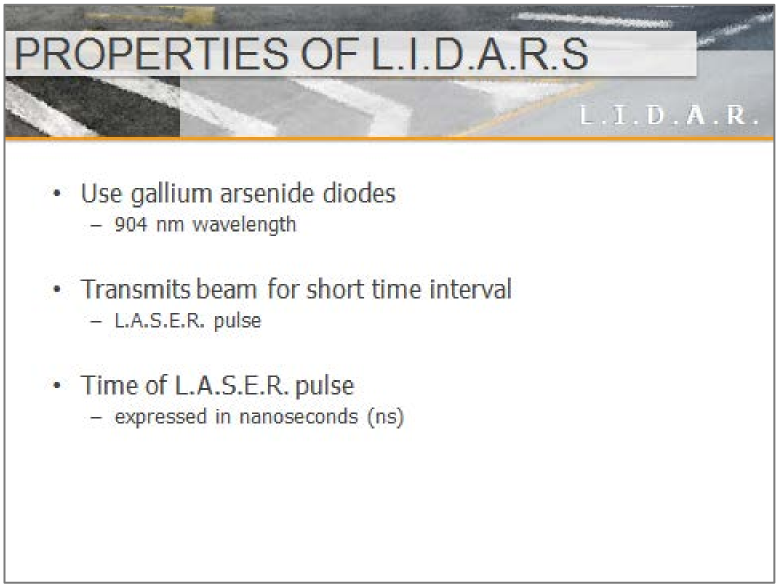
PROPERTIES OF L.I.D.A.R.S



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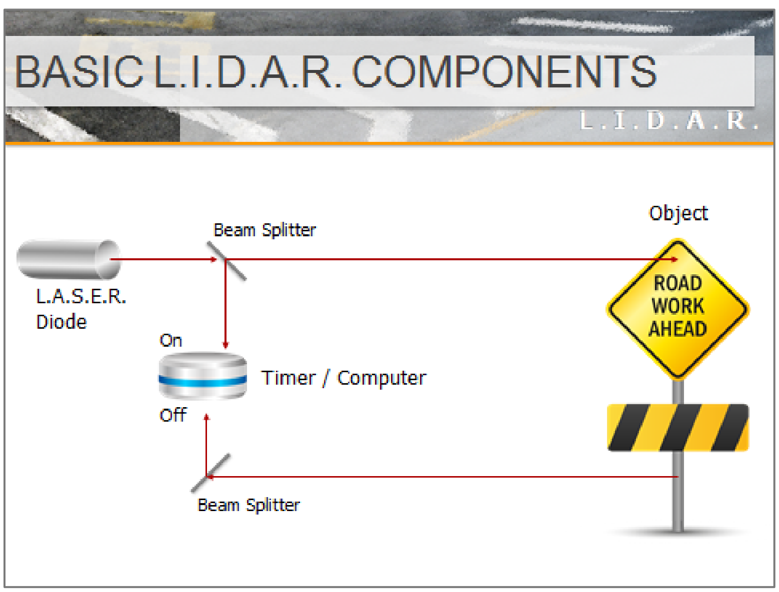
BASIC L.I.D.A.R. COMPONENTS



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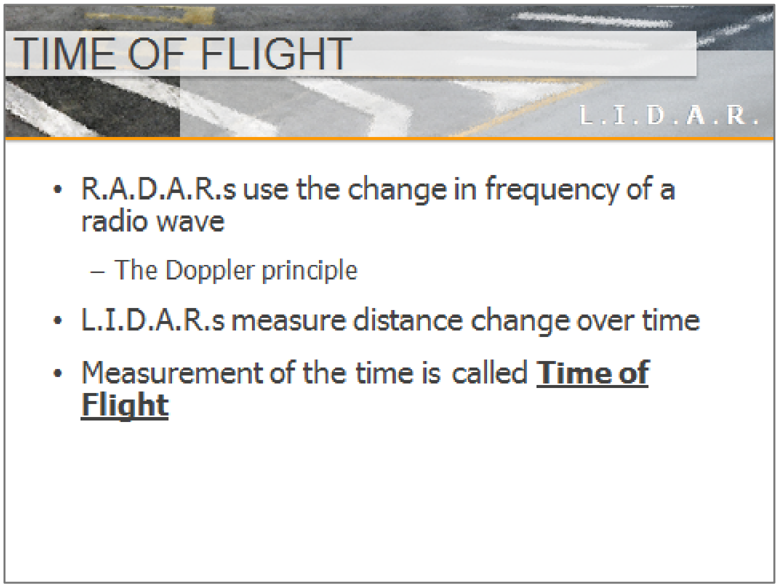
TIME OF FLIGHT



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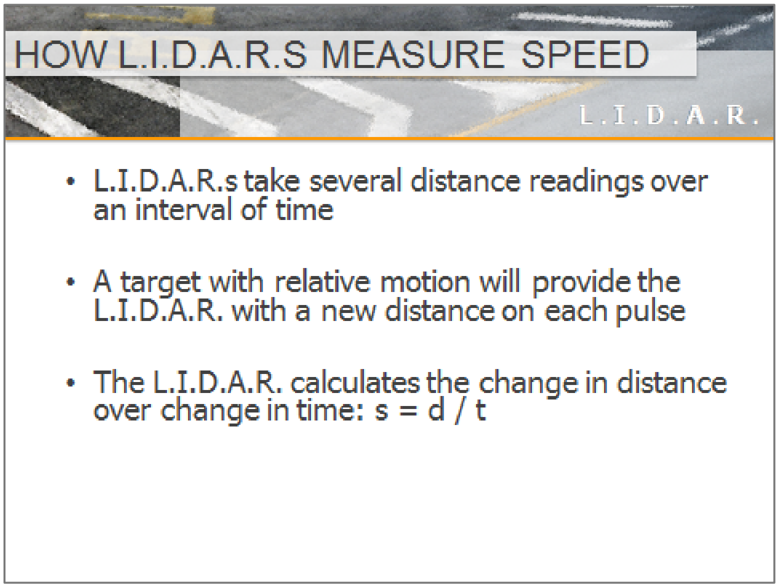
L.I.D.A.R. employs a time-of-flight method for taking measurements to determine the target vehicle's speed. This method of measurement may be made at any distance within the operating range of the instrument.

HOW L.I.D.A.R.S MEASURE SPEED

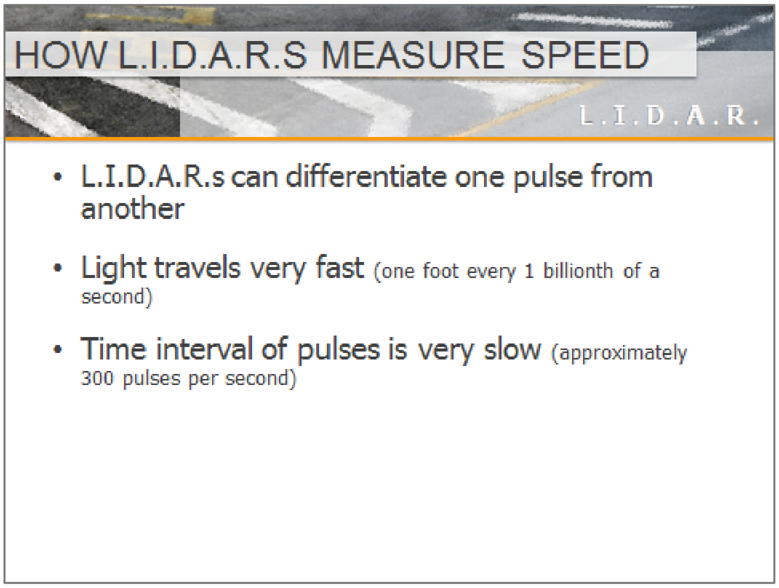


Slide 34.

When the trigger is pulled, the L.I.D.A.R. transmits hundreds of L.A.S.E.R. light pulses per second. When a pulse is transmitted, the timer is started. When the reflected pulse from the target vehicle is received, the timer is stopped. By comparing the elapsed time between the transmission and reception of the L.A.S.E.R. pulse with the speed of light, the instrument can calculate the range to the target vehicle. After making a specific number of these successive range measurements, the data is mathematically analyzed by the processing algorithm. The calculated target vehicle speed is therefore determined from a group of time and range measurements.

If the range to the target vehicle is increasing with time (the target vehicle is moving away from the instrument), some units will designate the speed reading as a negative value. If the range to the target vehicle is decreasing with time (the target is moving toward the instrument), the speed is designated as a positive value.

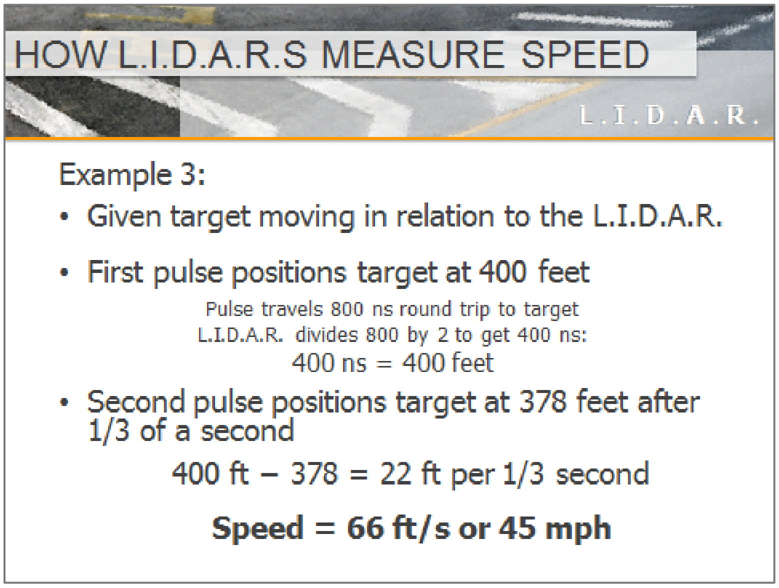
Although L.I.D.A.R. instruments employ a variation to the long-accepted time/distance method for speed measuring, it does not depend upon specific reference points for obtaining speed measurements. This process employed by the L.I.D.A.R. instrument is dynamic and occurs without the instrument operator having to identify specific reference points along the target vehicle's path-of-travel.



Slide 35.

If a L.I.D.A.R. transmits 300 pulses per second, then for a returning pulse to meet a departing pulse, the round-trip time for the returning pulse would be 3.3 million nanoseconds or 3.3 million feet – approximately 631 miles!!!

EXAMPLE 3: SPEED MEASUREMENT



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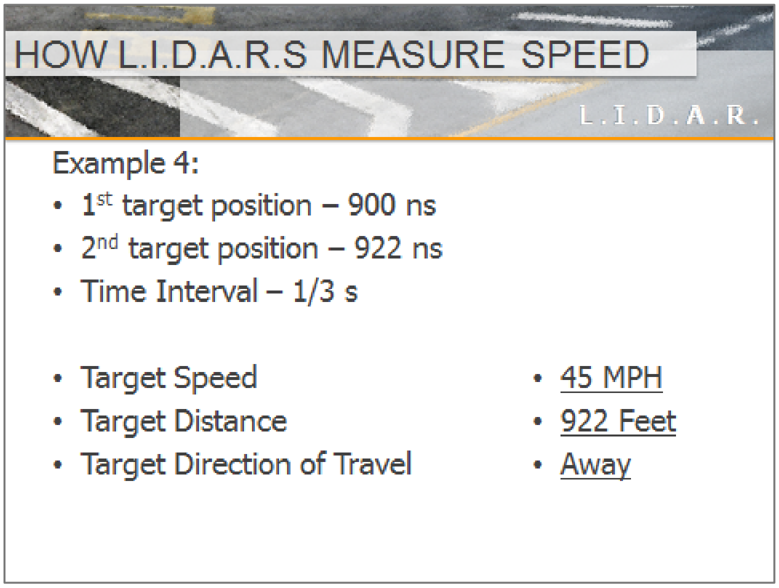
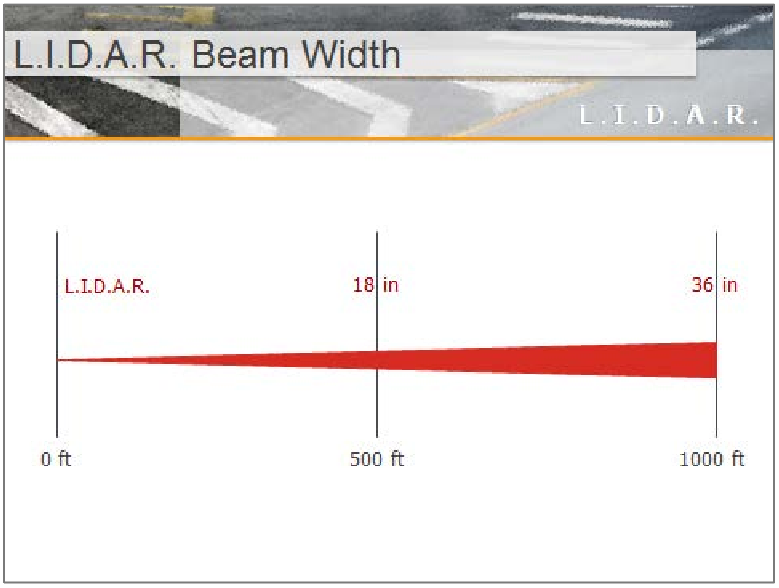
EXAMPLE 4: SPEED MEASUREMENT



Slide 37.

L.I.D.A.R. BEAM WIDTH



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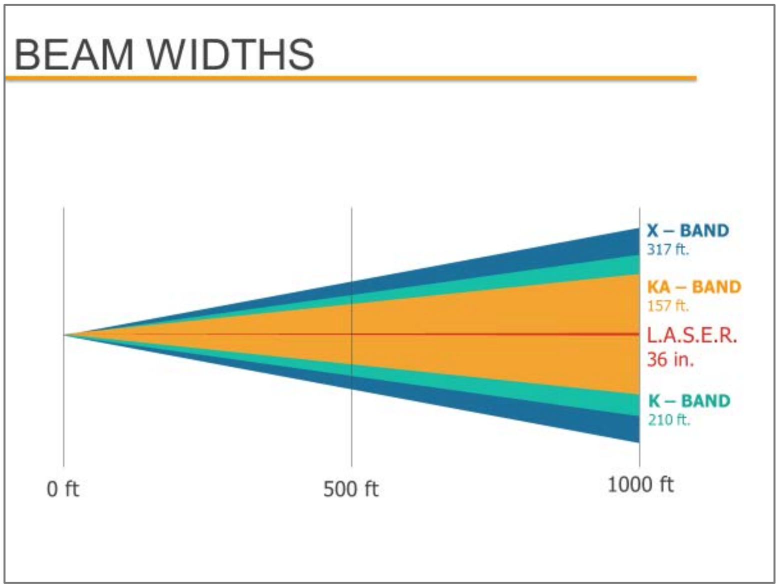

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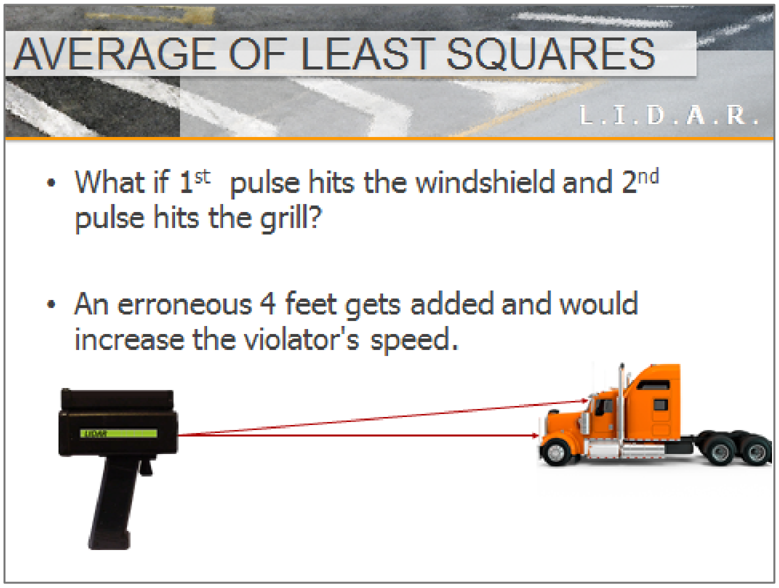
AVERAGE OF LEAST SQUARES



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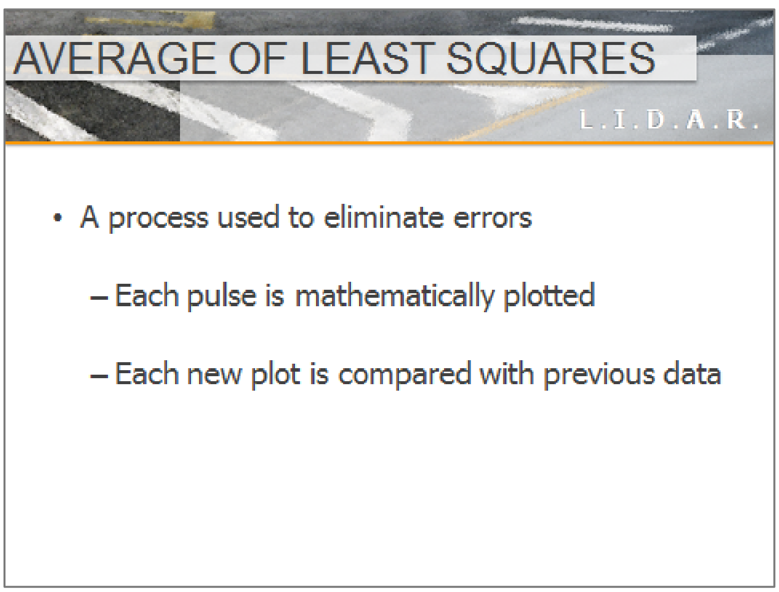
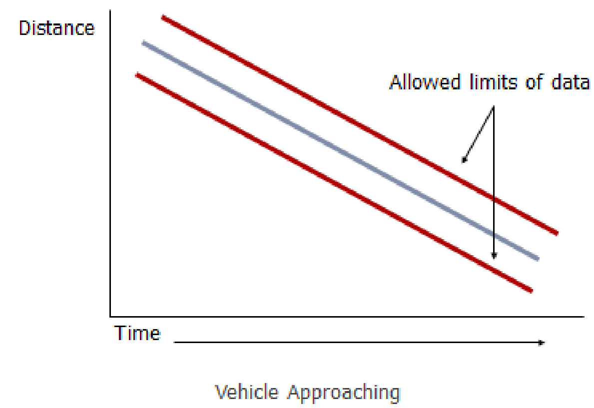


Slide 41.

AVERAGE OF LEAST SQUARES



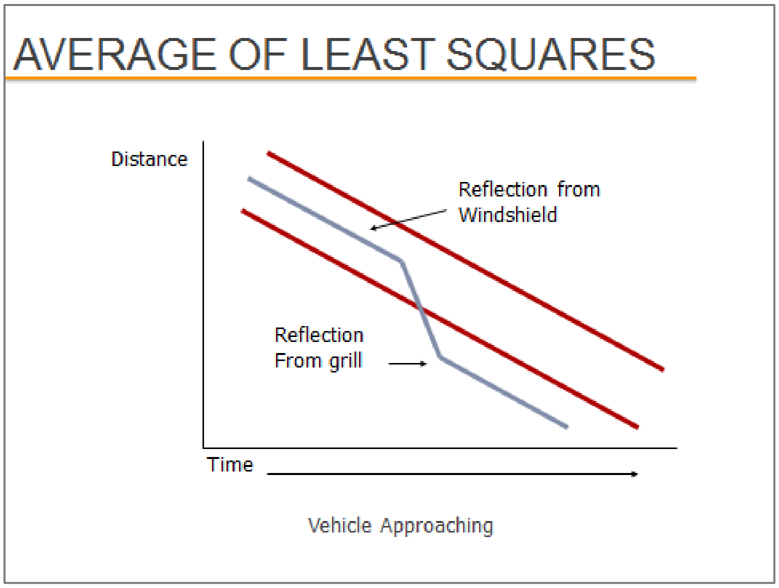
Slide 42.

AVERAGE OF LEAST SQUARES

L.I.D.A.R.

- Sudden changes in targeting points can result in an erroneous speed display
- This data would fall outside the limits set by the L.I.D.A.R.
- Speed reading not displayed during time data falls outside limits

Slide 43.



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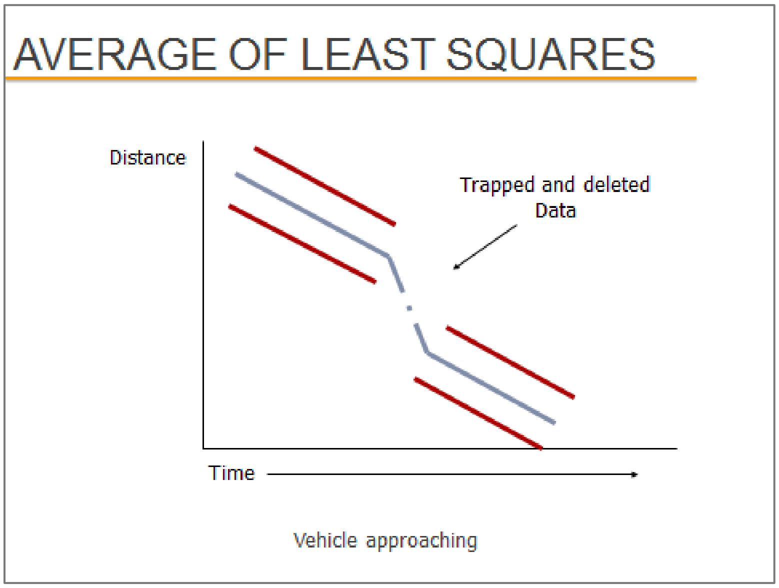


Slide 45.

L.I.D.A.R. TARGETING

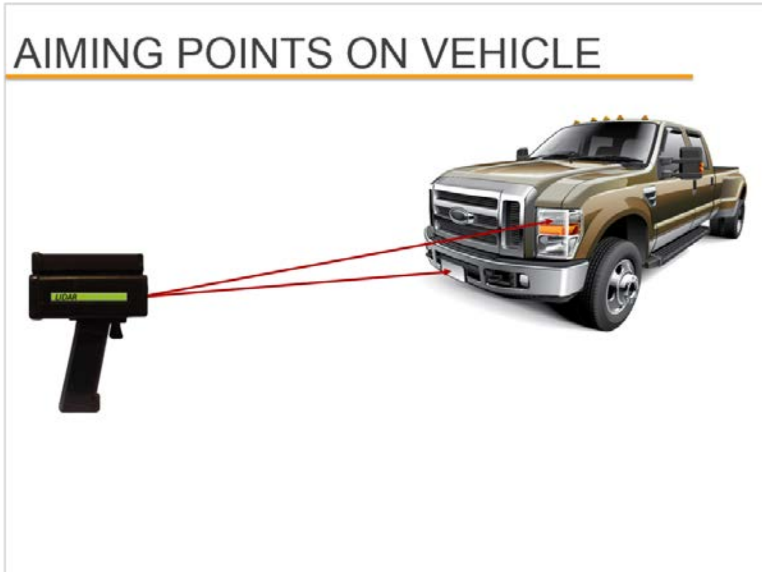
Slide 46.

The target vehicle's size, shape, and composition do not affect the L.I.D.A.R. device. When aiming the L.I.D.A.R. device at a target vehicle, some parts of the vehicle provide a better reflective surface. The target vehicle's ability to reflect at optical wavelengths will affect the device's range.

Parts that reflect light are the best L.I.D.A.R. signal reflectors. The best reflective surfaces on receding vehicles are usually the license plate or the tail light reflectors. For oncoming traffic, the best place to aim is normally the front license plate, the headlights, or the turn signal reflectors.

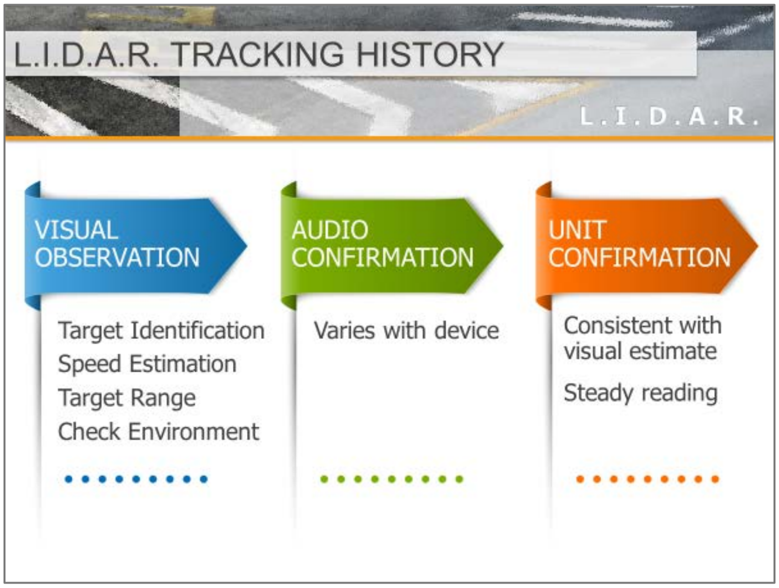
The color or cleanliness of the vehicle may also help increase the range of the L.I.D.A.R. device. Light colors reflect better than dark colors. Clean vehicles reflect better than dirty vehicles.

Keep in mind the diameter of the L.I.D.A.R.'s transmitted signal is very narrow at a distance of 500 feet. This requires accurate aiming on target vehicle. Large amounts of motion may make it difficult to obtain a speed reading when aiming at a target vehicle.



Slide 47.

TRACKING HISTORY



Slide 48.

The L.I.D.A.R. operator should continuously monitor traffic for potential violators. Any enforcement action resulting from a speed measurement obtained with a L.I.D.A.R. instrument must be supported by several vital elements that comprise what is referred to as a "tracking history."

L.I.D.A.R. units provide audio feedback from the device (refer to owner's manual).

Steady or multiple read-outs are necessary to avoid the sweep effect, discussed in Chapter 4.

4

L.I.D.A.R. EFFECTS

Estimated time for Chapter 4: 15 Minutes

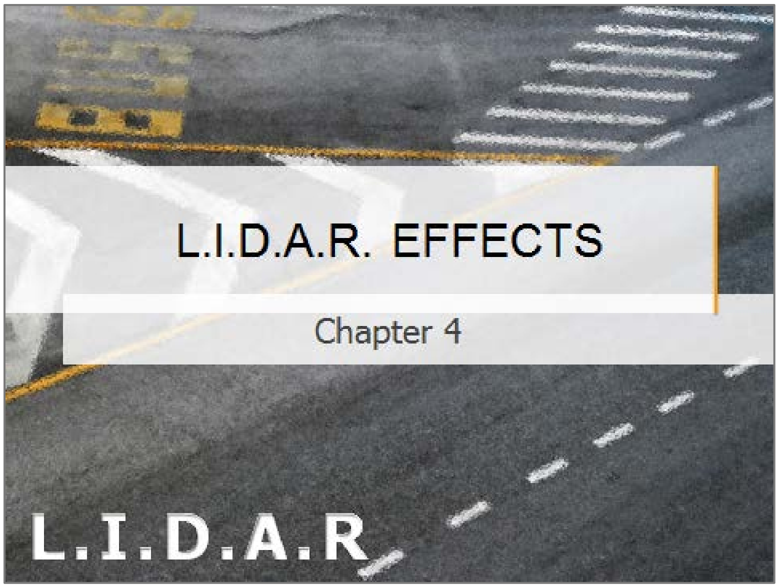
L. I. D. A. R.

Contents

Objectives

By the end of this chapter, you will be able to:

- Discuss L.I.D.A.R. effects



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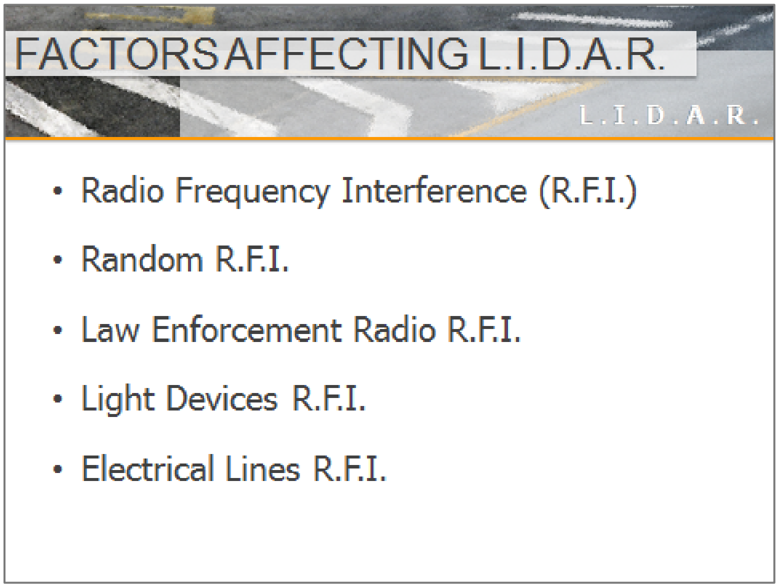
FACTORS AFFECTING L.I.D.A.R.



Slide 50.

The L.I.D.A.R. operators should recognize and understand various effects that may affect the L.I.D.A.R. device.

Radio Frequency Interference (R.F.I.)

There are several radio frequency sources capable of generating signals that may interfere with the operation of L.I.D.A.R. devices. Unlike R.A.D.A.R., L.I.D.A.R. devices use infrared light and are not as likely to be affected by R.F.I. sources. The L.I.D.A.R.'s R.F.I. indicator is usually the only indication that there is an R.F.I. source.

Weak R.F.I. signals are generally discarded when the L.I.D.A.R. device receives a stronger reflected signal from the target vehicle.

Law Enforcement Radio R.F.I.

Law enforcement radios, portable radios, or business band radios may produce R.F.I. indications. The interference produced by these types of radios is generally a result of their powerful transmitters.

To avoid/eliminate:

- Do not transmit patrol vehicle's law enforcement radio, a portable radio, or a business band radio while operating the L.I.D.A.R. device
- Develop a valid tracking history

Lighting Devices R.F.I.

Certain types of lighting equipment such as mercury vapor, neon, or fluorescent lights are capable of producing R.F.I. L.I.D.A.R. devices should not be aimed directly at bright lights.

To avoid/eliminate:

- Select an operation site free from this type of potential interference
- Develop a valid tracking history

Electrical Lines R.F.I.

High voltage electrical lines, electrical transformers, or electrical substations may produce R.F.I.

To avoid/eliminate:

- Select an operational site free from this type of potential interference
- Develop a valid tracking history

Most L.I.D.A.R. devices have built in R.F.I. detection that will not allow a target reading to be displayed if R.F.I. is detected. Consult your operator's manual to determine specifics of your unit.

Slide 51.

Windshield

The windshield does not affect the accuracy of the L.I.D.A.R. device; it may only reduce the range.

Weather

Although the L.A.S.E.R. emissions used by L.I.D.A.R. devices are not in the visible spectrum, they are close enough in wavelength that atmospheric or climatic conditions that impair vision also affect L.I.D.A.R. speed-measuring device operations.

Rain, smoke, fog, and airborne dust particles will reduce the ability to acquire a target.

Low Voltage

The L.I.D.A.R. device will be disabled in accordance with the specific manufacturer's specifications when a low voltage situation is experienced. The operator should check the power source if this happens. In the absence of a loose connection or other readily identifiable solutions, the L.I.D.A.R. device should be removed from service and repaired.

A L.I.D.A.R. operator will learn to identify and disregard unusual readings and R.F.I.s through training and experience.

SWEEP EFFECT

SWEEP EFFECT

L.I.D.A.R.

- Caused by changing targeting point while transmitting L.A.S.E.R. pulses
- Creates gradual change in speed data instead of sudden change
- L.I.D.A.R. may allow data in and see the change as an increase in speed depending on how wide the limits are set in the average of least squares error trappings

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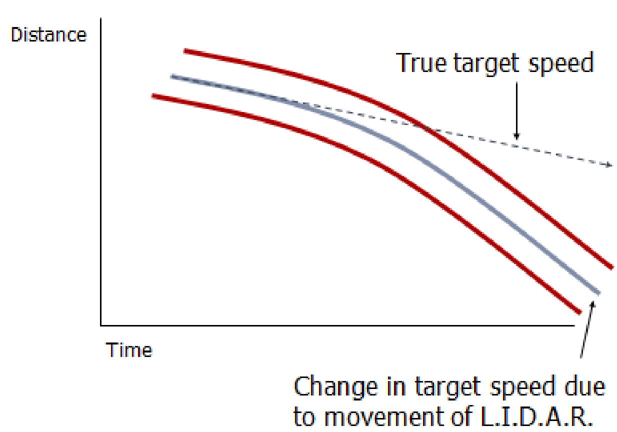
SWEEP EFFECT



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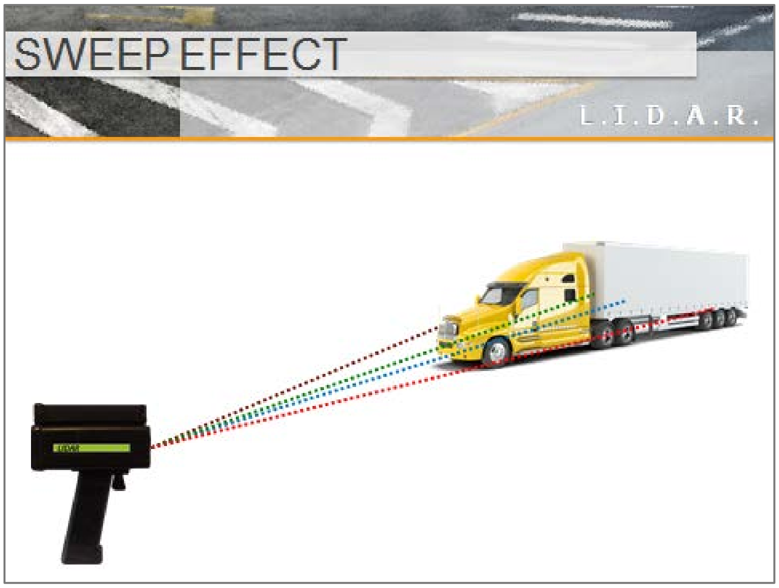

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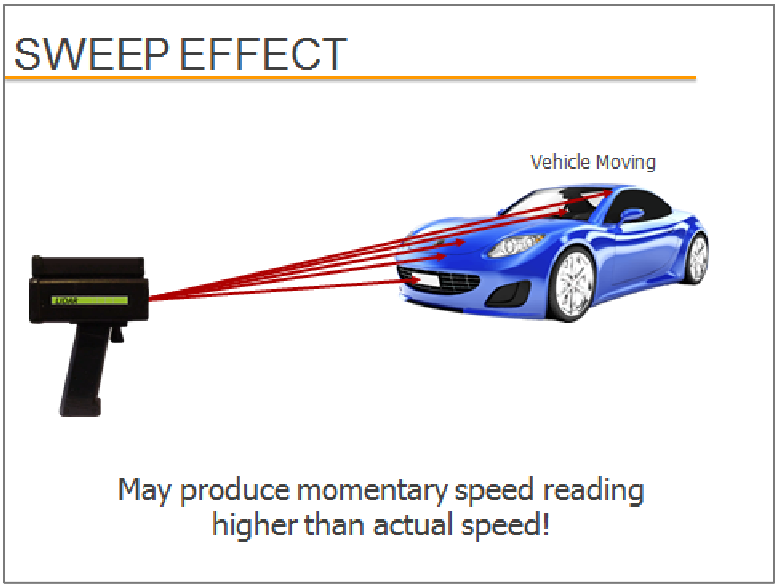


Slide 55.

When a L.I.D.A.R. signal strikes at an angle to a vehicle's surface the signal's area of influence on that surface is oval shaped. The L.I.D.A.R. signal's reflection may come from either the front or the back of this oval area.

If a reflection comes first from the front then moves to the rear because of target or L.I.D.A.R. device movement, the overall distance has changed (increased) therefore the speed calculation results in a lower than true speed.

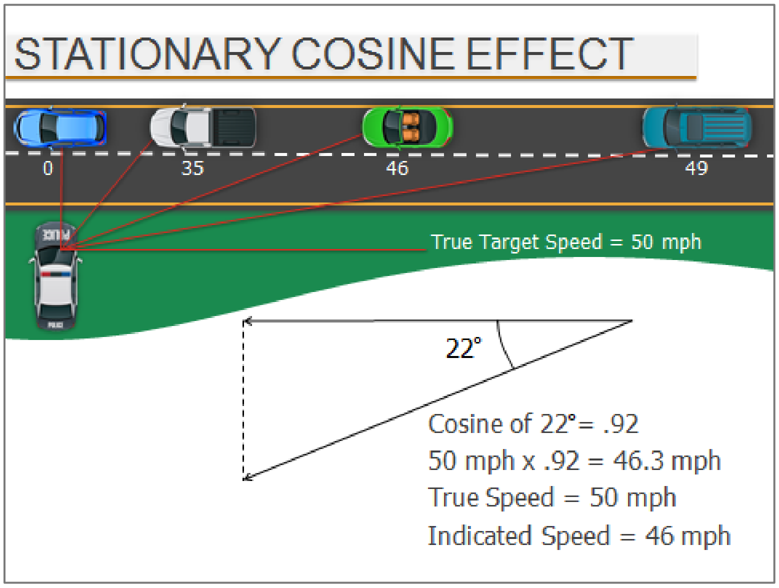
If a reflection comes first from the rear then moves towards the front, then the calculation will result in a higher than true speed.

It is essential that the L.I.D.A.R. operator maintain a steady aiming point on the target vehicle to avoid this effect.

To avoid/eliminate:

- Hold the aim point steady on a single portion of the target vehicle
- Develop a solid tracking history
- Steady or multiple read-outs

COSINE EFFECT



Slide 56.

If a target vehicle were moving directly toward or away from the L.I.D.A.R. device, the relative motion as measured by the L.I.D.A.R. device would be equal to the target vehicle's true speed. Often this is not the case. For safety reasons, operations are set up a short distance off the traveled portion of the road. Therefore, vehicles traveling along the roadway will not be heading directly toward or away from the L.I.D.A.R. device and an angle is created between the target vehicle's direction of travel and the L.I.D.A.R. device's position.

When a target vehicle's direction of travel creates a significant angle with the position of the L.I.D.A.R., the measured speed will be less than the true speed. Since the time/distance calculation is based on the relative speed, the L.I.D.A.R. speed measurement may be less than the vehicle's true speed. This is known as the cosine effect.

The difference between the measured and true speed depends upon the angle between the travel direction of the target vehicle and the position of the L.I.D.A.R. (the greater the angle, the lower the measured speed). This effect always works to the motorist's advantage. The cosine effect is not significant if the angle itself remains small.

The cosine effect decreases as the range to the target vehicle increases. As the target vehicle approaches the L.I.D.A.R. device, the angle then increases. As soon as this angle becomes large enough, the L.I.D.A.R. unit will measure the target's speed as less than its true speed.

To minimize the cosine effect, the angle should be kept small by setting up the L.I.D.A.R. device as close to the road as possible without creating safety risks. The L.I.D.A.R. should be targeted down the road at sufficient distances so as not to create a cosine effect.

COSINE EFFECT

True Speed as Affected by the Cosine Effect

Angle Degrees	30 mph	40 mph	50 mph	55 mph	60 mph	70 mph
0	30.00	40.00	50.00	55.00	60.00	70.00
1	29.99	39.99	49.99	54.99	59.99	69.99
3	29.96	39.94	49.93	54.92	59.92	69.90
5	29.89	39.85	49.81	54.79	59.77	69.73
10	29.54	39.39	49.24	54.16	59.09	68.94
15	28.98	38.64	48.30	53.12	57.94	67.61
20	28.19	37.59	46.99	51.68	56.38	65.78
30	25.98	34.64	43.30	47.63	51.96	60.62
45	21.21	28.28	35.36	38.89	42.43	49.50
60	15.00	20.00	25.00	27.50	30.00	35.00
90	0.00	0.00	0.00	0.00	0.00	0.00

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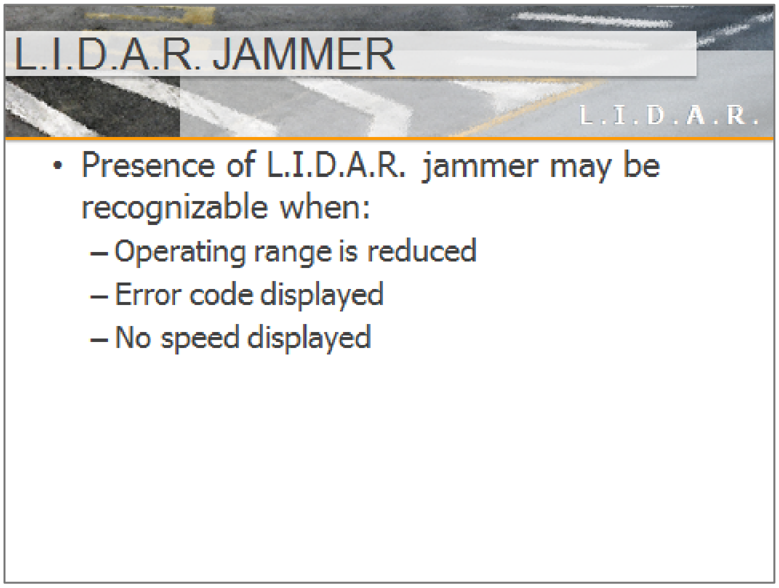
Cosine Effect Table

The table indicates how L.I.D.A.R. speed measurements differ from true speed because of the cosine effect.

The cosine effect does not become a factor until the angle reaches about 10 degrees. When a target vehicle passes by at a 90-degree angle, the L.I.D.A.R. is unable to perceive any vehicle speed because the target is getting neither closer to or farther from the device. This can be understood by imagining a target vehicle being driven in a perfect circle around a L.I.D.A.R. device.

Because the vehicle is getting neither closer to nor farther from the L.I.D.A.R., at 90 degrees, there is no way to measure time/distance. Because the distance part of the equation is not changing or zero, the speed measurement becomes zero.

L.I.D.A.R. JAMMER



Slide 58.

A L.I.D.A.R. transmitter when used as a jamming device does not violate FCC regulations. This is because L.I.D.A.R. uses light instead of radio waves.

The presence of a L.I.D.A.R. jammer may be recognizable when the L.I.D.A.R. device:

- Operating range is reduced
- Displays an error code
- Displays no speed

5

SET UP

Estimated time for Chapter 5: 5 Minutes

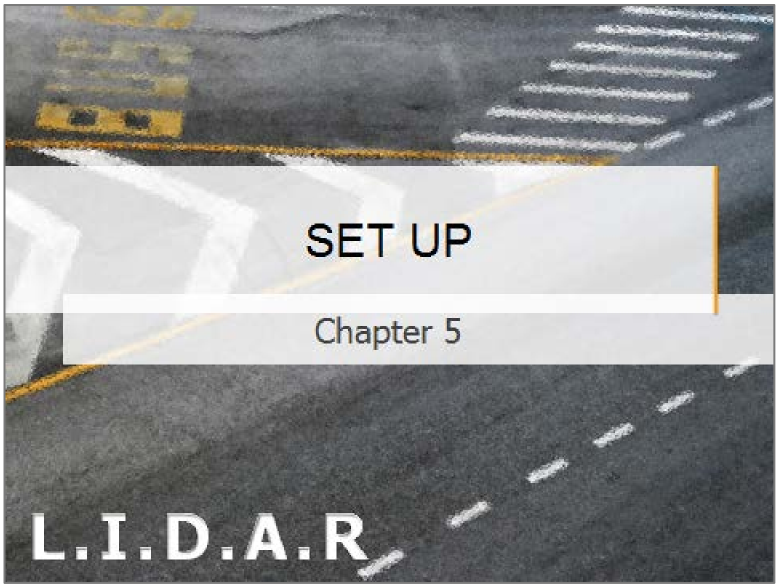
L. I. D. A. R.

Contents

Objectives

By the end of this chapter, you will be able to:

- Set up L.I.D.A.R.



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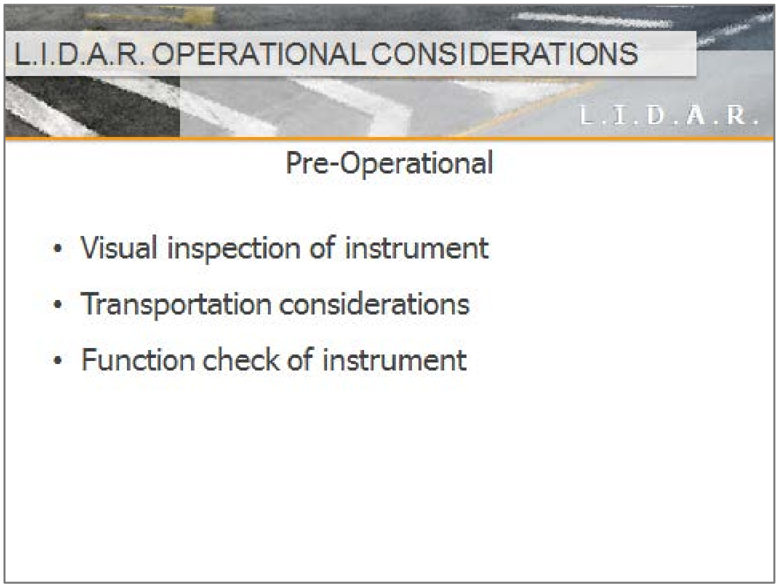
OPERATIONAL CONSIDERATIONS



Slide 60.

Operational considerations begin when the L.I.D.A.R. operator removes the device from its storage case. The operator should use the operator's manual to locate each component and understand the features and functions of the components. The operator should then inspect the device for:

- External damage
- Missing components
- Damage or defects that may cause the L.I.D.A.R. device to function improperly

If any problem exists, the device should be removed from service and be repaired.

Care and Handling

- Periodic cleaning of the external optical surfaces when necessary
- Towel off any excess moisture and air-dry the device at room temperature when the device gets wet
- Be extremely careful when cleaning the lenses (The range of the device will be reduced if the lenses become excessively scratched)
- The operator should not aim the device at any bright light sources. This includes the sun. (Doing this may reduce its operational range)

Transportation Considerations

Care should be used with transporting L.I.D.A.R. devices.

The L.I.D.A.R. device should be transported in the patrol vehicle following the manufacturer's recommended procedures. The design of a specific L.I.D.A.R. device will dictate the requirements for transportation.

Take precaution with the L.I.D.A.R. device to prevent occupant injury in the event the patrol vehicle is involved in a crash or evasive driving maneuvers.

6

TESTING

Estimated time for Chapter 6: 10 Minutes

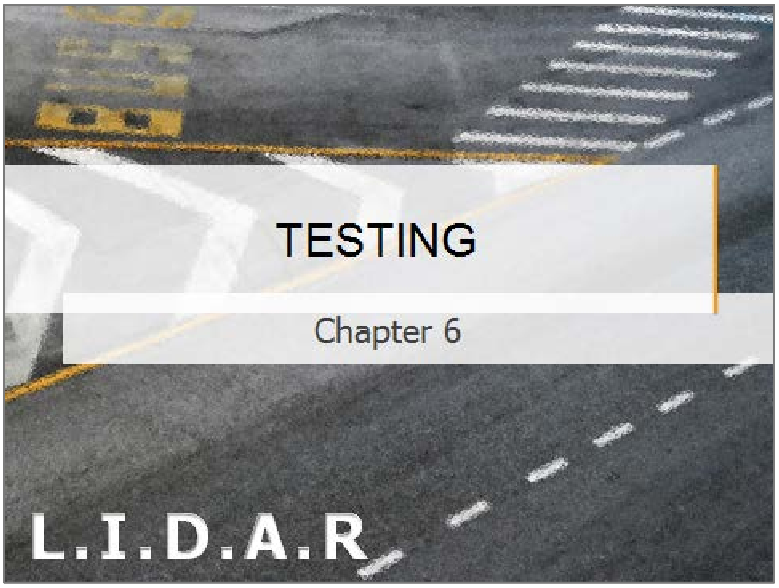
L. I. D. A. R.

Contents

Objectives

By the end of this chapter, you will be able to:

- Perform function tests



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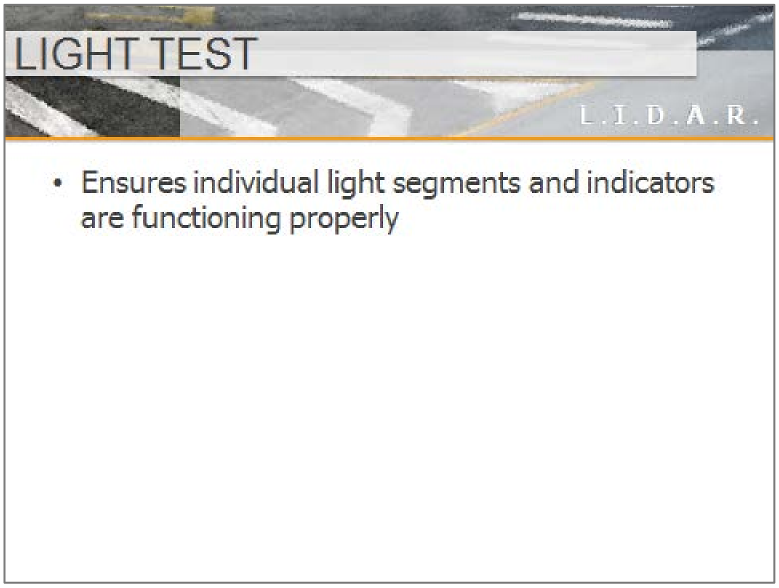
OPERATORS SHOULD CONDUCT ALL TESTS IN ACCORDANCE WITH MANUFACTURER'S SPECIFICATIONS.

Perform function tests per manufacturer specifications and jurisdictional requirements.

Note: "Checks" and "tests" are used interchangeably

LIGHT TEST

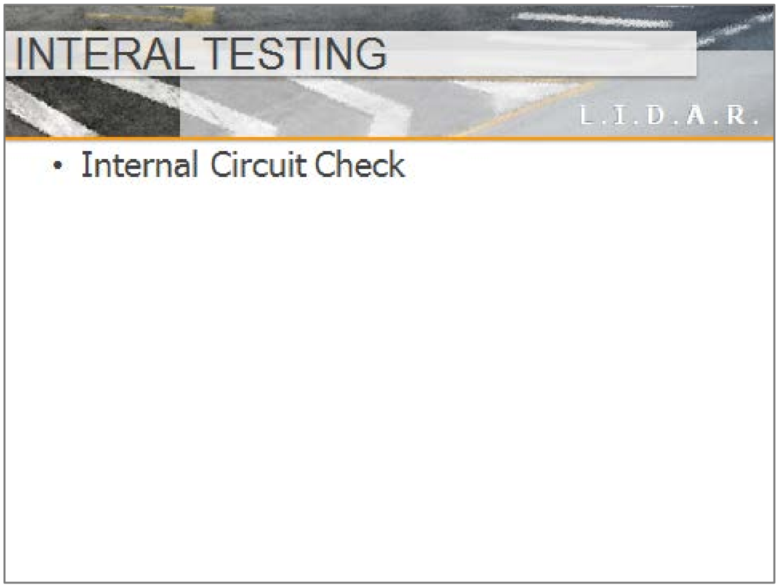


Slide 62.

Light Segment and Indicators Test

The L.I.D.A.R. operator will perform a light test to ensure that all the individual light segments and indicators are functioning properly. If any L.I.D.A.R. device fails to perform the light test as required by manufacture specifications or if any lighting segment is not functioning properly, the L.I.D.A.R. device should be removed from service until repaired.

INTERNAL TESTING

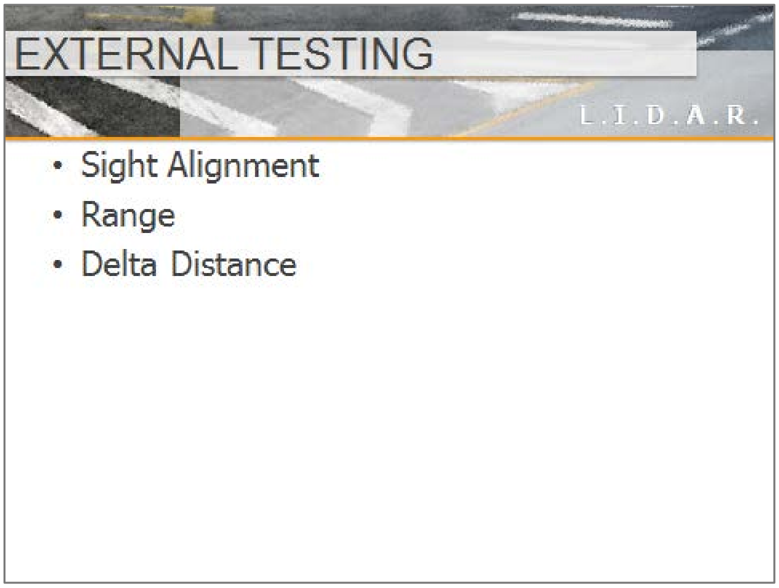


Slide 63.

Internal Circuit Check

The L.I.D.A.R. operator will perform an internal circuit check. If the L.I.D.A.R. device fails to perform the internal circuit check as required by manufacture specifications, the L.I.D.A.R. device should be removed from service until repaired.

EXTERNAL TESTING



Slide 64.

Sight Alignment:

The purpose of sight alignment tests is to verify that the L.A.S.E.R. beam is aligned with the reticule or cross hairs.

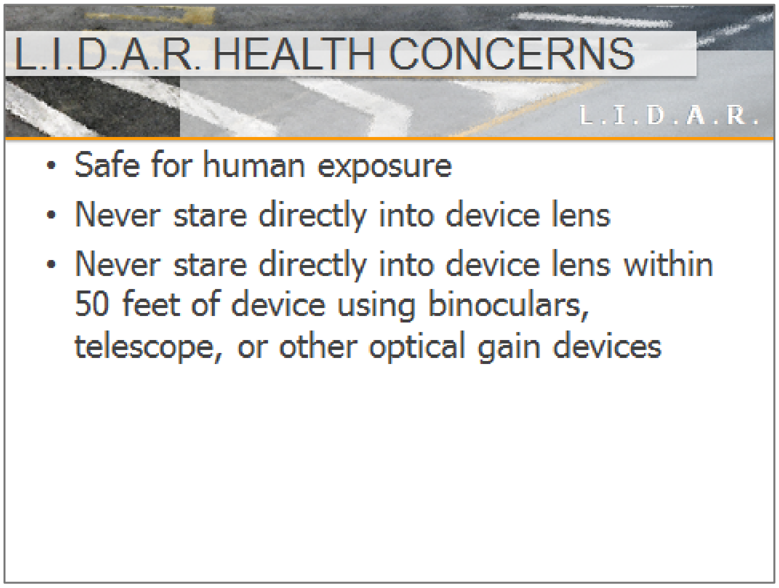
Range (Fixed Distance) Function Check:

The L.I.D.A.R. operator will check the range function by sighting on a fixed object from a point that was measured manually.

Delta (Differential) Distance Test

The purpose of this test is to ensure the unit is accurately calculating target speeds. During this test, the operator takes two different distance measurements so the unit can run a calculation and display a known speed rating based on the distance difference.

L.I.D.A.R. HEALTH CONCERNS



Slide 65.

L.I.D.A.R. devices are considered Class 1 Eye Safety devices by the United States Food and Drug Administration (FDA). This implies that the devices are considered safe based upon current medical knowledge. While they are Class 1 devices and are inherently eye safe, certain reasonable precautions should be taken in their operation.

- Never stare directly into the device lens
- Never stare directly into the device lens within 50 feet of the device using binoculars, telescope, or other optical gain devices

During normal operations, L.I.D.A.R. devices are safe for human exposure. L.I.D.A.R. devices emit less power and energy than television remotes, flashlights, and L.A.S.E.R. tag games.

7

LEGAL CONSIDERATION

Estimated time for Chapter 7: 30 Minutes

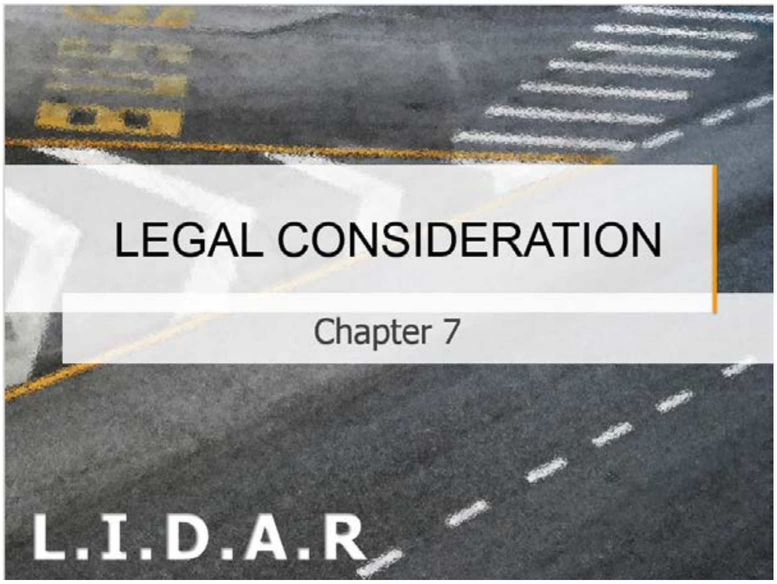
L. I. D. A. R.

Contents

Objectives

By the end of this chapter, you will be able to:

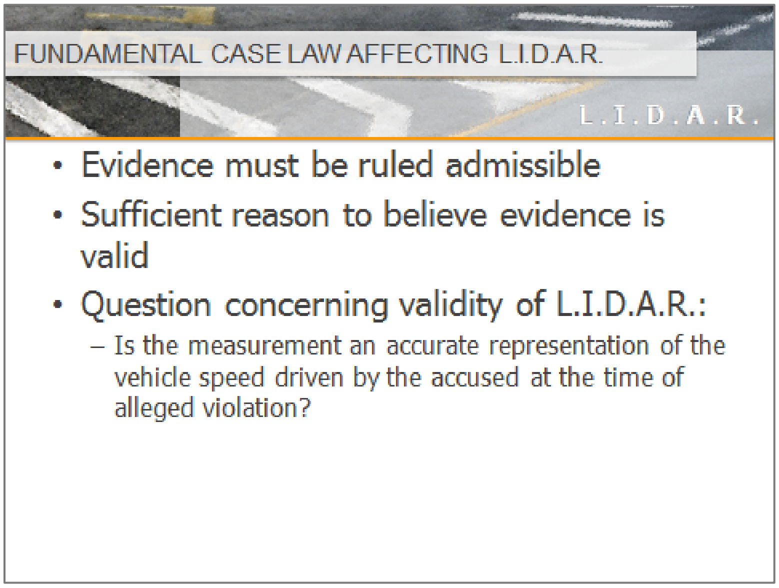
- Discuss legal considerations pertaining to L.I.D.A.R.
- Discuss the requirements needed for citation documentation and/or courtroom testimony



Slide 66.

SUPPLEMENT 1: Additional Court Cases

FUNDAMENTAL CASE LAW AFFECTING L.I.D.A.R.

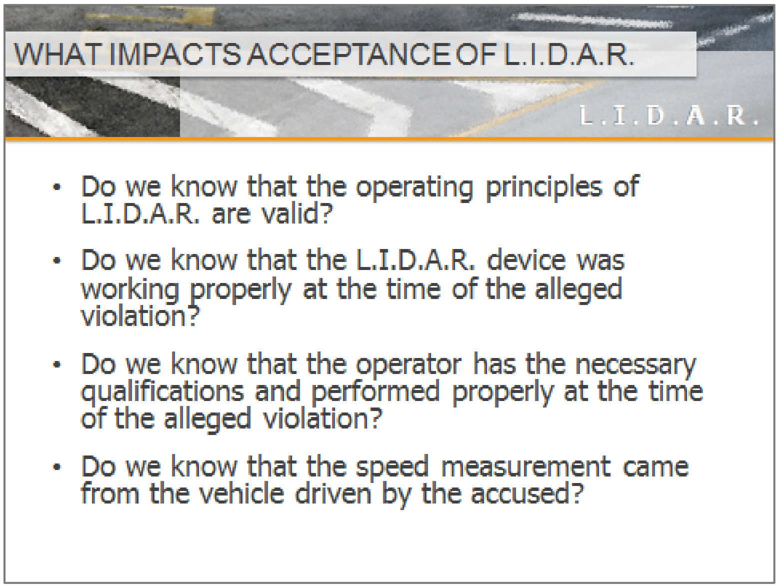


Slide 67.

L.I.D.A.R. speed-measuring devices are used in traffic enforcement to acquire evidence. To be useful, the evidence must be ruled admissible and there must be sufficient reason to believe evidence is valid for it to be admitted.

The question concerning the validity of a L.I.D.A.R. speed measurement is:

- Is this measurement an accurate representation of the speed of the actual vehicle driven by the accused at the time of the alleged violation?



Slide 68.

- Are the operating principles of L.I.D.A.R. valid?
- Was the L.I.D.A.R. device was working properly at the time of the alleged violation?
- Is the operator qualified to use the device, and did so correctly at the time of the alleged violation?
- Can it be demonstrated the speed measurement came from the vehicle driven by the accused?

The validity of scientific principles used in a speed-measurement device has been settled and judicial notice is taken that both R.A.D.A.R. and L.I.D.A.R. are reliable and accurate technologies for measuring speed. The principle of judicial notice applies to facts that are common knowledge and states that it is not necessary to introduce evidence to prove what common knowledge is.

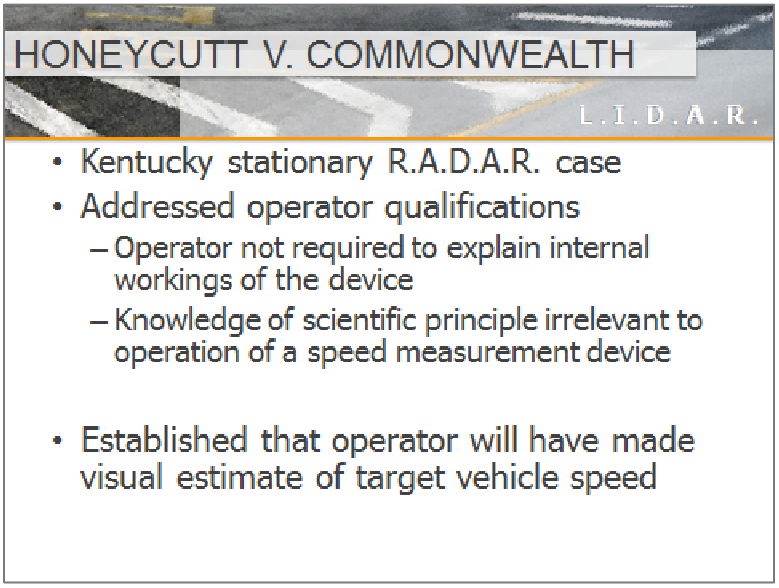
We know that the scientific principles used in L.I.D.A.R. are valid and common knowledge. This principle involves basic concepts like the speed of light (186,282 miles per second) and the formula for speed, i.e., $speed = \frac{distance}{time}$.

Ensuring that a L.I.D.A.R. device is functioning correctly is critical to making fair and accurate measurements of speed for enforcement purposes. Because the device is working properly today does not mean it will work properly tomorrow. The law enforcement officer must be prepared to provide evidence that the device was working properly at the time the speed measurement was made.

Courts have long accepted the practice of "before-and-after" testing. Before-and-after testing requires the device be shown working properly both at the beginning and end of the tour of duty during in which the measurement of the suspect vehicle's speed was taken. These actions support the argument that when measurements are taken between the start and end of a shift, the device was working properly.

1. The operator can establish that he/she was trained in the use of the specific device.
2. Where applicable, that the law enforcement officer has been trained to a specific standard or curriculum content in compliance with established statute(s).
3. The operator followed established operating procedures for the specific device.
4. The operator performed and verified the required pre-and post-operational accuracy checks.
5. The operator had an opinion as to the target vehicle speed that was independent of the speed-measuring device.
6. The enforcement action resulted only after the operator's opinion was corroborated by the speed-measurement device and demonstrated a clear-cut violation of the applicable speed laws.

HONEYCUTT V. COMMONWEALTH



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The question of operator qualifications was addressed by the Kentucky Court of Appeals in the landmark (R.A.D.A.R.) case Honeycutt v. Commonwealth. "Honeycutt" established that a speed-measurement device operator need not be able to explain the internal workings of the device. This case set a standard in 1966 for acceptable use of and testimony about R.A.D.A.R.

Also, knowledge of the scientific principle is irrelevant to the operation of a speed measurement device. The defense cannot question the operator's knowledge of the scientific principles.

The operator should not attempt to describe or explain these principles in courtroom testimony.

In Honeycutt v. Commonwealth, the court ruled that it is sufficient to have enough knowledge and training to properly:

- Set up the device
- Test its accuracy
- Read the device to obtain the speed measurement

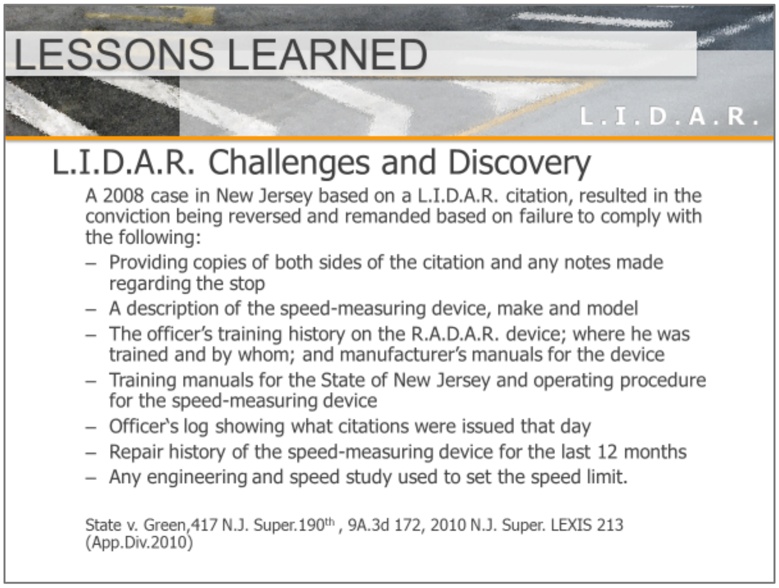
The impact of this ruling on an officer's testimony suggests:

- You must establish that you have the necessary qualifications and training for a L.I.D.A.R. operator
- You must establish that the device was set up properly and working normally
- You must establish that the L.I.D.A.R.'s accuracy was verified with a proper test

How can we verify that the L.I.D.A.R. speed measurement came from the accused's vehicle?

- The speed-measurement device was operated in accordance with established procedures
- The officer must make a visual estimate of the vehicle's speed
- The L.I.D.A.R. speed measurement must be relatively close to the initial visual estimate

LESSONS LEARNED: L.I.D.A.R. CHALLENGES AND DISCOVERY



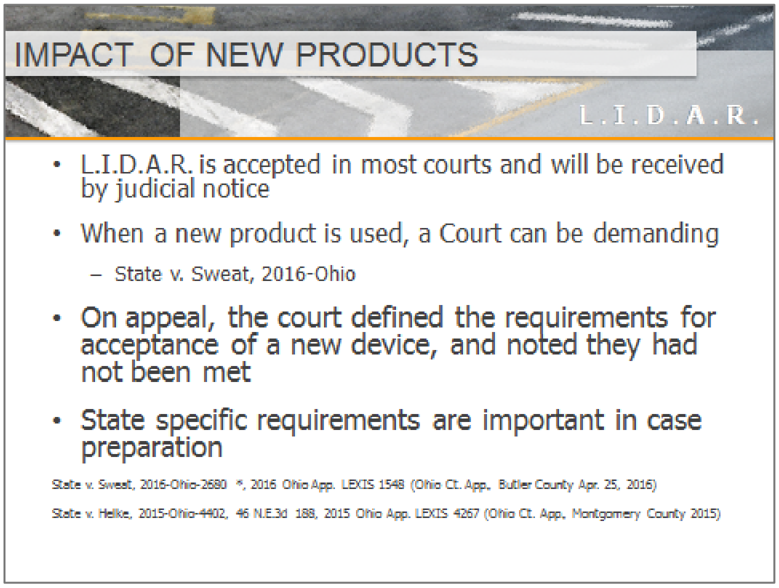
Slide 70.

The New Jersey case includes additional elements, such as providing copies of the citation(s) and any notes associated with the violation, being able to produce training records and curricula, daily activity logs, the maintenance records for the device, and even data to justify the established speed limit.

While these kinds of expectations are not likely to arise in most speeding cases, the elements laid out in State v Green reflect a very different set of issues unrelated to the reliability of L.I.D.A.R. technology.

Law enforcement officers should be prepared to address such questions if they arise. Having access to device maintenance records and traffic engineering and speed study data are also valuable resources.

IMPACT OF NEW PRODUCTS



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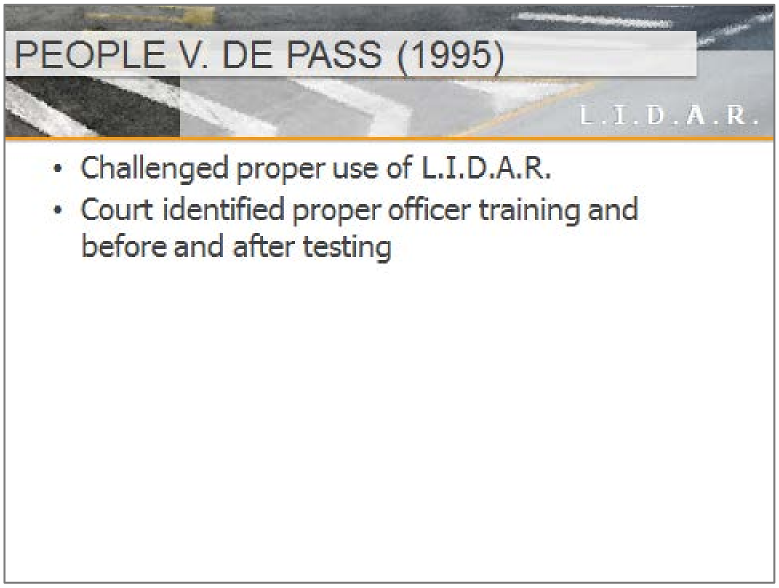
Note that when a new product is used, acceptance and judicial notice is not always a given. L.I.D.A.R. is accepted in most courts and will be received by judicial notice, which is not always the case for new speed-measuring devices. Here is language from a 2016 Ohio appeal:

> This court has previously recognized that the reliability of a speed-measuring device can be established in one of three ways: a reported municipal court decision from this district, a reported or unreported case from our appellate court, or the previous consideration of expert testimony by the trial court as noted on the record. State v. Starks, 196 Ohio App.3d 589, 2011-Ohio-2344, 964 N.E.2d 1058 (12th Dist.). Within Starks, ***we noted that no such decision existed wherein any court in this district took judicial notice of the reliability of the (XXXXXXX) and no court had considered expert testimony on the issue***. The circumstances set forth in Starks have not changed, as the state has never offered expert testimony to establish the scientific reliability of the XXXXXXX in our district. (manufacturer/model name omitted for purposes of this curriculum)
>
> Understanding the requirements within your State are critical to making effective cases if judicial notice is based on similar factors, or other legal requirements.

PEOPLE V. DEPASS



Slide 72.

In a lower-case ruling, a New York court held in favor of L.I.D.A.R. evidence.

The court ruled that speed calculations of motor vehicles made by a L.A.S.E.R. device is scientific evidence and admissible in court, based in part on testimony given by an astrophysicist on the basic workings of the device. The device has been used by the space shuttle astronauts and is now widely used by law enforcement officers for measuring the speed of vehicles.

A qualified scientist and astrophysicist explained the principles utilized in the operation and use of the hand-held device for determining speed of a moving vehicle. His testimony made clear that the device makes use of principles that are well accepted in the scientific community, as it uses the principle that the speed of light is known and constant.

It further relies on the accepted understanding that a L.A.S.E.R. beam emitted from a L.A.S.E.R. generator is very narrow in width and will not spread significantly after emission and is emitted in a narrow frequency band.

In addition to a L.A.S.E.R. emitter, the device in question also contained a photo diode, a clock, and a computational device. In operation, when a short L.A.S.E.R. beam burst is emitted toward an object having a reflective surface, the time at which the reflected beam is received back at the photo diode is determined. Based upon the time between L.A.S.E.R. beam emission and return and the known speed of light, the distance between the object and the L.A.S.E.R. device is determined by simple arithmetic calculation. If two or more sequential beams are emitted toward a specific vehicle and the return times are measured, the difference in the distances measured for each emission can be used to determine the difference between the locations of the vehicle at two points.

By knowing the difference in time between each of the emission returns, and then dividing the difference in distance by the time elapsed between the two returns, the velocity of the vehicle between the two points is determined.

Testimony given was that these principles of operation are widely used in L.A.S.E.R. range finders, in geodesic survey work and in many other applications. The device in question had been used on several space flights in the previous two years to measure distances between the Space Shuttle and other objects.

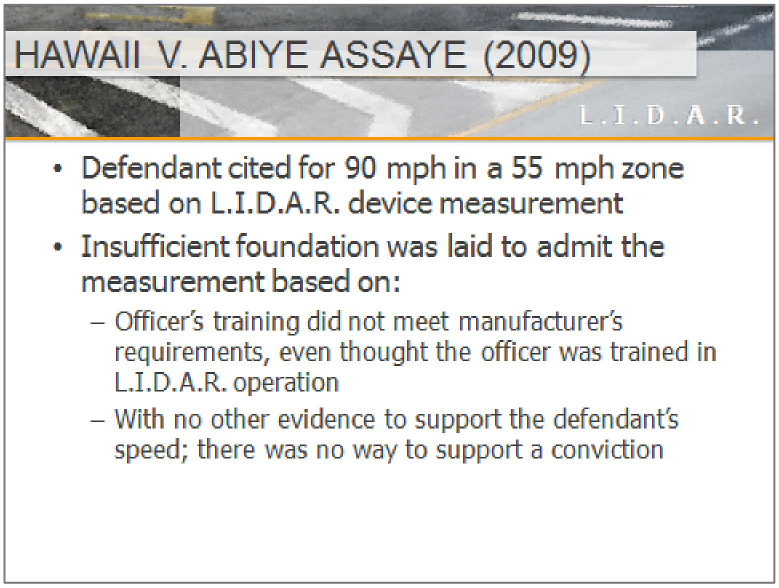
A data base survey has revealed the existence of over 1500 publications dealing with the use of L.A.S.E.R.s to determine distance or measure velocity. The same principle of operation is also used by airport "R.A.D.A.R." which uses pulsed radio waves rather than L.A.S.E.R. pulses to locate the positions of aircraft flying in the vicinity. The only difference is in the wavelength of radio waves as compared to that of L.A.S.E.R. light.

Considerable care appears was taken to ensure the accuracy of readings taken with the device which emits 60 pulses within about one third of a second when activated.

The first several pulses establish a range to the target. The next 40 pulses are then transmitted and the reflections received back by the diode clock combination.

For a reading of speed to be displayed, 30 pulses must return to the diode and result in speed determinations within one (1) mile per hour. The emissions of the pulses are computer generated. The computer also does the calculations and insures that the calculated velocity values formed fit within the allowable tolerance, i.e. +/-1 mile per hour at a speed of 60 miles per hour.

HAWAII V. ABIYE ASSAYE



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On September 30, 2009, the Supreme Court of Hawaii reversed a L.I.D.A.R. court case stating the prosecution has not adduced "sufficient evidence to prove every element of the offense beyond a reasonable doubt." This case resulted from a citation issued September 5, 2007, by a Honolulu police officer, certified to operate a specific L.I.D.A.R. device. The officer testified he had measured Assaye's vehicle moving at 90 mph in a 55-mph zone from 492 feet. The officer had tested the L.I.D.A.R. exactly as he had been trained and in accordance to the manufacturer's specifications. Tests included:

1. Self-Test,
2. Light Segment Test,
3. Scope Alignment Test, and
4. Known Distance Test (including a delta-distance test)

The Honolulu Police Officer had used the same L.I.D.A.R. for the past 15 months and had never experienced any problems with this equipment. Why did the court dismiss this case?

The court held that an inadequate foundation was laid to show that the speed measured by the LADAR device could be relied on as a substantive fact.

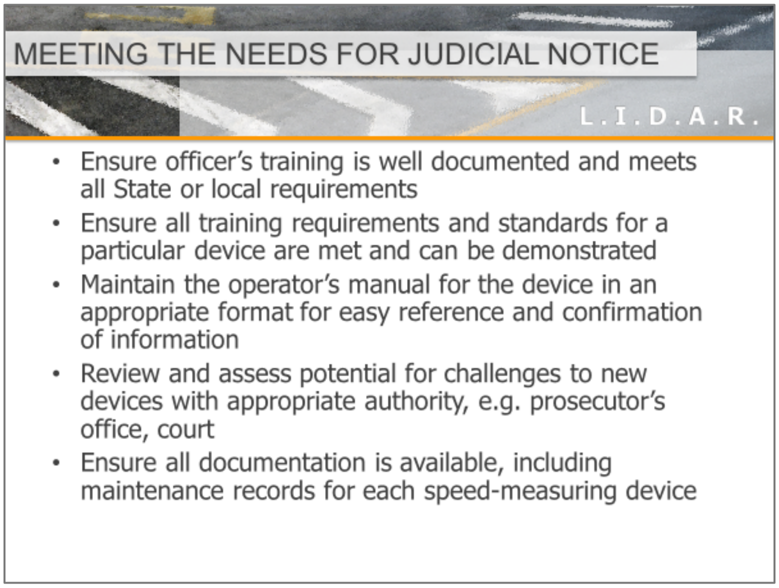
The prosecution was required to prove that accuracy of the device was tested per procedures recommended by the manufacturer and that the officer was qualified by training and experience to operate that device. Namely, the prosecution must establish whether the nature and extent of the officer's training in the operation of the device met requirements indicated by the manufacturer.

Although the officer testified that he was certified to use the device, this did not show his training met the manufacturer’s requirements.

Because an improper foundation was laid for the admission L.I.D.A.R. device reading and because no other evidence was admitted at trial to establish the defendant’s speed, the evidence was insufficient to support the defendant’s conviction.

This case underscores the importance of being properly trained to use a specific device and having the materials available to demonstrate the operation was consistent with the training, e.g., device operator’s manual and/or training curricula.

MEETING THE NEEDS FOR JUDICIAL NOTICE



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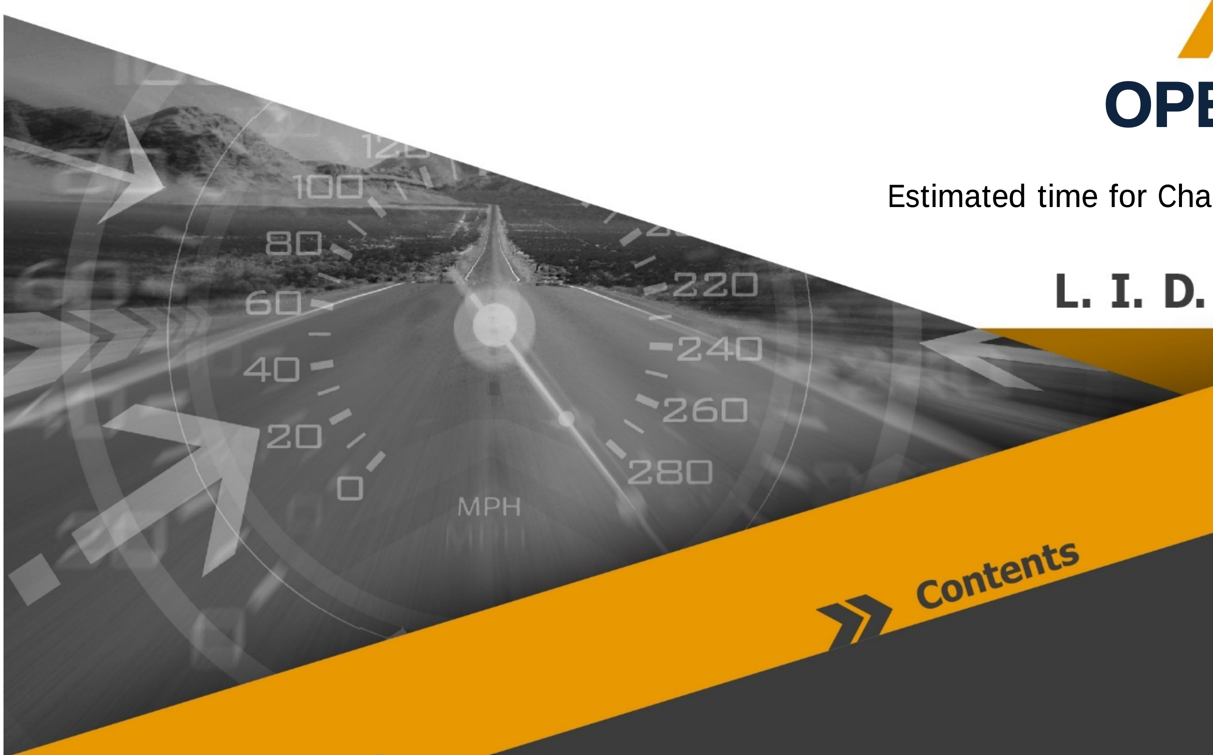
Hawaii v Assaye illustrates the potential issues that may arise with the introduction of new technology or substantial changes in comparison to judicial notice given to older devices.

While the scientific principles of how L.I.D.A.R. functions remain constant, the standards and specifications provided by the manufacturer for the appropriate use of a particular device must be considered and met to help establish judicial notice. Having all relevant records for both the operator and speed-measuring device can become critical to the admissibility of evidence. Discussing any issues of admissibility with local prosecutors and/or review with counsel is highly recommended when using new devices.



8

OPERATE

Estimated time for Chapter 8: Varies

L. I. D. A. R.

Objectives

By the end of this chapter, you will be able to:

- Operate a L.I.D.A.R. speed-measuring device

Contents

OPERATOR PRACTICUM

Note: This is a perishable skill and individuals should practice occasionally. The operator should be acclimated to location prior to enforcement.

This purpose of this practicum is to give you the opportunity for hands-on practice with similar L.I.D.A.R. device(s) you will be using in your department.

Remember the most important criterion in this practicum is your safety, the safety of other students and of the motoring public.

Each student will take turns as the operator.

Begin by setting up the unit and running through its various testing procedures. You must follow all approved operating procedures that would be taken in actual patrol situations.

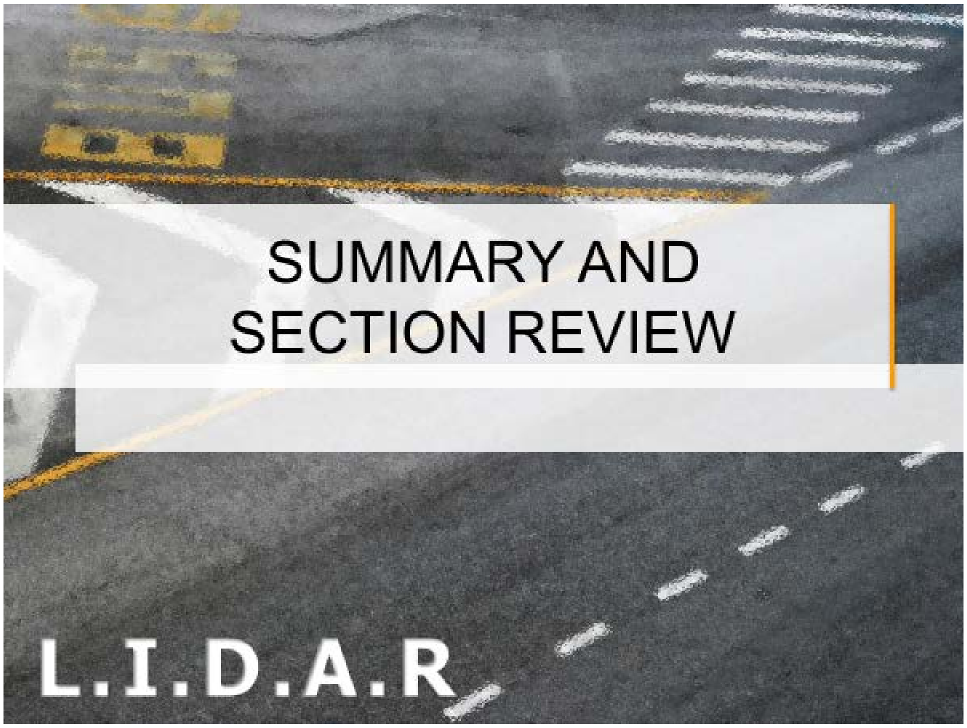
After setting up and testing the L.I.D.A.R. device, you will be allowed to obtain at least 20 practice target readings.

You should feel free to ask questions during your practice session.

Keep in mind and point out various elements of supportive evidence to the instructor as they arise. You should identify the elements needed to develop a tracking history for each target vehicle.

You should evaluate other group members for any actions you consider inappropriate or inaccurate. You should disassemble and dismount the unit per your agency guidelines at the end of your turn. The groups will return to the classroom after everyone has had a turn as operator.

SUMMARY AND SECTION REVIEW (20 Minutes)



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POSTTEST

Additional Uses of LIDAR

https://science.larc.nasa.gov/lidar/

LIDAR: Not enough for a speeding ticket, but it is just fine for NASA space investigations, astronomy, geology and oceanography. See 41 uses of LIDAR at: http://grindgis.com/data/lidar-data-50-applications

Some States require training statutorily:

(a) In any judicial or administrative proceeding in which the results of a R.A.D.A.R., L.A.S.E.R or similar device used to measure the speed of a motor vehicle are being introduced for the purpose of proving the speed of the motor vehicle or the conduct of the driver of the vehicle, such results shall not be admissible for such purposes unless the law enforcement officer operating the device has been trained pursuant to guidelines established by the National Highway Traffic Safety Administration or the Tennessee peace officer standards and training (POST) commission.

Tenn. Code Ann. § 24-7-124

Honeycutt vs. Commonwealth

This case set a standard in 1966 for the acceptable use of and testimony about R.A.D.A.R..

Concepts in this case are now reflected in statutes and other cases like:

Minnesota v Olson from 2016. It centered on the Minnesota statute that requires:

1) the officer operating the device has sufficient training to properly operate the equipment;
2) the officer testifies as to the manner in which the device was set up and operated;
3) the device was operated with minimal distortion or interference from outside sources; and
4) the device was tested by an accurate and reliable external mechanism, method, or system at the time it was set up.

Minn. Stat § 169.14, subd. 10(a).

State v. Olson, 887 N.W.2d 687 *, 2016 Minn. App. LEXIS 81 (Minn. Ct. App. 2016)

Vermont Supreme Court in 2011.

On appeal, in a one-sentence argument, defendant asserts that the court erred in admitting the LIDAR results because R.A.D.A.R. and LIDAR are not the same, no Vermont authorities confirm the reliability or admissibility of LIDAR technology, and the district court did not give "judicial notice" of the reliability of the technology. We find no merit to this argument. Defendant has not identified any evidence suggesting that the LIDAR device incorporates a novel technology or is significantly different from or less accurate than other speed-detection devices. Indeed, several jurisdictions, including Illinois, have held that the reliability of this technology has been sufficiently demonstrated to allow its introduction into evidence without first holding an underlying evidentiary hearing on its reliability. See, e.g., State v. Williamson, 144 Idaho 597, 166 P.3d 387, 389-90 (Idaho Ct. App. 2007) (citing other jurisdictions that have accepted general reliability of L.A.S.E.R device in support of holding "that L.A.S.E.R speed detection devices are generally reliable and their results may be admitted into evidence in Idaho courts" without either taking specific judicial notice or requiring scientific evidence of L.A.S.E.R's reliability); People v. Mann, 397 Ill. App. 3d 767, 922 N.E.2d 533, 537-38, 337 Ill. Dec. 410 (Ill. App. Ct. 2010) (concluding that decisions from other jurisdictions "are ample authority that the use of LIDAR to measure the speed of moving vehicles is based on generally accepted scientific principles"). Defendant's reliance upon Canulli is unavailing insofar as the appellate court in that case reversed the trial court because it had relied upon an inadequately litigated, nonbinding decision in another trial court case involving a different type of L.A.S.E.R technology from the technology being challenged in Canulli. See Mann, 922 N.E.2d at 535-36; Canulli, 792 N.E.2d at 444-45. Accordingly, the hearing officer did not abuse his discretion in admitting results from the use of the LIDAR L.A.S.E.R device without first holding an evidentiary hearing on the device's reliability.

State v. de Macedo Soares, 2011 VT 56 *, 190 Vt. 549, 26 A.3d 37, 2011 Vt. LEXIS 58 (Vt. 2011)

Judicial Notice

Note that when a new product is used, a Court can be demanding. While LIDAR is accepted in most courts and will be received by judicial notice, that is not always the case for new speed measuring devices. Here is language from a 2016 Ohio appeal:

This court has previously recognized that the reliability of a speed-measuring device can be established in one of three ways: a reported municipal court decision from this district, a reported or unreported case from our appellate court, or the previous consideration of expert testimony by the trial court as noted on the record. State v. Starks, 196 Ohio App.3d 589, 2011-Ohio-2344, 964 N.E.2d 1058 (12th Dist.). Within Starks, we noted that no such decision existed wherein any court in this district took judicial notice of the reliability of the (XXXXXXX) and no court had considered expert testimony on the issue. The circumstances set forth in Starks have not changed, as the state has never offered expert testimony to establish the scientific reliability of the (XXXXXXX) in our district.

State v. Sweat, 2016-Ohio-2680 *, 2016 Ohio App. LEXIS 1548 (Ohio Ct. App., Butler County Apr. 25, 2016)

Another in which the devise required expert testimony in Ohio is:

State v. Helke, 2015-Ohio-4402, 46 N.E.3d 188, 2015 Ohio App. LEXIS 4267 (Ohio Ct. App., Montgomery County 2015)

Hawaii v. Abiye Assaye 2009

Defendant was cited for speeding after a police officer’s L.A.S.E.R gun revealed that he was traveling at 90 m.p.h. in a 55-m.p.h. zone. On review of the appellate court order affirming defendant’s speeding conviction, the court held that an inadequate foundation was laid to show that the speed measured by the L.A.S.E.R gun could be relied on as a substantive fact. The prosecution was required to prove that the L.A.S.E.R gun's accuracy was tested per procedures recommended by the manufacturer and that the officer was qualified by training and experience to operate the particular L.A.S.E.R gun; namely, the prosecution must establish whether the nature and extent of the officer's training in the operation of the L.A.S.E.R gun met the requirements indicated by the manufacturer. Although the officer testified that he was certified to use the L.A.S.E.R gun, that did not show that his training met the L.A.S.E.R gun manufacturer’s requirements. Because an improper foundation was laid for the admission L.A.S.E.R gun reading and because no other evidence was admitted at trial to establish defendant’s speed, the evidence was insufficient to support defendant’s conviction.