OUTLINE	NOTES

I. BASIC PRINCIPALS OF RADAR SPEED MEASUREMENT

A. R.A.D.A.R. - RAdio Detection And Ranging

1. Radio-frequency energy is generated by a transmitter.

2. An antenna forms the energy into a beam and the beam is transmitted into space.

3. When the energy of signal strikes an object, a small amount is reflected back to the antenna.

4. From the antenna, the reflected signal is sent to the receiver. If the signal is strong enough it is detected.

5. Radio energy always travels at 186,000 miles per second.

II. THE WAVE CONCEPT

A. Signal Speed -- Constant

1. All RADAR signals travel at the speed of light. (186,000 mile per second)

2. Both transmitted and received RADAR signals always travel at 186,000 miles per second.

B. Wavelength

1. The distance from the beginning of the peak to the end of the valley of the wave. *(may vary)*

C. Frequency

1. The number of waves transmitted in one second of time. *(may vary)*

III. POLICE TRAFFIC RADAR ASSIGNED FREQUENCIES

A. Police traffic RADAR devices operated in the microwave frequency band and billions of waves per second are transmitted.

1. X-band frequency – 10.525 billion waves per second or 10.525 gigahertz. The signal length is approximately 1-1/5 inches.

2. K-band frequency – 24.15 billion waves per second or 24.15 gigahertz. The signal length is approximately a ½ inch.

3. Ka band frequency – 34.2 billion waves per second or 34.2 Gigahertz (35.5 gigahertz for Golden Eagle II). The wavelength is approximately .35 of an inch.

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IV. THE DOPPLER PRINCIPAL

A. Christian Johann Doppler, an Australian physicist, is credited with having discovered that relative motion causes signal's frequency to change.

B. The Doppler Principal can be described as follows:

1. 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.

C. Relative Motion

1. If the relative motion brings the objects closer together, the frequency will be increased.

2. If the relative motion brings the objects farther apart, the frequency will be decreased.

3. Frequency change only occurs when there is relative motion.

V. THE RADAR BEAM

A. The radio wave energy transmitted by police traffic RADAR is concentrated into a cone-shaped "beam." Most of the energy transmitted remains in the central core of the beam. The concentration of energy drops off quickly as one gets further away from or off to one side of the main beam.

B. The RADAR beam is infinite unless if is affected by the following:

1. Reflected

2. Refracted

3. Absorbed

C. RADAR Range

1. The range, or maximum distance, at which the RADAR beam can interpret a reflected signal, is dependent on the sensitivity of the antenna receiver.

2. If the RADAR operational range could be seen, it might take on the appearance of an elongated cigar.

D. RADAR Beam Width

1. Beam width will vary from manufacture to manufacture and from model to model. The National Institute of Standards and Technology in a laboratory environment found that beam widths vary from 11.5 degrees to 24.2 degrees.

VI. PRINCIPALS OF STATIONARY RADAR

A. Stationary RADAR is based on the Doppler Principal.

1. Must include a transmission source that is also a receiver (RADAR antenna) and an object that can reflect the transmitted radio waves back to the transmission source (target vehicle.)

2. There must be relative motion between the two sources.

B. Stationary RADAR Angular (Cosine) Effect

1. When a target vehicle's direction of travel creates a significant angle with the position of the stationary RADAR, the relative speed will be less than the true speed. This is known as the angular or cosine effect.

2. When the target vehicle is far away, the angle that exists is very small. However, as the target vehicle approaches, the angle between RADAR and the target vehicle increases.

3. To minimize the angular effect on stationary RADAR, the angle should be kept small by setting up the RADAR as close to the road possible without creating a safety risk. The antenna should be aligned straight and level down the roadway so that target vehicles can be perceived and displayed by the RADAR before they get close enough to create an angular effect.

VII. PRINCIPALS OF MOVING RADAR

A. Moving RADAR uses the same RADAR beam to obtain two different speeds.

1. The speed of the target vehicle in relation to the patrol vehicle.

2. The speed of the patrol vehicle in relation to the stationary terrain around it.

B. When the moving RADAR beam is transmitted, most of it simply goes on forever without striking anything. A portion of the beam strikes the moving target vehicles and is reflected back. Still, another portion of the beam strikes the stationary terrain in front of the RADAR and is also reflected back.

C. The RADAR's antenna is able to detect and process two reflected signals. One signal from the stationary terrain and second signal from the target vehicle. The signal returning from the target has undergone a frequency change know as the high Doppler Shift (higher frequency.) The signal returning form the terrain is known as the low Doppler shift (lower frequency.) The

RADAR computes the difference between the low and high Doppler or change in frequency, and displays a speed. The radar unit must determine Patrol Speed (low Doppler) prior to determining target speed.

D. If a patrol vehicle is traveling at 50 mph with the target vehicle is approaching at 70 mph, the two vehicles are closing in on each other at a related speed of 120 mph. The RADAR subtracts the relative patrol car speed from the closing speed, and the relative target of 70 mph appears in the display window. The following formula is used to compute target speed in the moving mode:

TARGET SPEED = CLOSING SPEED – PATROL SPEED

TS = CS – PS

Example: 70 = 120 – 50

E. In Same Direction Moving Radar the principles remain the same in regards to two reflected signals, but the radar unit will only process a target signal that is plus or minus 3 to 55 mph of the patrol speed. This target signal will is referred to as the "Difference Doppler shift" versus the High Doppler shift as used in Opposite Direction Moving Radar.

F. If a patrol vehicle is traveling at 65 mph and a target vehicle is approaching from the rear at 80 mph, the radar unit would detect the Difference Doppler Shift of 15 mph. Since the target vehicle is moving faster than the patrol vehicle, the 15 mph difference will be added to the patrol vehicle speed for a target display reading of 80 mph. (As shown below in item H)

G. The Same Direction Moving Radar mode can also distinguish a Difference Doppler shift when the patrol vehicle is traveling faster than the target vehicle. In those cases the Difference Doppler shift would be subtracted from the patrol speed. This situation would not occur since departmental policy prevents radar enforcement action when the patrol vehicle is exceeding the posted speed limit.

H. The following formula is used to compute target speed in the same direction mode of radar:

Target Speed = Patrol Speed + or – Difference Speed

TS = PS + or – DS

Example 80 = 65 + 15

I. Moving RADAR Angular (Cosine) Effect

1. In moving RADAR, the angular effect can produce RADAR displayed speeds less than the target's actual speed. This occurs most often when an approaching target vehicle gets close enough to the antenna to create a significant angle. Some of the following conditions could induce cosine in the moving mode:

   a. Highways where the median is wide enough to create a large angle between the RADAR antenna and the target vehicle.

b. If a vehicle is approaching a moving patrol unit from around a curve and unlikely to be moving straight at the antenna. Again, the RADAR may perceive the target's speed as less than it really is.

G. Improperly high RADAR target displays can result due to the angular effect through conditions that exist naturally or created by the officer in the moving RADAR mode. It is critical that the officer knows how to avoid these situations when possible and to recognize that the speed is artificially high.

VIII. TARGET VEHICLE IDENTIFICATION

A. When more than one vehicle is present, RADAR operation must include the accurate identification of a specific target vehicle. In such cases, the operator must:

1. Understand how the RADAR unit "decides" which target vehicle's speed to display.

2. Understand that the RADAR is only one of several pieces of supportive evidence required for the positive identification of a speeding motorist. Together this group of evidence is called a "tracking history."

B. RADAR "Decision" Process

1. The RADAR unit's operation is affected by three factors:

a. Reflective Capability

b. Position

c. Speed

C. Role of Supportive Evidence – Tracking History

1. The RADAR displayed speed measurement is only one part of evidence and cannot be the sole basis for any enforcement action. Therefore a tracking history must be obtained for each RADAR based enforcement action. The elements of a tracking history are as follows:

a. Visual estimation of target speed

b. Audio tracking

c. Target speed display

d. Patrol speed verification (moving mode only)

e. Target speed discrimination test (same direction)

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D. Operational Control

1. The range control allows an adjustment to the RADAR instrument's sensitivity to reflected signals and can be used to reduce target identification problems.

2. The RADAR transmission remains steady and unaffected by the range control. This control only affects the RADAR's ability to process a signal.

E. Six Elements of a Speeding Offense

1. Driver

2. Location

3. Speed

4. Conditions

5. Tracking History

6. Vehicle Identification

IX. FACTORS AFFECTING RADAR OPERATION

A. There are certain factors can affect police traffic RADAR. Some of these factors are unavoidable and the result of natural causes. The factors that affect police traffic RADAR are as follows:

1. Interference

   a. Harmonics – High-tension power lines or radio transmissions

   b. Moving Objects – Moving signs or fan blades moving inside or outside the patrol car.

2. Multi-Path Beam Cancellation Effect

   a. 180 degree phase inversion between the direct path signal from the target vehicle and the signal from the reflected path. Signals are "out of phase" and cancel each other out.

3. Scanning Effect

   a. Rapidly swinging the RADAR antenna.

4. Panning Effect

   a. If the antenna is pointed at it own counting unit a speed-reading may appear.

5. Turn-on Power Surge

    a. Suddenly tuning on the RADAR unit's power may result in a speed-reading due to a sudden surge of voltage to the unit.

6. Mirror Switching Effect (not applicable)

    a. RADAR units that can display the readout backwards allowing the operator to read the number in the rearview mirror.

7. Patrol Speed Shadowing Effect

    a. The patrol car's speed will be displayed as the difference in speeds between the patrol car and a truck rather than the patrol car and the stationary terrain.

8. Batching Effect

    a. Rapid acceleration or deceleration of the patrol vehicle making it unable for the counting unit to keep up with the drastic changes in speed.

9. Wet Conditions- only reduces effect range and does not affect accuracy.

10. Cosine Effect- In stationary mode it always benefits the violator.

11. Target Speed Discrimination – Same Direction mode only.

X. CASE LAW CONCERNING THE OPERATION OF RADAR

A. State v. Tomanelli - Supreme Court of Connecticut

1. The use of the tuning fork is efficient, convent and popular method of testing a RADAR unit's accuracy.

2. The tuning fork accuracy may be challenged. The Department of State Police certifies tuning forks for accuracy every six months.

B. Honeycutt v. Commonwealth - Kentucky Court of Appeals

1. Established operator qualifications for RADAR operation.

2. Officer must have the knowledge to set up, test and operate RADAR

C. State v. Hanson - Wisconsin Court Case

1. This landmark case addressed several issues concerning the use of moving RADAR. As with earlier case law, Hanson affirmed that:

a. The operator must have sufficient training and experience in the operation of moving RADAR.

b. The moving RADAR instrument must have been in proper working condition when the violation took place

c. The moving RADAR instrument was used where road conditions would distort readings as little as possible.

d. The patrol car's speed was verified.

e. The RADAR instrument was tested for accuracy within a reasonable amount before and after the arrest.

D. State v. Dantonio - Supreme Court of New Jersey

1. Court took judicial notice of the Doppler principal.

E. Information that is maintained for court testimony.

1. Site Information

2. Device Information

3. Enforcement Action

4. Test Procedures and Information

XI. PREPARATION AND USE OF RADAR

A. A-B-C of RADAR Assembly

1. A – Antenna

2. B – Box (CPU)

3. C – Current *(make sure power is off)*

B. Procedures to ensure accuracy of the RADAR unit.

1. Internal Circuit Test

2. Light Segment Test

4. External Tuning Fork Test

5. Patrol Speed Verification

OUTLINE	NOTES

XII. RADAR DETECTOR DETECTOR

A. Purpose and basic theory of operation

1. Every RADAR detector while in operation is emitting a radio frequency at approximately 11.55 GHZ.

2. The VG2 Radar Detector Detector is a superhetorodyne microwave receiver tuned to receive radio signals in the Radar Detector frequency range.

3. We have been using the radar detector detector since 1990 for enforcement provisions.

B. Installation of the RADAR Detector Unit

1. The Interceptor must be plugged into a 12VDC-power source. If an external battery pack is used and less than 11VDC is supplied to the unit, it may beep intermittently. Use alternate power source vehicles equipped with, same as radar uses.

2. The most updated version of the unit employs grounding circuitry which eliminates false signals ("beeps") sometimes generated by high power electrical accessories found in police vehicles (i.e. roof lights, computers, radios).

3. Radio Frequency Interference (RFI), when transmitting on mobile police radio may cause interference on the Interceptor, similar to radar.

4. The interceptor should be mounted by its magnetic or Velcro on the dashboard area so that it's receiving antenna points, unobstructed, out of the windshield.

5. Microwaves easily travel through glass windshields but will bounce off metal surfaces. Metallic objects located between the interceptor and target vehicle will block or weaken an incoming radar detector bouncing off metal objects. However, this situation does not usually produce a steady, prolonged signal.

C. Preparation for Use

1. The self-test button should be depressed for about one second so that both an audible and visual alert results. The unit generates a signal, similar to a radar detector internally when the self-test button is depressed, if the unit's circuitry is not functioning correctly and it should be returned to Administrative Headquarters with letter detailing problem.

2. The self-test button should be depressed at the onset on equipment use. Typically the unit is retested after each violation is encountered or as instructed by the local judicial authorities.

3. All units are factory set so that at maximum sensitivity the noise floor of the received signal is obtained. This results in intermittent audio beeps which are generated by the thermal noise of the unit itself. It is our manufacturer's recommendation that the sensitivity know never be rotated past the 2 o'clock position for regular field use. This will prevent possible misinterpretation of the thermal noise signal with that of a radar-warning device.

D. Operation

1. When a radar detector signal is encountered the bar graph display will light up more fully as the field strength or intensity of the signal is greater. Thus the display will show maximum field strength when the interceptor is pointed directly at the signal source, i.e. target vehicle. The audible alarm will activate when the unit encounters a signal regardless of direction.

2. The unit's reception is directional in nature and exhibits a receiving lobe which is +300 in a funnel shape from the receiving antenna. (See illustration in the instructions.) Range of the unit is dependent upon two variables:

3. The strength of the microwave emission from the radar detector. Poorly designed radar detectors tend to have highest emission levels in all directions from the unit. More expensive models employ shielding and leak only low emissions from their receiving antenna.

4. Microwave transmission is "line of sight". The higher the radar detector is positioned in the target vehicle, the further its microwave leakage will disperse, making it an easier target for the interceptor, i.e. radar detectors mounted in the sun visors of high commercial vehicles or transport trucks will be picked up by the Interceptor from the greatest distances. A radar detector mounted in the spoiler of a low sports car will be the most difficult for the interceptor to identify. However, radar detectors mounted in this fashion will also have the poorest range to detect radar signals.

5. Whenever an alarm signal is encountered, a target vehicle should be identified. If the interceptor begins to beep slowly when it is aimed at the target vehicle and then increases in rate of beeping rapidly as the

vehicle approaches, the interceptor should be aimed away from the target vehicle for a moment, then aimed back at it. The signal should drop off completely then resume. This procedure will verify that the target vehicle is the source of the signal the interceptor is receiving.

6. The signal received by the Interceptor will be steady, continuous and prolonged when a radar detector equipped vehicle is encountered at an identifiable range. Once the vehicle passes by the interceptor, the signal will drop off immediately. When the officer pursues the vehicle and pulls up beside it, the alert on the interceptor will resume if the radar detector is still on.

7. The interceptor may also be positioned 90° to vehicle traffic flow in order to achieve better selectivity of vehicles. When using the interceptor in this mode, the alarm signal will cease once the rear bumper of the target vehicle passes the interceptor. Caution must be exercised on multi-lane roadways to identify the correct vehicle.

E. Violator check procedure

1. When a driver surrenders or a search locates a radar detector, the unit should be checked to verify that it is a functional radar warning device. This can be done by verifying that the unit creates an alarm in the interceptor. It should also be checked with a radar set to verify that it reacts to radar with an alarm.

2. Care should be exercised to follow these procedures because there have been numerous occasions where dummy or non-operating radar detectors have been submitted to police officers, while actual operating devices remain hidden or custom installed in the vehicle.

3. Some radar detectors employ a receiving antenna or horn mounted in a hidden location behind the front grill or bumper, and a separate remote head control box, which is mounted in the vehicle. If the receiving antenna remains wired directly to the vehicle's battery, the vehicle will continue to emit a microwave signal even through the driver will not be alerted to radar. Where possible the horn should be disconnected or removed to prevent the vehicle from being pulled over by another officer. You should not do any disconnecting. Allow the vehicle owner/operator to do this with the above recommendation about what would occur.

F. Interference

1. Consistent usage of the interceptor will allow the operator to distinguish the difference between a false and actual alarm.

a. Any microwave signal operating in the same spectrum as the interceptor (approximately 11ghz) may create a false alert. Examples of potential interference include alarm and surveillance systems, microwave relay towers for TV and telephone communication systems. Signals from these sources may intermittently trigger the interceptor and spurious readings may result. However, these devices have a wider frequency bandwidth than the interceptor operates on, so that a steady and prolonged signal does not result on the interceptor.

b. Field-testing has shown that a radar detector emission is the only signal which creates a steady and prolonged alert on the interceptor. A continuous alert from the interceptor along with the proper identification of a target vehicle, as previously discussed is a sure indication that a microwave signal is emanating from the target vehicle.

c. Motor vehicles are not equipped with any standard or other electronic accessories which operate in the 11ghz microwave spectrum, except for a radar detector. Cellular phones or CB radios do not operate in the microwave spectrum and will not create a continuous alarm from the interceptor, like a radar detector.

d. There have been cases where officers have encountered remotely mounted radar detectors wired to the ON/OFF switches of accessories like cellular phones. This can be misleading because the signal appears to be present only when the accessory is turned on.

G. Maintenance

1. The interceptor requires no regular maintenance other than to verify its operation by the "self-test" button prior and after use.

2. If the power light does not come on, check the 2A fuse located in the cap of the cigarette lighter adapter. Make certain this connector is securely plugged in.

3. Since the interceptor creates an audible and visual signal momentarily when the power switch is activated, a loose power connector or partially broken wire could result in erratic signals, especially when traveling over bumps or when moving the power cord. If this condition is evident, have the connector or cord repaired.

4. Do not transmit with your radar set directly into the receiving antenna or horn of the interceptor at close range (less than 10 feet). Permanent damage to the interceptor may result if this occurs.

H. Operating Instructions

1. Place the Interceptor VG-2 unit onto the mounting plate or into a suitable location so that the unit's receiving antenna is not facing any metallic obstructions and is pointing into the direction from which a signal is anticipated to come (radar detector equipped vehicles).

2. Plug the cigarette lighter adapter into a 12 VDC power source (negative ground).

3. Set volume and sensitivity adjustment knobs fully clockwise (maximum level position).

   NOTE: The following test procedure assumes that no external signal from a radar detector is being received. The presence of such signal will cause a continuous pulsating in the bar graph display and pulsating audio "beeps" without activation of the self-test button.

4. Turn the power switch to the "ON" position. The Green LED indicator should come on. The field strength bar graph will momentarily fully light up and the audio alarm will "beep" momentarily.

5. Press the "self-test" push button for approximately one second, verify that the field intensity bar graph momentarily lights up fully and that the audio alarm "beeps". After the button is released, the bar graph should go off in steps from right to left and the audio "beep" should sound intermittently. If all the conditions occur as described, the unit is now ready for use.

6. When a radar detector signal is picked up, the bar graph will light up as a function of the received signal intensity. The audio alarm will also generate a pulsating "beep". The "beep" sound intensity can be decreased by rotating the volume control counter clockwise. The sensitivity control will adjust the threshold at which the received signal starts to trigger the audio "beep". When this control is rotated counter clockwise, a stronger signal is required to trigger the audio "beeper". NOTE: *Do not adjust sensitivity knob past the two o'clock position during normal use.*

7. When an incoming signal's strength is increasing, the portion of the bar graph lighting up will increase also and the audio "beeping" will become more regular and frequent.

8. When the interceptor antenna is perfectly aligned with the direction from which a radar detector signal is coming, the indicated signal

strength will be the highest.

9. By using the information in the above two paragraphs and changing the direction into which the interceptor is pointing, it is possible to identify the location (vehicle) of the signal source.

10. If the signal source (vehicle) is moving, the signal strength will drop off very rapidly when it passes by the interceptor. This will only be apparent if the operator does not follow the signal source (vehicle) with the interceptor antenna.

11. When the interceptor is not in use, switch the power.

NOTE: Do not transmit on mobile police band radio while operating VG-2 Interceptor. The outgoing radio transmission signal may cause the Interceptor VG-2 to falsely indicate the presence of a radar detector.

WARNING: *Do not point the receiving antenna of the Interceptor directly at satellite dishes or other Microwave Communication equipment.*

I. Attorney General's Opinion on RADAR Detector Detectors

1. Attorney General's Opinion March 16, 1990, dealing with use of Radar Detector.

   a. No prohibition on the use of such device.

   b. If you stop violator and all you have is the RDD alert and driver of vehicle will not allow search, <u>you will release unless you can develop other evidence such as:</u>

      (1). Overt movement.

      (2). Observing cord.

      (3). See hand reach up and remove item.

      (4). See item hid under seat, paper, etc.

XIII. PACE

A. Can be used with radar by itself.

B. Advantages

1. Work alone

2. Cover wide area
3. Moving with traffic
4. Selective enforcement vehicles
5. Observe traffic
6. Any weather condition can use
7. High traffic areas can use

C. Techniques

1. Go with flow of traffic and follow vehicles that pass you and which appear to be exceeding the speed limit.
2. Look for traffic ahead of you, pulling away or entering from entrance ramps at high rate of speed.
3. Park in low visibility areas and pull out after suspected speed violators.
4. Observe vehicles going in opposite direction and turn on vehicles that appear to be exceeding the speed limit. Do not turn as in pursuit of radar violation.
5. You will not pace a suspect's vehicle if the police vehicle is in front of the suspect's vehicle.

D. Procedure

1. Police vehicle <u>must</u> have a calibrated speedometer.
2. Maintain a safe cushion zone between violator and police vehicles.
3. Increase police speed to maintain constant space between vehicles.
4. The longer the distance the better in determining a true speed.
5. Maintain the speed of the violator using your speedometer.

E. Errors

1. <u>Do not</u> use catch up speed in determining violators speed.
2. If violator reduces or increases speed, <u>you</u> have to do the same to maintain distance.
3. You have to keep vehicle under constant observation.
4. Vehicles coming in between you and violator, not other traffic.

XIV. Other Issues

** A. Enforcement actions shall not be based on race, sex, religion, nationality, economic status or sexual preference. As with all law enforcement responsibilities, execution of authority should be done in a fair and impartial manner. When this is not followed, it discredits the Officer, the organization, the Commonwealth and the profession as a whole.

OUTLINE	NOTES
B. The safety of the motoring public and the officer is of utmost importance. When conducting speed enforcement activities, always be conscious of all safety issues, such as the location of the stop, weather conditions, method of changing directions and traffic congestion.	

When conducting any form of speed enforcement and there is any doubt in your mind as to legitimacy of the violation, do not initiate a traffic stop. If the traffic stop has already been executed it shall be appropriate to issue a verbal warning to the motorist should any doubt arise to the legitimacy of the stop.