Speed-Measuring Device Operator Training

Instructor Manual

R. A. D. A. R.

NHTSA
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

TSI
Transportation Safety Institute

R.A.D.A.R. COURSE OVERVIEW

This course is designed to prepare students to operate a R.A.D.A.R. speed-measuring device.

- Learning Objectives
  - Describe the origin of R.A.D.A.R. technology as related to speed measuring
  - Explain the Doppler Principle
  - Explain the scientific principles of R.A.D.A.R. technology as related to speed measuring
  - Discuss modes of R.A.D.A.R. operation
  - List the elements of tracking history for each mode of operation
  - Discuss R.A.D.A.R. effects
  - Identify the components and features of the specific R.A.D.A.R. device(s) used
  - Set up R.A.D.A.R.
  - Perform function tests
  - Discuss legal considerations pertaining to R.A.D.A.R.
  - Discuss the requirements needed for citation documentation and/or courtroom testimony
  - Operate a R.A.D.A.R. speed-measuring device
- Section Review
- Optional Written Pretest
- Written Posttest
- Practical/Proficiency Testing
- Course Evaluation

Materials

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

Operation of Specific R.A.D.A.R. Device(s)

The study materials for this section must be obtained through the direct examination of instructions provided by the manufacturer of each R.A.D.A.R. device.

Specific information on component assembly, nomenclature, power supply, testing, etc., must be gleaned from materials supplied by the manufacturers. Because modifications are constantly being made to both new and existing R.A.D.A.R. devices, it would be impossible to provide up-to-date operating materials with this course.

It is possible that the terminology and operating procedures supplied by the manufacturer may conflict with the instruction you receive in this course. Wherever possible, terminology and procedures should conform to those used in this program.

1

INTRODUCTION/HISTORY

Estimated time for Chapter 1: 15 Minutes

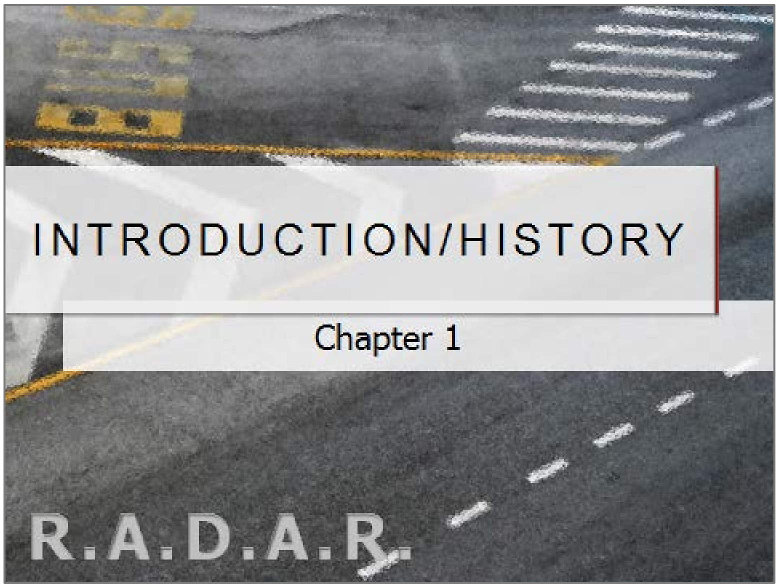
R. A. D. A. R.

Contents

Objectives

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

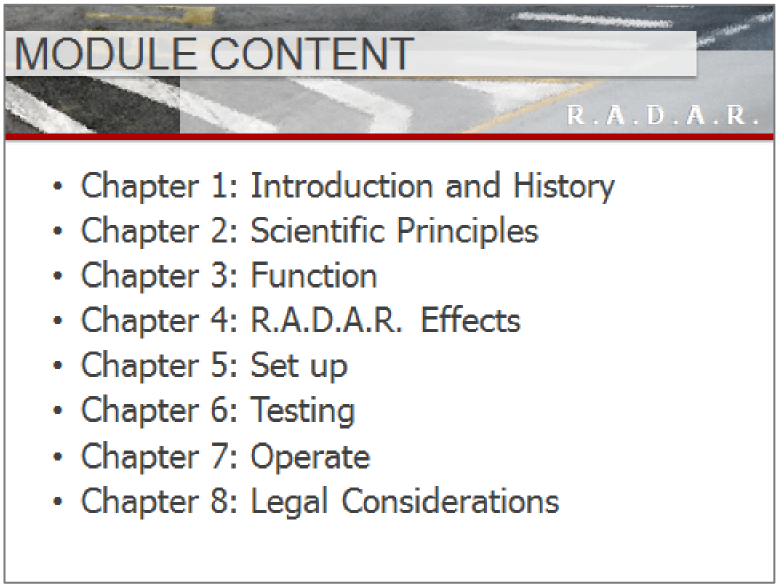
- Describe the origin of R.A.D.A.R. technology as related to speed measuring



Slide 1.

R.A.D.A.R. speed-measuring devices are effective tools for measuring vehicle speed. As the technology improves, R.A.D.A.R. devices will continue to be a major component of highway safety.

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 R.A.D.A.R. module is specifically designed to provide operators the knowledge and skills necessary to properly operate R.A.D.A.R. speed-measuring devices.

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

R.A.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 testimony in court.

PRETEST (OPTIONAL)

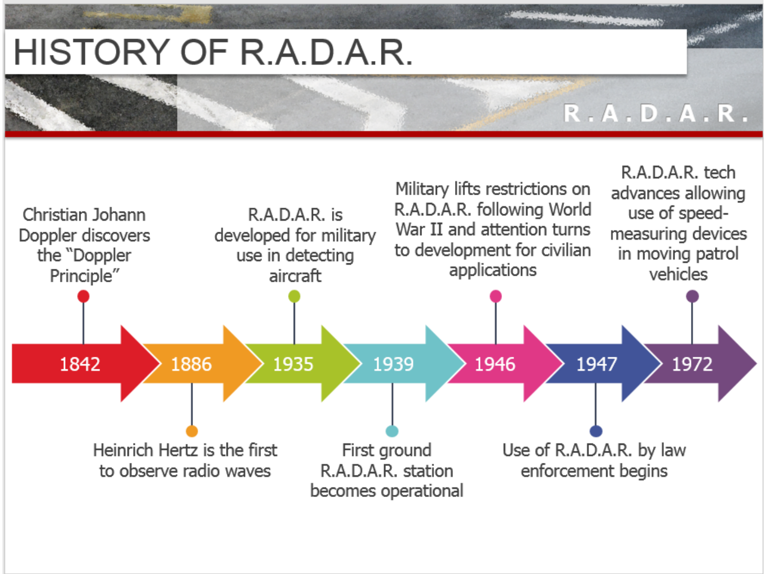
R.A.D.A.R. Handout 1: R.A.D.A.R. Pretest (Optional)

Instructor should administer pretest found in the back of this manual.

Slide 3.

R.A.D.A.R. is an acronym of the phrase **RA**dio **D**etection **A**nd **R**anging.

HISTORY OF R.A.D.A.R.



Slide 4.

In 1842, Christian Johann Doppler, an Austrian physicist, discovered that relative motion causes a signal's observed frequency to change by studying soundwaves. It was later determined that this principle applies to all kinds of waves, including light and radio waves. We now refer to this scientific fact as the "Doppler Principle."

Physicist Heinrich Hertz first observed radio waves in 1886 while conducting experiments verifying theoretical predictions made 20 years earlier by James Clerk Maxwell.

R.A.D.A.R. was first used for measuring distance. In 1935, R.A.D.A.R. was developed for use by the military in detecting approaching aircraft and in determining its position. The first ground R.A.D.A.R. stations became operational in 1939. The military lifted security restrictions for R.A.D.A.R. following World War II. In 1946, military research in R.A.D.A.R. declined and attention turned to the development of civilian applications like radio astronomy and weather R.A.D.A.R.

In 1947, law enforcement began using R.A.D.A.R. for measuring the speed of vehicles. In 1972, R.A.D.A.R. technology was advanced which allowed for speed-measuring devices to be used in moving patrol vehicles.

2

SCIENTIFIC PRINCIPLES

Estimated time for Chapter 2: 60 Minutes

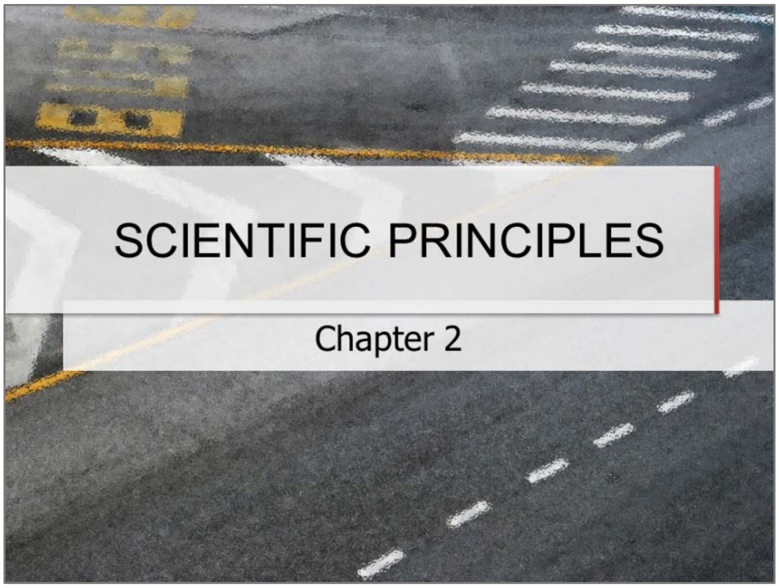
R. A. D. A. R.

Contents

Objectives

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

- Explain the scientific principles of R.A.D.A.R. technology as related to speed measuring



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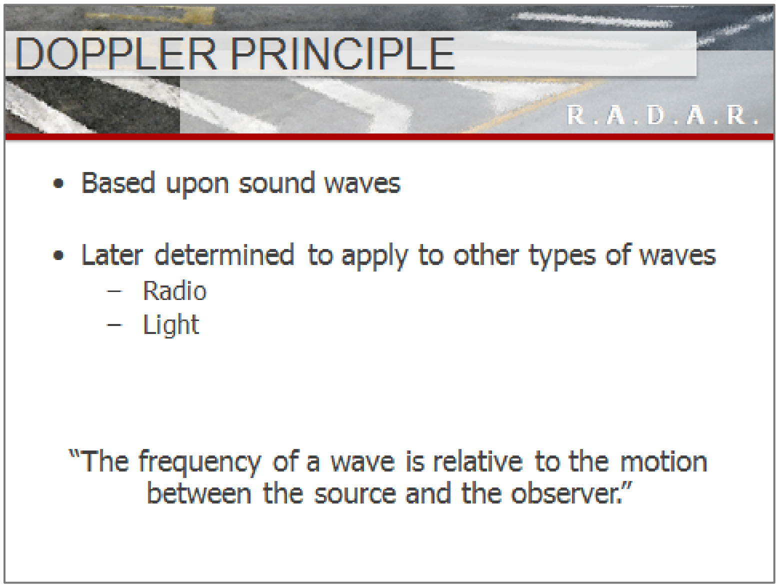
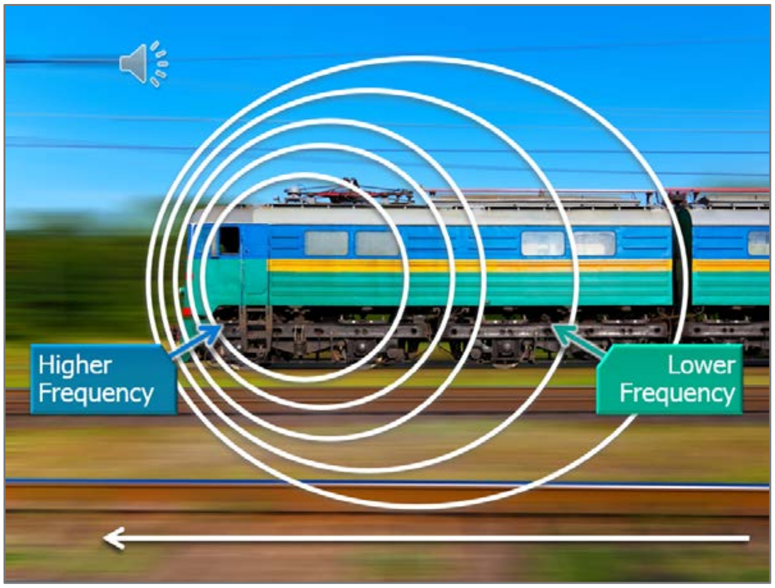
Even though there are many variations and features between types and models of R.A.D.A.R., the scientific principles remain the same: radio-frequency energy is generated by a transmitter, the antenna forms the energy into a beam, and the energy is propagated into space. When the energy strikes an object, a small amount is reflected back to the antenna. From the antenna, it is sent to the receiver where, if the signal is strong enough, it is recognized or "detected." This indicates that a target is present in the beam. The way in which the energy is reflected from the target is processed by the receiver, which determines what type of information will be available to the operator.

DOPPLER PRINCIPLE



Slide 6.

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."



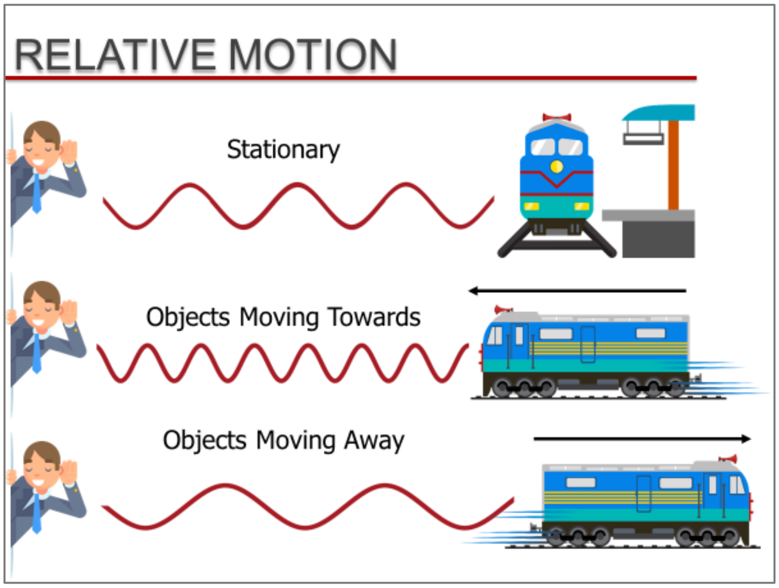
Slide 7.

Click the play button next to the speaker icon on the slide to play the audio clip of the train whistle. Point out the change in pitch of the train whistle.

The same principle can be applied if you stand by a road and listen to a passing vehicle.

Most know how the Doppler Principle affects sound waves. By standing near a railroad track, the sound of an approaching train has a higher pitch than after the train has passed. The frequency of the train's sound is changed due to relative motion; as the train approached, you heard a higher frequency sound, as soon as the train started to move away, the sound changed to a lower frequency.

RELATIVE MOTION



Slide 8.

R.A.D.A.R. devices use specific characteristics of radio energy to measure speed.

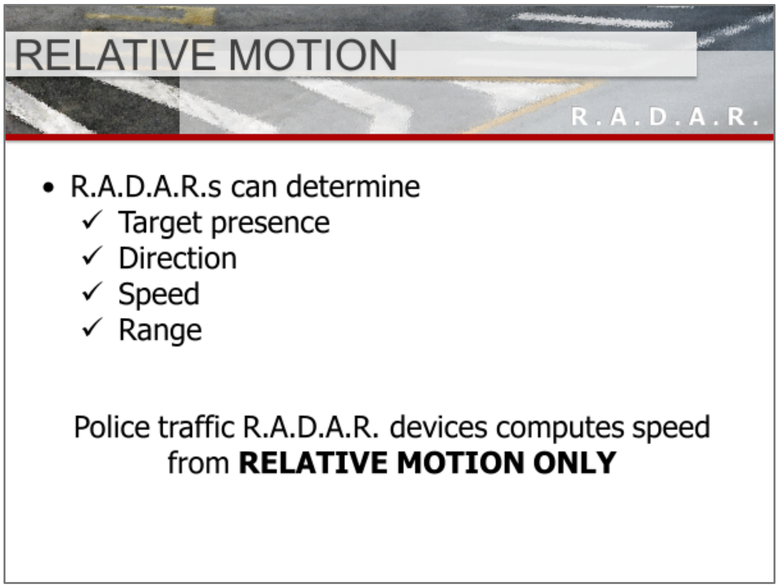
When the Doppler principle is applied to R.A.D.A.R., if there is relative motion (toward or away) between a R.A.D.A.R. and an object, the frequency of the reflected signal will be different from the frequency of the transmitted signal. This change, or shift, in frequency is known as the "Doppler shift."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

If the relative motion is bringing the object and the R.A.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 R.A.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 R.A.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 R.A.D.A.R. and the object. Relative motion will occur only when the object and the R.A.D.A.R. are not moving in the same direction, at the same speed.



Slide 9.

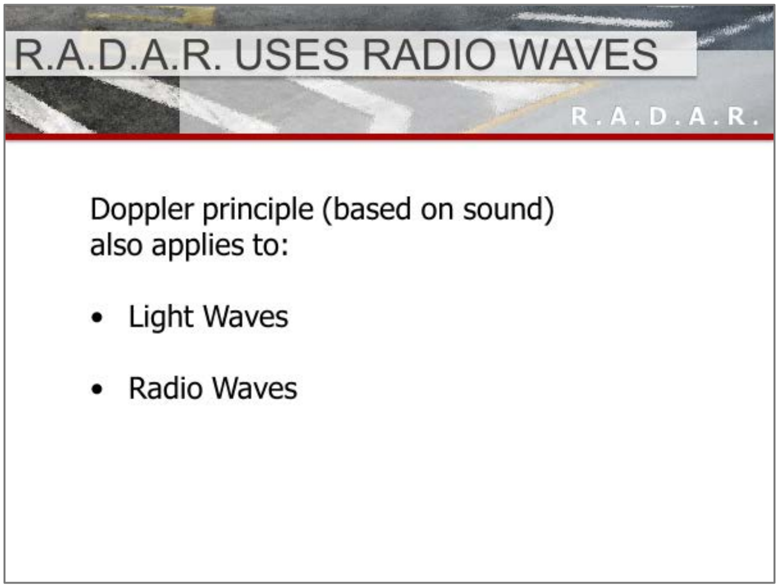
Three types of Relative Motion:

1. R.A.D.A.R. stands still and the object moves
2. R.A.D.A.R. moves and the object stands still
3. Both the R.A.D.A.R. and the object are moving, if they both move at different speeds, or in different directions, so that the distance between them is changing

When the Doppler Principle is applied, R.A.D.A.R. compares the transmitted and reflected frequencies to determine the speed of the relative motion. The R.A.D.A.R. cannot determine whether the object is moving, if the R.A.D.A.R. is moving, or if they are both moving. The R.A.D.A.R. determines how fast they are moving relative to each other.

It is not necessary to understand how or why the Doppler Principle works to become a competent R.A.D.A.R. operator. However, operators should be aware that there is valid scientific basis for R.A.D.A.R. speed measurement.

RADIO WAVES

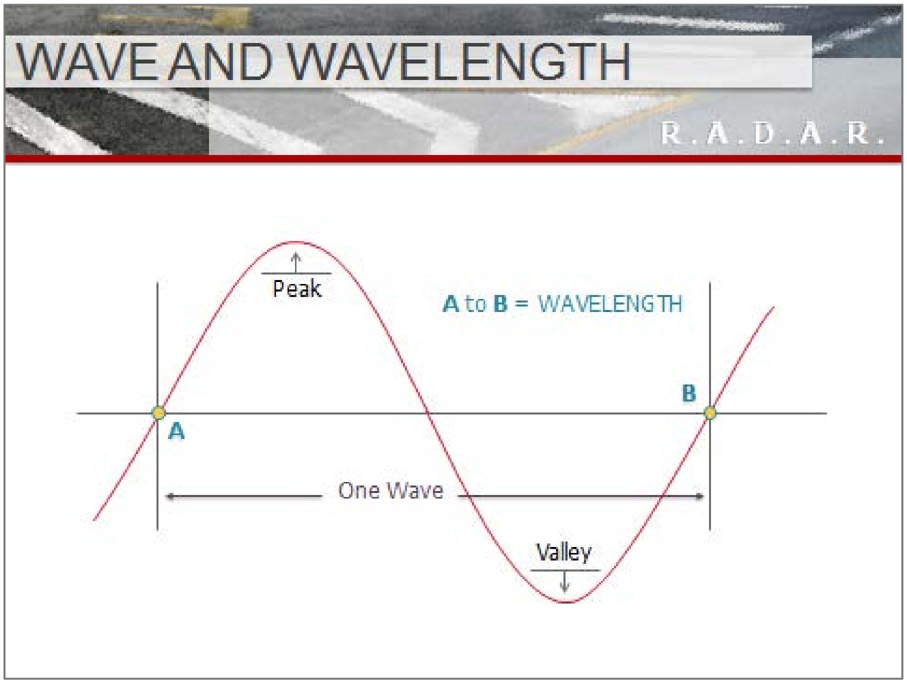


Slide 10.

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

Radio 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.

WAVELENGTH AND FREQUENCY



Slide 11.

Note: A non-propagating signal cannot be assigned a wavelength.

Activity: Use a slinky to provide a representation of a R.A.D.A.R. wave.

The Wave Concept of Radio Signals

To understand how R.A.D.A.R. measures speed we must understand how radio signals can be changed. Radio signals are made of waves. Even though we cannot see radio waves, we can see other kinds of waves, e.g., waves on water. Each wave is made of a series of peaks and valleys.

Every radio signal has its own characteristic wave. If the signal is changed, then the wave is changed.

Every radio signal has two related characteristics that distinguish it from every other signal.

1. **Wavelength** is the distance from the beginning of the peak to the end of the valley. Wavelength is a property associated with the propagation of a reoccurring signal. A wave usually consists of many cycles (not just one).

2. **Frequency** is the number of the recurrences of a signal during one second of time. Frequency refers to the oscillation rate of a periodic signal (source).

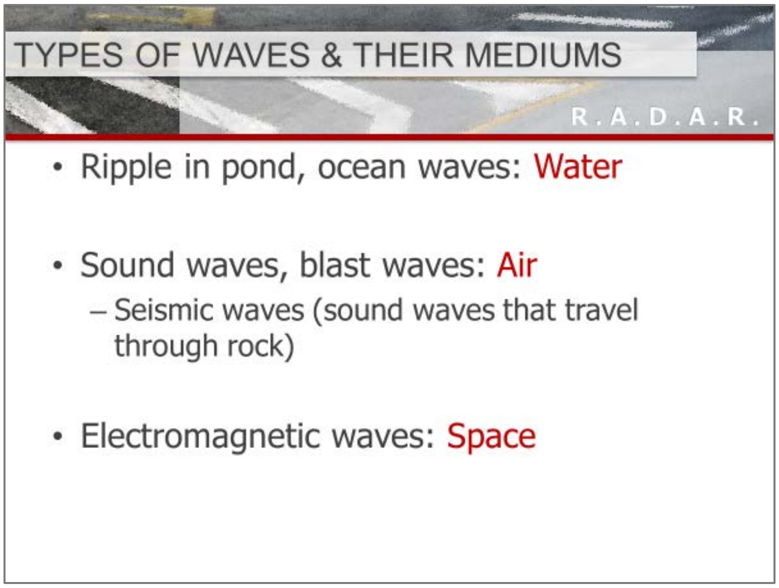
Relationship between Frequency and Wavelength

Every radio signal has its own frequency and wavelength.

The speed of all radio signals is constant = the speed of light (approximately 186,282 miles per second, or 30 billion centimeters per second). This relationship is illustrated by a mathematical formula:

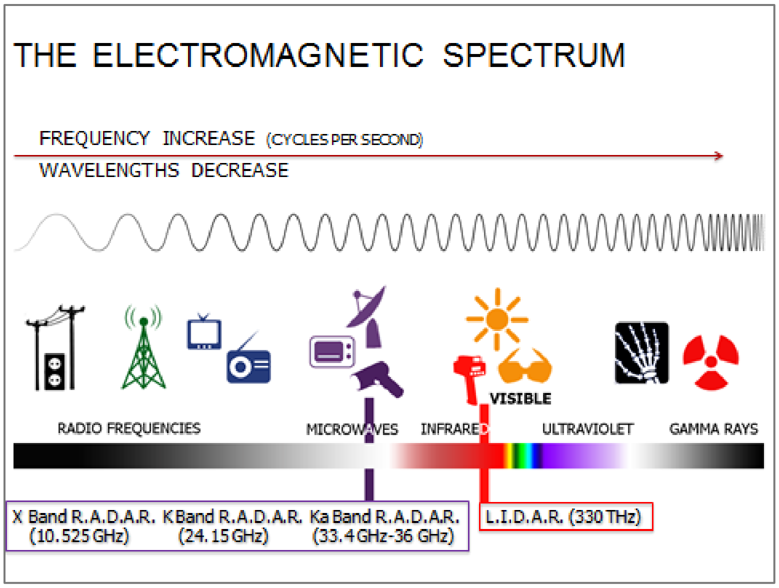
$$\boldsymbol{wavelength * frequency = speed\ of\ light}$$

Whenever a signal is changed, the signal speed remains the same. As the frequency increases, the wavelength will shorten. As the frequency decreases, the wavelength will lengthen.



Slide 12.

We focus on Electromagnetic waves in this course.



Slide 13.

SUPPLEMENT 1: Frequency Formula

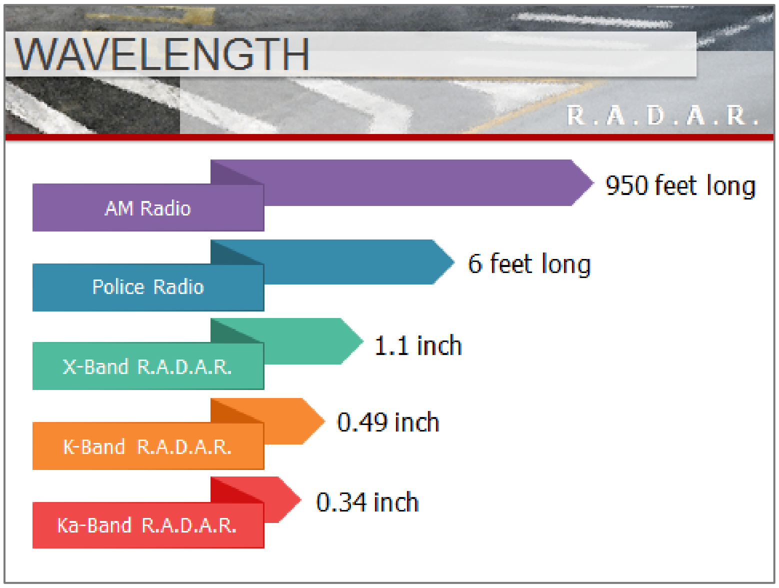
NOTE: All supplements are optional and can be used to further class understanding.

R.A.D.A.R. Speed-Measuring Devices Assigned Frequencies

R.A.D.A.R. speed-measuring devices transmit in the microwave frequency band, which means billions of waves per second (gigahertz). Compared to other types of radio transmissions, the wavelength of these signals is very short.

The Federal Communications Commission (FCC) has assigned the following R.A.D.A.R. frequency bands:

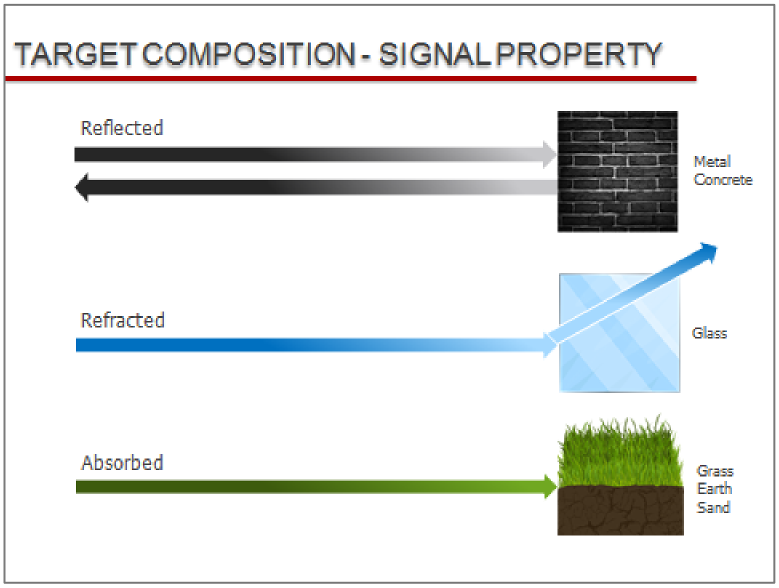
1. The **X-band R.A.D.A.R.** frequency is 10,525,000,000 waves per second (10.525 gigahertz).
2. The **K-band R.A.D.A.R.** frequency is 24,150,000,000 waves per second (24.15 gigahertz).
3. The **Ka-band R.A.D.A.R.** frequency ranges between 33.4 and 36 gigahertz.



Slide 14.

1. The **X-band R.A.D.A.R.** wavelength is about 1.1 inches (2.79 centimeters).
2. The **K-band R.A.D.A.R.** wavelength is about .49 inch (1.24 centimeters).
3. The **Ka-band R.A.D.A.R.** wavelength is between .35 inches and .33 inches (between .88 and .83 centimeters) respectively.

THE R.A.D.A.R. BEAM



Slide 15.

Activity: use flashlight beam to illustrate R.A.D.A.R. beam. An antenna horn from a dismantled R.A.D.A.R. is also useful to illustrate the shape of the beam. Then use the flashlight with mirror, dark black non-reflective material, and glass of water to demonstrate these characteristics.

R.A.D.A.R. Beam Characteristics

The distance the transmitted beam travels is infinite unless it is reflected, absorbed, or refracted by an object. To various degrees, waves striking a surface are always reflected and refracted by the surface and absorbed by the medium beneath the surface.

Reflected

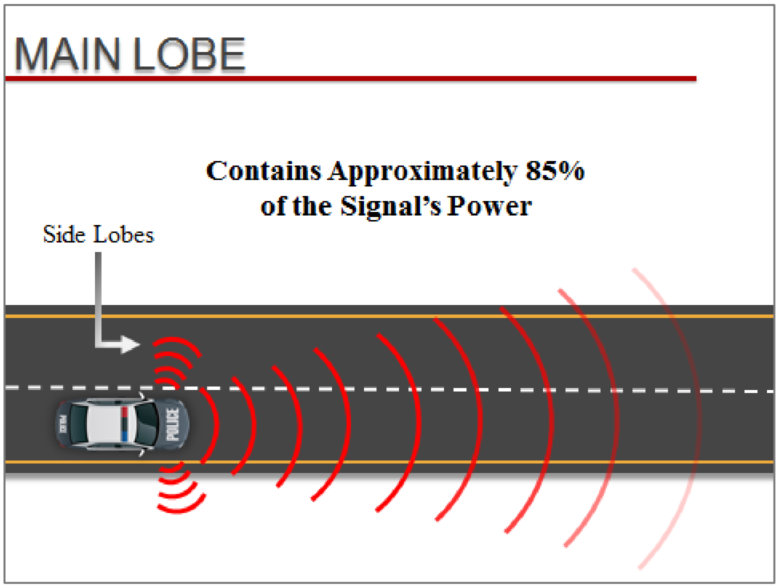
The beam is reflected from a solid, nontransparent material. Typical objects that reflect the beam are made of metal, concrete, or stone.

Refracted (glass, plastic)

The beam is refracted because it passes through a material that is transparent to the R.A.D.A.R. beam. The term refraction refers to the change of direction of radio waves passing through some substances. Almost all forms of glass and plastic will refract the R.A.D.A.R. beam. (An example of refraction becomes evident when a straight object placed partway into water appears to be bent.)

Absorbed

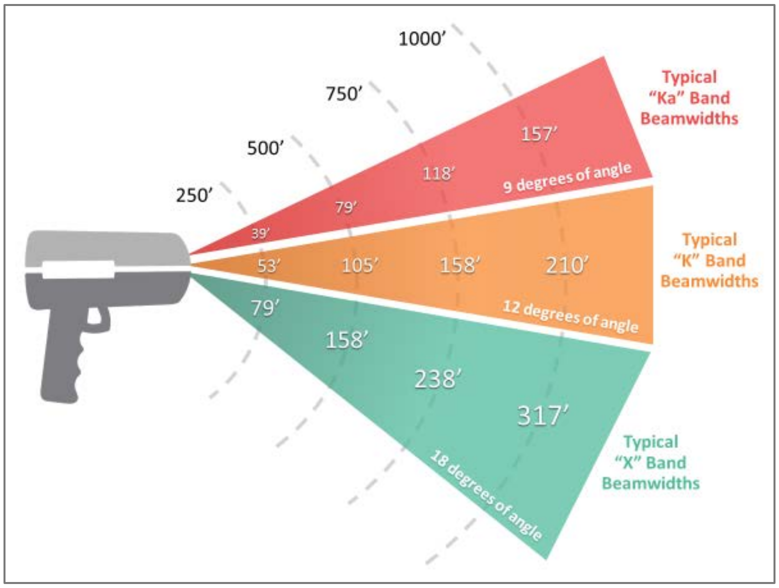
The beam is absorbed into the material. The beam is largely absorbed by grass, dirt, and leaves, with little energy being reflected to the antenna.



Slide 16.

The radio wave energy is transmitted by the antenna on the R.A.D.A.R. device and is concentrated into a cone-shaped "beam" that resembles a flashlight's beam. Most of the transmitted energy remains near the central core of the beam. The amount of energy decreases rapidly as the distance from the device increases. This energy is measured at points on a line at right angles to the main axis of the R.A.D.A.R. beam.

The portion of the R.A.D.A.R. energy close to the antenna is called the side lobes. The energy level in the side lobe is weak and normally does not affect R.A.D.A.R. operation.



Slide 17.

R.A.D.A.R. BEAM WIDTH

 **SUPPLEMENT 2: Beam Width Worksheet (15 Minutes)**

Beam width will vary with each device model. The angle of the emitted R.A.D.A.R. beam will determine the relative beam width. This angle may vary from 9 degrees to 18 degrees depending on the manufacturer.

For example, a beam emitted at an 18-degree angle will be approximately 80 feet wide at 250 feet from the source; 160 feet wide at 500 feet from the source; and 320 feet wide at 1,000 feet from the source.

Even with a device that emits a beam with a relatively narrow angle of 9 degrees, the beam width would be approximately 40 feet at 250 feet from the source; approximately 80 feet wide at 500 feet from the source; and around 160 feet wide at 1,000 feet from the source.

This makes it impossible for the R.A.D.A.R. operator to select or focus on a single target vehicle at any significant distance. It is vital the operator understands that simply pointing the antenna at a specific target vehicle will not necessarily result in a speed reading from only that vehicle when other vehicles are within the R.A.D.A.R.'s operational range. Other criteria must be used to determine which vehicle's speed the R.A.D.A.R. is displaying. It is not necessary for the operator to know the beam width of the R.A.D.A.R. wherever it is being aimed. The beam width at any operational distance is much wider than the roadway making lane selection nonexistent with current R.A.D.A.R. devices.

Not all the transmitted signal is contained within the specified beam width:

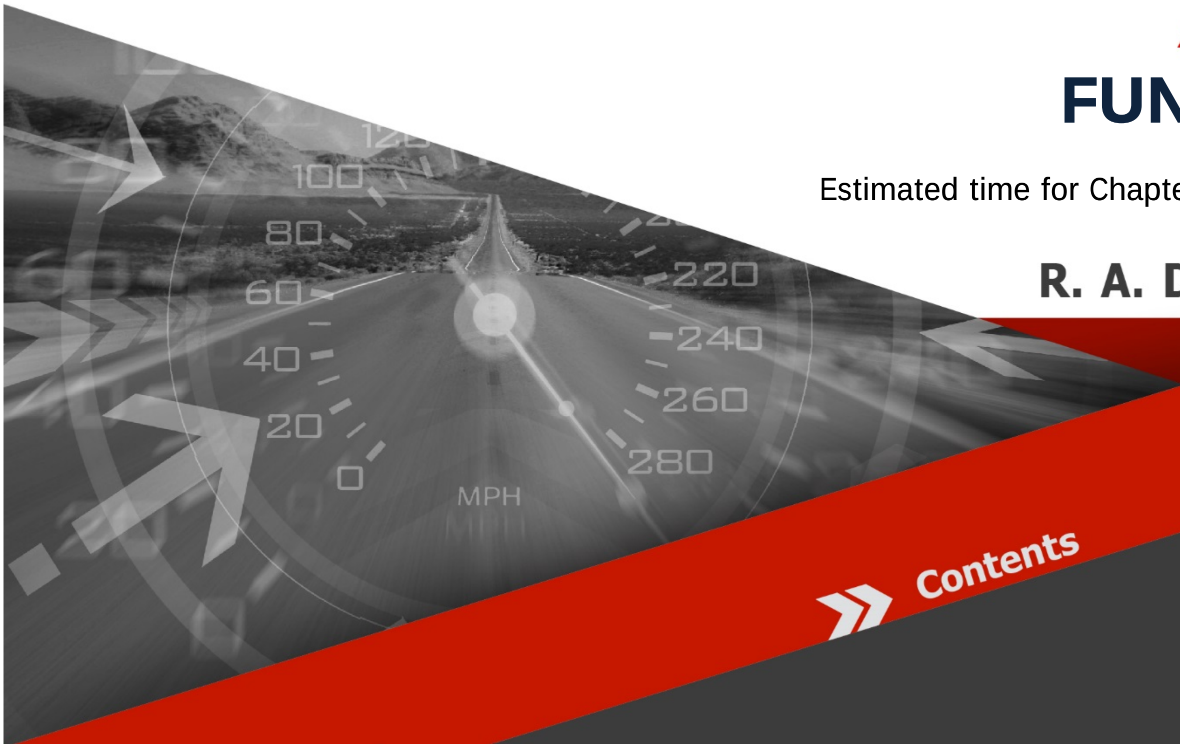
- Some of it is emitted at a greater angle
- The speed of vehicles outside the main portion of the beam can be displayed
- Normally, the reflected signals from vehicles inside the main portion of the beam are stronger than the reflected signals of vehicles outside the main portion of the beam
    - The R.A.D.A.R. device will normally display the speed of the stronger signal
    - The operator must understand that R.A.D.A.R. devices are not lane-selective

3

FUNCTION

Estimated time for Chapter 3: 60 Minutes

R. A. D. A. R.

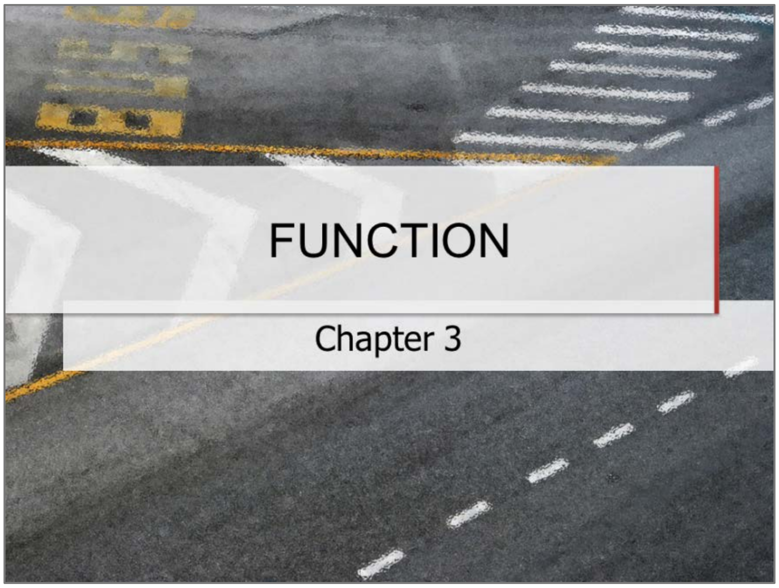


Contents

Objectives

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

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



Slide 18.

Method of R.A.D.A.R. Speed Measurement

R.A.D.A.R. devices transmit radio signals. When radio signals strike an object, some of the signal is reflected toward the R.A.D.A.R.

If there is relative motion between the R.A.D.A.R. and the reflecting object, the reflected signal will be different from the transmitted signal:

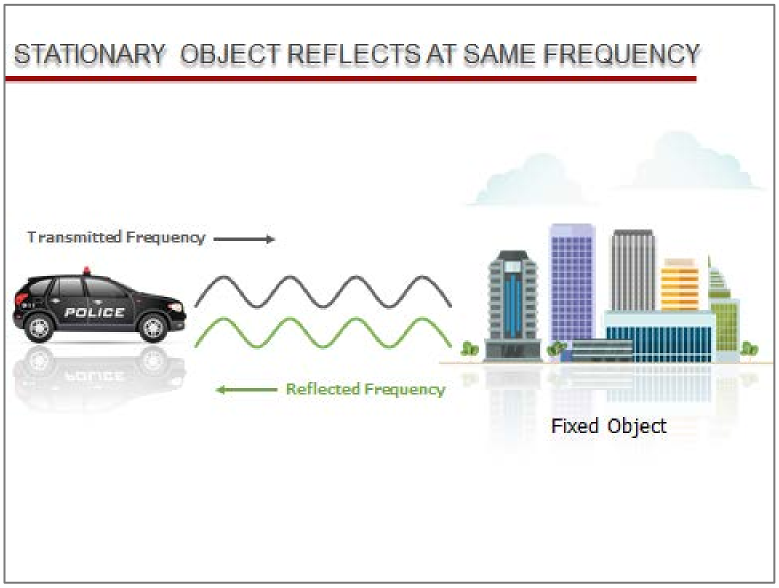
- The motion changes the frequency of the reflected signal
- The faster this motion, the more the frequency changes
- The R.A.D.A.R. device measures how much the frequency of the reflected signal has changed
- The amount of change indicates the speed of the relative motion

DEVICES AND MODES OF OPERATION

Slide 19.

Introduce the two types of R.A.D.A.R. devices and the three R.A.D.A.R. modes of operation. The following slides provide more detail on each mode and Chapter 5 will provide detail on device set up.

STATIONARY R.A.D.A.R.



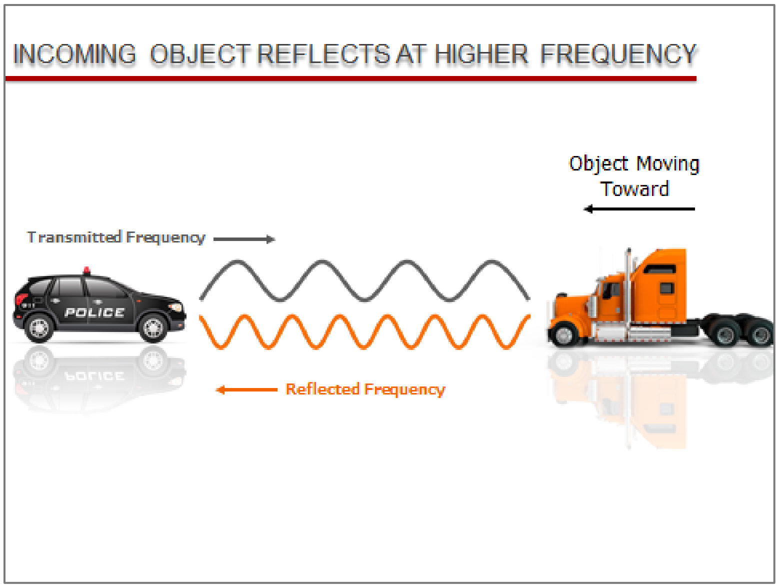
Slide 20.

Ask Students:

Q) What happens when a R.A.D.A.R. beam is transmitted into empty space?
A) The beam will go on forever and you will not obtain a reading.

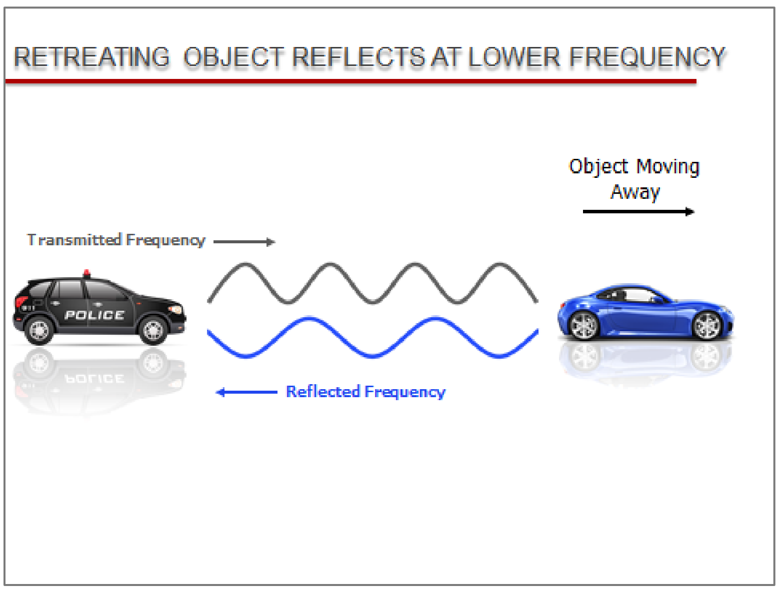
We illustrated the Doppler Principle in Chapter 2 with a moving train (transmission source) and a stationary detector (human listener). Stationary R.A.D.A.R. involves transmitting a signal from a fixed position. Some of the transmitted signal is reflected from a moving object and returned to the R.A.D.A.R.

- A R.A.D.A.R. beam transmitted into empty space will go on forever and obtain no reading
- A R.A.D.A.R. beam transmitted down a roadway on which no objects are moving will also obtain no reading



Slide 21.

If the target is moving toward the R.A.D.A.R. device, the frequency is increased.



Slide 22.

If the target is moving away from the R.A.D.A.R. device, the frequency is decreased.

Vehicle Speed M.P.H.	Frequency Shift (waves per second)		
	"X" Band	"K" Band	"Ka" Band
1	31.4	72	99.6-107.3
5	157	360	498-536.5
10	314	720	996-1073
15	471	1080	1494-1609.5
25	785	1800	2490-2682.5
40	1256	2880	3984-4292
55	1727	3960	5478-5901.5
70	2198	5040	6972-7511
80	2512	5760	7968-8584
100	3140	7200	9960-10730

Slide 23.

SUPPLEMENT 3: Doppler Shift Worksheet (15 Minutes)

The stationary R.A.D.A.R. utilizes the difference between the transmitted and received frequencies multiplied by a constant to calculate target speed.

In the case of X-band, the constant for 1 mile per hour is 31.4 cycles per second.

In the case of K-band, the constant for 1 mile per hour is 72 cycles per second.

In the case of Ka-band, the constant for 1 mile per hour ranges from 99.6 to 107.3 cycles per second.

These frequency changes are measurable by the R.A.D.A.R. device.

Doppler R.A.D.A.R. can only measure the motion of the target vehicle relative to that of the R.A.D.A.R.

- Doppler R.A.D.A.R. cannot indicate which is moving: the target, the R.A.D.A.R. device, or both
- All that is determined is how fast the target and R.A.D.A.R. device are moving relative to each other

A stationary R.A.D.A.R. signal striking a motionless target will return a reflected signal at the same frequency that is being transmitted.

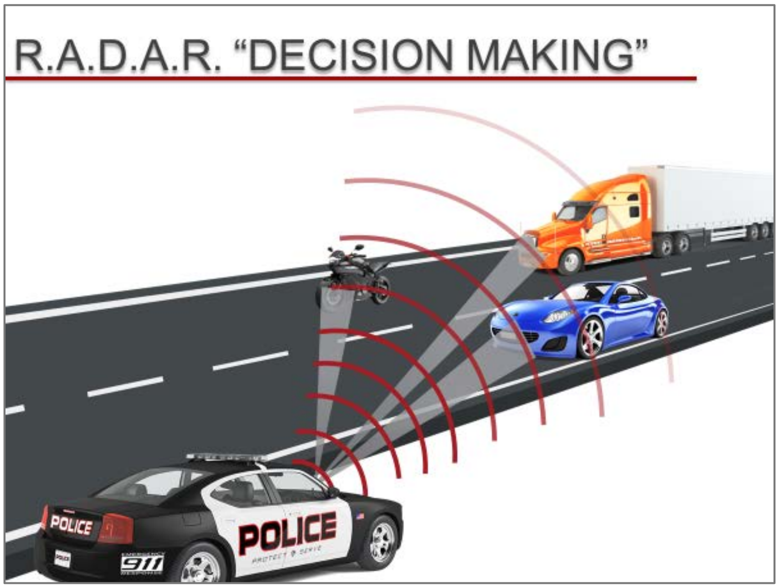
R.A.D.A.R. "DECISION MAKING"

Slide 24.

The R.A.D.A.R. beam can be several hundred feet wide in its operational range. The R.A.D.A.R. may receive signals from all vehicles within the beam. The speed displayed on the R.A.D.A.R. is normally the strongest signal received.

R.A.D.A.R. "decision making" is affected by three factors:

1. Reflective capability
   - Depends on the vehicle's size and shape
     - A large truck will reflect a stronger signal than a passenger vehicle when both are the same distance from the R.A.D.A.R. device
     - The shape and composition of the target vehicle will also affect the signal reflected (e.g., fiberglass does not reflect as well as metal)
2. Position
3. Speed



Slide 25.

Use a whiteboard or flip chart to depict the three factors:

1. Reflective capability
2. Position
3. Speed

Position of the target vehicles relative to each other and the R.A.D.A.R. device affects the reflected signal strength. Normally, the target vehicle that is closest to the R.A.D.A.R. antenna will have the stronger reflected signal. This vehicle is normally the one displayed on the R.A.D.A.R. device. This is because the closer the target, the strongest the reflected signal appears to the R.A.D.A.R. device relative to the other vehicles on the road. The actual speed of the target vehicle is usually the least dominant of the three factors.

Most R.A.D.A.R.s are designed to display the strongest signal received.

The Inverse Square Rule

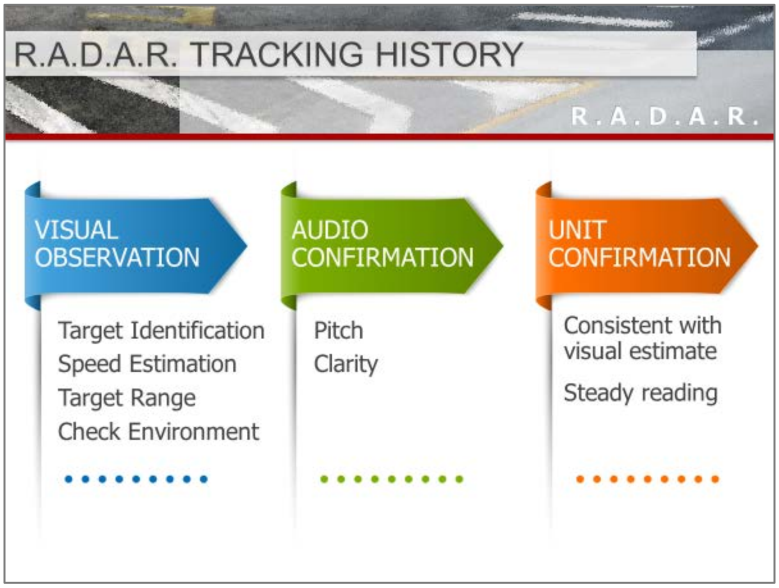
Reflective capability and position are the primary factors determining which vehicle's speed will be displayed by the R.A.D.A.R. Multiple targets of unequal size may create a problem in target identification. To understand this, it is necessary to understand what happens to the R.A.D.A.R. energy after it leaves the antenna.

1. When first transmitted by the antenna, almost all the radio wave energy is concentrated in a circle a few inches in diameter.
2. At 250 feet from the antenna, most of the energy is spread over an area 70 feet in diameter.
3. At 500 feet, the diameter of the circle is twice as large as at 250 feet and it contains about the same amount of energy, spread over four times the area.
4. At 1,000 feet, the same amount of energy is spread over a circle twice as large as the circle at 500 feet and four times as large as the circle at 250 feet. The energy is now spread over an area 16 times as large as it was at 250 feet and the signal is now correspondingly 16 times weaker.

This relationship between signal strength (energy) and distance from its source is called the inverse square rule. Speed does not follow the inverse square rule.

- Depending on the R.A.D.A.R. device used, speed becomes a factor when comparably-sized vehicles are approaching close to one another
- Speed is usually the least important of the three factors

TRACKING HISTORY FOR STATIONARY OPERATIONS



Slide 26.

VISUAL OBSERVATION

- Target Identification
- Speed Estimation
- Target Range
- Check Environment

The visual element is the first part of any speed enforcement action. The officer's attention is drawn to the passing, weaving, etc. of the vehicle. Target identification has now been made.

Now that the vehicle in question has been identified the officer makes an estimation of that vehicle's speed. Additional observations of the vehicle's movement, compared to other vehicles, allow the officer to estimate the target vehicle's speed. The time between target identification and speed estimation will decrease and, with experience, estimation will be close to the target vehicle's true speed.

As the speed estimation is being determined, the officer should note the distance the target vehicle is from his/her location.

The officer should also note the environment in which the target vehicle is traveling. Weather, pedestrian traffic, business or school districts, and construction areas may later be essential in proving a violation of a specific speed law.

AUDIO CONFIRMATION

- Pitch
- Clarity

Audio confirmation of a target vehicle is also a part of developing a valid Tracking History.

A strong, clear tone indicates a good, clear, received signal. A broken or scratchy audio tone indicates a weak received signal, which could indicate that the device is picking up interference.

UNIT CONFIRMATION

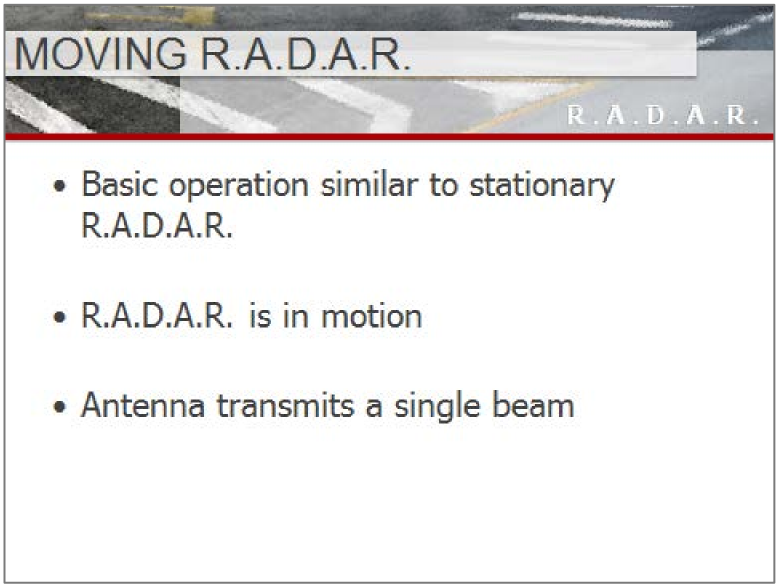
- Displayed target speed is consistent with estimated speed and audio
- Steady reading

The final stage of developing a Tracking History is the confirmation of a speed-measuring device.

A steady read-out with a speed-measuring device is preferred. The key is to be able to articulate the device reading came from the target vehicle.

Once the steady read-out is obtained, it must match, within reason, the operator's visual estimation of the target vehicle's speed.

MOVING R.A.D.A.R.



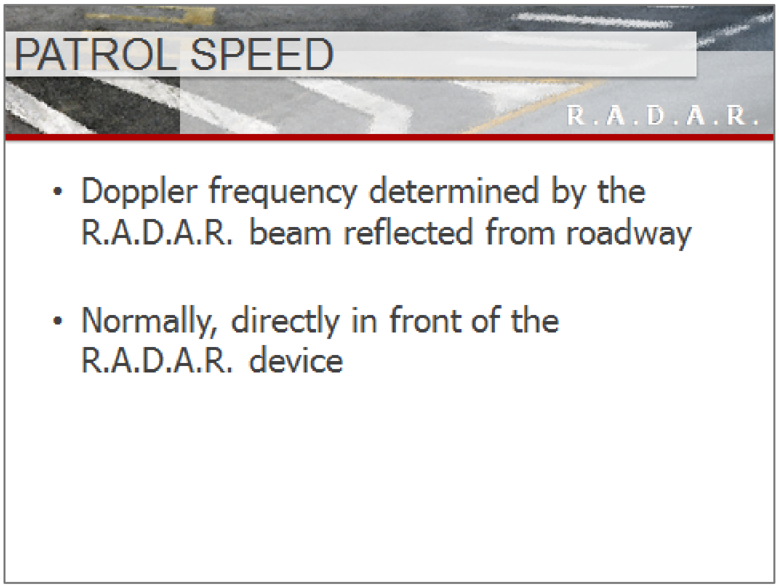
Slide 27.

Principles of Moving R.A.D.A.R.

Moving R.A.D.A.R. is a R.A.D.A.R. device being operated from a moving patrol vehicle. Just like stationary R.A.D.A.R., it works based on the Doppler Principle.

Moving R.A.D.A.R. devices measure two speeds.

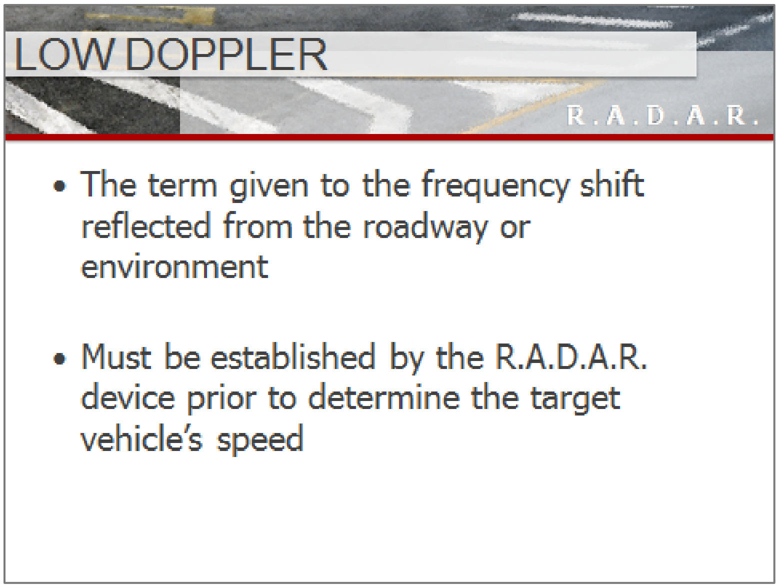
- The speed of the patrol vehicle relative to the roadway
- The speed of a target vehicle relative to the moving patrol vehicle



Slide 28.

PATROL SPEED

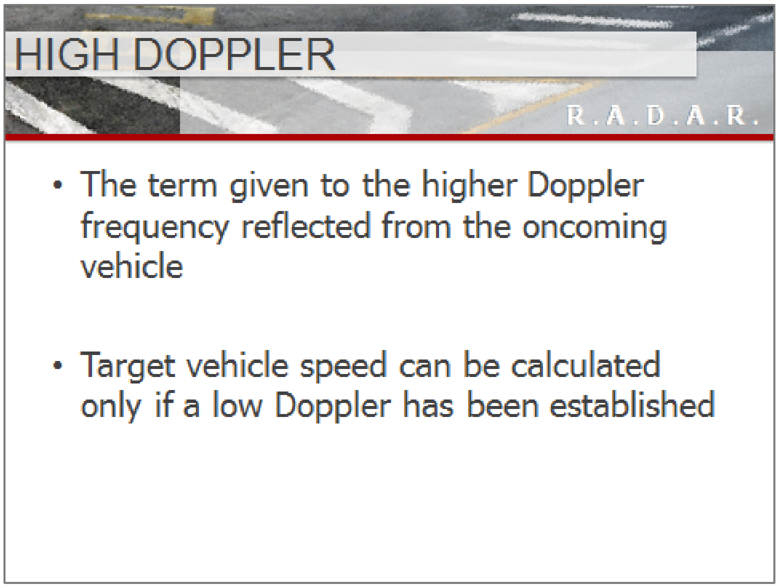
Moving R.A.D.A.R. uses these two speeds to determine the target vehicle's speed. It measures the patrol vehicle's speed relative to stationary terrain within the environment. The beam strikes the ground or objects beside the roadway and reflects to the R.A.D.A.R. This reflected signal undergoes a "low Doppler" shift.



Slide 29.

LOW DOPPLER

The amount of Doppler shift indicates the speed of the moving R.A.D.A.R. relative to the stationary ground. The greater off angle ground reflections, the greater the patrol and target speed error. This will be discussed further in Chapter 4: Effects.

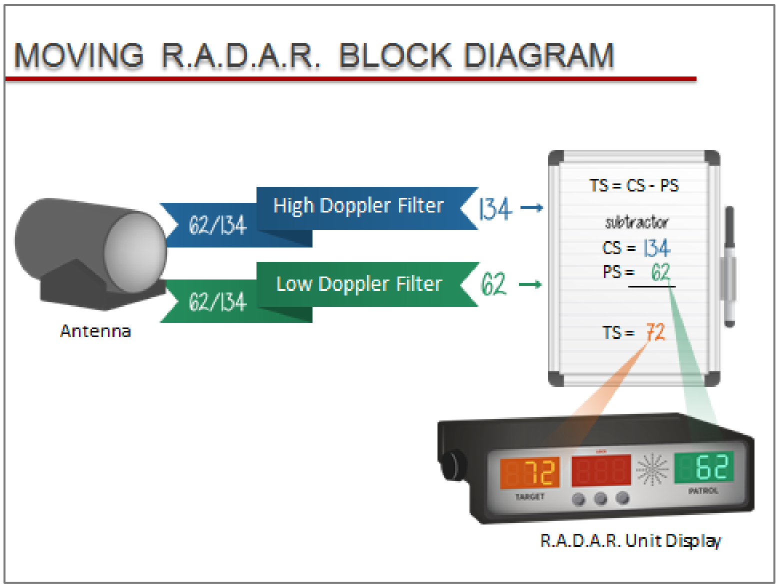


Slide 30.

HIGH DOPPLER

The speed at which the target vehicle is approaching the patrol vehicle is also determined through the Doppler principle.

A R.A.D.A.R. beam transmitted from the moving patrol vehicle strikes the approaching target vehicle. The R.A.D.A.R. beam is reflected from the moving target to the moving patrol vehicle. The signal returned to the R.A.D.A.R. receiver has undergone a “high Doppler” shift.

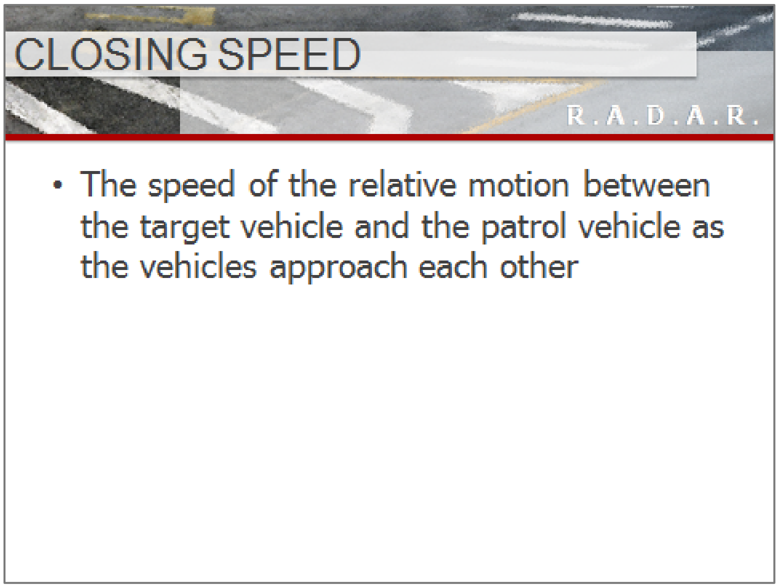


Slide 31.

TS=Target Speed

CS=Closing Speed

PS=Patrol Speed

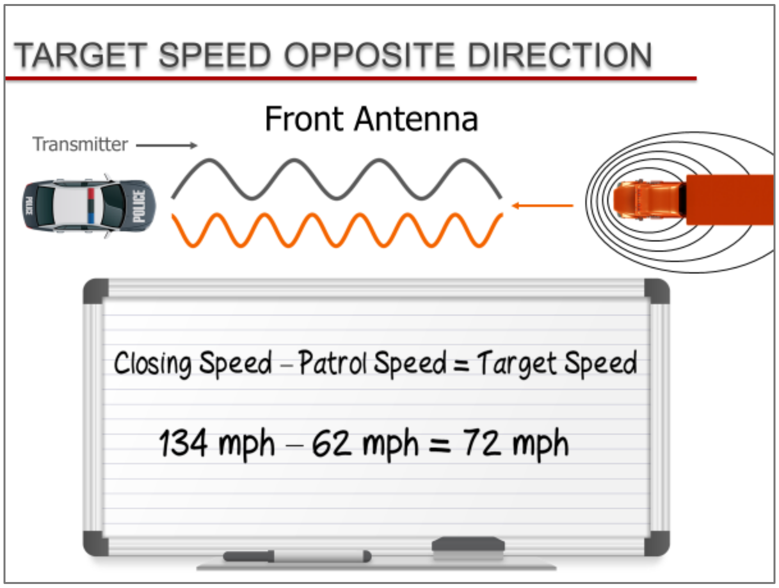


Slide 32.

CLOSING SPEED

The R.A.D.A.R. device translates the Doppler shift into a speed measurement. This speed measurement represents the relative speed of the two vehicles. The amount of this Doppler shift depends on the relative speeds of the two vehicles.

What we want to know is the target vehicle's speed.

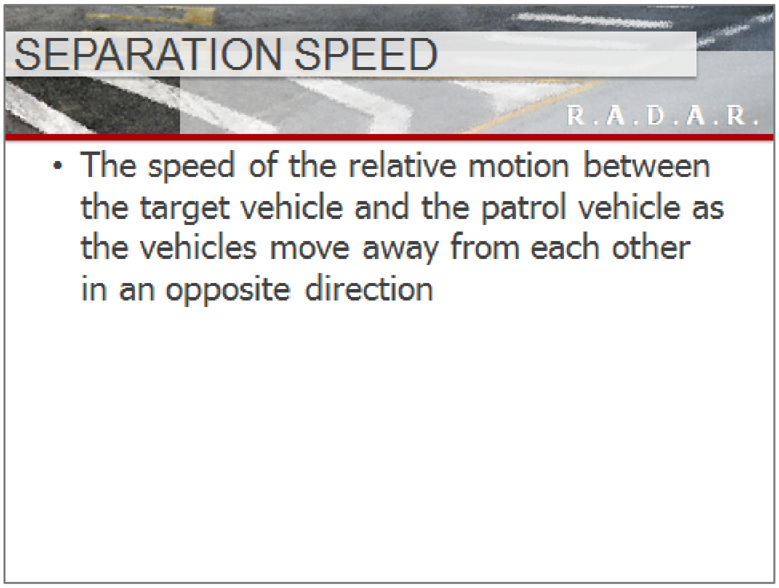


Slide 33.

TARGET SPEED OPPOSITE DIRECTION

With opposite direction, front antenna, the target vehicles speed is computed:

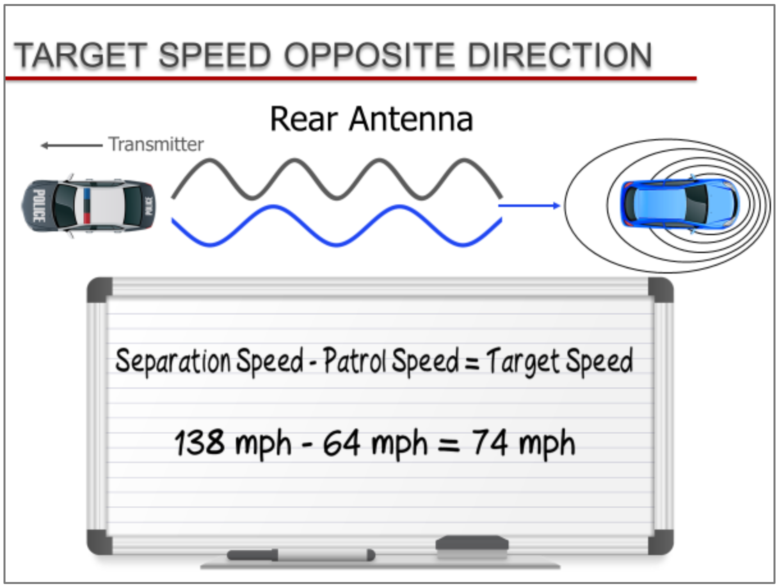
$$target\ speed\ (TS) = closing\ speed(CS) - patrol\ speed(PS)$$



Slide 34.

SEPARATION SPEED

With opposite direction, rear antenna - If the target vehicle has already passed by the moving patrol vehicle and is receding, target speeds can still be computed provided a rearward facing antenna is used.



Slide 35.

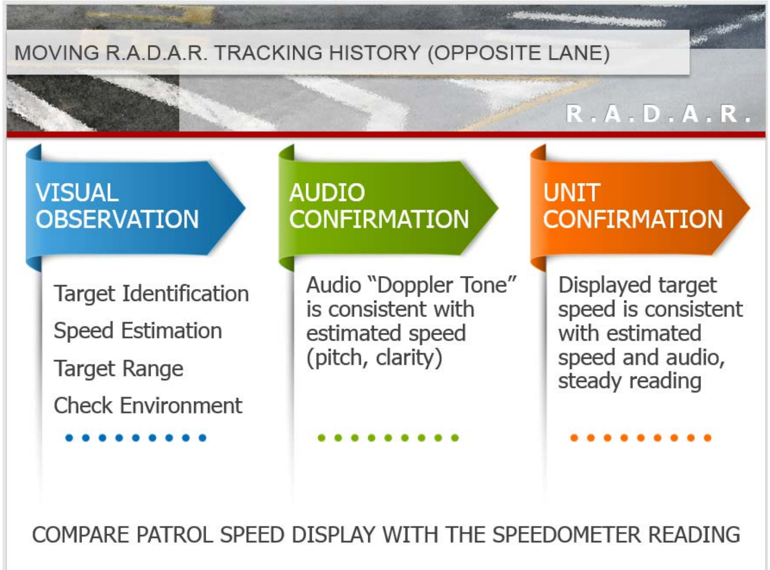
TARGET SPEED OPPOSITE DIRECTION

For opposite direction, the formula changes to:

$$target\ speed\ (TS) = separation\ speed(SS) - patrol\ speed(PS)$$

The target speed is computed automatically by the R.A.D.A.R. device. All moving R.A.D.A.R. devices must display the target speed and patrol speed.

MOVING R.A.D.A.R. TRACKING HISTORY (OPPOSITE LANE)



Slide 36.

Review and discuss "verify patrol speed".

Discuss issues of locking target speed: policy, safety, equipment.

Visual Observation

- Identify Target
- Estimate Speed
- Estimate Range
- Check Environment

Audio Confirmation

- Pitch
- Clarity

Unit Confirmation

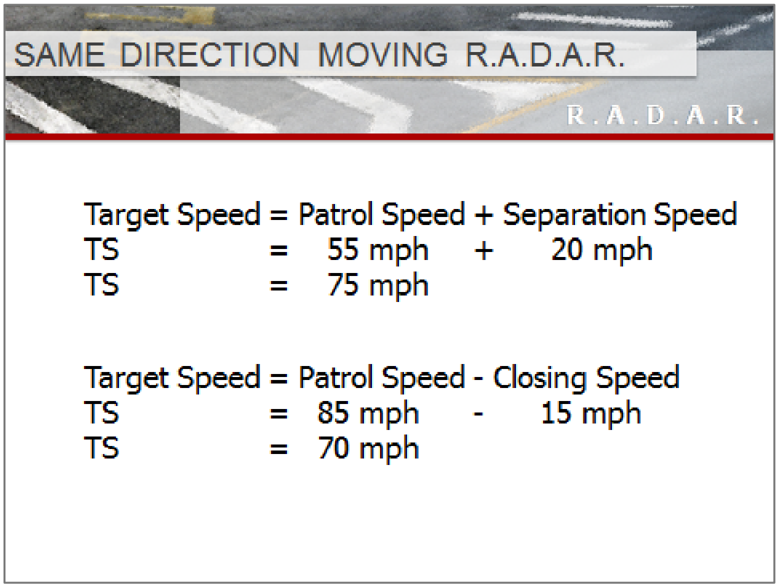
- Steady Readout
- Consistent with Visual Estimate
- Verify Patrol Speed

Track through Lock

This term refers to the ability of R.A.D.A.R. devices to continue tracking a target after the target speed has been locked. This enables the operator to continue to develop the tracking history.

Automatic locks and/or alarms are not approved features of current R.A.D.A.R. devices and should never be used. A qualified technician should disable these features, if present. Use of the automatic lock or alarm does not allow proper tracking history.

SAME DIRECTION MOVING R.A.D.A.R.



Slide 37.

Same direction moving R.A.D.A.R. uses the same Doppler Principle that all R.A.D.A.R. devices employ.

Same direction moving R.A.D.A.R. also measures the difference in relative motion between the target vehicle and the patrol vehicle.

The relative motion measured between the vehicles may be added or subtracted from the patrol vehicle speed depending upon whether the target vehicle is traveling faster or slower than the patrol vehicle.

Normally, same-direction moving R.A.D.A.R. devices are unable to automatically differentiate between the target moving faster or slower than that of the patrol vehicle.

The operator must determine which case is present and manually switch the R.A.D.A.R. to the correct mode for computation of the target speed.

The following examples serve to illustrate how same direction moving R.A.D.A.R. computes target speeds.

Example One:

A 75-mph passenger vehicle traveling in the same direction and in front of a 55-mph patrol vehicle is calculated in the following manner when the operator has placed the R.A.D.A.R. in the “Target Faster” computation mode.

$$target\ speed = patrol\ speed + separation\ speed$$

$$TS = 55mph + 20mph = 75mph$$

In this example, if the R.A.D.A.R. is incorrectly placed in “Target Slower” mode, the 20-mph would be subtracted from the patrol speed and an erroneous 35-mph target speed displayed.

Example Two:

A 70-mph target vehicle being pursued by a patrol vehicle traveling 85-mph is calculated in the following manner when the operator has placed the R.A.D.A.R. in the “Target Slower” computation mode.

$$target\ speed = patrol\ speed - closing\ speed$$

$$TS = 85mph - 15mph = 70mph$$

In this example, if the R.A.D.A.R. is incorrectly placed in “Target Faster” mode, the 15-mph would be added to the patrol vehicle speed resulting in an erroneous 100-mph target speed display.

Same direction moving R.A.D.A.R.s with the antenna pointed rearward or one that has a second rear antenna go through the same computations.

Target Identification Considerations

Same direction moving R.A.D.A.R. is subject to all the same target identification variables that affect opposite direction moving or stationary R.A.D.A.R.

These include the R.A.D.A.R. decision-making factors:

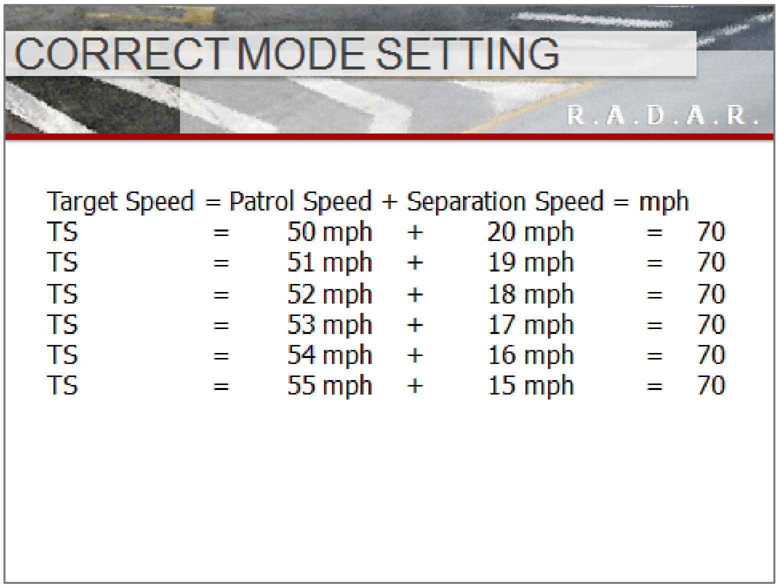
- Reflective capability
- Position
- Speed

Same direction R.A.D.A.R. is also affected by three additional target identification factors specific only to its operation. Same direction moving R.A.D.A.R. devices:

1. Only permit targets to be processed and displayed that are within a fixed range, up or down, from the speed the patrol vehicle is traveling at that moment. This "window" of speeds is relatively wide and will not pose any real operational problem. The width of this window is dependent upon the specific model of R.A.D.A.R. used, but is most often at least half of the patrol vehicle speed.

2. Are limited in their ability to display target speeds very close to the patrol vehicle speed. These R.A.D.A.R. devices will not process target speeds closer than three to six miles per hour, up or down, from the patrol vehicle's actual speed depending upon the manufacturer. The R.A.D.A.R. operator cannot establish patrol vehicle speeds at or near the enforcement threshold point to be enforced. A patrol vehicle's speed, matched to the flow of traffic around it, will be blind to most those vehicles. R.A.D.A.R. in same direction moving mode can ignore many large close-by trucks and display the speed of a distant motorcycle. Outside of this narrow range, reflective capability and position again become significant factors. Testing indicates that the greater the Doppler shift the greater the sensitivity of same direction moving R.A.D.A.R.

3. Some R.A.D.A.R.s discriminate between faster and slower targets. The operator is required not only to survey the operational area of the R.A.D.A.R. for faster vehicles being correctly displayed in "Target Faster" mode but also slower vehicles being incorrectly displayed in "Target Faster" mode by the R.A.D.A.R. device. This inability of same direction moving R.A.D.A.R.s to discriminate between faster and slower targets decidedly complicates the operation of this type of R.A.D.A.R. The operator has a ready means available for determining if a target speed is displayed in the proper "Target Faster" or "Target Slower" mode. If the R.A.D.A.R. has correctly computed the target speed, changes in the patrol vehicles speed will not affect the target speed reading. If the incorrect mode is being used, the target speed will go up and down respectively with the acceleration and deceleration of the patrol vehicle.

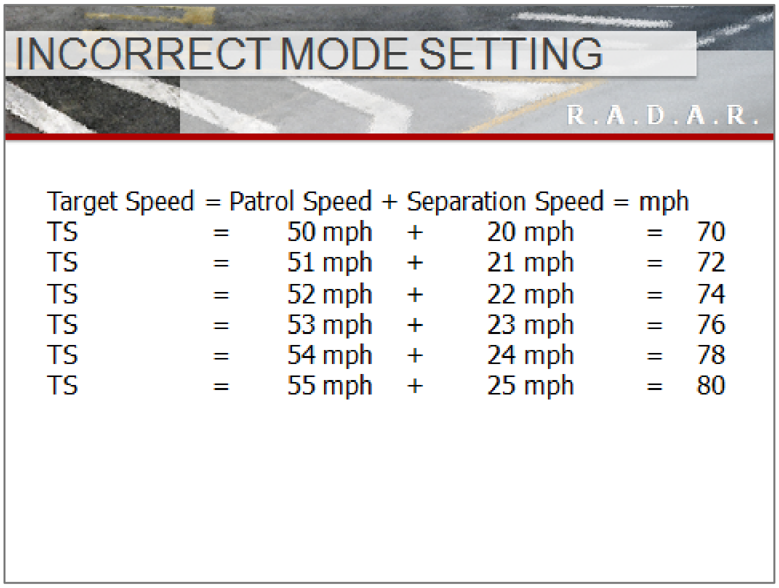


Slide 38.

Correct Mode Setting

Example One:

A target vehicle traveling a steady 70-mph is pulling away from a patrol vehicle which is slowly accelerating from 50- to 55-mph. With the R.A.D.A.R. in “Target Faster” mode, the computations on the slide above will occur.



Slide 39.

Incorrect Mode Setting

Example Two:

A R.A.D.A.R. has been incorrectly left in the "Target Faster" mode and is displaying a steady 30-mph target vehicle as a 70-mph vehicle with the following computations occurring:

By gradually varying the patrol vehicle's speed up or down a few miles per hour, the target speed display should remain constant if the correct calculation mode is being used. If the target speed display does fluctuate up with the patrol speed changes, the R.A.D.A.R. may be calculating a target speed in the wrong mode.

Rapidly changing target speed window fluctuations can also be the result of the R.A.D.A.R. displaying several different vehicles intermittently.

In the correct mode, the separation speed will decrease as the patrol speed increases thus keeping the target speed a constant and accurate 70-mph.

When a same direction moving R.A.D.A.R. is in an incorrect mode for the proper calculation of target speed, the target speed display will change by two miles per hour for each one mile per hour change in patrol vehicle speed.

Regardless of the cause, rapid target window fluctuations are not acceptable and any readings obtained should be disregarded for enforcement purposes.

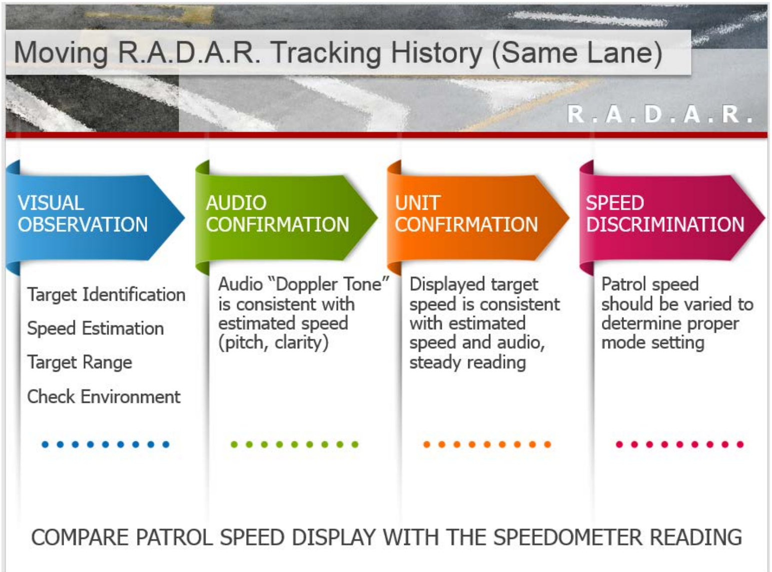
Target Speed Discrimination Test

To ensure that the target speed displayed is being correctly interpreted by the same direction moving R.A.D.A.R. in respect to the "Target Faster" or "Target Slower" modes, the operator must gradually vary the patrol vehicles speed by a few miles per hour up or down.

If the target speed display remains constant, the R.A.D.A.R. is verified as calculating in the correct speed discrimination mode. If the target speed display fluctuates with the patrol speed changes, then the operator must disregard the target speed for enforcement purposes.

This test becomes an integral part of tracking history for same direction moving R.A.D.A.R.

MOVING R.A.D.A.R. TRACKING HISTORY (SAME LANE)



Slide 40.

Review and discuss "speed discrimination test".

Point out that if there is any doubt about the accuracy of the R.A.D.A.R. device speed reading, do not take any enforcement action.

Student should be aware of the accuracy of the patrol vehicle speedometer.

Visual Observation

- Identify Target
- Estimate Speed
- Estimate Range
- Check Environment

Audio Confirmation

- Pitch
- Clarity

Unit Confirmation

- Steady Readout
- Consistent with Visual Estimate
- Speed Discrimination Test
- Verify Patrol Speed

AS WITH ALL R.A.D.A.R. ACTION WHEN IN DOUBT, DO NOT ISSUE A CITATION.

4

R.A.D.A.R. EFFECTS

Estimated time for Chapter 4: 45 Minutes

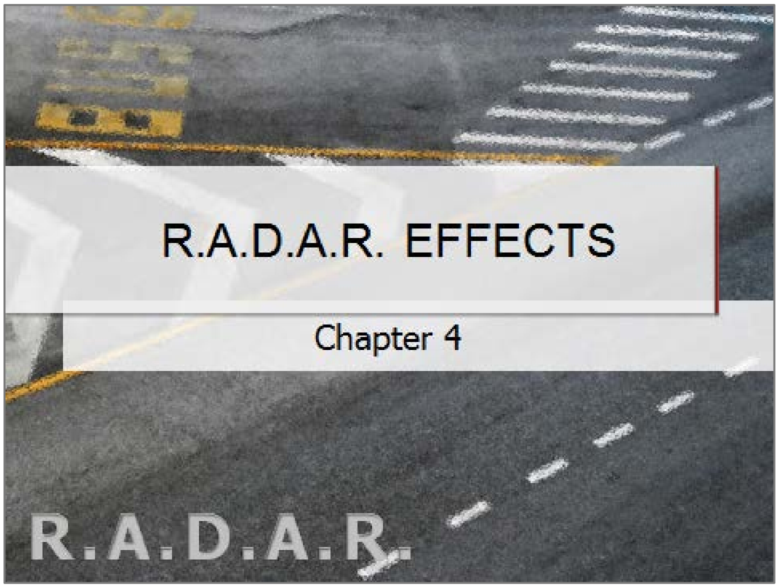
R. A. D. A. R.

Contents

Objectives

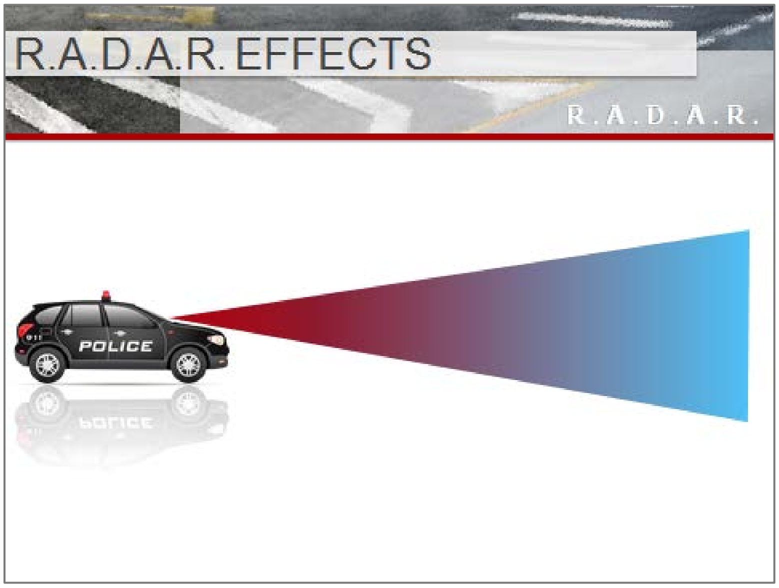
By the end of this chapter, you will be able to:

- Discuss R.A.D.A.R. effects



Slide 41.

FACTORS AFFECTING ALL R.A.D.A.R. OPERATION



Slide 42.

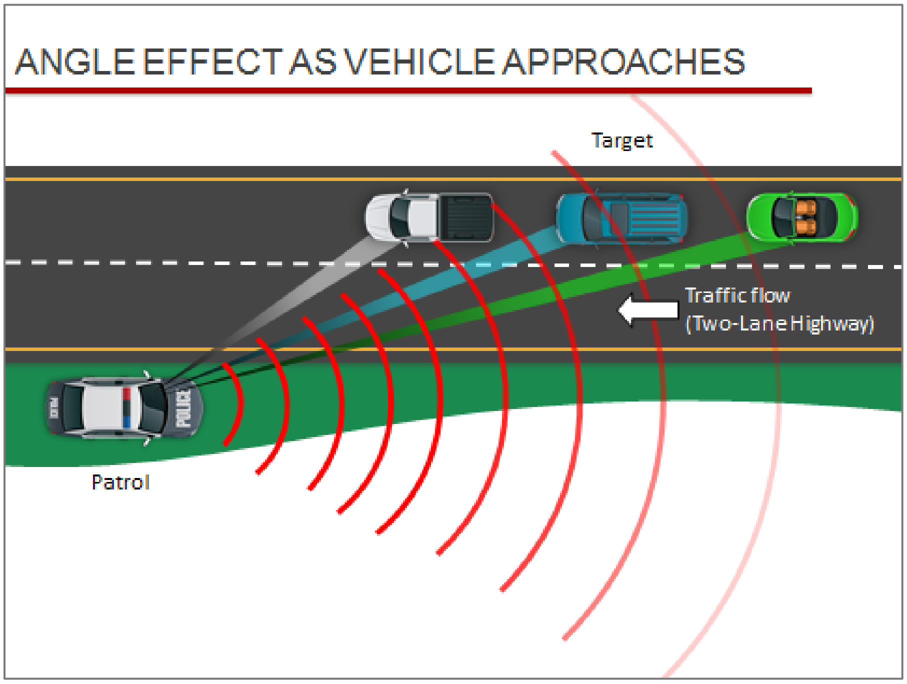
Many of these effects may be demonstrated in the classroom.

Ask students for examples found during day-to-day operation for each of the following specific effects.

Charges have been made that false readings can be displayed on a R.A.D.A.R. device. This is true, but most of these instances are avoidable with proper understanding of the R.A.D.A.R. device. Some are a result of natural causes, and most are recognizable to the trained operator. It is important to understand that interference can make it appear that a R.A.D.A.R. device is not working properly. A well-publicized court filing in Dade County, Florida v. Aguilar, in the spring of 1979 cast considerable doubt on R.A.D.A.R.'s accuracy. The case cited examples where R.A.D.A.R. devices clocked a tree moving at over 80-mph and a house moving at 28-mph. The cause of the strange readings was interference combined with improper operating procedures. Knowing how to avoid interference can reduce problems of this type.

Slide 43.

STATIONARY COSINE EFFECT



Slide 44.

R.A.D.A.R. will only measure the exact speed of a target vehicle when it is traveling directly at or straight from the R.A.D.A.R. device. If an angle exists, the cosine effect occurs.

The cosine effect only results in a stationary R.A.D.A.R. device displaying a speed less than the target vehicle's true speed. **This will always be to the motorist's advantage.**

TRUE SPEED AS AFFECTED BY THE COSINE EFFECT

Angle Degrees	30 mph	40 mph	50 mph	55 mph	60 mph	70 mph
0	30	40	50	55	60	70
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	00.00	00.00	00.00	00.00	00.00	00.00

Slide 45.

SUPPLEMENT 4: Stationary Cosine Effect Worksheet (15 Minutes)

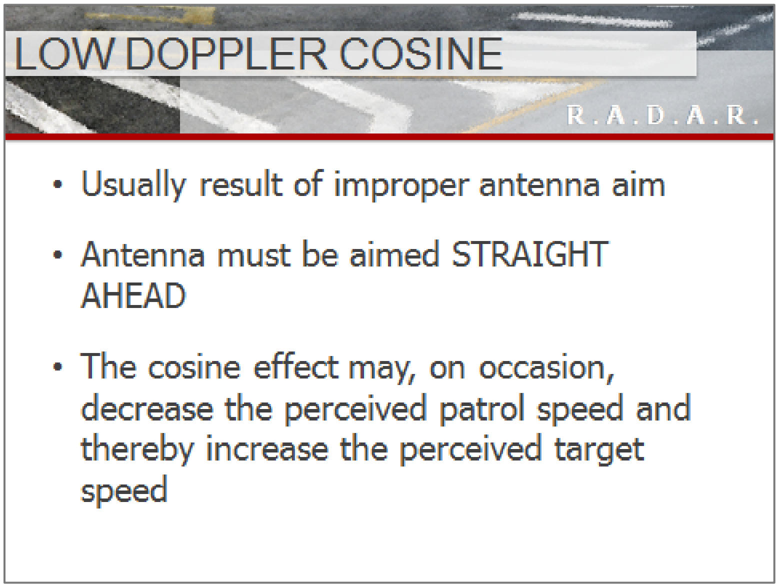
The cosine effect is not significant if the angle remains small. It starts becoming a factor at about 10 degrees. At a 90-degree angle, the R.A.D.A.R. device will not see a target vehicle speed because the motion of the target is moving neither towards nor away from the R.A.D.A.R. device.

The speed of a vehicle driving in circles around a R.A.D.A.R. device would not be displayed because the cosine effect would make it effectively invisible. The R.A.D.A.R. device would see no relative motion.

With the R.A.D.A.R. antenna pointed at an approaching vehicle, as the vehicles get close enough to produce a significant angle, the result is a reduced display of the target vehicle's speed.

The R.A.D.A.R. operator should set up the R.A.D.A.R. device as close to the roadway as possible. A rule of thumb is 10 feet from the edge of the roadway for every 100 feet the target vehicle is down the roadway. Align the antenna as straight down the road as possible. Based on the unit's decreasing speed reading, it may give the appearance that the vehicle is slowing down as it passes. Although this may be partially true, this is due to the cosine effect.

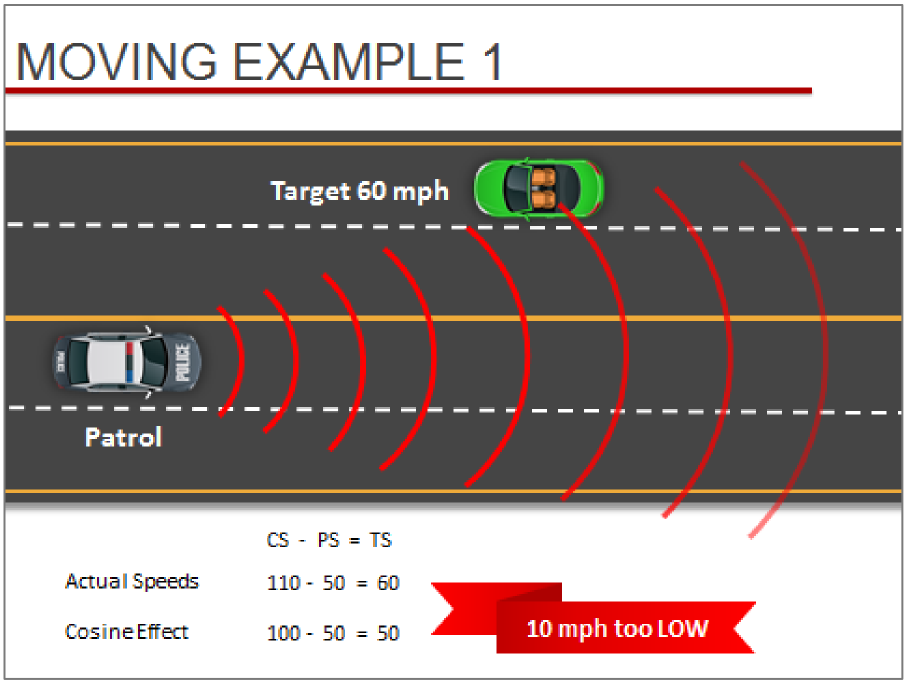
MOVING R.A.D.A.R. COSINE EFFECT



Slide 46.

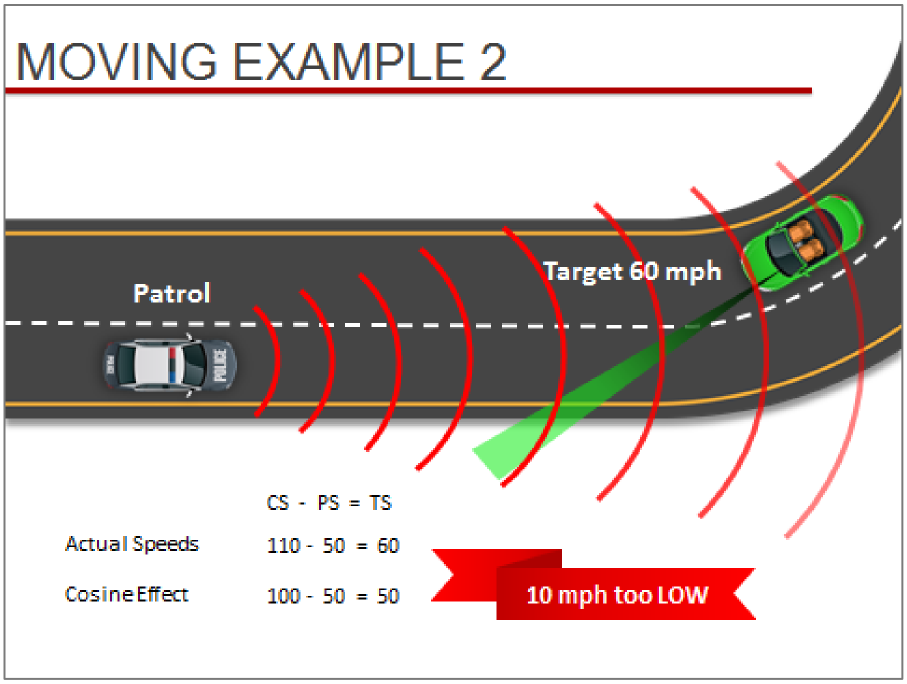
SUPPLEMENT 5: Moving R.A.D.A.R. Cosine Worksheet (15 Minutes)

The cosine effect with moving R.A.D.A.R. may result in a high target vehicle speed display, but most often, the cosine effect with moving R.A.D.A.R. will result in a low target vehicle's speed, just as in stationary operations.



Slide 47.

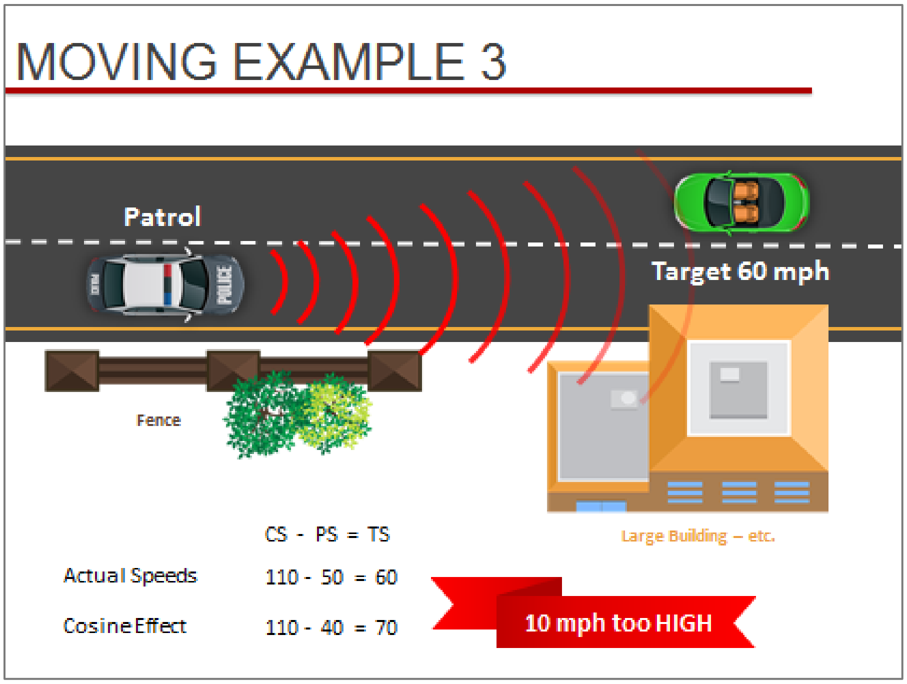
When an approaching vehicle gets close enough to the R.A.D.A.R. to create a significant angle, the result is a LOW target vehicle speed.



Slide 48.

A curve in the road could cause the target vehicle to approach the R.A.D.A.R. at a significant angle resulting in a LOW target vehicle speed.

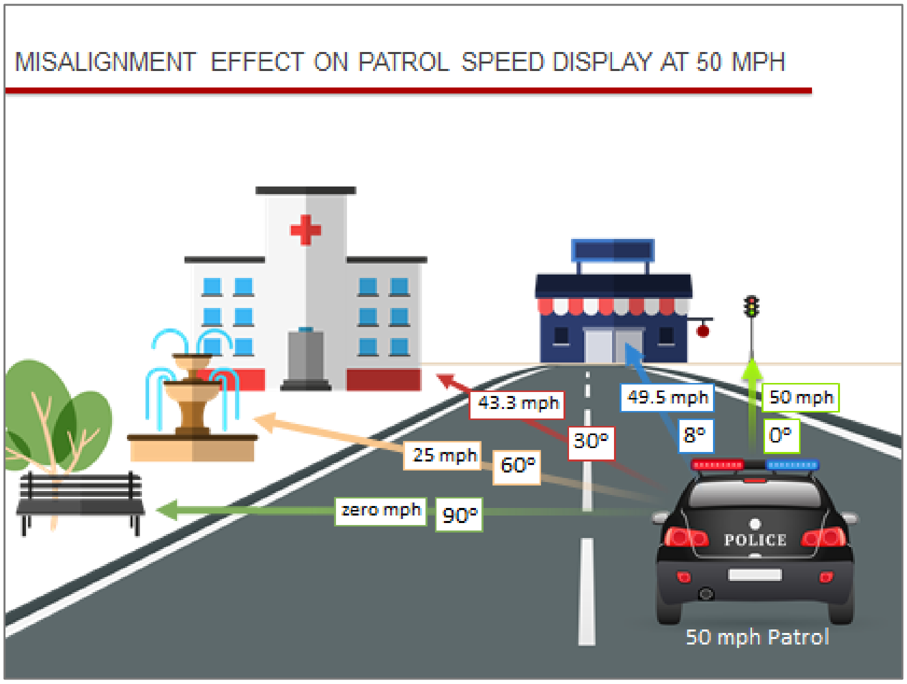
A low target speed reading can result only if the patrol vehicle speed is being computed correctly. Conditions can exist that will lead to a high target vehicle speed being displayed by the R.A.D.A.R. device. The computation of a higher target speed could result if a less-than-true patrol speed is used by the R.A.D.A.R. device.



Slide 49.

An improper target speed can result if the patrol speed signal is received from some roadside object at an angle to the patrol vehicle's path of travel not from the stationary terrain ahead of it, e.g., a fence by the side of the road. The target speed will be high because the R.A.D.A.R.'s reading of the patrol vehicle's speed is low. This condition normally occurs only for a short period and is easily detected by the operator comparing the displayed patrol speed with the patrol vehicle's speedometer.

MISALIGNMENT EFFECT ON PATROL SPEED DISPLAY AT 50-MPH



Slide 50.

A patrol vehicle signal less than actual speed will result in a higher-than-actual target speed reading.

Straight-ahead antenna alignment is necessary. Misalignment of the antenna, no matter how slight, may increase the possibility of a high target speed reading.

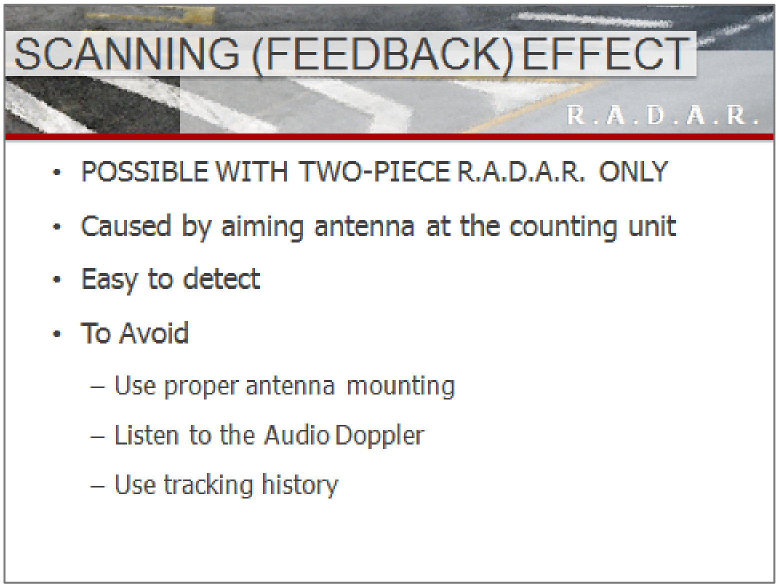
Unavoidable conditions may also create improperly high target speeds.

All moving R.A.D.A.R. devices must have both a target speed display and a patrol speed display.

Comparing the patrol speed display with the certified patrol vehicle speedometer allows the R.A.D.A.R. operator to ensure that the R.A.D.A.R. device is measuring the patrol vehicle's speed accurately.

This test is an integral part of tracking history for moving R.A.D.A.R.

SCANNING (FEEDBACK) EFFECT

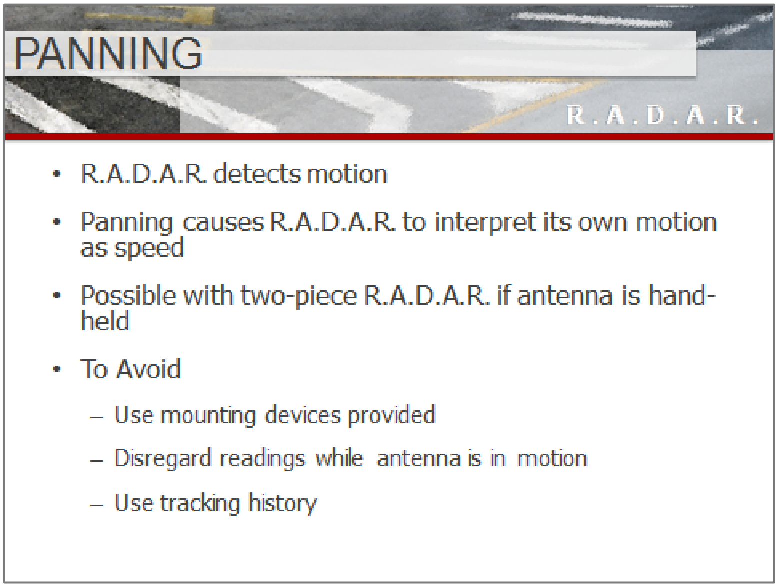


Slide 51.

Suggested prop: instructor may demonstrate by aiming antenna at counting unit.

This effect, possible only with a two-piece R.A.D.A.R. device, occurs when the antenna is aimed across the counting unit. The result is an erroneous display accompanied by a high squealing audio Doppler. This is avoided by the proper set up and/or use of the device.

PANNING EFFECT

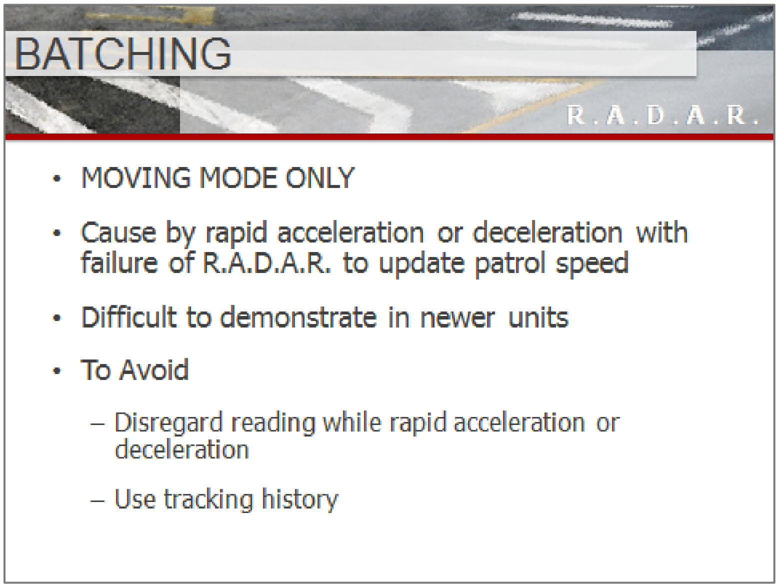


Slide 52.

Instructor may demonstrate in the classroom by a rapid swing of the R.A.D.A.R. device while transmitting.

This is caused by the rapid movement of the R.A.D.A.R. antenna. Remember that R.A.D.A.R. detects motion and cannot differentiate between antenna movement and target movement.

BATCHING EFFECT (MOVING MODE ONLY)

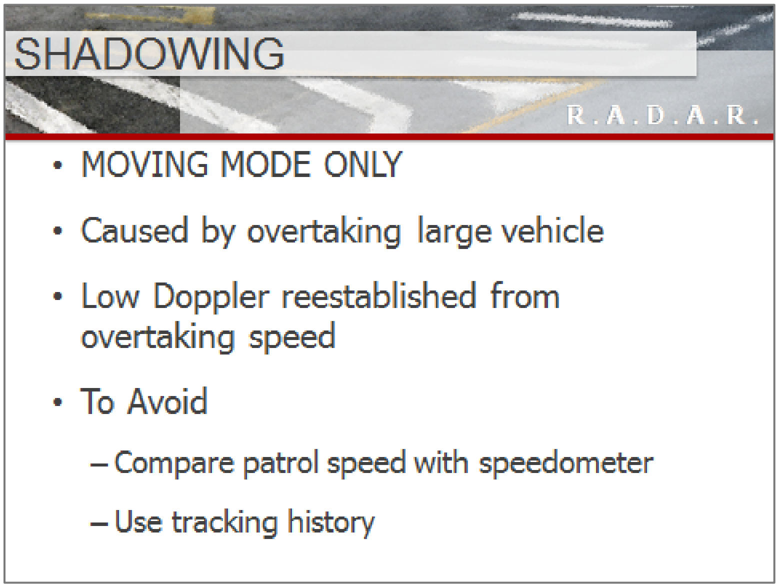


Slide 53.

This effect may only be demonstrated by older devices **in a controlled field, not on a public roadway.**

This is caused by the R.A.D.A.R. device's failure to update the patrol speed during rapid acceleration or deceleration. Current devices are not subject to this effect, but older devices may display false readings. It is caused by the R.A.D.A.R. updating the low Doppler and high Doppler signals at different intervals. Proper tracking history will help alert the operator.

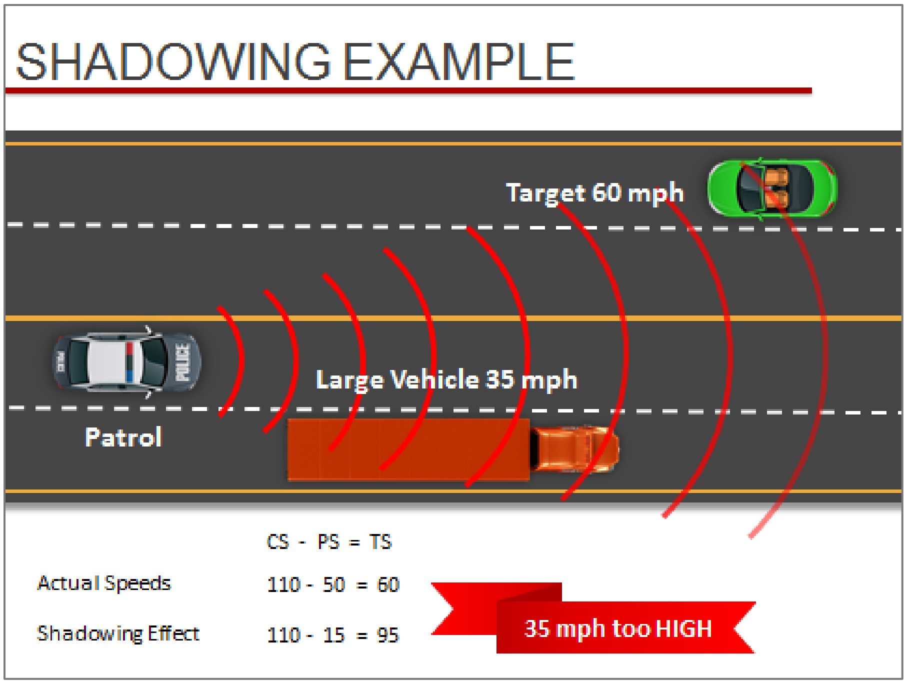
SHADOWING (MOVING MODE ONLY)



Slide 54.

Demonstration of this effect usually requires a multi-lane roadway with slower moving, same direction vehicles.

This effect occurs when the closing or receding speed between the patrol vehicle and a slow-moving vehicle ahead is interpreted as the patrol speed (low Doppler). The "hot spot" has shifted from the roadway to the rear of the slow-moving vehicle. The result is a higher target speed display. Verification of patrol speed during the tracking history will identify this affect.



Slide 55.

SUPPLEMENT 6: Shadowing Worksheet (10 Minutes)

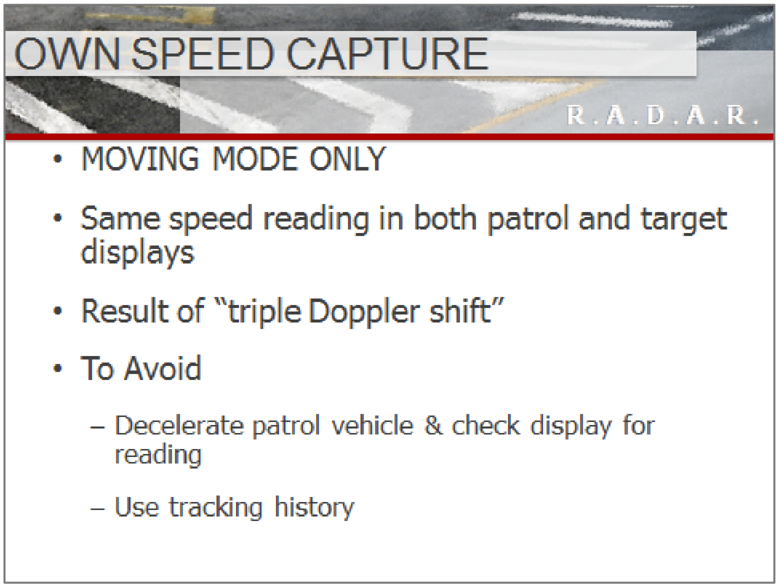
CLOSING SPEED CAPTURE (MOVING MODE ONLY)

Some newer R.A.D.A.R. devices have a control to lessen this effect.

This may be demonstrated during fieldwork.

The patrol speed is no longer displaying the ground speed but is now displaying the closing speed. A closing speed may be displayed in the patrol speed window if the ground speed (low Doppler) is lost.

OWN SPEED CAPTURE



Slide 56.

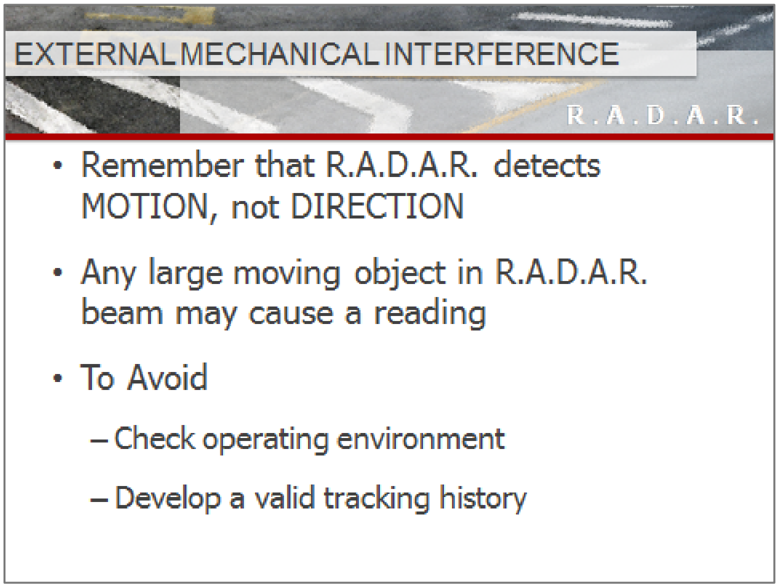
Demonstrate during fieldwork if possible.

This effect results from the patrol speed appearing simultaneously in both the patrol and target windows. It is caused by the R.A.D.A.R. beam bouncing from the "hot spot" back to the front of the patrol vehicle, then back to the roadway, and back to the R.A.D.A.R. antenna. A "triple shift" has occurred which results in a false target speed reading.

Some R.A.D.A.R. devices have the capability to blank the display when identical readings occur.

To avoid, simply decelerate the patrol vehicle by taking your foot off the accelerator. If the patrol speed displayed changes from an identical reading to a lower speed than the target window, the target speed reading is correct.

EXTERNAL MECHANICAL INTERFERENCE



Slide 57.

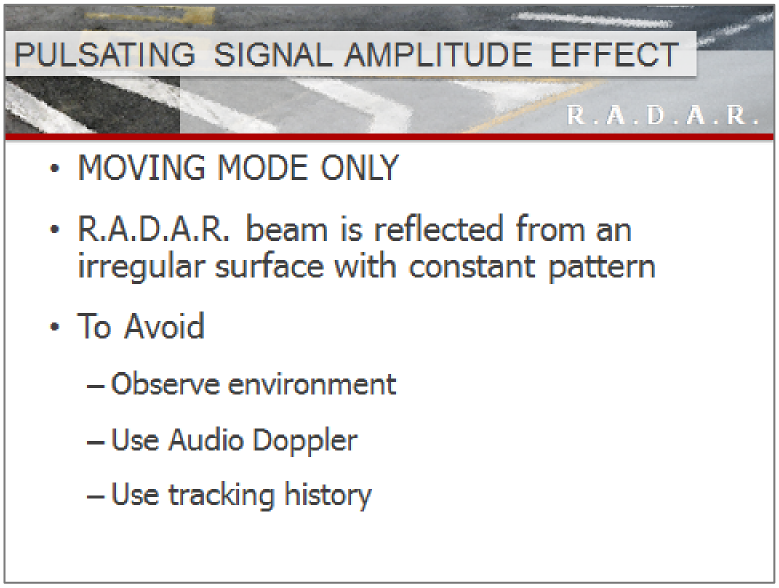
Suggested prop: aim antenna toward projector fan, room air conditioner, etc. to obtain a reading.

Remember that R.A.D.A.R. detects motion and not direction. In addition to moving vehicles, many other objects in our enforcement environment are in motion. These moving objects can cause a reading on the R.A.D.A.R.

Large signs in motion, roof air conditioning fans, and other mechanical devices are examples of moving objects that may cause external mechanical interference.

When a valid target vehicle produces sufficient signal strength to overcome the weak signal of the moving object, the target vehicle will produce the display. Use of the tracking history will allow the operator to identify mechanical effects and disregard them.

PULSATING SIGNAL AMPLITUTE EFFECT



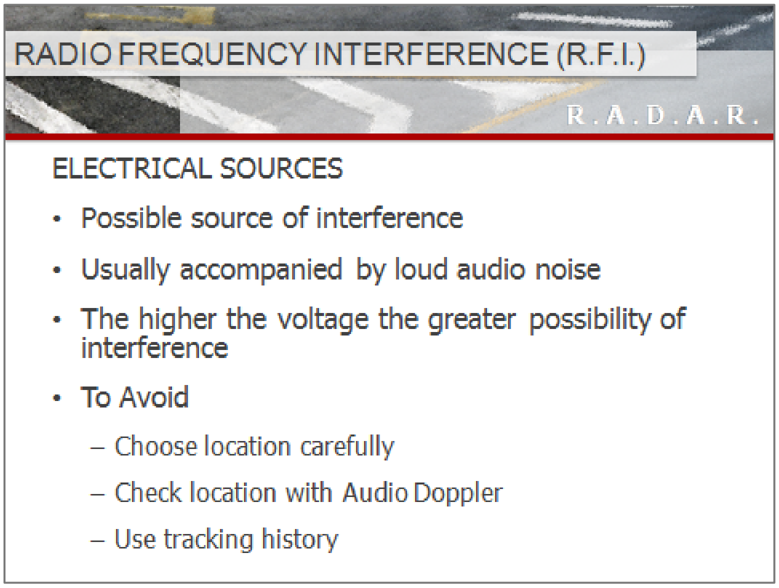
Slide 58.

Demonstrate during fieldwork if possible.

Sometimes called "picket fence" effect.

If the R.A.D.A.R. beam is reflected from an irregular surface with a consistent pattern, such as a chain link fence, the returned signal may be interpreted as a multiple Doppler shift. A false target speed display may occur. The audio Doppler sound will be consistent with the pattern that is returning the R.A.D.A.R. signal.

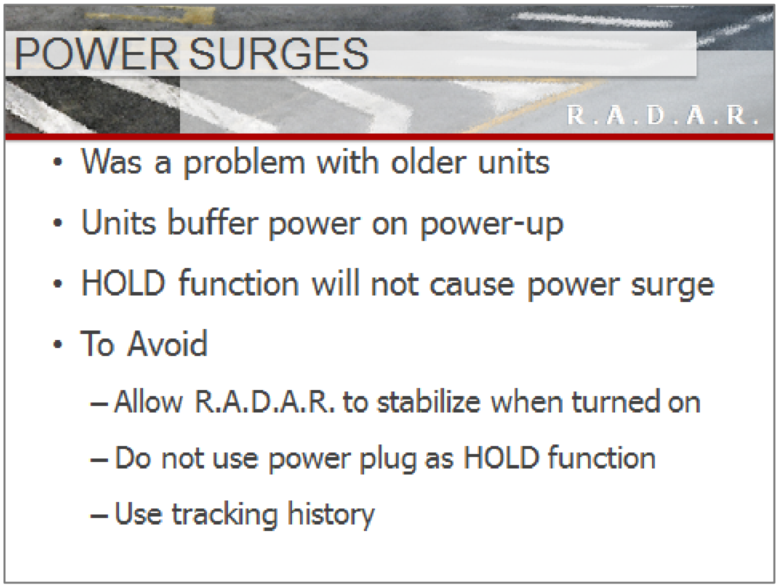
R.F.I. FROM OTHER ELECTRICAL SOURCES



Slide 59.

Electrical sources of Radio Frequency Interference (R.F.I.) include overhead high-voltage power lines, transformers, and certain other electrical devices such as arc welders and medical equipment. This interference is usually identified by very noisy buzzing or humming of the audio Doppler.

IRREGULAR POWER SUPPLY CONDITIONS



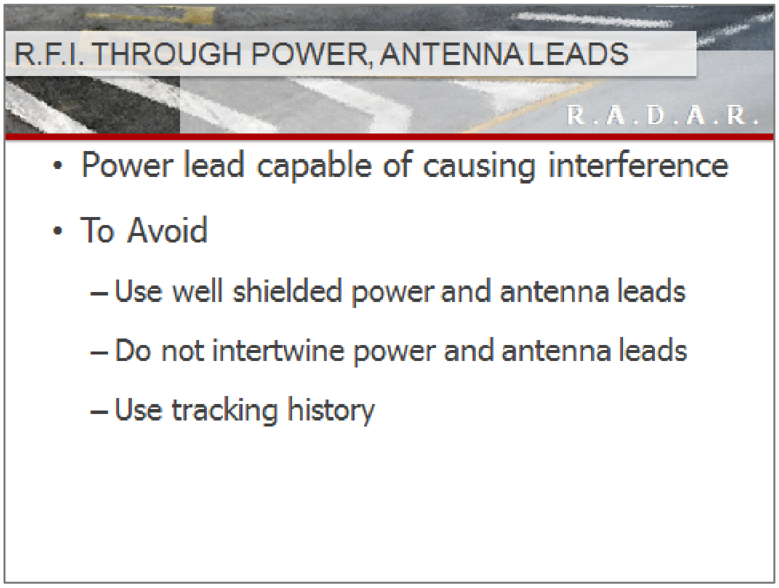
Slide 60.

Demonstrate during fieldwork if possible by starting a patrol vehicle while R.A.D.A.R. device is already turned on.

Either abnormally high or low power to the R.A.D.A.R. device may cause problems. High voltage (power surge) although infrequent may cause device damage or the fuse to blow. Low voltage usually results in the device automatically shutting off.

Police motorcycles tend to be highly susceptible to this condition. General results will be the blanking of any locked speed and possible complete shutdown.

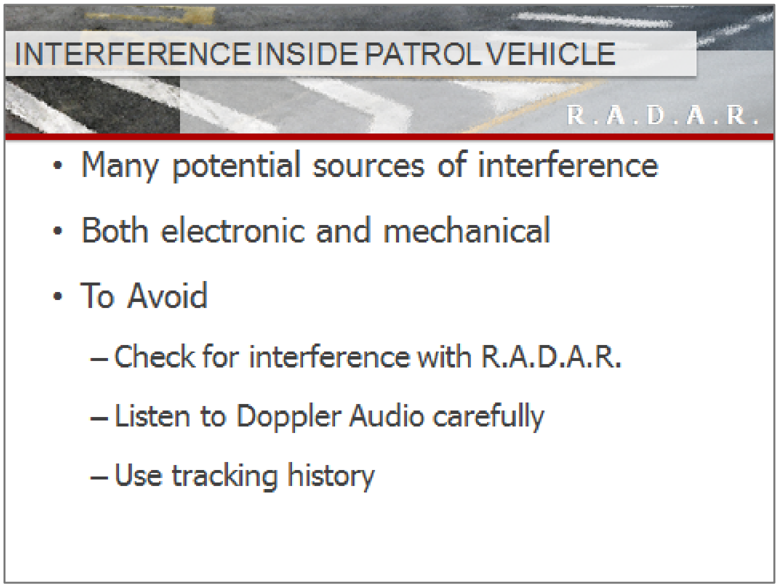
R.F.I. THROUGH POWER AND ANTENNA LEADS



Slide 61.

The vehicles' electrical system is a prime source for R.F.I. through the lack of proper or adequate shielding of the various wires. Shielding refers to the wrapping of copper braid or tin foil strips around the primary current carrying part of a wire. The shielding prevents the radio frequency energy from "escaping" the protected lead. To avoid this effect, make sure the antenna and power leads are well shielded and kept separate.

INTERFERENCE INSIDE THE PATROL VEHICLE

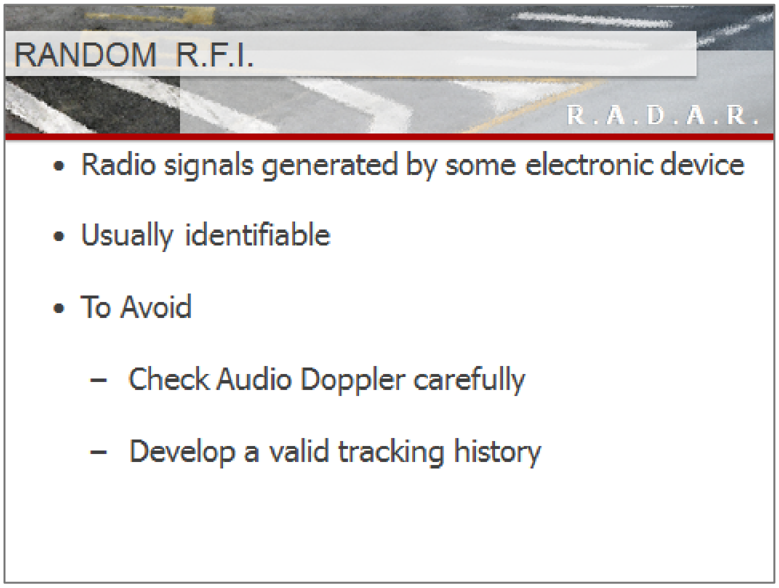


Slide 62.

> Suggested prop: activating a handheld police radio while activating the R.A.D.A.R. device.
>
> Other demonstrations can be done while in the patrol vehicle.

Within every patrol vehicle, there are a surprising number of interference sources. Sources range from mechanical devices such as heater/defroster fans and transmission components to electronic devices such as the various radios (AM/FM radio, CB radio, police radio), electronic clock, or computerized engine ignition parts. Audio Doppler is most important in this situation.

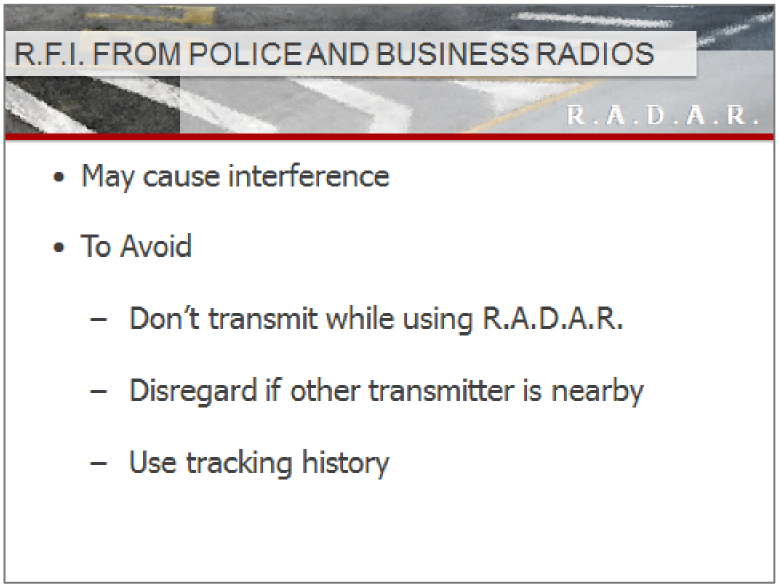
RANDOM R.F.I.



Slide 63.

There are ever increasing numbers of electronic devices capable of generating R.F.I. signals. These signals are potential sources of interference due to the sensitivity of R.A.D.A.R. devices. However, these interference signals are quite weak and using tracking history will allow accurate R.A.D.A.R. use.

R.F.I. FROM RADIO TRANSMISSIONS

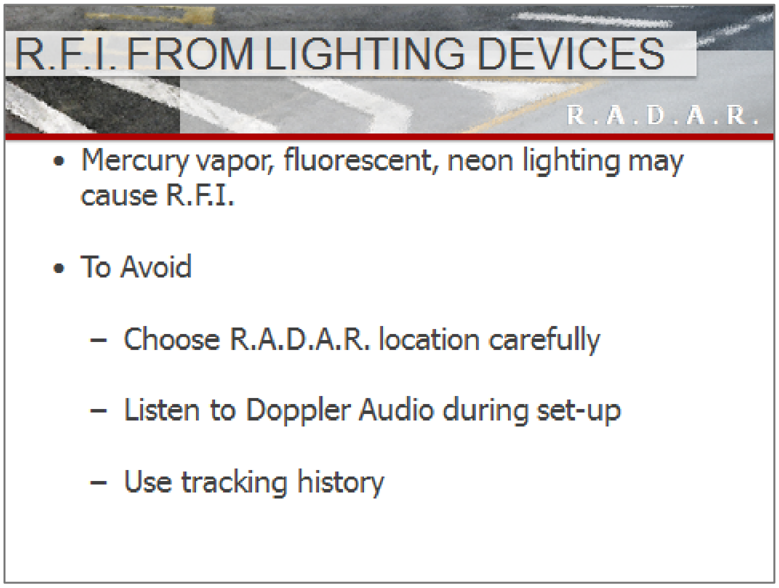


Slide 64.

Suggested props: cell phone, handheld radios, walkie-talkie.

R.A.D.A.R. devices may be affected by R.F.I. from radios both inside and close to the patrol vehicle. This is a result of both transmitter power and inadequate shielding. These include police band, CB, cellular phone, and business band radios. Tests have proven that external radio transmitters must be very close to a patrol vehicle to cause R.F.I. However, prudent operation should include checking the environment for their presence. Use of the tracking history will help identify these sources of R.F.I.

R.F.I. FROM ELECTRICAL LIGHTING

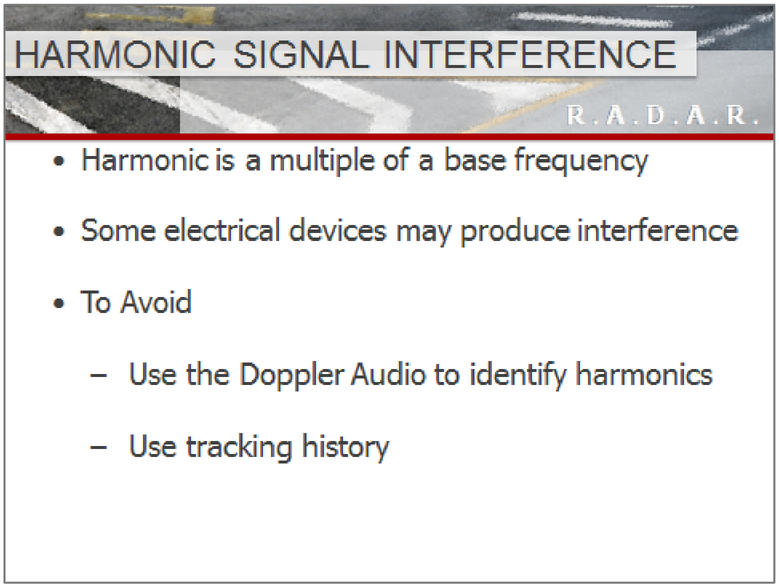


Slide 65.

Suggested prop: aim antenna at fluorescent lights.

Certain types of lighting equipment such as mercury vapor, neon, and fluorescent lights can cause erroneous readings. This is due to their emission of a signal that is equal to multiple R.A.D.A.R. operating frequencies. The audio Doppler will be especially helpful in detecting this interference source.

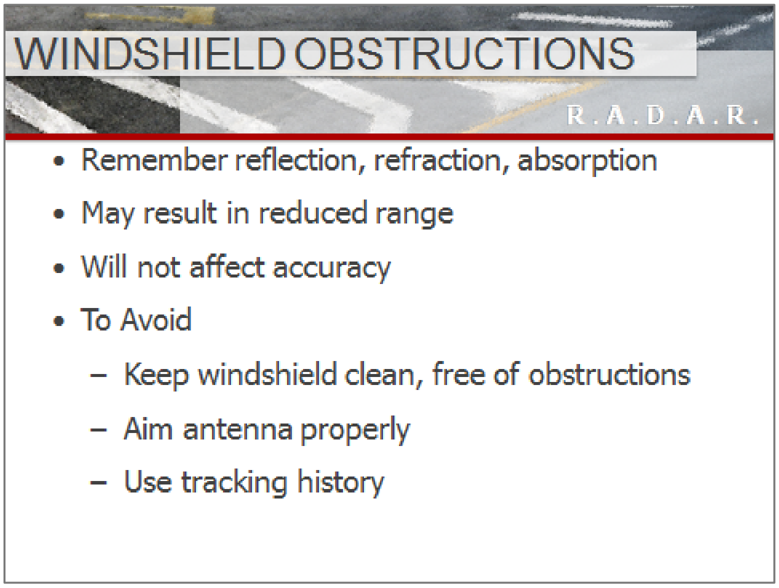
HARMONIC SIGNAL INTERFERENCE



Slide 66.

A harmonic is a multiple of a base frequency. There are many electrical devices that may emit a harmonic signal capable of interfering with the R.A.D.A.R. This interference will also produce noisy audio Doppler.

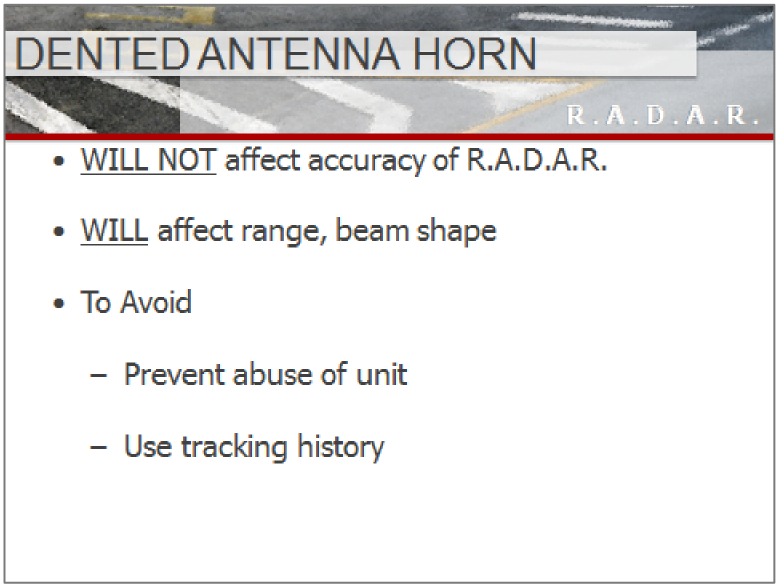
WINDSHIELD OBSTRUCTIONS



Slide 67.

Windshield obstructions can cause reduced range. The windshield should be kept clean and clear of obstructions.

DENTED ANTENNA HORN



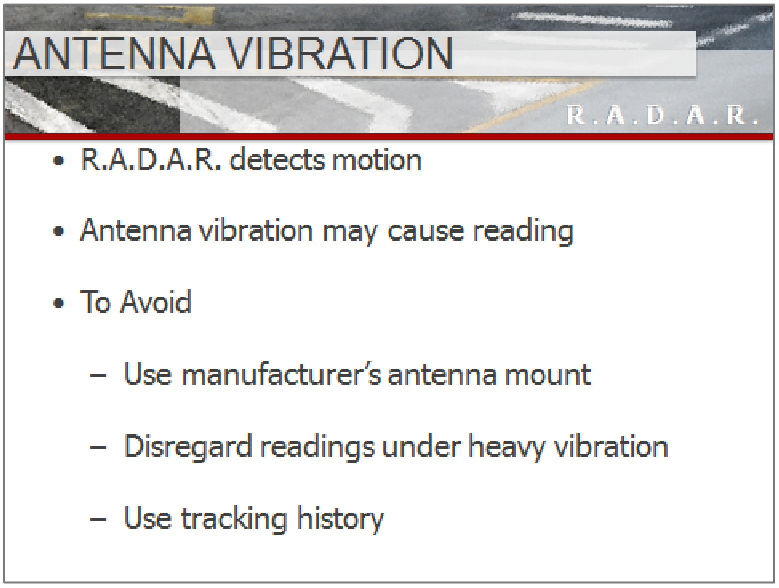
Slide 68.

This effect is usually found on older handheld devices with exposed antenna horns.

Some R.A.D.A.R. antennas are subject to damage. A dented antenna horn may cause distortion of the shape of the R.A.D.A.R. beam as it leaves the antenna. This may result in the beam striking and/or R.A.D.A.R. receiving signals from an unanticipated target.

Devices with damaged antenna horns should be repaired.

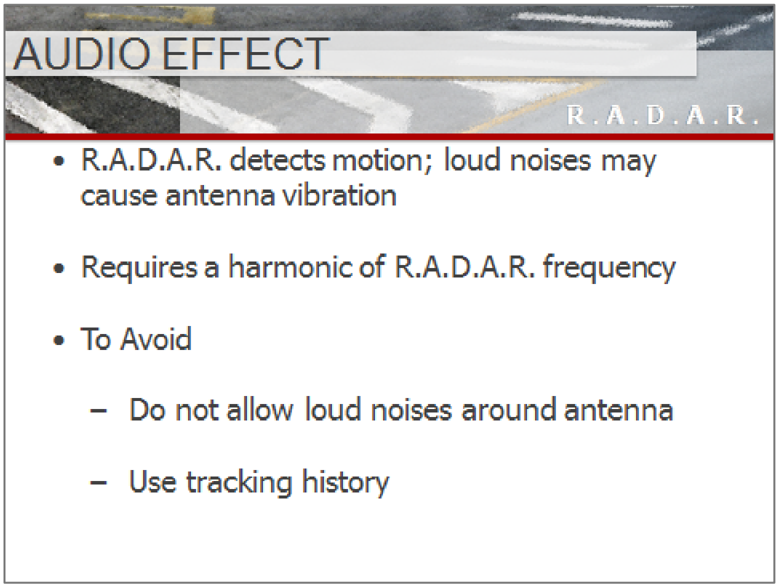
ANTENNA VIBRATION



Slide 69.

Again, the vibration of the R.A.D.A.R. antenna may cause a false reading. The antenna should be mounted per the manufacturer's recommendations in a manner that will reduce vibration. Readings obtained while traveling over very rough or uneven roadways should be carefully checked for tracking history.

AUDIO EFFECT

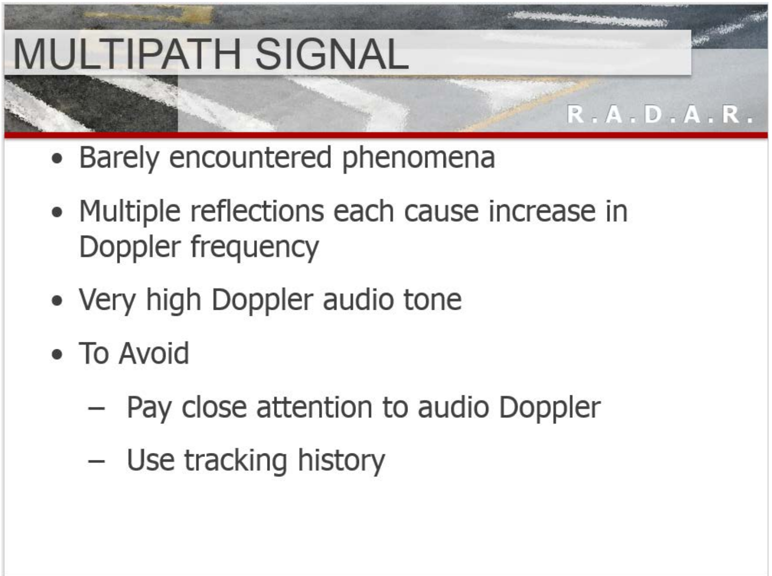


Slide 70.

Instructor can demonstrate by whistling loudly at the face of the antenna.

The audio effect is the result of very loud sounds vibrating the R.A.D.A.R. antenna or objects in the R.A.D.A.R. beam which results in the interpretation of the vibration as motion. Avoid the operation of R.A.D.A.R. in the presence of loud noises.

MULTIPATH SIGNALS



Slide 71.

These are caused by multiple reflections of the R.A.D.A.R. signal, which increase in frequency with each reflection. The results are an unusually high target speed and audio Doppler. The tracking history will disclose this effect.

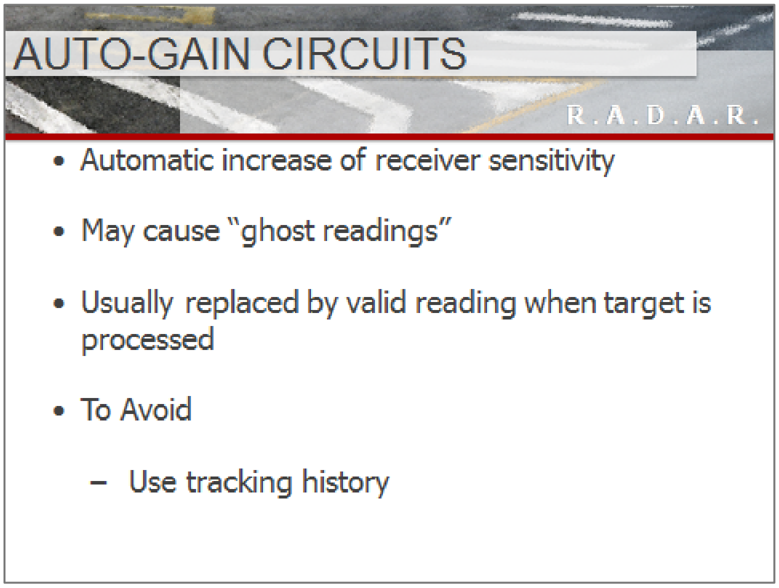
MULTIPATH BEAM CANCELLATION

This effect may be demonstrated in the field if the instructor or students know of an area where it takes place.

A 180 degree "phase inversion" of the R.A.D.A.R. signal causes the reflected signals to interfere with each other. This results in R.A.D.A.R. blind spots - locations where vehicles simply cannot be "seen" by the R.A.D.A.R. even though visible with the naked eye.

Blind spots are created at places where the R.A.D.A.R. beam is reflected off many surfaces, such as roadway, fence posts, buildings, or trees. The reflected beams, in effect, cancel each other out. The operator must be alert to the possibility of the R.A.D.A.R. displaying a vehicle well behind the target vehicle in the blind spot. There is no remedy to multipath beam cancellation besides avoiding such areas and obtaining a complete tracking history.

AUTOMATIC RECEIVER GAIN



Slide 72.

Attempt to demonstrate in class and in the fieldwork.

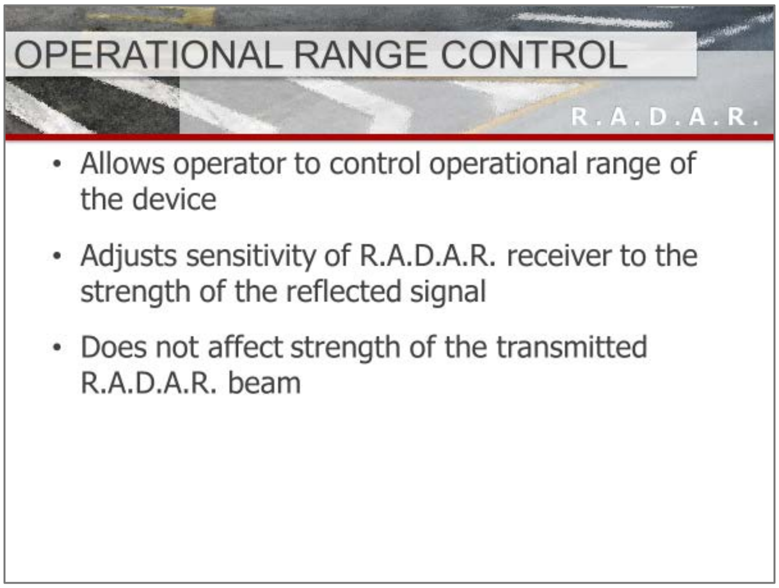
In the absence of a valid target, some R.A.D.A.R. devices will attempt to seek a signal. In doing so, the R.A.D.A.R. receiver is "wide open" allowing spurious (ghosts) readings to occur. An example frequently given is the infamous 88-mph tree. Lack of a valid target and no tracking history will alert the operator to this condition.

THE EFFECT OF TERRAIN ON TARGET IDENTIFICATION

The optimum terrain for R.A.D.A.R. enforcement is a straight, level roadway. R.A.D.A.R. works on a line-of-sight basis and will not normally display vehicles around a curve or over a hill. Hills can cause the greatest problem in target identification.

- R.A.D.A.R. can overshoot lead vehicles and strike vehicles far behind
- Operator discretion in the selection of a working area is necessary

OPERATIONAL RANGE CONTROL



Slide 73.

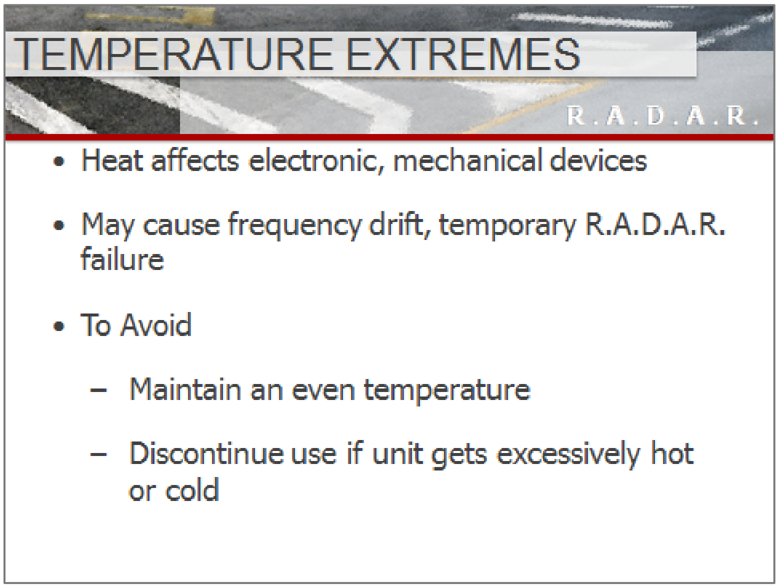
Some R.A.D.A.R. devices allow the operator to control the operational range of the device. This feature adjusts the sensitivity of the R.A.D.A.R. receiver to the strength of the reflected signal. It does not affect the strength of the transmitted R.A.D.A.R. beam - this remains steady.

Operational range control can be used to reduce target identification problems. A low setting will cause the R.A.D.A.R. to be sensitive to only very strong signals, thereby reducing its effective range. A high setting will cause the R.A.D.A.R. to be sensitive to very weak signals, thereby increasing its effective range. Experimentation at each enforcement location is necessary to obtain the optimum range. The range setting must be high enough to allow a significant tracking history to be obtained.

1. Set the sensitivity level at a low setting
2. Increase the sensitivity while watching vehicles until the optimum range is found for the location

For moving R.A.D.A.R., the sensitivity setting must be higher. The operational range control is only approximate. The control is usually designed to account for the "average" vehicle. Rain or snow will decrease the R.A.D.A.R.'s range slightly. Adjusting the R.A.D.A.R.'s range control, which affects only the sensitivity of the R.A.D.A.R. receiver, will not fool R.A.D.A.R. detectors, which monitor the unaffected transmission.

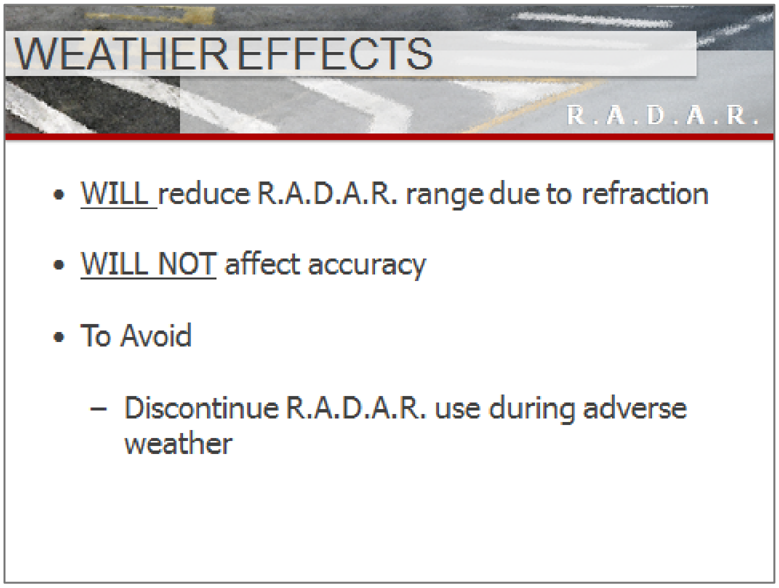
TEMPERATURE EXTREMES



Slide 74.

R.A.D.A.R. devices may be sensitive to extremes of heat and cold. They may cause total failure or improper readings. Your set-up accuracy tests will tell you whether the devices are operating correctly.

WEATHER EFFECTS

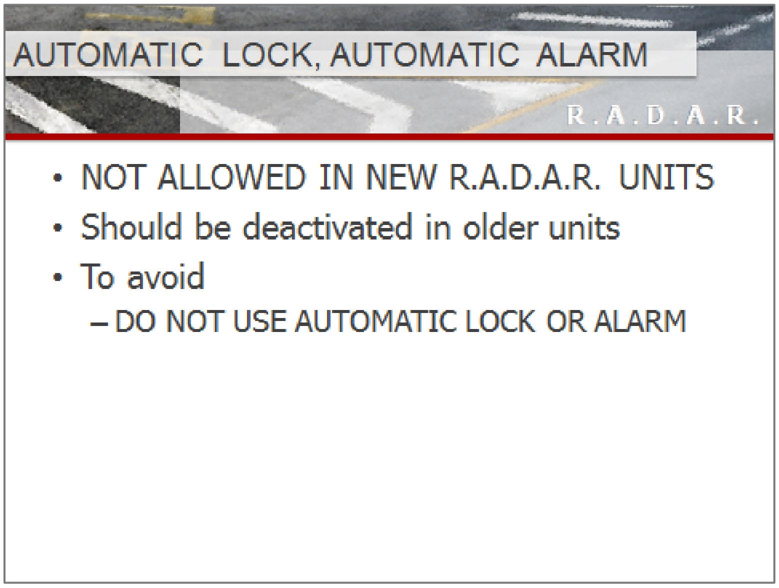


Slide 75.

> Demonstration depends upon weather conditions at the time of the class. Simulations of rain and fog can be done with garden hose and roadside flare.

Rain, snow, and fog will cause R.A.D.A.R. beam scattering and refraction. The usual result is reduced range. Wet roadways may also cause the loss of the low Doppler signal thereby losing patrol speed, resulting in no reading. Adverse weather conditions also inhibit the acquisition of good tracking history.

AUTOMATIC LOCK, AUTOMATIC ALARM

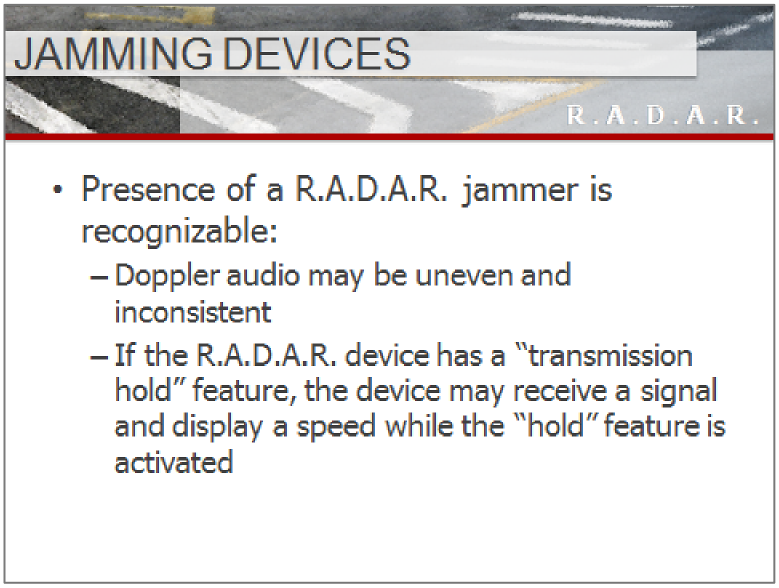


Slide 76.

Emphasize they are not to be used.

DO NOT USE!

JAMMING DEVICES



Slide 77.

Attempting to create false or distorted signals is known as jamming. Jamming is rarely encountered. The primary types of jamming devices are L.I.D.A.R. and R.A.D.A.R. transmitters. A frequency transmitter sends out a strong signal with a frequency close to that of the police speed-measuring device.

- The device "sees" this signal instead of the signal reflected from the vehicle The speed-measuring device records either no speed measurement or an obviously inaccurate measurement
- The R.A.D.A.R. frequency transmitter, when used as a jamming device, violates FCC regulations
- Make sure of your legal ground before taking any enforcement action

The presence of a R.A.D.A.R. jammer is recognizable:

- If the Doppler audio is uneven or inconsistent
- If the R.A.D.A.R. device has a "transmission hold" feature, the device may receive a signal and display a speed while the "hold" feature is activated

Public misconceptions believed to be able to jam R.A.D.A.R.:

- Strips of metal foil on vehicle
- Hanging chains
- Metal objects in hubcaps
- Horn-honking

5 SET UP

Estimated time for Chapter 5: 20 Minutes

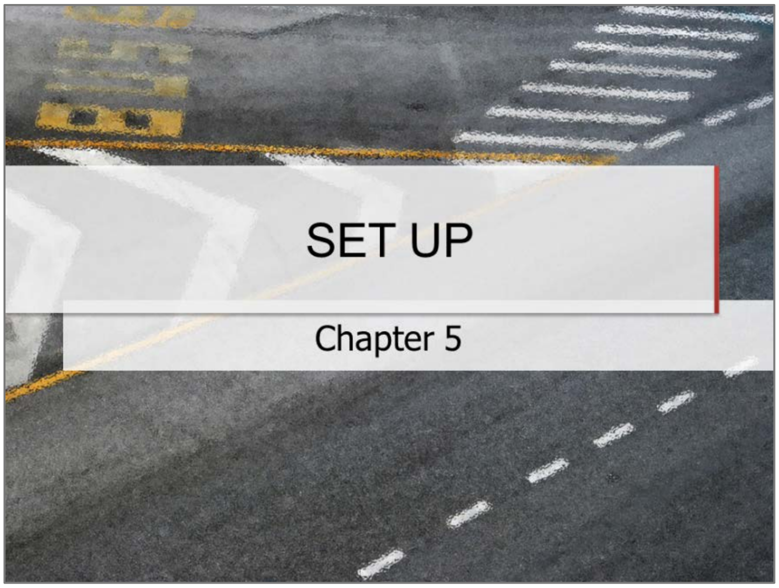
R. A. D. A. R.

Contents

Objectives

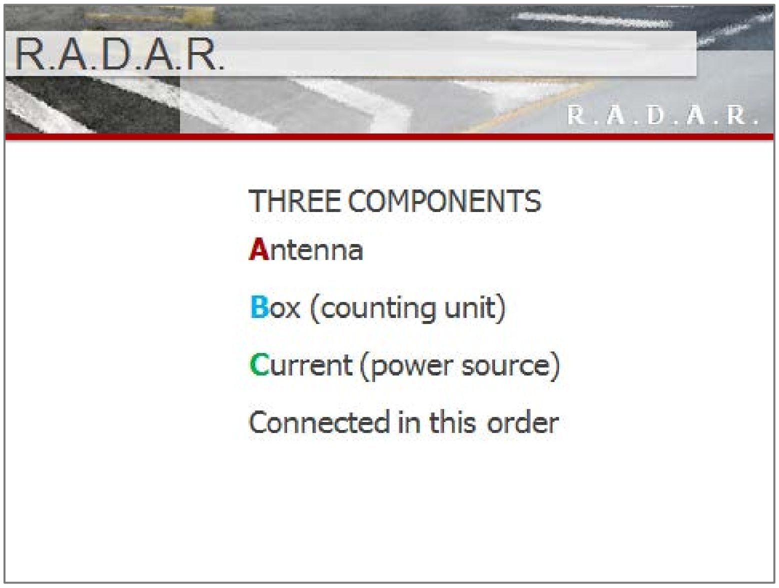
By the end of this chapter, you will be able to:

- Set up R.A.D.A.R.



Slide 78.

R.A.D.A.R. INSTALLATION CONSIDERATIONS



Slide 79.

Recommend showing photos of your agency's equipment.

Discuss the expense of replacing, repairing, and maintaining devices if not properly installed and handled.

Instrument Component Assembly

R.A.D.A.R. devices fall into two categories: one-piece and two-piece. A one-piece device has the R.A.D.A.R. antenna and the counting unit housed in a single component. Two-piece devices have separate components for antenna and counting unit.

The R.A.D.A.R. device's structure (one-piece, two-piece) and the manufacturer's recommendations will determine how and where it will be installed in the patrol vehicle.

(The safety of the patrol vehicle driver and passengers should be the paramount consideration). A poorly secured R.A.D.A.R. device can become a dangerous projectile in the event of any sudden change of patrol vehicle speed or direction. Since a two-piece R.A.D.A.R. device creates the most problems in installation, proper mounting of the counting unit and antenna must be discussed.

General Operational Considerations

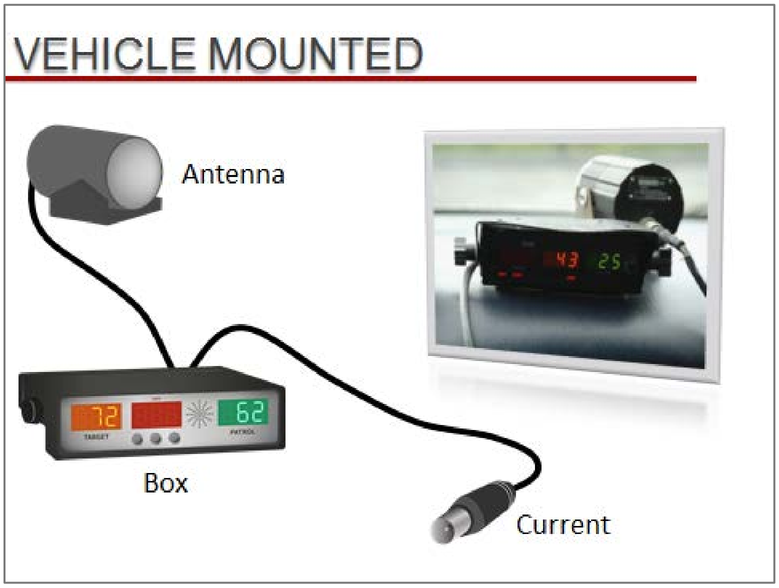
Most R.A.D.A.R. devices currently on the market require similar setup procedures. First you assemble and install the device components, then perform the required tests for accuracy. Chapter 5 will detail the exact procedures for the specific R.A.D.A.R.(s) you will use (there are differences among the various manufacturers devices and the exact procedures involved). However, certain procedures are common for all R.A.D.A.R. devices; this section will deal with those procedures.

HANDHELD

Slide 80.

A one-piece device requires no component assembly. The device is merely plugged into a power source (typically a cigarette lighter) to be ready for use. However, always be sure that the device's power is turned off before plugging in the device. Leaving the switch on during plug-in can result in a blown fuse or damage to the device.

VEHICLE MOUNTED



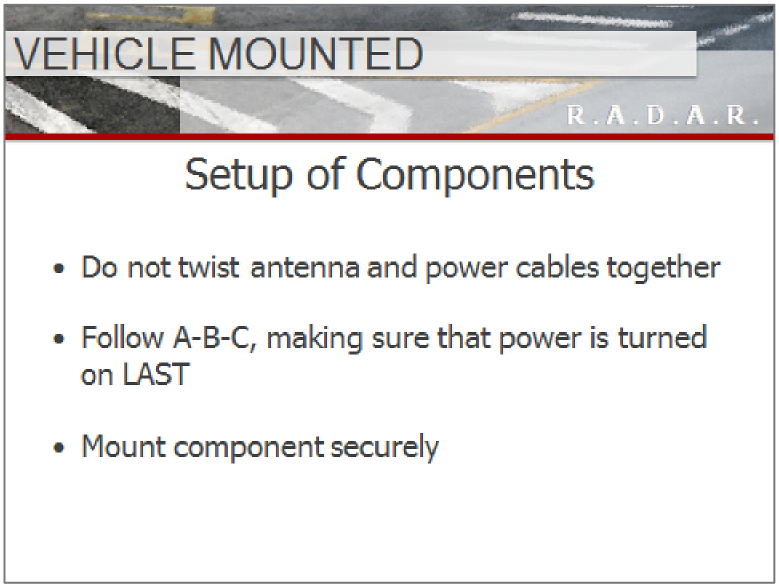
Slide 81.

Two-piece devices require some component assembly. First, the antenna must be attached to the counting unit. This in turn is connected to the power source. The R.A.D.A.R. device may then be turned on. As with one-piece devices, failure to follow this sequence can result in a blown fuse or possible device damage.

Mounting the Box (Counting Unit)

The size and shape of the counting unit component is likely to dictate where in the patrol vehicle it may be mounted. Usually, it is mounted on the dash or console. In any case, the safety of the mount, the visibility of the R.A.D.A.R. speed display(s), and whether the counting unit is obstructing the operator's vision are all factors to consider in mounting.

SETUP OF COMPONENTS



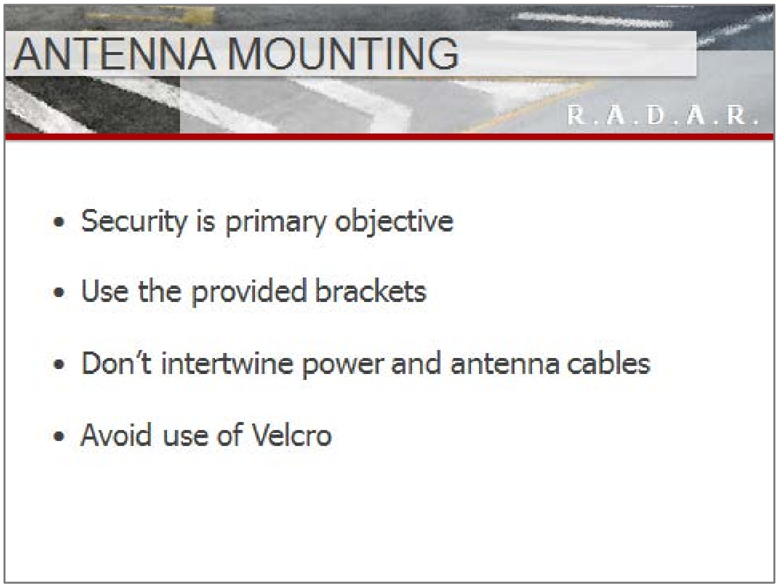
Slide 82.

A good method to recall this procedure is to think of it as the “A-B-C” of R.A.D.A.R. assembly:

- A-antenna
- B-box (counting unit)
- C-current

Make sure to use a power source in accordance with manufacturer requirements.

ANTENNA MOUNTING



Slide 83.

The antenna may be provided with mounting brackets allowing inside dash mounting, outside window mounting, or sometimes both. The operator should be aware of the advantages and disadvantages of each type of antenna mounting. Again, the size and shape of the antenna will affect its mounting.

The primary advantage of mounting the antenna outside is that it is away from the potential areas of interference that may be generated inside the patrol vehicle. Its primary disadvantage is that the antenna may be exposed to inclement weather, which can cause increased maintenance problems. Few, if any, current antennas can be classified as weatherproof, although many are reasonably weather-resistant. It is strongly recommended that the antenna not be left outside in wet weather. Changes in temperature do not significantly affect the antenna. The possibility of the antenna being either accidentally or deliberately damaged when mounted outside must also be considered.

The antenna should be placed inside if the patrol vehicle will be unattended for any significant length of time.

The primary advantage of inside mounting is that you need not worry about inclement weather. The chances of vandalism and accidental damage are also minimized. The disadvantage of mounting the antenna inside is that there is more potential for interference within the patrol vehicle.

Dash-mounting the R.A.D.A.R. as close to the windshield as possible and maintaining the proper straight-ahead antenna alignment will significantly reduce the potential for interference.

The type of R.A.D.A.R. device (hand-held or two-piece), the mounting brackets available, the manufacturer's recommendations, and your agency's policies, will generally govern how you mount the antenna.

Basic guidelines include:

- Avoid mounting the antenna so that it is pointing at the operator or passenger
- Do not mount the antenna so that the counting unit is in the R.A.D.A.R. beam

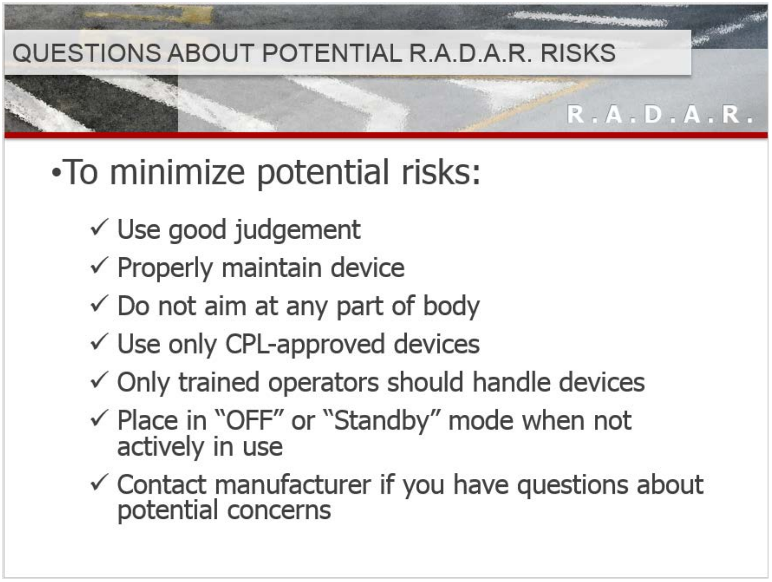
Antenna Alignment

With stationary R.A.D.A.R., the antenna can be aimed toward vehicles either approaching or going away from the R.A.D.A.R. When the antenna is aimed toward approaching traffic, the idea is to complete the speed measurement before the target vehicle reaches you.

When the antenna is directed toward receding traffic, the suspected speeding vehicle can pass the R.A.D.A.R.'s position and the idea is to make a speed measurement before it gets out of range.

Both antenna directions have their merits and there will be times and places where either one will be advantageous. It is important to understand that the stationary R.A.D.A.R. device will work equally well either way. Whether a target is approaching or receding has no effect on its speed relative to the R.A.D.A.R.

QUESTIONS ABOUT POTENTIAL R.A.D.A.R. RISKS



Slide 84.

The potential risks of developing types of cancer from exposure to R.A.D.A.R. devices have periodically been studied for several years. Law enforcement officers face potential cancer risk through exposure not only to radiation, but to chemical compounds, sunlight, cell phones, tobacco use, and a host of other factors.

For many years, there have been concerns about cancer in general, and testicular cancer resulting from prolonged exposure to radiation from R.A.D.A.R. units laid on the lap of officers during periods of non-use.

Research into cancer risk and exposure for law enforcement officers has been, "sparse and subject to limitations in exposure assessment and other methods. Results from three studies suggested possible increased mortality risks for all cancers, and cancers of the colon, kidney, digestive system, esophagus, male breast, and testis, as well as Hodgkin's disease. Few incidence studies have been performed, and results have been mixed, although some associations with police work have been observed for thyroid, skin, and male breast cancer." [1]

Per the World Health Organization, "People who live or routinely work around R.A.D.A.R.s have expressed concerns about long-term adverse effects of these systems on health, including cancer, reproductive malfunction, cataracts and changes in

[1] Wirth, M., Vena, J. E., Smith, E. K., Bauer, S. E., Violanti, J., & Burch, J. (2013). The Epidemiology of Cancer Among Police Officers. American Journal of Industrial Medicine, 56(4), 439–453. http://doi.org/10.1002/ajim.22145

behavior or development of children. A recent example has been the alleged increase in testicular cancer in police using speed control hand-held R.A.D.A.R. "guns." With respect to R.A.D.A.R. devices used by law enforcement, the World Health Organization indicates "**Speed control R.A.D.A.R.s** are handheld by police in many countries. The average output power is very low, a few milliwatts, and so the units are not considered hazardous to health, even when used in very close proximity to the body."[2]

Good judgement should be used in the handling and operation of any device that emits radiation. This includes traffic R.A.D.A.R. devices. Law enforcement officers should always operate the R.A.D.A.R. unit in accordance with the manual provided by the manufacturer and/or training provided in the use of the specific instrument. Some general guidelines for the handling and operation of R.A.D.A.R. include:

- Ensure devices are properly maintained
- Do not aim devices at any part of the body
- Use only CPL-approved devices
- Only trained operators should handle devices
- When not actively being used, place in "OFF" or "Standby" mode
- Contact the device manufacturer if there are questions about potential concerns

If there are questions about the safety associated with a R.A.D.A.R. device, use should be discontinued and the device taken out of service for maintenance and/or possible repairs by a qualified technician.

[2] http://www.who.int/peh-emf/publications/facts/fs226/en/

6
TESTING

Estimated time for Chapter 6: 10 Minutes

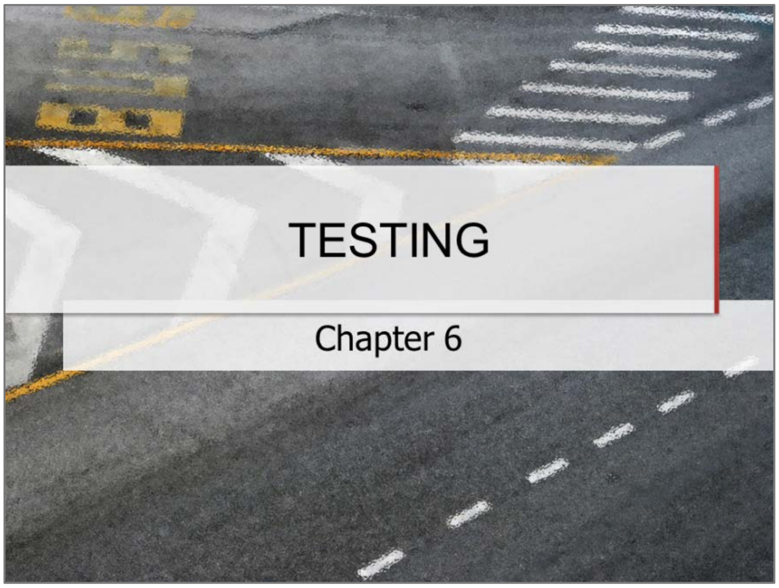
R. A. D. A. R.

Contents

Objectives

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

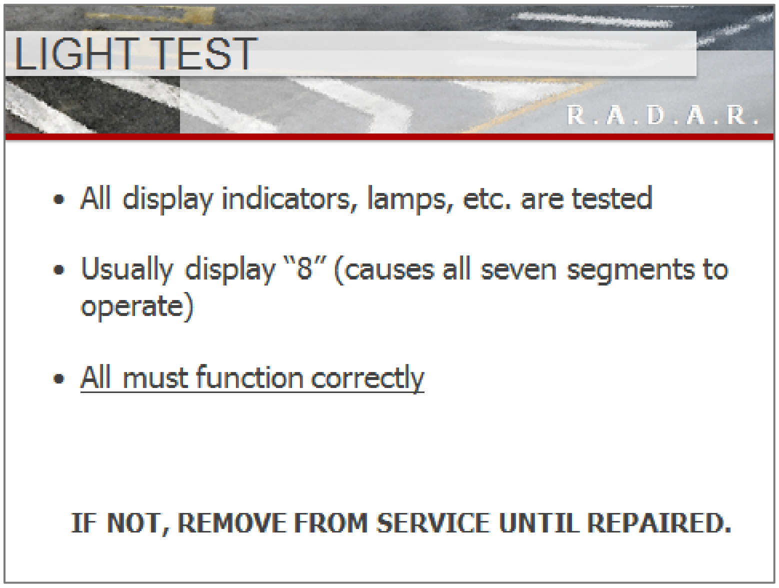
- Perform function tests



Slide 85.

Over the years, procedures have evolved to test the accuracy of R.A.D.A.R. devices. Each device should be tested per the manufacturer's specifications. Ideally, every device should be accompanied by a manufacturer's operator manual.

LIGHT TEST

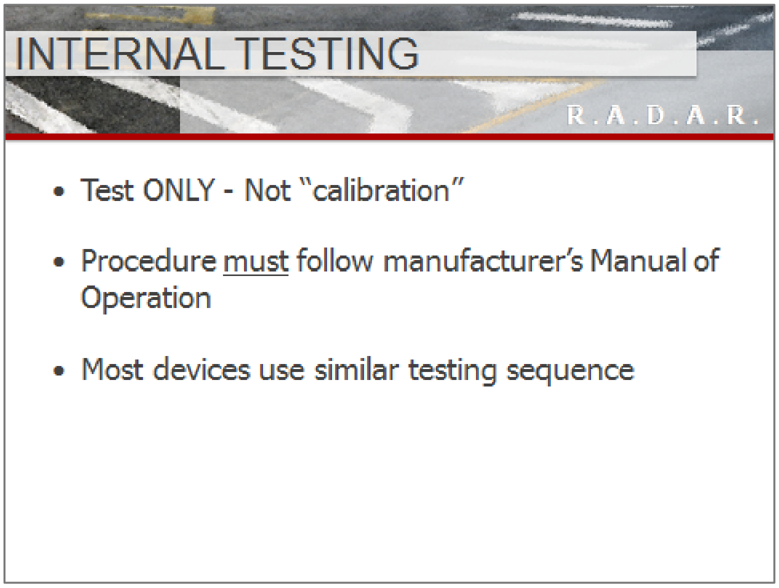


Slide 86.

Manufacturer testing guidelines are an absolute minimum. Operator manual should be available.

R.A.D.A.R.s must have a feature that allows the operator to test all the light segments on the R.A.D.A.R. display(s). A burned-out light segment could cause the operator to make a mistaken speed reading. If a burned-out segment is discovered, the R.A.D.A.R. device should be taken out of service and repaired. In some devices, this test and the internal circuit test are combined.

INTERNAL CIRCUIT TEST



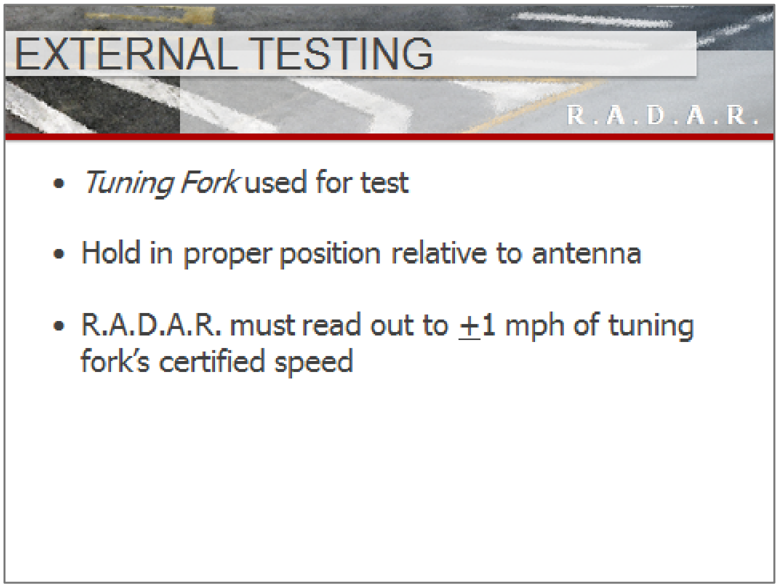
Slide 87.

Suggested props: specific R.A.D.A.R. devices used by the students which are fully operational. Demonstrate each aspect of testing as well as practical testing of the student. ("Tell-show-do")

Use LITS when setting up your device. **L**ight Segment Test, **I**nternal Circuit Test, **T**uning Fork Test, and **S**peedometer Verification. This is not in every user manual, but if you follow this, your equipment should be accurate.

The internal circuit test (ICT) checks the circuits inside the counting unit. It should be noted that the internal circuit test checks only the counting unit, not the antenna. On most R.A.D.A.R. devices, the internal circuit test is performed by pressing a button and checking the displays to verify that a specific value appears. (Check operator's manual for the expected internal circuit test results). In all cases, the internal test is passed only if the proper number appears. If any other number is displayed, remove from service until repaired.

EXTERNAL TUNING FORK TEST



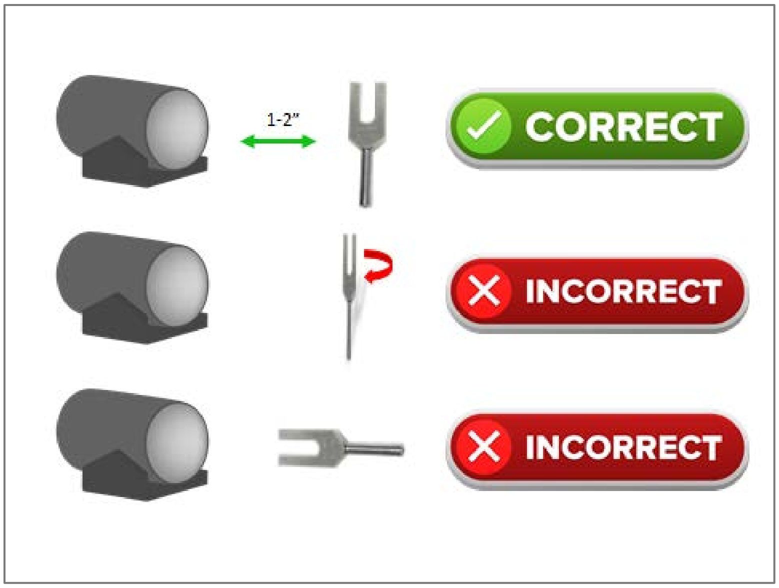
Slide 88.

The external tuning fork test checks both antenna and counting unit's ability to correctly process and display a simulated target speed.

To use the fork, grasp its handle and strike one of the tines against a firm surface. It is better to strike the fork against a surface that is reasonably firm but not as hard as the fork itself, such as the heel of your shoe or a padded steering wheel.

Striking the fork against a very hard surface, such as concrete or metal, may chip or break the fork. However, tests by the National Institute of Standards and Technology have shown that even a badly chipped fork will normally continue to vibrate properly and give accurate results.

Also, avoid striking the fork when the fork is extremely hot or cold. Extreme variations in temperature may cause an improper reading to be displayed. Holding the tuning fork comfortably in your bare hand will not affect the reading the R.A.D.A.R. displays. The allegation that a tuning fork being wet can affect the speed it displays on a R.A.D.A.R. device is without scientific basis.



Slide 89.

Demonstrate effect: use an X-band fork on a K-band device.

In preparing to perform the tuning fork test, point the R.A.D.A.R. antenna away from possible interference. If the antenna is pointed horizontally (i.e., toward any traffic) there may be interference with this test.

The actual distance the tuning fork is held from the antenna face is not critical, but one to two inches is accepted as optimum. The suggested procedure is to hold the fork so that the two tines line up one behind the other and only the side of one tine faces the antenna.

When you perform the tuning fork test, a speed measurement will appear on the R.A.D.A.R. device's display window. The speed measurement cannot differ from the fork's certified value by more than +1 miles per hour. For example, if you use a 65-mph fork to test the device's calibration, the test will be passed if the display does not read lower than 64 or higher than 66.

If the speed measurement should differ from the certified value by more than +1 miles per hour, the test should be repeated. If the deviation persists, remove the R.A.D.A.R. device from service until repaired.

Case law over the years has affirmed that using tuning forks is a valid check of a R.A.D.A.R. device's accuracy. Traditionally, only one tuning fork is needed to check a stationary R.A.D.A.R. device although local law or departmental policy may dictate using two or more forks.

For moving R.A.D.A.R., two forks are necessary. One tuning fork simulates a low-speed, usually 30- to 50-mph. The second tuning fork simulates a high-speed, usually between 60- and 90-mph.

Moving R.A.D.A.R. is checked by first striking the low-speed tuning fork and holding it in front of the antenna. This simulates the patrol speed in the patrol speed display window. A second, high-speed fork is then struck and held before the antenna. This simulates a closing speed. The second fork, presented in conjunction with the first fork, will simulate a target speed. The target speed should display the difference between the high and low-speed forks.

This process checks the R.A.D.A.R. device's ability to subtract the patrol vehicle speed from the closing speed (remember, TS=CS-PS).

R.A.D.A.R. tuning forks must not be mixed between X-band, K-band, and Ka-band R.A.D.A.R.s. An X-band fork used to test a K-band R.A.D.A.R. (and vice versa) will not yield accurate results.

Patrol Speed Verification Test

The R.A.D.A.R. tests for accuracy discussed so far (internal circuit test, light segment test, and external tuning fork test) apply to all traffic R.A.D.A.R. devices, moving and stationary. The final test, verification of the R.A.D.A.R. patrol speed readout against the patrol vehicle's certified speedometer, is required only for moving R.A.D.A.R. devices.

This check is to establish that the moving R.A.D.A.R. device is properly displaying the actual patrol vehicle's speed. The operator accelerates to a steady speed and compares the R.A.D.A.R.'s patrol speed readout with the patrol vehicle's certified speedometer. The speeds must correspond closely; if there is any noticeable deviation, the R.A.D.A.R. device should not be used.

It should be stressed that the R.A.D.A.R. device's failure to respond properly to any one of these tests calls for its immediate removal from service.

Subsequent Accuracy Tests

It can be assumed that the R.A.D.A.R. device was working properly when a speed measurement was made if it can be shown that the R.A.D.A.R. device was working properly both before and after the measurement was made.

Law enforcement agencies must determine the minimum requirements for testing the R.A.D.A.R. devices as part of their standard practices and in response to case law applicable to its jurisdiction. Some general guidelines and suggestions can be offered here.

Agencies may require these tests be performed at least twice, at the beginning and end of the duty shift in which the R.A.D.A.R. is operated; they may occur more frequently.

7

LEGAL CONSIDERATIONS

Estimated time for Chapter 7: 30 Minutes

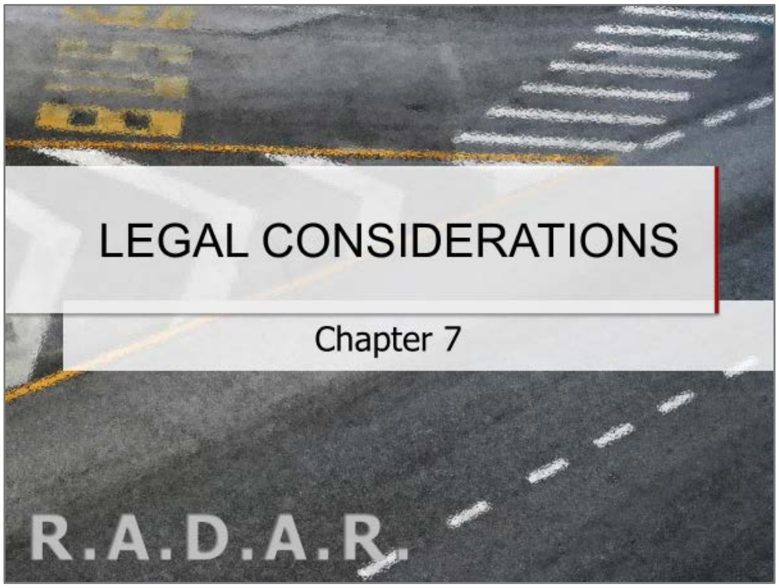
R. A. D. A. R.

Contents

Objectives

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

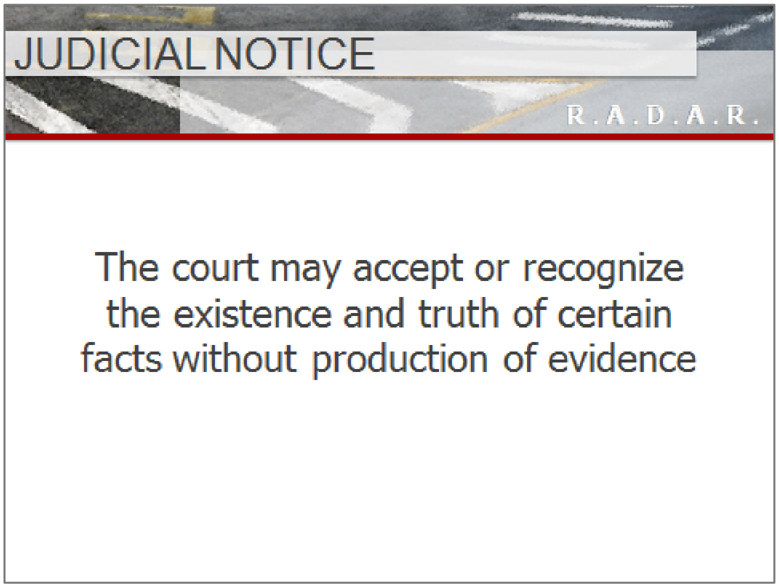
- Discuss legal considerations pertaining to R.A.D.A.R.
- Discuss the requirements needed for citation documentation and/or courtroom testimony



Slide 90.

Instructor should identify local case laws to discuss in this chapter.

JUDICIAL NOTICE

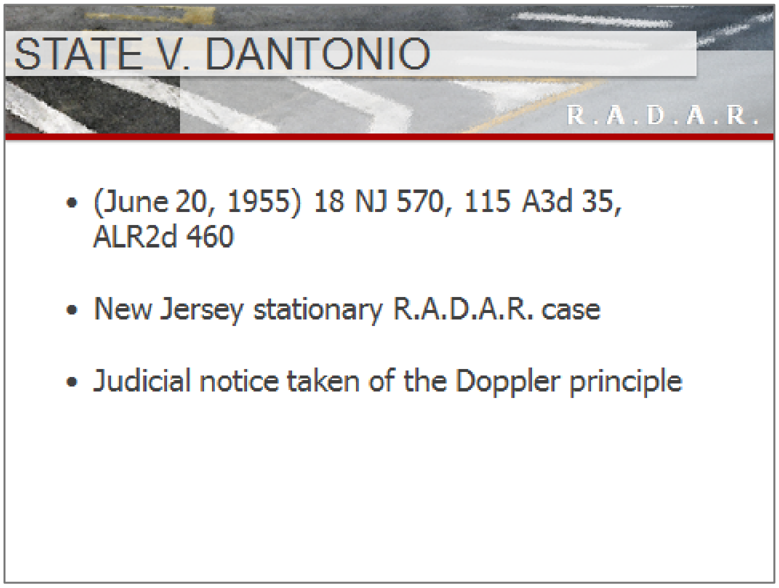


Slide 91.

The underlying operational principles must be shown to be scientifically reliable. Fortunately, these devices are receiving almost universal acceptance in court: some jurisdictions take judicial notice of their general suitability, but their scientific validity may need to be demonstrated in others. All courts may take judicial notice of the existence of certain conditions. To expedite the presentation of evidence, courts may recognize – or take "note" of – those facts or principles that are so widely known as to be familiar to reasonably well-informed people.

In the speed-measurement device context, for example, courts have commonly taken judicial notice of the existence of the Doppler effect – the principle underlying police R.A.D.A.R. – and of the underlying principles of devices, such as tuning forks, used to determine the accuracy and reliability of a speed-measurement device. Once the court takes judicial notice, no further proof of the issue is required.

STATE V. DANTONIO, 1955



Slide 92.

Stress definition of judicial notice as defined on the previous slide.

Judicial notice was extended to the Doppler Principle.

Courts first took judicial notice of scientific principles underlying traffic R.A.D.A.R. in 1955. In State v. Dantonio, the New Jersey State Supreme Court first recognized the Doppler principle in the context of speed enforcement:

“The law does not hesitate to adopt scientific aids to the discovery of truth which has achieved such recognition... Since World War II members of the public have become generally aware of the wide-spread use of R.A.D.A.R. methods in detecting the presence of objects and their distance and speed...”

However, judicial notice does not relieve the prosecution of the burden of proving that at the time the defendant’s speed was measured, the measurement device was working properly and the operator was using it properly.

Validity of underlying scientific principles: Frye-Standard

If the jurisdiction has not yet taken judicial notice of the speed-measuring device's general validity, the prosecution must demonstrate the scientific validity of the device type before the operator can testify concerning readings obtained from the device.

Courts generally apply the Frye Standard – a test established in Frye v. United States, 293F. 1013 (D.C. Cir. 1923) – or variations of it. Proof must be offered, via expert testimony, that:

- The scientific principle that the device employs to measure speed is widely accepted in the scientific community
  For example, with R.A.D.A.R. devices, the prosecution must show that the Doppler Principle is an accepted scientific principle within the scientific community for measuring the speed of an object
  - With speed-measuring devices, it must be shown that the device used to measure a vehicle's speed employs an accepted scientific principle properly; and,
  - It must be shown that the speed-measuring device operator has been trained and followed the recommended operating procedures

Device condition

It is not enough to offer in evidence the reading obtained from a speed-measuring device. It must be shown that the device was operating as designed when the reading was obtained.

This is universally recognized by the courts; in Everight v. City of Little Rock, the Arkansas Supreme Court took judicial notice of the principle underlying traffic R.A.D.A.R. but warned prosecutors and operators that case-specific proof would be required:

"We are of the opinion that the usefulness of R.A.D.A.R. device for testing [the] speed of vehicles has now become so well established that the testimony of an expert to prove the reliability of R.A.D.A.R. in this respect is not necessary. The courts will take judicial notice of such fact.

Of course, it will always be necessary to prove the accuracy of the particular device used in testing the speed involved in the case being tried."

Defense attorneys often challenge the device's operation at the time the reading was obtained. Courts cannot take judicial notice that the device was working as designed – the prosecution must be prepared to demonstrate that the device was operating as designed immediately prior to, and immediately following, the time the reading was obtained. If the prosecution is successful, the trier-of-fact may infer that the device was working as designed when it detected the target vehicle's speed.

Courts may, however, take judicial notice of techniques and equipment used to determine that a device works as designed. Commonly called calibration devices, such equipment verifies that the device is, when tested, operating in the manner the manufacturer intended.

Instructor should stress that the term "calibration" should not be used. R.A.D.A.R. operators perform "functions tests". They do not calibrate.

Operator Qualifications

Defense attorneys often attack the operator's qualifications. Training and certification records must be kept ready for production in court.

Training

Defense attorneys typically challenge the adequacy of the complaining operator's training. The prosecution must be ready to demonstrate that training occurred and was adequate. Most courts follow the reasoning of the Kentucky Court of Appeals, in Honeycutt v. Commonwealth, and require only evidence that the operator knew basic operational procedures:

"It is sufficient to qualify the operator that [he/she] have such knowledge and training as enables him to properly set up, test, and read the device; it is not required that [he/ she] understand the scientific principles of R.A.D.A.R. or be able to explain its internal workings; a few hours' instruction normally should be enough to qualify an operator."

So, proof that the operator knew how to activate, read, and test the speed-measuring device, and followed its standard operating procedures, is usually sufficient.

Certification

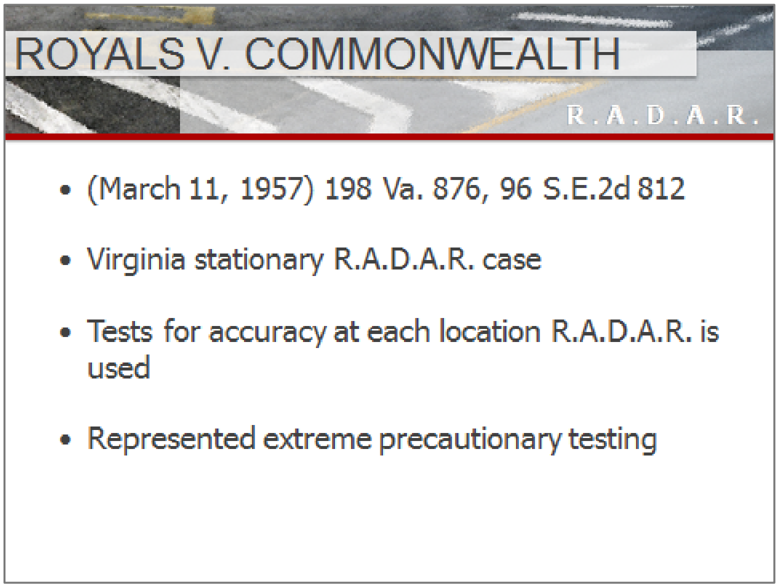
Some jurisdictions have established certification requirements and required periodic recertification for operators of speed-measuring devices.

Successful prosecutions are impossible absent a certified or properly qualified operator. Evidence of adherence to all certification requirements and protocols will be required in Court.

Proof of a speeding violation follows a common scenario. First the operator must form a visual estimate of the driver's speed based upon experience and training in speed estimation. A violation must be under either a basic or statutory speed law. The operator's visual estimation can be corroborated by a variety of speed-measuring devices that include the speedometer, R.A.D.A.R., L.I.D.A.R., time-distance Systems (VASCAR), and/or automated speed-measuring devices.

Operator presentation of sufficient documentation of conditions, device reliability, driver statements, and proof of operator qualifications will often be sufficient for a conviction.

ROYALS V. COMMONWEALTH, 1957



Slide 93.

The accuracy of a R.A.D.A.R. device, as distinguished from the accuracy of the R.A.D.A.R. principle, is not a proper subject for judicial notice. No court can accept every R.A.D.A.R. device as always being completely accurate. The prosecution must prove that a device functioned properly at the time in question.

What the court may do is take judicial notice of certain methods or techniques for determining accuracy. It can reasonably be assumed that if a device was checked for accuracy at various established intervals and through accepted methods, that device's readings would be accepted as accurate.

In Royals v. Commonwealth of Virginia, the court quoted, with approval, Dr. John M. Kopper, a recognized authority on electronics:

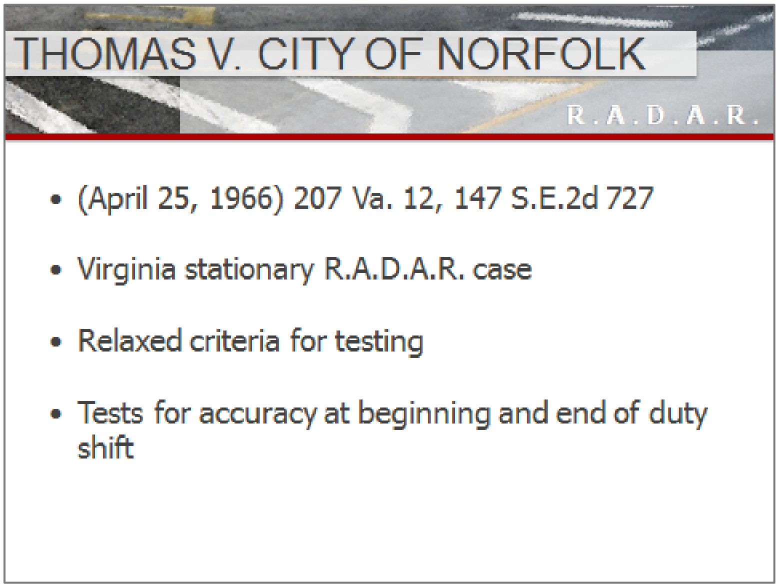
"It is important to check the meter for accuracy each time it is set up for use; if the meter is to be used at two sites in one morning then it should be checked at each site to avoid the contention that the meter was thrown out of adjustment during transit. The meter should be checked before the beginning of the period of observation of highway and at the end of the period. In scientific work, it is usual to assume that if a given device reads correctly at the beginning and end of a set of measurements, its readings during the interval were also correct. The check can be made by having a vehicle with a certified speedometer run through the zone of the meter twice, once at the speed limit for the zone and once at a speed 10 or 15 miles per hour greater. As the test vehicle goes by the meter the driver can notify the operator of the meter what

[the] speed is. If the difference between the speedometer reading and the R.A.D.A.R. meter reading is more than 2 miles per hour, steps should be taken to see why this is the case and to remedy the matter. Such a test naturally requires a periodic checking of the speedometer of the test vehicle. If such a procedure is carried out each time the R.A.D.A.R. meter is set up, the check measurements made with the automobile speedometer become supporting evidence."

These steps, however, represented the extreme in precautionary testing.

Although few operators test speed-measuring devices in such fashion today, the testing theory remains valid. Frequent accuracy checks improve cases. Devices should be checked at the beginning and the end of the operational period. Some courts and agencies require that devices be checked following each enforcement action. A Tuning fork, which cause R.A.D.A.R. devices to display a specific result, is an acceptable accuracy-checking device. Courts may require proof that the device was working properly.

THOMAS V. CITY OF NORFOLK, 1966

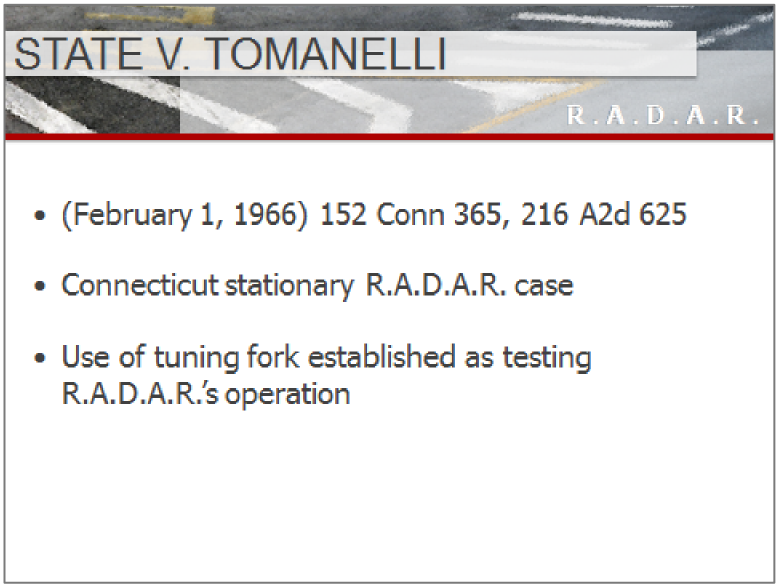


Slide 94.

In **Thomas v. City of Norfolk**, the court indicated that it would be sufficient to test the R.A.D.A.R. device at the beginning and end of each duty shift. If the device tested properly at these times, it could be presumed to have functioned properly between times.

Many agencies instruct their R.A.D.A.R. operators to conduct the tests as part of both the setup and tear down at each place they make R.A.D.A.R. measurements. This ensures that the before and after tests are made within a reasonable time of any speed measurement and enforcement action. It also eliminates any possibility that the R.A.D.A.R. might malfunction in transit between locations.

STATE V. TOMANELLI, 1966



Slide 95.

Instructor should stress definition of judicial notice as defined in the beginning of this chapter. Judicial notice was extended to the tuning fork test as being an accurate way of testing the accuracy of a R.A.D.A.R. device.

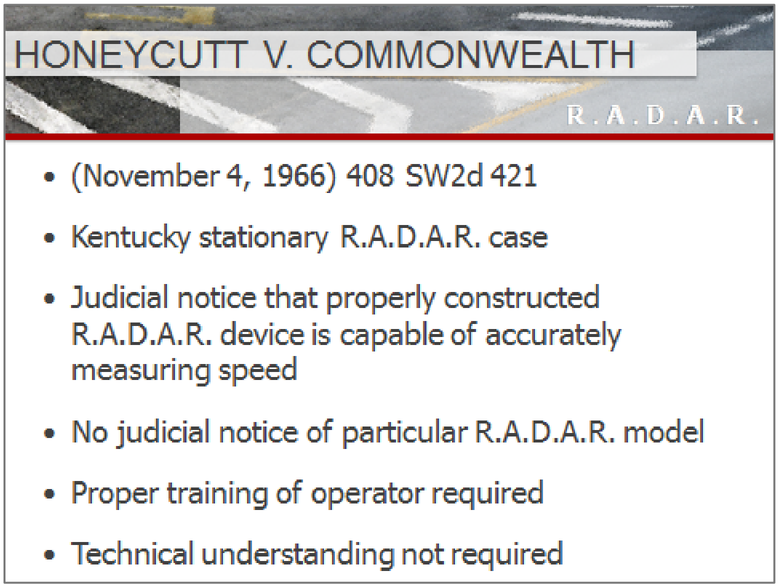
The use of a tuning fork is an efficient, convenient, and popular method of testing a R.A.D.A.R. device's accuracy. The use of the tuning fork as a reliable test of accuracy was established by the Supreme Court of Connecticut in State v. Tomanelli. However, the court pointed out that the tuning fork's own accuracy may be questioned:

"The operator relied, for his assurance on the accuracy of the device he was using, on tuning fork tests made before and after the defendant's speed was recorded. These tests, in brief, were made by activating what were described as 40-, 60-, and 80-mph tuning forks and by observing, in each test, that the speedometer and graphic recorder of the R.A.D.A.R. device indicated corresponding readings of 40-, 60-, and 80-mph.

The theory of the test is that each tuning fork is set to emit a wave frequency corresponding to a mile-per-hour speed equivalent. It is obvious that the tuning forks themselves must be shown to be accurate if they are to be accepted as a valid test of the accuracy of the R.A.D.A.R. device. No attempt appears to have been made to establish the accuracy of the tuning forks. On the other hand, no effort was made by the defendant to attack the accuracy of the tuning forks.... Under these circumstances the accuracy of the R.A.D.A.R. device was unimpeached."

In effect, the courts have recognized the tuning fork as an accurate testing device. If no challenge is offered, the tuning fork's accuracy may be assumed and therefore the accuracy of any R.A.D.A.R. device properly tested by that tuning fork.

HONEYCUTT V. COMMONWEALTH, 1966



Slide 96.

Operator Qualifications

- Point out that the operator must know how to “set up, test, and read” the R.A.D.A.R. device
- The vehicle in question must be closest to, out in front, and well separated from other vehicles
- The R.A.D.A.R. operator must visually estimate target vehicle speed

The courts seemed to have had little difficulty in outlining the R.A.D.A.R. operator’s qualifications. In Honeycutt v. Commonwealth, the Kentucky Court of Appeals defined them clearly:

“It is sufficient to qualify the operator that he [sic] have such knowledge and training as enables him to properly set up, test, and read the device; it is not required that he understand the scientific principles of R.A.D.A.R. or can explain its internal workings; a few hours’ instruction normally should be enough to qualify an operator.... In the instant case the policeman had received 13 weeks training as a R.A.D.A.R. repairman and had operated R.A.D.A.R. device for almost 2 years. We think this was sufficient qualification to make his testimony competent. A reading of his testimony indicates that he understood how to operate the device.”

The courts thus established that a R.A.D.A.R. operator need be neither technician nor physicist.

It is not important whether the operator fully understand everything about a R.A.D.A.R. device's internal workings.

The courts also established that the targeted vehicle be out front, closest, and well separated from the other vehicles on the roadway at the time of the speed measurement. Honeycutt also established that the R.A.D.A.R. operator will have made a visual estimate of the target vehicle speed.

Sufficient Time of Observation

The vehicle must have been observed for enough time to identify it specifically and to identify it as the speeding vehicle. Testimony must persuade the trier-of-fact that the observation period was long enough to allow the operator to identify the vehicle as the "right" one.

Sufficient Circumstances

The operator must have observed the vehicle under circumstances that render sufficient identification possible. The operator's testimony may need to include details permitting the trier-of-fact to find that the identification was reasonable: for example, operators must be ready to explain how they identified a speeding vehicle at night.

Traffic density

The defense may challenge the operator's identification of the target vehicle by claiming that traffic was too dense to permit proper target recognition.

Attorneys may ask:

1. How dense was surrounding traffic?
2. Was the speeding vehicle surrounded by vehicles? If so, were they smaller, the same size, or much larger?
3. How many vehicles were near the vehicle?
4. If other vehicles were near, how could the defendant's vehicle be singled out and identified as speeding?

When vehicle identification is challenged, many courts require proof that:

Visual observation suggested that the vehicle was speeding. The operator must testify that when he/she first saw the vehicle, it appeared to be speeding. This may require testimony indicating the operator had experience "visually estimating" speed violations, such as training in that technique and subsequent field experience.

Device-based measurement confirmed the initial suspicion. The operator must testify that he/she verified the suspicion by obtaining a timely device-based (i.e., R.A.D.A.R., VASCAR, L.I.D.A.R., TDS, stopwatch) reading on the target vehicle.

He/She should be ready to demonstrate that standard operating procedures and applicable regulatory protocols were followed (if any exist in the charging jurisdiction) and that there were minimal interfering conditions.

Sufficient tracking history - The operator should be able to show a good tracking history. In essence, that he/she obtained an initial visual estimation and a subsequent device-based verification and then "tracked" the vehicle visually and by device to affirm his/her initial findings. For example, the Audio Doppler feature available on some R.A.D.A.R. units can strengthen tracking history evidence.

Vehicle characteristics

Operators must be able to identify the target vehicle by its external characteristics.

Operators may typically be asked:

1. What characteristics or factors facilitated the identification?
2. Was the vehicle damaged?
3. Could distinctive noises be heard?
4. Was exhaust present?
5. What color was the vehicle?
6. Did it "stand out in the crowd?"
7. What was its make and model? How did you know?

Lighting conditions

Operators may be asked:

1. Lighting conditions may affect operators' ability to identify the target vehicle.
2. Was it light or dark?
3. If it was dark, how was the vehicle readily identified?
4. Was the sun in the operator's eyes? If so, how could he/she identify the target vehicle?
5. Was the sun in the driver's eyes? If so, was the speed reasonable?

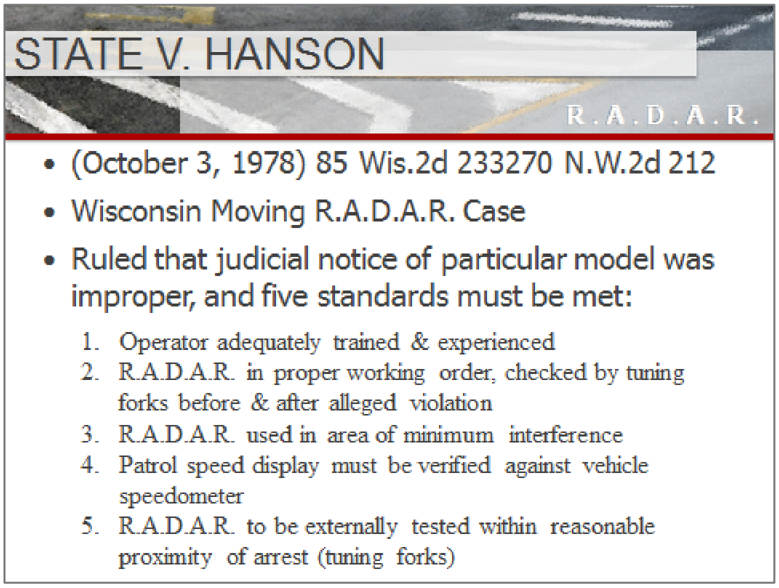
"Turn-around" and "catch-up" time

Some delay is inherent in speed enforcement. Operators using stationary devices must start from a stopped position and catch up to the target. Operators using "moving" devices, such as moving R.A.D.A.R., must slow, turn around, and then catch up to the target.

Defense attorneys frequently ask these questions when challenging identification:

1. How long did it take to turn the police car around to pursue the speeding vehicle?
2. How long did it take to catch up?
3. If a turn-around was necessary, did the operator lose sight of the target vehicle?
4. If the operator lost sight of the target, how long was visual contact lost?
5. Did the operator identify characteristics of the target before the turn-around?

STATE V. HANSON, 1978



Slide 97.

Moving R.A.D.A.R. presents special problems in vehicle identification because the speed of the patrol vehicle itself enters the picture. In effect, when moving R.A.D.A.R. is used, the courts demand that the officer verify both the defendant's vehicle speed and that of the patrol vehicle at the time of the violation.

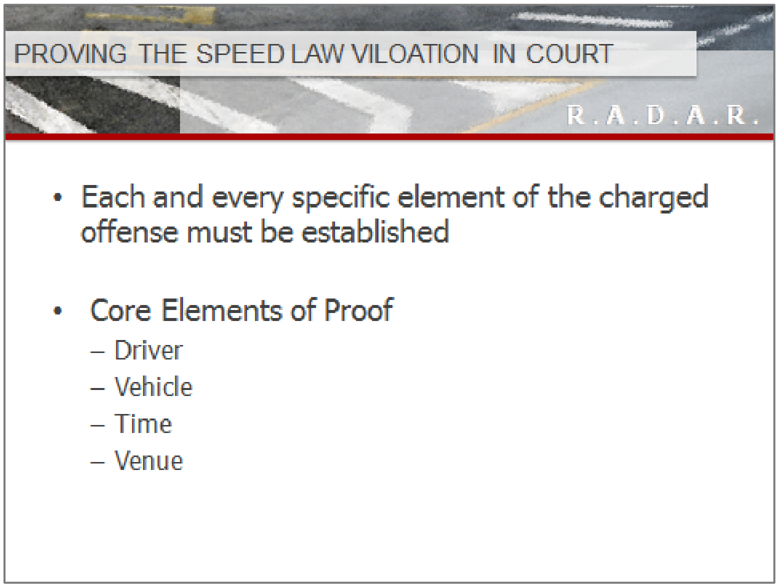
In 1978, in the landmark case of State v. Hanson, the Wisconsin Court addressed several issues on the use of moving R.A.D.A.R. As with earlier case law, Hanson affirmed that:

- The operator must have sufficient training and experience in the operation of moving R.A.D.A.R.
- The moving R.A.D.A.R. device must have been in proper working condition when the violation took place

Of major interest was the court's ruling that the officer must establish that:

- The moving R.A.D.A.R. device was used where road conditions would distort readings as little as possible
- The patrol vehicle's speed was verified
- The device's accuracy was tested within a reasonable time before and after the arrest

PROVING THE SPEED LAW VIOLATION IN COURT



Slide 98.

Obtaining a conviction for a traffic violation is like obtaining one for a criminal violation. Each specific element of the charged offense must be established. In cases charging speed law violations, this is true regardless of whether the Basic or Statutory Rules is charged and regardless of the type of device used to measure the speed.

Core Elements of Proof: Driver, Vehicle, Time, Venue

The prosecution must prove through the testimony of the complaining operator that a specific driver drove a specific vehicle at a specific time and place. These elements are customarily proven from traffic citations upon which the complaining operator has detailed the critical information. The operator uses the information to refresh his/her recollection of the events. Accordingly, it is critical to review the citation before testifying.

Driver - Defendant

(1) The driver charged with a speed law violation is the defendant. Prove his/her identity and that the operator stopped the vehicle and identified the driver as the defendant and that he/she was driving at the time the operator observed the violation. When the case comes to trial, the operator must identify the defendant as the same person he/she identified as the driver during the stop.

(2) Operators should note the driver's remarkable characteristics: i.e., facial hair, unique hairstyles, scars, marks and tattoos, to aid in court identification. Because drivers sometimes switch places with passengers to avoid enforcement action, noting such characteristics as soon as a violation is observed, but prior to turnaround, should aid initial identification.

Vehicle

(1) Prove that a vehicle, as defined by the traffic code used in the charging jurisdiction, was used to commit the offense.

Time and Venue

(1) Prove that the driver drove the vehicle at a time and place. In most jurisdictions, speed laws apply only on roadways (as defined in the relevant traffic code); however, some jurisdictions also limit speeds in other areas, such as private property.

Sufficient Observation

The operator must be prepared to demonstrate that he/she observed the vehicle for enough time, and under sufficient circumstances, to form an opinion concerning its speed.

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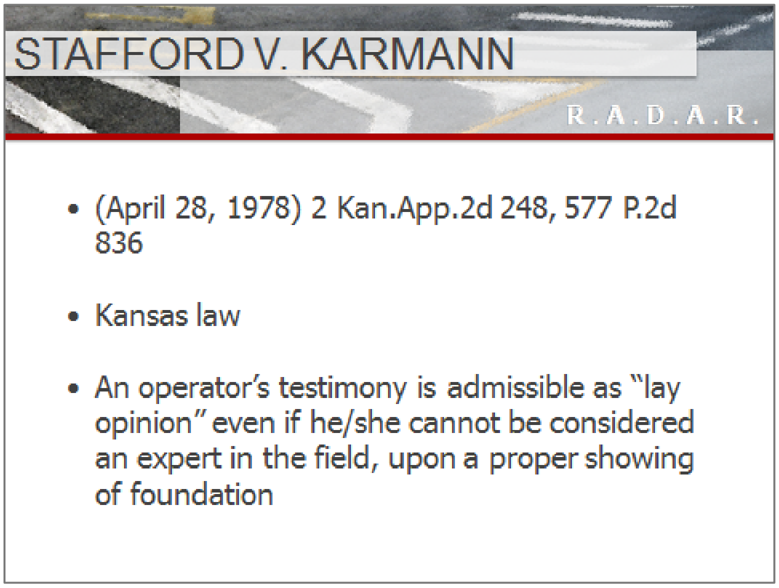


Slide 99.

May not be necessary in statutory speed law jurisdiction.

Opinion Concerning Speed

The operator must present an opinion regarding the alleged speed. However, opinion evidence, in the form of the operator's testimony, is inadmissible without a proper showing of foundation. In other words, the operator must demonstrate that he/she has some experience or training upon which to base the opinion. Courts generally find that opinion testimony may be based on foundation consisting of experience driving a vehicle, training, basis of knowledge, and sufficient observation.

An operator's testimony is admissible as "lay opinion" even if he/she cannot be considered an expert in the field, upon a proper showing of foundation. Some jurisdictions require lay testimony be rationally based upon the witnesses' observation and helpful to a clearer understanding of his/her testimony.

These factors may bear upon the admissibility of an operator's opinion:

Observation Time

How long did the operator observe the vehicle?

Experience

How much experience does the operator have in speed estimation/measurement? Was this the operator's first speed enforcement experience or has he/she been involved in speed enforcement for some time?

Training

How much speed enforcement training, if any, has the operator received? Was formal training successfully completed?

Certification

Some jurisdictions require operators to hold current certification on speed-measuring devices. In these jurisdictions, the prosecution must prove that the complaining operator held current certification at the time the operator detected the charged violation.

Perception

Was the operator able to accurately perceive the vehicle? What is the operator's visual acuity?

Speed Exceeded Lawful Speed

The prosecution must prove that the defendant's speed violated the basic speed rule or a statutory speed law.

Measurement Device and Operator Considerations

Attacking the device used to measure the defendant's speed, and the operating operator's use of that device, are favorite methods for defense attorneys. Operators must be prepared to demonstrate that the device was suitable for the speed measurement, that the device was in proper working order when the defendant's speed was measured, and that the operator was qualified to use the device.

Device Suitability

R.A.D.A.R., L.I.D.A.R., time-distance (VASCAR, etc.) devices, and even stopwatches share a characteristic critical to successful speed violation prosecutions. Each must be shown to be suitable for the task of measuring vehicle speed.

MOOT COURT DISCUSSION (20 Minutes)

The instructor should prepare sample cases for the students to experience a typical R.A.D.A.R. case.

This practicum provides practical experience in prosecuting a R.A.D.A.R. speeding citation.

The preparation and presentation of the R.A.D.A.R. case for prosecution is the final step in the enforcement process. Each element must be present to be successful in court. This practicum will address elements necessary for the preparation of a R.A.D.A.R. speeding case.

The preparation of a R.A.D.A.R. case is no different from any other case. There are certain requirements that must be met or else the case will either be dismissed or will otherwise fail.

The preparation of the case follows a natural sequence so that the presentation phase is complete, concise, and correct. This exercise provides detail of the required elements in a typical case. Each jurisdiction should make sure that these elements meet the requirements of the local courts and make amendments or additions, as necessary.

Generally, the preparation of the case must ensure:

1. That all elements of the offense were present
2. That the speed-measuring device was utilized in compliance with appropriate law

Establishing the elements of the offense requires that the officer can show that certain requirements are met with regards to the location, officer, R.A.D.A.R. device, speeding vehicle and violator.

- The officer was working in a location which was within his/her jurisdiction of authority and that the alleged violator was also in that jurisdiction
- The alleged violation occurred where the public has a right of vehicular access
- The roadway in use by the alleged violator was marked or signed as required by State and/or local law
- The officer's location provided a clear and unobstructed view of the enforcement area, observed the violation, and made a visual estimate of the violator's speed based on that observation

- The officer, based on his/her training and experience, believed that the violator's speed exceeded the marked or signed statutory limit (or, basic speed under the conditions)
- The officer has had the required formal R.A.D.A.R. training (qualification or certification)
- The officer has sufficient experience and expertise in the use of R.A.D.A.R. and specifically in the particular device used
- The R.A.D.A.R. device and its tuning fork(s) hold a current and valid certification of accuracy from an appropriately licensed R.A.D.A.R. technician
- The R.A.D.A.R. device was set up and tested prior to its enforcement use using the manufacturer's recommended procedures (operator's manual) and that the device "passed" the operational tests therefore demonstrating that the device was operating properly
- The R.A.D.A.R. device was tested at the end of its use and that the device was operating properly

  Note: The recommended minimum testing interval is at the beginning and the end of the officer's duty shift. Agency or officer policy will determine the actual testing frequency, which may be more often, such as before and after each violator contact.

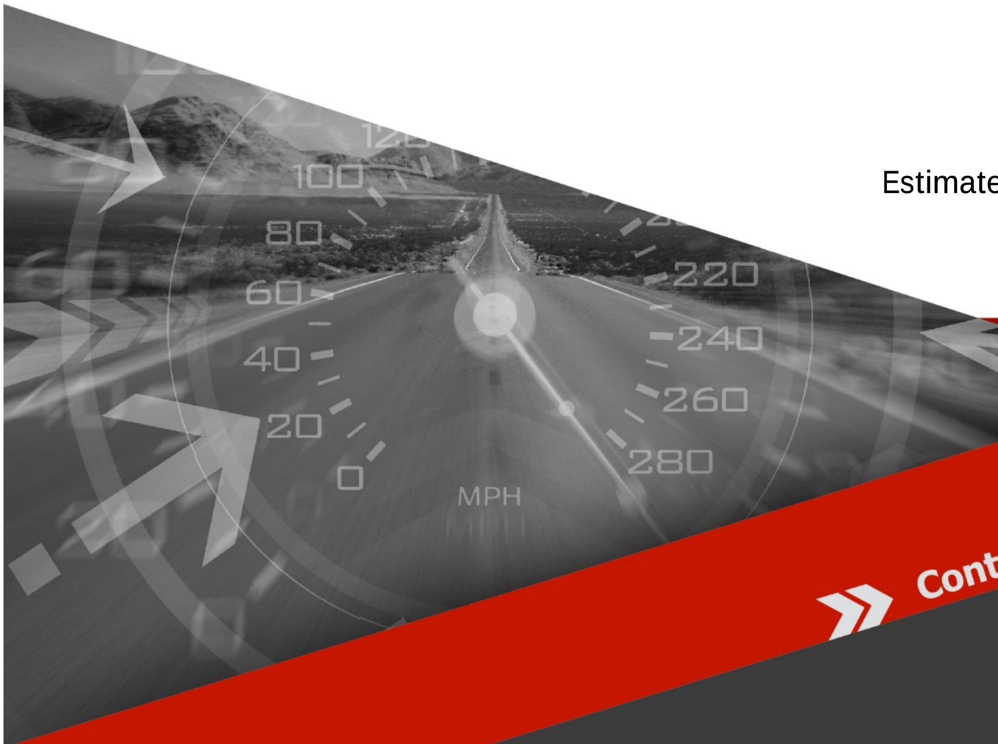
- The vehicle stopped was the same vehicle that the officer first observed and estimated its speed and subsequently measured its speed with the R.A.D.A.R. device
- The operator of the speeding vehicle was properly identified through accepted identification documents, i.e., driver's license, I.D., other
- The vehicle operator so identified was issued a citation, ticket, notice of infraction, etc.

8

OPERATE

Estimated time for Chapter 8: Varies

R. A. D. A. R.



Contents

Objectives

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

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

OPERATOR PRACTICUM

Instructor should follow suggested procedures detailed in this section. This should allow the student to demonstrate competency in R.A.D.A.R. operation.

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

The instructor should break the class into groups to give students the opportunity for hands-on practice with similar R.A.D.A.R. device(s) they will be using in their departments. It is recommended that the groups be no larger than four students to one instructor or aide. Student group size can be smaller if additional instructors or approved R.A.D.A.R. operators are available.

The selection of a practice site is at the discretion of the course administrator. Remember the most important criterion is the safety of the student and the motoring public if the practice segments are to be conducted on a highway. The lead instructor must keep the exercises simple, organized, and safe for all students. Instructors should notify the law enforcement agency charged with the patrol of an area when operating R.A.D.A.R. at a location. This will eliminate confusion over the presence of the student patrol vehicle and will ensure that the student patrol vehicle does not interfere in any way with the normal patrol procedures for that area.

The instructor's task is to monitor each student's performance, provide necessary instruction and demonstration, and determine when each student has achieved the satisfactory level of skill proficiency.

A suggestion is for the student operator to be in the driver's seat and other students should be in the back seat, while the instructor is in the front passenger seat. Each student will take a turn as the driver/operator. Refer to agency practice and policy.

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

After setting up and testing the R.A.D.A.R. device, the student should be allowed time for at least 20 practice target readings for each applicable mode. Follow your State and local guidelines for certification.

The students should be encouraged to ask questions during the practice session (e.g., about false or "ghost" readings, interference, the panning effect).

Students must keep in mind and should point out various elements of supportive evidence to the instructor as they arise. The various elements of supportive evidence include visual estimate, audio Doppler, R.A.D.A.R. reading, and speedometer verification needed to develop a tracking history for each target vehicle.

Students should evaluate each other for any actions they consider inappropriate or inaccurate. The driver/operator should disassemble and dismount the unit per their agency guidelines at the end of each turn. The groups will return to the classroom after students have had turns as driver/operator.

R.A.D.A.R. Handout 2: R.A.D.A.R. Practicum

A set of work exercises that may be used in this field practice segment are found in this handout. It contains a series of experiments that a student or group of students can conduct to determine the tendencies and limitations of a particular R.A.D.A.R. device. The format may be used as written or modified to meet the instructor's specific needs.

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 R.A.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 student driver/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.

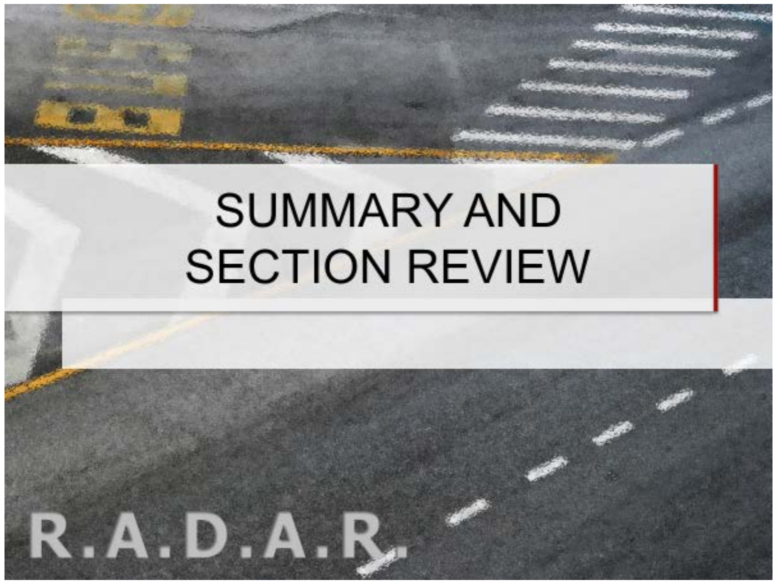
After setting up and testing the R.A.D.A.R. device, you will be allowed time for at least 20 practice target readings for each applicable mode.

You should feel free to ask questions during your hands-on training (e.g., about false or "ghost" readings, interference, the panning effect).

Keep in mind and point out various elements of supportive evidence to the instructor as they arise. The various elements of supportive evidence include visual estimate, audio Doppler, R.A.D.A.R. reading, and speedometer verification 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 turns as driver/operator.

SUMMARY AND SECTION REVIEW



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POSTTEST

R.A.D.A.R. Handout 3: R.A.D.A.R. Posttest

Instructor should administer posttest found in back of this manual.

FREQUENCY FORMULA

Frequency x Wave Length = The Speed of Light

The speed of light as measured by National Institute of Standards and Technology, (NIST), is 186,282.396 miles per second.

There are 63,360 inches in a mile.

Most wavelengths can more easily be visualized in fractions of an inch than in fractions of a mile. Therefore, you must convert miles per second to inches per second. This is done by multiplying by 63,360 or dividing by 63,360 depending on which conversion you are attempting to make.

Examples:

<u>K-band:</u>

$$frequency * \frac{wavelength}{\#\ of\ inches\ in\ a\ mile} = speed\ of\ light$$

$$\mathbf{24,150,000,000} * \frac{\mathbf{.488729918}\ \boldsymbol{in}}{\mathbf{63,360}\ \boldsymbol{in}} = \mathbf{186,281.999}\ \boldsymbol{miles\ per\ sec}$$

$$\frac{speed\ of\ light * 63{,}360}{frequency} = wavelength$$

$$\frac{186{,}282 * 63{,}360}{24{,}150{,}000{,}000} = .488729918\ in$$

BEAM WIDTH COMPUTATIONS

$$BW = 2D(TAN\frac{1}{2}\angle)$$

	($\angle$) TRANSMISSION ANGLE	(D) DISTANCE	(BW) BEAM WIDTH
1.	12°	105	FT.
2.	12°	286	FT.
3.	16°	116	FT.
4.	16°	306	FT.
5.	18°	96	FT.
6.	18°	319	FT.
7.	24°	84	FT.
8.	24°	510	FT.
9.	9°	686	FT.
10.	9°	544	FT.
11.	12°	1467	FT.
12.	24°	1270	FT.
13.	9°	1619	FT.
14.	18°	1598	FT.
15.	16°	1321	FT.

DOPPLER SHIFT COMPUTATIONS

Compute the correct speeds in miles per hour given the following Doppler shift.

K- Band Transmitted Signal: 24,150,000,000 CPS

$$Difference = Transmitted - Returned$$

To calculate Doppler shift to speed: $72CPS = 1mph$

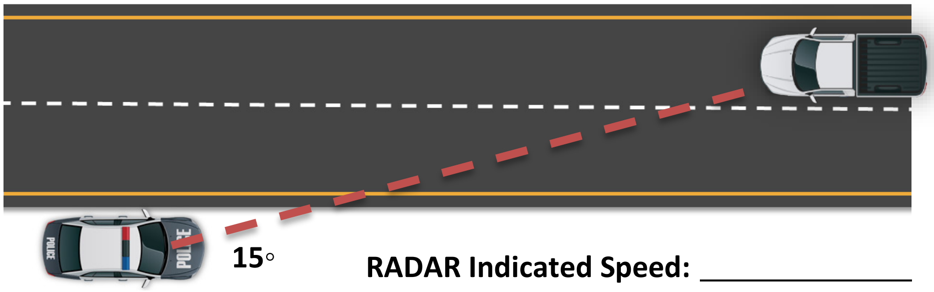
Example: $3000 \div 72 = 41mph$

	Returned Signal	Difference	Miles Per Hour	Toward or Away
1.	24,150,002,880	2880 CPS		
2.	24,149,998,488	1512 CPS		
3.	24,150,005,616	5616 CPS		
4.	24,150,003,960	3960 CPS		
5.	24,149,994,816	5184 CPS		
6.	24,149,992,362			
7.	24,150,008,280			
8.	24,149,996,760			
9.	24,149,990,280			
10.	24,150,010,800			

Look at the returned signal for each problem and determine whether the target is moving toward the source or away from the source.

STATIONARY COSINE EFFECT WORKSHEET

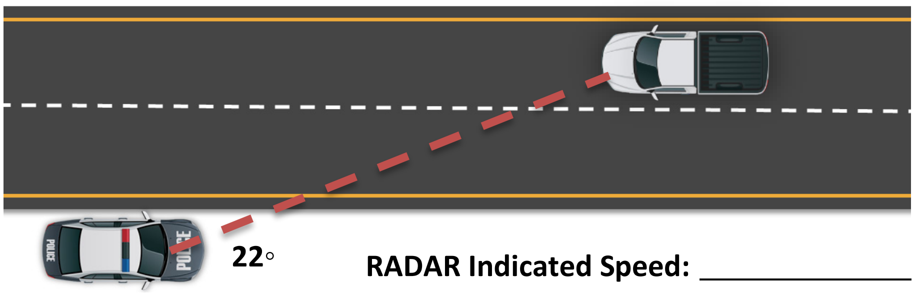
True Speed 60 mph



15°

RADAR Indicated Speed: ______________

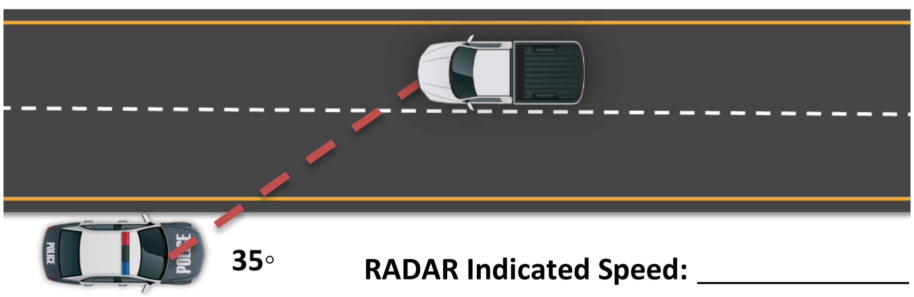
True Speed 60 mph



22°

RADAR Indicated Speed: ______________

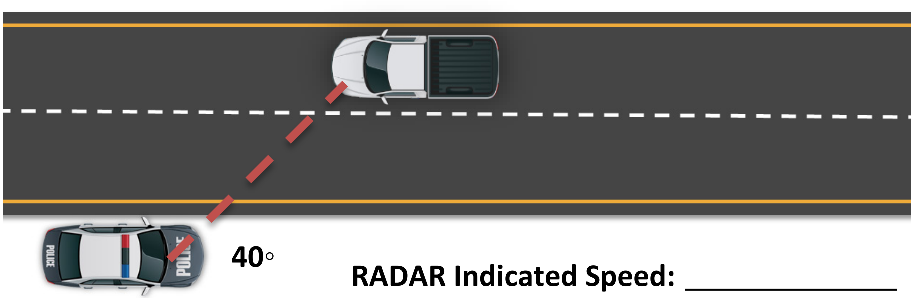
True Speed 60 mph



35°

RADAR Indicated Speed: ______________

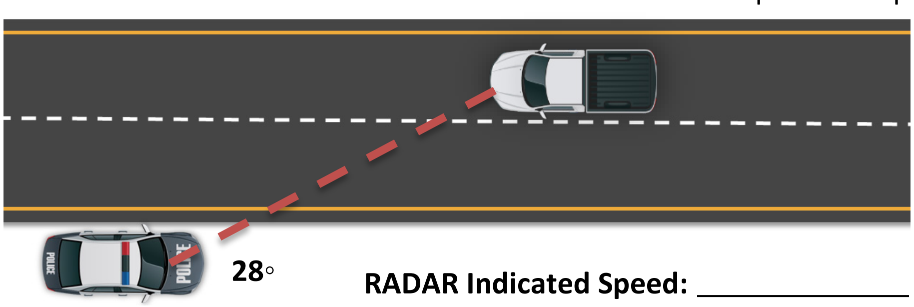
True Speed 45 mph



40°

RADAR Indicated Speed: ______________

True Speed 57 mph

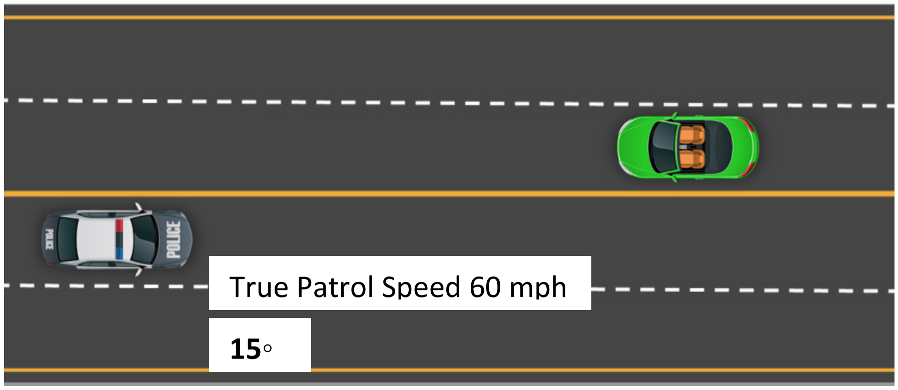


28°

RADAR Indicated Speed: ______________

MOVING COSINE EFFECT WORKSHEET

True Speed 60 mph

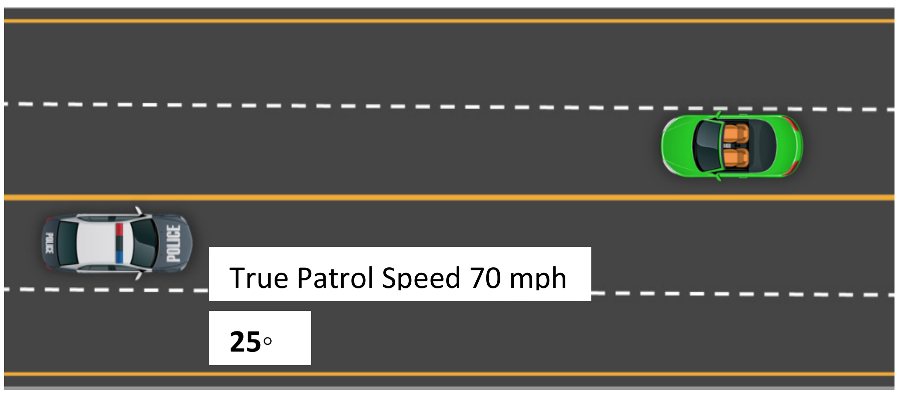


Closing Rate: __________

Patrol Indicated Speed: __________

Target Indicated Speed: __________

True Speed 65 mph

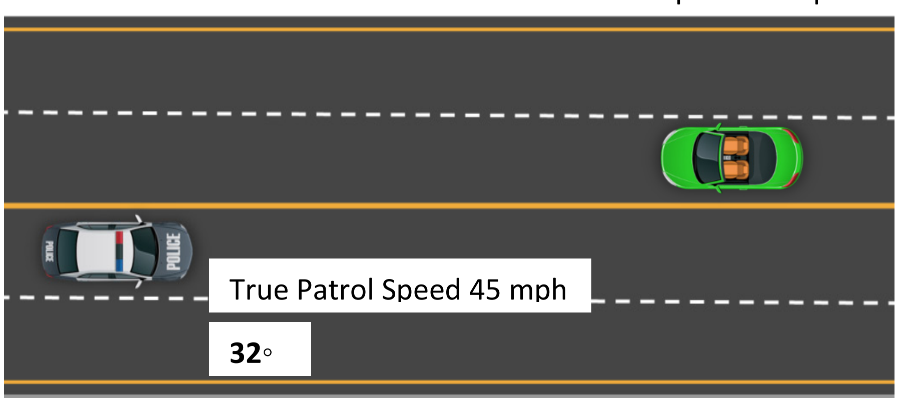


Closing Rate: __________

Patrol Indicated Speed: __________

Target Indicated Speed: __________

True Speed 50 mph



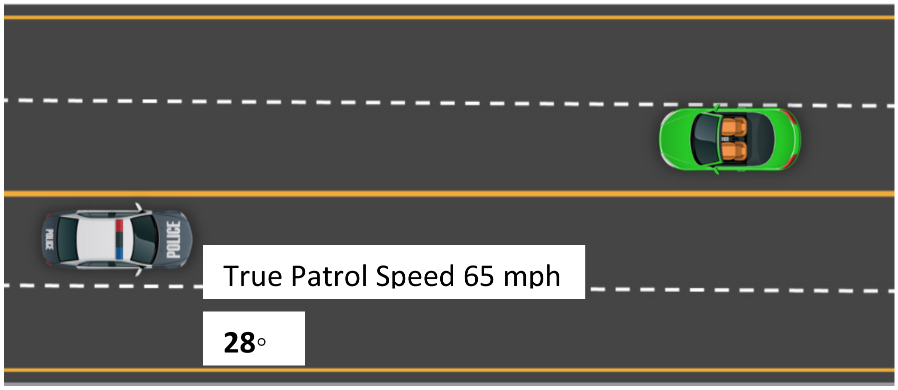
Closing Rate: __________

Patrol Indicated Speed: __________

Target Indicated Speed: __________

MOVING COSINE EFFECT WORKSHEET

True Speed 70 mph

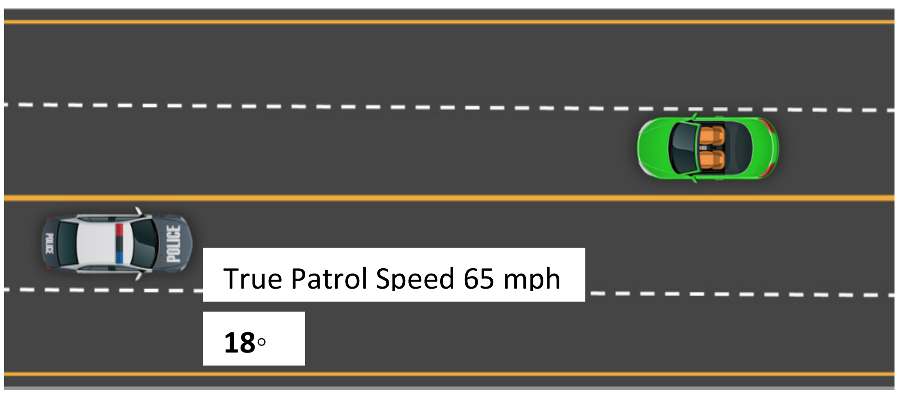


Closing Rate: __________

Patrol Indicated Speed: __________

Target Indicated Speed: __________

True Speed 65 mph

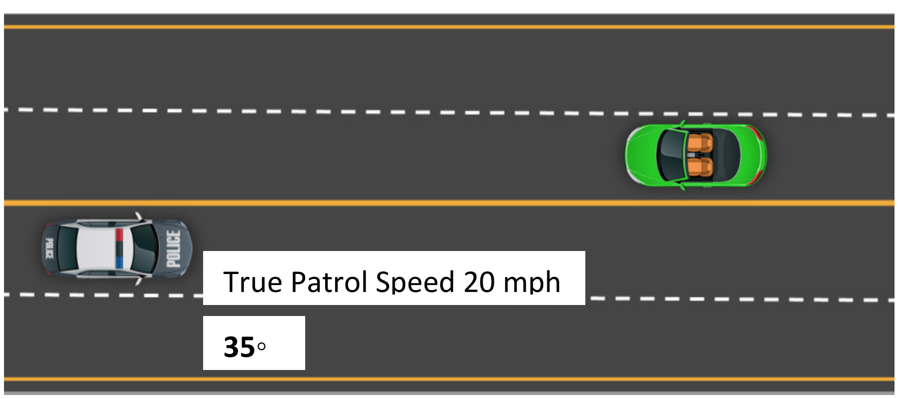


Closing Rate: __________

Patrol Indicated Speed: __________

Target Indicated Speed: __________

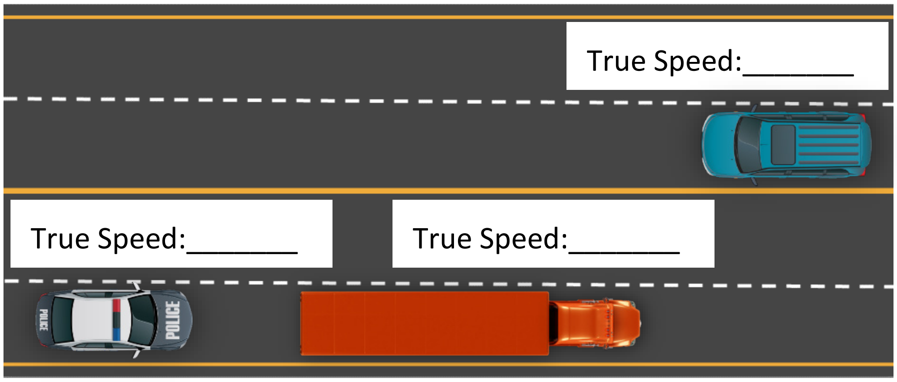
True Speed 23 mph



Closing Rate: __________

Patrol Indicated Speed: __________

Target Indicated Speed: __________



Closing rate of speed computed by RADAR: ________________

Patrol vehicle speed displayed by RADAR: _________________

Target vehicle speed displayed by RADAR: _________________

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RADAR PRACTICUM

Practical exercises should follow the instructions for each RADAR device.

Tuning Fork

Hold an oscillating (struck) tuning fork approximately 3 feet from the face of the traffic radar antenna. Is there an appropriate display on the readout?

Yes_____ No ______

Slowly move the oscillating the tuning fork towards the face of the radar antenna. Approximately how close to the face of the antenna does the tuning fork have to come before an appropriate reading appears on the readout display?

_____Inches

Are the two above measurements approximately the same (within 1 or 2 inches of each other)?

Yes_____ No _____

If the answer is "no", then explain why there would be a difference.

Hold the oscillating tuning fork directly in front of the of the antenna at a distance of approximately 1 foot. Slowly move the fork out of the main lobe of the antenna beam. Approximately how many degrees can the tuning fork be moved to the side of the beam before the display on the readout disappears?

____Degrees

RADAR PRACTICUM

A. Antenna Alignment

1. Vertical Alignment

Aim the radar antenna beam so that it is parallel with the surface of the roadway. Approximately how far down the roadway can the unit first detect a full-sized passenger vehicle?

_____Feet

Aim the antenna beam up approximately 20 degrees from the surface of the roadway. In this position, how far down the roadway can the unit now first detect a full-sized passenger vehicle?

_____Feet

Aim the antenna beam up approximately 40 degrees from the surface of the roadway. In this position, how far down the roadway can the unit now first detect a full-sized passenger vehicle?

_____Feet

Aim the antenna beam down approximately 20 degrees to the surface of the roadway. In this position, how far down the roadway can the unit now first detect a full-sized passenger vehicle?

_____Feet

Horizontal Alignment-Stationary radar

This experiment requires the use of both the radar device and a motor vehicle. The radar device is to be operated as stationary radar. The antenna is to be aimed straight down the road. The target vehicle is to be accelerated to 50 mph (according to that vehicles speedometer). At this point, record the reading on your display.

_____mph

Now repeat this experiment with the radar antenna misaligned approximately 10 degrees out-of-true. What is the reading displayed?

_____mph

Keep repeating the experiment, successively misaligning the radar antenna 10 degrees further out-of-true until the antenna is aimed 90 degrees (at a right angle) to the oncoming target vehicle. The target vehicle, meanwhile, should make each pass at 50 mph. What are the readings (if any) for each successive misalignment?

DEGREES	DEGREES
20______mph	60______mph
30______mph	70______mph
40______mph	80______mph
50______mph	90______mph

Panning

Holding the antenna of a two-piece unit or holding a one-piece unit, pan the horizon in a fast, sweeping motion and record the effects this has on the readout in your display window.

_____mph

Scanning

With the radar turned on, scan or point the antenna beam at the readout module. (Note: This can only be accomplished with a two-piece unit, unless you pan a hand-held unit at another hand-held unit.) Record the reading that was obtained.

_____mph

Power Surge

With the radar device turned off, apply power to the unit (turn it on). Note any display that occurs as the power is applied.

_____mph

Audio Use

Describe the audio (if you unit has this feature) as a target vehicle approaches your radar operating position and suddenly decelerates. Does the sound frequency increase or decrease, and how does it sound?

Does a truck have a radar audio sound different from a motorcycle when both are going 50 mph?

_____Yes _____No

Describe the sound, if any.

Interference Readings

With the radar antenna held in your hands, check around the interior of the patrol vehicle and attempt to find areas that will produce interference of "ghost" readings. Vary the speed of your heater of defroster fans, the air conditioning fan, the vehicle's engine speed, etc. Watch the readout and record the readings displayed together with what caused them.

REVVED ENGINE:

HEATER AT LOW:

HEATER AT HIGH:

DEFROSTER:

OTHERS:

Citizen's Band Radio Effect

With someone else helping you, have a CB radio "keyed up" while its antenna is in your radar's beam. Have the CB set move through the beam while keyed and observed the effects, if any, on your readout.

RESULTS:

Public Band Radio Effect

While using the radar to track a target vehicle, key the police radio in your patrol vehicle. Record the effect, if any.

RESULTS:

Whistling on Citizen's Band Radio

Have an assistant whistle into the microphone of a CB set that has its antenna in your radar's beam.

RESULTS:

Experiments Specific to Radar

The following three experiments require the use of a moving radar device, a patrol vehicle, and a target vehicle.

Horizontal Antenna Alignment - Moving Radar

With the antenna pointed straight down the road, establish a patrol vehicle speed of 30 mph and an approaching target-vehicle speed of 40 mph. Record the reading on your radar displays.

0 degrees Patrol speed:___mph. Target speed:___mph.

Repeat this experiment with the antenna misaligned approximately 10. What are the readings displayed?

10 degrees Patrol speed:___mph. Target speed:___mph

Keep repeating the experiment, successively misaligning the radar antenna 10 degrees or more until the antenna is aimed 90 degrees (at a right angle) to the approaching target vehicle. The target vehicle should make each pass at 40 mph. What are the readings, if any, for each successive misalignment?

20 degrees	Patrol speed:	mph.	Target speed:	mph.	30
degrees	Patrol speed:	mph.	Target speed:	mph.	40
degrees	Patrol speed:	mph.	Target speed:	mph.	50
degrees	Patrol speed:	mph.	Target speed:	mph.	60
degrees	Patrol speed:	mph.	Target speed:	mph.	70
degrees	Patrol speed:	mph.	Target speed:	mph.	80
degrees	Patrol speed:	mph.	Target speed:	mph.	90
degrees	Patrol speed:	mph.	Target speed:	mph.	

Batching Effect

Because of the stress placed on the motor vehicle and the fuel required to produce the batching effect, it is recommended that this experiment be conducted only once. It would also be helpful in this experiment to have a partner to assist you. Rapidly accelerate the patrol vehicle and continuously monitor the speedometer reading.
Note the difference in speeds between the vehicle speedometer and the patrol ("VERIFY") display on a moving radar device as you "floor it".

Note: This exercise can be duplicated using a stationary radar device, but the batching effect concerns only moving radars. As you "floor it", record the readouts on the radar display as your calibrated speedometer shows 25 mph and 40 mph.

25 mph______ 40 mph _____

While batching can occur under heavy deceleration, you will not be experimenting with this effect. However, if batching did occur while you were slamming on the brakes, what would be the effect on the target speed display by the radar?

Check one: _____Higher-than-true-speed:
_____ Lower-than-true-speed:

Explain your reasoning:

____

____

Shadowing

Individual radar devices will vary in their susceptibility to this effect. Attempt to create the shadowing effect with your department's radar. A shadowing effect can sometimes be achieved by accelerating up to or past a large vehicle, such as a truck, that is moving in the same direction you are. Describe the circumstances that create a shadowing effect and the effect that was produced:

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RADAR FORMULAS

BEAM WIDTH

$BW = 2D\left(TAN\frac{1}{2}\angle\right)$ or more simply

9° RADAR ∠	=	.16 X Distance in feet
12° RADAR ∠	=	.21 X Distance in feet
16° RADAR ∠	=	.28 X Distance in feet
18° RADAR ∠	=	.31 X Distance in feet

COSINE (Stationary Mode)

Indicated Speed	=	True Target Speed X Cosine ∠
True Target Speed	=	Indicated Speed ÷ Cosine ∠

COSINE (Moving Mode, with Nichols effect and Shadow effect.)

Adjusted Target Speed	=	True Target Speed X Cosine ∠
Closing Rate Speed	=	Patrol Speed + Adjusted Target Speed

*Adjust Patrol Speed if necessary for Low Doppler Cosine or Shadow effect or both.

Low Doppler Cosine Effect

Adjusted Patrol Speed	=	True Patrol Speed X Cosine ∠

Shadow Effect

Adjusted Patrol Speed	=	True Patrol Speed (or adjusted Patrol Speed if Low Doppler Cosine present) – shadow vehicle speed
Indicated True Target Speed	=	Closing Rate Speed – Adjusted Patrol Speed

COSINE	=	Negligible until 10 degrees is exceeded
STATIONARY COSINE	=	Always in favor of the violator
MOVING COSINE		A cosine error on the patrol speed will result in a high target speed reading. YOU MUST VERIFY PATROL SPEED WITH SPEEDOMETER.

MOVING RADAR

Target Speed = Closing Speed – Patrol Speed

Target Speed = Separation Speed – Patrol Speed

TIME DISTANCE EQUATIONS

Reaction Time Distance	=	Speed X (Perception + Reaction) Time X 1.5 X 1.47
Speed	=	(Reaction Time) Distance ÷ 1.47 ÷ (Perception + Reaction) Time
(Perception + Reaction) Time	=	(Reaction Time) Distance ÷ 1.47 ÷ Speed
Velocity	=	Speed X 1.47

TOTAL STOPPING DISTANCE

S^2 ÷ 30 X Drag Factor + Reaction Time Distance

(S^2 ÷ 22.5) + (S X 1.47 X 1.5)

Drag Factor: Use .75

Reaction Time Distance: Speed X 1.47 X 1.5

RADAR: RAdio Detection And Ranging

TRACKING HISTORY

Visual	ID Target Est. Speed Est. Range Check Environment
Audio	Pitch Clarity
Speed Verification	Constant Readout Consistent with Visual Estimate Verify Patrol Speed with Speedometer

Scanning: Pointing antenna at counting unit Panning:
Swinging stationary unit toward target Simulation Test:
(Moving)

Patrol	35
Target	30

R.A.D.A.R. Module Test

Speed Measuring Device Operator Training

Name____Date________________

Agency____

1. The __________ Principle is relative motion between two objects and the signal change received due to the relative motion.

   A. Wavelength

   B. Doppler

   C. RADAR

   D. Hertz

2. The Doppler Principle was later determined to apply to:

   A. Infrared waves

   B. Radio Waves

   C. Light Waves

   D. B and C

3. Wavelength is the distance from __________.

   A. Peak to Valley

   B. Beginning of Peak to Valley

   C. End of Peak to beginning of Valley

   D. Beginning of Peak to end of Valley

4. A stationary R.A.D.A.R.'s transmitted signal at a stationary object reflects at the __________ frequency and __________ obtain a reading.

   A. Same, will

   B. Lower, will not

   C. Same, will not

   D. Lower, will

5. Tracking history has three major steps a R.A.D.A.R. operator should follow. Which of the following does **not** belong?

    A. Visual Observation

    B. Target Speed Confirmation

    C. Audio Confirmation

    D. Frequency Determination

6. If an angle exists in stationary mode, the __________ effect occurs and will always be to the motorist's advantage.

    A. Scanning

    B. Cosine

    C. Panning

    D. Batching

7. R.A.D.A.R. speed measuring devices fall into two categories, one-piece or two-piece, and will all have three components, __________, __________, and __________.

    A. antenna, receiver, trigger

    B. antenna, counting unit, power (current)

    C. receiver, counting unit, RFI

    D. antenna, RFI, power (current)

8. The "A-B-C" of R.A.D.A.R. assembly refers to:

    A. Antenna, Battery, Counting Unit

    B. Aim Before Calibration

    C. Aim Beam Consistently

    D. Antenna, Box (Counting Unit), Current

9. Which of the following is true regarding internal circuit tests?

   A. If conducted properly, it is the only test needed to very accuracy

   B. Once the tests are concluded, the R.A.D.A.R. can be considered re-calibrated

   C. All light segments must be working properly

   D. The unit can be used if a light segment is malfunctioning only if the operator can determine that it will not create the illusion of a possible higher than normal violator's speed

10. Courts first took judicial notice of the Doppler principle in State V. __________.

    A. Price

    B. Fuentes

    C. Cleary

    D. Dantonio

11. In __________ V. Commonwealth the courts outlined R.A.D.A.R. operator's qualifications as; (1) ability to set up, test, and read the R.A.D.A.R. device. (2) vehicle identification. (3) visual estimate of target vehicle speed.

    A. Honeycutt

    B. Witt

    C. Thompson

    D. Kehne

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R.A.D.A.R. Module Test

(Answer Sheet)

Speed Measuring Device Operator Training

1. The __________ Principle is relative motion between two objects and the signal change received due to the relative motion. (Ch. 2, Pg. 12)

   A. Wavelength

   B. Doppler

   C. RADAR

   D. Hertz

2. The Doppler Principle was later determined to apply to: (Ch. 2, Pg. 12)

   A. Infrared waves

   B. Radio Waves

   C. Light Waves

   D. B and C

3. Wavelength is the distance from __________. (Ch. 2, Pg. 18)

   A. Peak to Valley

   B. Beginning of Peak to Valley

   C. End of Peak to beginning of Valley

   D. Beginning of Peak to end of Valley

4. A stationary R.A.D.A.R.'s transmitted signal at a stationary object reflects at the __________ frequency and __________ obtain a reading. (Ch. 3, Pg. 28)

   A. Same, will

   B. Lower, will not

   C. Same, will not

   D. Lower, will

5. Tracking history has three major steps a R.A.D.A.R. operator should follow. Which of the following does **not** belong? (Ch. 3, Pg. 33)

   A. Visual Observation

   B. Target Speed Confirmation

   C. Audio Confirmation

   D. Frequency Determination

6. If an angle exists in stationary mode, the __________ effect occurs and will always be to the motorist's advantage. (Ch. 4, Pg. 57)

    A. Scanning

    B. <u>Cosine</u>

    C. Panning

    D. Batching

7. R.A.D.A.R. speed measuring devices fall into two categories, one-piece or two-piece, and will all have three components, __________, __________, and __________. (Ch. 5, Pg. 96)

    A. antenna, receiver, trigger

    B. <u>antenna, counting unit, power (current)</u>

    C. receiver, counting unit, RFI

    D. antenna, RFI, power (current)

8. The "A-B-C" of R.A.D.A.R. assembly refers to: (Ch. 5, Pg. 98)

    A. Antenna, Battery, Counting Unit

    B. Aim Before Calibration

    C. Aim Beam Consistently

    D. <u>Antenna, Box (Counting Unit), Current</u>

9. Which of the following is true regarding internal circuit tests? (Ch. 6, Pg. 105)

    A. If conducted properly, it is the only test needed to very accuracy

    B. Once the tests are concluded, the R.A.D.A.R. can be considered re-calibrated

    C. <u>All light segments must be working properly</u>

    D. The unit can be used if a light segment is malfunctioning only if the operator can determine that it will not create the illusion of a possible higher than normal violator's speed

10. Courts first took judicial notice of the Doppler principle in State V. __________. (Ch. 8, Pg. 117)

    A. Price

    B. Fuentes

    C. Cleary

    D. <u>Dantonio</u>

11. In __________ V. Commonwealth the courts outlined R.A.D.A.R. operator's qualifications as; (1) ability to set up, test, and read the R.A.D.A.R. device. (2) vehicle identification. (3) visual estimate of target vehicle speed. (Ch. 8, Pg. 125)

    A. <u>Honeycutt</u>

    B. Witt

    C. Thompson

    D. Kehne