Police Traffic Radar - Facts, Physics and Fantasy

James O. Harris
Harris Technical Services
Traffic Accident Reconstructionists
Port St. Lucie, FL 34953

This article has been written for attorneys representing defendants in civil, criminal and administrative proceedings. It is a technical guide on generally accepted police procedure in the enforcement of traffic speed laws using various speed measuring devices. It is not legal advice or a guide on legal proceedings. It does not provide instructions or advice on how to avoid detection or prosecution for the violation of any laws. Due to the number of variations in state laws and the design of individual traffic speed measuring devices, this work is provided without warranty or guarantee, express, or implied, to any particular situation. The author does not recommend or encourage the violation of any traffic laws. Do not operate a vehicle in other than a safe and prudent manner at a speed reasonable for the existing conditions. This work is protected under copyright laws.

Always use your seat belt. Never drink and drive. Drive defensively.

In 1906, the Supreme Court of Pennsylvania (Brazier v. City of Philadelphia, 215 Pa. 297, 64 A 508, 510 (1906)), in affirming a ruling under a city ordinance for speeding at the then outrageous speed of 7 m.p.h., said, "It is only necessary to resort to the most cursory observation to find the evidence that many drivers of automobiles, in their desire to put their novel and rapid machines to a test of their capacity, drive such vehicles through the streets with a reckless disregard of the rights of others."

And with these words, the contest between the motorist and traffic law enforcement officials began in earnest. The motorist, sometimes traveling at a speed higher than the law allows while evading detection, and the police, trying to find them. Through the years, technology has entered the game and for every new measure taken by one side the other has found, or tried to find, a counter-measure. Radar has been the preferred device by the police for many years and motorists have responded with a variety of counter-measures.

Take this short test to find out how much you really know about police traffic radar.

1. Aluminum foil strips placed inside the hubcaps will prevent the vehicle from being detected by police radar. True or false?

2. Metal chains hanging from the metal frame of a car will ground the body and prevent the car from being detected by police radar. True or false?

3. The police can use radar to accurately determine your speed when you are on the far side of a hill because the radar beam follows the Earth's terrain. True or false?

4. When a radar traffic unit is calibrated, that means every reading taken by a police officer is correct. True or false?

5. Radar detectors will always provide ample warning to slow down when police traffic radar is nearby. True or false?

6. An FCC radio license is required for anyone that operates traffic radar. True or false?

7. The picture taken by photo radar is absolute evidence you were speeding. True or false?

If you said true to any of the above, read the rest of this article. Every statement is false.

The term "radar" is an acronym, it stands for Radio Detection and Ranging. Radar technology was first developed by the British shortly before World War II. The principles of radar are based on the laws of physics. Despite the efforts of any state legislature to write laws to the contrary, anyone operating radar must have a basic understanding of the applicable physics to operate radar correctly. Without this understanding, a police officer running radar is very likely to write speeding citations that are not deserved.

The National Highway Traffic Safety Administration has published a training program for traffic radar operators. (Basic Training Program in Radar Speed Measurement, U.S. Department of Transportation, National Highway Traffic Safety Administration.)

This manual is the basis for the training and certification programs presented by all the states. Each state may modify the course to comply with and incorporate state laws but the basic material must be presented. In Unit 1 it states, "It is not enough to know how to turn radar on and measure a vehicle's speed."

There is more involved than just pointing a radar gun down the road and writing tickets. Much more.

Wavelength, speed and frequency --

Just as police officer has to know how radar works to prosecute, you have to have a basic understanding to defend a radar speeding ticket. If you don't have a grasp on the physics, then nothing else in this treatise will make sense and you could miss an excellent opportunity to have a citation dismissed for lack of evidence.

A radar unit transmits radio signals. The same kind of radio signal transmitted by any radio station, CB radio, or TV station. Radio signals go out in waves, like the waves on a pond surface that has been disturbed. The waves radiate out in a continuous series, so many per second, and will continue to go on forever unless they are absorbed, reflected or refracted by another object in the path. If reflected, they bounce back in the direction they came from, back to the transmitting unit.

A traffic radar beam may transmit as many as 36 billion waves per second. The waves are continuous as long as the radar is transmitting and will travel on forever unless absorbed, reflected or refracted. Because traffic radar uses very little power, the waves can be absorbed easily by particles in the atmosphere. This limits the operational range of traffic radar.

If the object they bounce off is moving towards or away from the transmitter, then the object's motion changes the signal, the wavelength and frequency are changed. The receiving part of the radar gun detects this change, calculates it and displays the change in miles per hour. Fairly simple.

As stated before, radio signals, or radar signals, go out in waves, a series of peaks and valleys. The distance from the beginning of a peak to the bottom of a wave is one wavelength. A wavelength is a measurable distance. An X band wave measures 1 1/5 inches long while K band has a wavelength of 1/2 inch. Compared to other types of radio transmissions, radar waves are very short.

The number of waves sent out in one second is called the frequency. Frequency is controlled by the transmitting unit. Radar operates in extremely high frequencies, in the microwave or gigahertz band, way above the AM and FM radio bands. Two frequencies assigned to traffic radar are X band and K band. X band radar is assigned 10.525 Ghz. (10,525,000,000 waves per second) and K band operates at 24.15 Ghz. (24,150,000,000 waves per second).

X and K band radars are the ones the motorist is most likely to encounter. The FCC also permits burglar-alarm motion sensors and supermarket door openers to operate in this frequency. X band radar was first commonly used in the 1960's. K-band has been around since the 70's.

When the FCC authorized police use of another microwave band, the Ka-band in 1982 (radar gun makers did not produce the radar guns to use it until 1989), the frequency available for clocking speeds jumped to a wide band, from 34.20 to 35.20 Ghz. In 1992 this was expanded to a bandwidth of 33.40 to 36.00 Ghz. Radar operating in this range is called wide-band radar.

All radio signals travel at one speed, the speed of light, which is 186,000 miles per second. This never changes. If a radar signal is sent out on a certain frequency with a certain wavelength, it will continue on at that frequency and wavelength unless it hits something. If it is reflected by a stationary object, then it will bounce back at the same speed and frequency and the wavelength will be the same. The traffic radar readout will display 0 miles per hour because the object is not moving. But if it is reflected off an object that is moving towards or away from the radar unit, it will come back at the same speed but the frequency and wavelength will change. The readout will indicate the speed the object is moving relative to the receiver in miles per hour.

The receiver on the radar unit measures the difference in the wavelength and frequency received compared to what was sent out. If the moving object is coming towards the radar, then the wavelength will be shorter, it is compressed, and the frequency must be higher, more waves in a given distance. If it is going away, the wavelength will be longer, it extends and the frequency must be lower. The speed of the signal never changes, just the wavelength and frequency. See the diagram on the next page.

The scientific principle on which radar works, as described above, is called the Doppler Principle. It is named after the discoverer Christian Johann Doppler, an Austrian physicist. The Doppler Principle states "When there is relative motion between two objects, one of which is emitting energy in waves, the frequency of the energy wavelength will be changed because of the relative motion." The key words here are "relative motion".

Relative motion is a change in distance between two objects over a period of time. But not all moving objects are moving relative to each other. A group of passengers on a jet plane traveling along at 300 m.p.h. have no relative motion between themselves, they are all moving along together at 300 m.p.h. and the relative distance between them is not changing. But there is relative motion between them and the friends they left behind at the airport. Two cars going along a highway, both at 65 m.p.h., in the same direction, have no relative motion between them. But there is relative motion between them and the police car parked on the side. There is also relative motion between them and the oncoming traffic. It is this motion that radar detects. The relative motion between the radar unit and a target vehicle.

Reflection, refraction and absorption --

Radar depends on a reflected signal. If no signal is reflected, there is nothing for the radar's internal computer to compute. Cars make excellent reflectors. Radar reflects very nicely off metal and hard, opaque plastics. A radar's return signal comes mainly from the body of the car but in the case of those vehicles with fiberglass bodies, it may get a return from the engine. Fiberglass is essentially transparent to radar. Unless, of course, you have a metallic paint.

Radar signals can be absorbed. Trees, bushes, snow, earth, all absorb a radar signal. A radar signal can be refracted. An example of refraction is the multi-colored band of light passing through a crystal prism. The radar signal can enter a prism, bend while passing through and be lost as it disperses. Military jets, such as the F117 Stealth Fighter, use the absorption and refraction concepts to avoid enemy radar. The aircraft body is coated with materials that resist reflecting radar signals. The airplane has few broad, flat, distinctive surfaces to reflect a signal. The aircraft was designed with radar avoidance as the primary goal.

Some auto accessory firms make nose covers and front license plate covers for cars that they claim will prevent traffic radar from receiving a return signal. This is all hype. To effectively prevent your car from reflecting radar signals, you would have to remove all the glass, headlights and turn signals and cover every exposed part with a non-reflective coating. According to my friends in the Defense Department, the coating alone would cost you about $250,000. If you could get it. They do not sell it at your local auto parts store. Don't forget to change the entire body style to present as small a surface as possible front and rear. For considerably less you could cover the entire car, from the ground up, with foam rubber one foot thick. Then you would have a stealthy car. Foam rubber absorbs radar signals.

While a basic knowledge of the physics of radar is necessary to operate it correctly, you cannot use any of this information to fight a traffic ticket. In June 1955, the New Jersey Supreme Court took judicial notice of the Doppler Principle. Every other state quickly followed suit. The courts have decided the Doppler Principle is a scientific fact that you cannot argue about.

The Kentucky Court of Appeals, in the case of Honeycutt v. Commonwealth, ruled a radar operator need not be able to explain the internal workings of a radar unit; that knowledge of the Doppler Principle is irrelevant to radar operation; that the defense cannot question the operator's knowledge of the Doppler Principle or other scientific principles and the operator will not be allowed to describe or explain these principles in court.

Since you cannot defend a traffic ticket based on the physics, or challenge the operator on how the radar unit works, what's left? Plenty. Most people drive a car but not many know how it works, let alone the physics involved. There are rules in driving they obey even if they do not know exactly why. They know they have to step on the brake pedal to slow down but do not know how the brakes work. The same is true with radar operators. Some know they have to do certain things, but do not know why. Because they do not know the "why," they tend to bend the rules for convenience or forget some of the procedures. Therein lies the defense.

Calibration --

Just because a radar gun is calibrated does not mean it is being used properly. Calibration is a check of the internal functioning of the unit. There are two types of calibration. The first calibration test is the internal circuit check. The operator presses a test button and should get speed readings, set by the manufacturer, that indicates the computer is functioning correctly. If the readings are correct, proceed to the next test.

The second test uses tuning forks. Tuning forks vibrate at specified pitches. The back and forth movement of the forks corresponds to a speed, the sound from the tuning forks has nothing to do with the calibration. A tuning fork is struck against a hard surface and then held in front of the radar gun. The speed displayed on the radar gun must match the speed stamped on the tuning fork +/- 1 mile per hour. Two tuning forks are used, one reflecting a low speed, about 35 m.p.h., and the other a speed around 65 m.p.h. If the unit does not pass these tests, it must be repaired by the manufacturer. Judicial notice was taken of the tuning fork method of calibration by the Connecticut Supreme Court in the case of State v. Tomanelli.

When a radar gun is calibrated, or more precisely tested for accuracy, is up to the individual police department. Some require it be tested at the beginning and end of each shift, others after every citation is issued. Still others leave it to the officer's discretion. As long as the officer can testify that he tested the unit within a reasonable time before and after a citation is issued, the courts will accept that it was working correctly when the citation was issued.

An officer can be challenged on the performance of the calibration test. Every manufacturer of traffic radar provides two tuning forks with the unit. The tuning forks have serial numbers stamped on them. Those supplied with a particular radar gun can only be used with that unit, they cannot be used to calibrate any other radar gun. Performing just the internal circuit test is not sufficient. An external test with tuning forks, conducted strictly in accordance with the manufacturer's detailed instructions, must be accomplished. To challenge an officer on the test procedures, a copy of the operating manual for the radar gun used must be obtained as there are minor differences between makes and models of radar guns.

If the officer did not have the operator's manual with him when he conducted the test, and he cannot explain the exact procedure for performing the calibration test without it, then the accuracy of any reading is questionable. It is rare for an officer to have the operator's manual with him when he conducts the calibration test. Usually they are stored back at the department if one is kept on file at all. If the wrong tuning forks were used, the readings are equally questionable regardless of the calibration test results.

Targeting vehicles --

This is the area where most citations can be challenged. A radar beam cannot be seen so how is the officer to know which vehicle he is tracking? How is he to know he is not getting a false return?

Police traffic radar does not operate like airport radar. There is no screen showing the positions of vehicles, it does not rotate or sweep an area. There is no screen showing a number of blips with data beside each one. It is single point radar that only displays a speed reading, a number, from a target within a fairly narrow area.

The radar beam goes out in a fan pattern. The further away from the transmitter the radar beam travels, the wider it gets. Generally, radar guns send out a beam at an initial angle of between 11 and 18 degrees. At 12 degrees, a K band beam becomes 420 feet wide at 2000 feet away. Any vehicle moving within the beam can reflect the signal. The radar gun can only display one speed at a time and does not show the operator which vehicle is being tracked. Traffic radar, unlike airport radar, does not give the location of the target, just a speed.

To help ascertain a good track, traffic radar provides audio doppler. This is a whistling sound or tone. The pitch of the tone corresponds with the speed calculated by the radar receiver. The higher the pitch of the tone, the higher the speed. If the sound is clear and steady, then the radar unit has a good track and is receiving a strong return signal. If the sound is fuzzy, noisy or broken, then the track is not strong and the displayed speed, if any, is questionable. Some officers turn the audio doppler tone volume down so low it cannot be heard. After a few hours this noise can become annoying so they just turn it off. An audio doppler tone is required for a traffic radar track. Having just the visual display is not sufficient.

Outside interference can produce false radar readings. Outdoor moving signs, motion detectors on burglar alarms, airport radar, radio transmitters, telephone lines moving in the wind, can all produce false, momentary, readings but they will not send back a clear steady tone. The interpretation of the audio doppler is required to confirm the speed displayed on the radar unit.

A maker of radar detectors once ran an ad that pictured a radar gun aimed at a group of trees and the unit was displaying a speed of 65 m.p.h. The not-too-subtle suggestion was radar makes mistakes and you can protect yourself from being invited to appear in court by buying one of his radar detectors. What the advertiser did not show in the picture was the hand held radio being keyed right next to the radar receiver. The radar receiver was picking up interference from the radio transmitter and displaying the interference as speed. It was not producing an acceptable audio tone.

One of the first things shown to a radar operator in training is the 35 m.p.h. defroster. Radar units, when mounted on the dash of a patrol car, will pick up the movement of a windshield defroster fan running on high and display a speed. The audio tone will be fuzzy and broken. Solid returns will override this interference, a clear audio tone will be heard.

For the officer to confirm he has a good radar track, a strong, clear, steady tone is required. If the tone changes in pitch, then the displayed speed reading must also change accordingly. This is something that takes practice but a competent operator can estimate the speed of a tracked vehicle just by the tone. Fortunately, this is not enough to get a conviction.

Now that we know how to determine a false signal from a good return using the audio doppler, the only question remaining is which vehicle is being tracked? Traffic radar only displays numerical speed readings, not which vehicle is being tracked.

For the officer to issue a citation, he has to see the vehicle speeding. He must make a visual estimate of the car's speed in addition to the speed displayed on the radar gun and the audio tone. They all have to match. Some police officers are very good at estimating speeds and others not so good. If you go to court, they will all say they estimated your speed at the same speed displayed on the radar unit. It would be very difficult to challenge someone on their ability to visually estimate vehicle speeds. Most state certification courses require at least 20 hours of hands on training during which the trainee is required to accurately estimate vehicle speeds before being shown the radar reading.

When the officer makes the visual speed estimate, he also has to make sure the vehicle he is observing is within the radar's operational beam, that there is no interference that would produce a false return in the area and that the vehicle is out front and by itself. Large vehicles and faster vehicles return stronger signals than smaller or slower vehicles. If any other cars or trucks are in the immediate vicinity of the car the officer visually estimates to be speeding, then an argument can be made that he cannot be certain which vehicle was being tracked by the radar. Radar cannot pick out a single vehicle in a tight group.

Shadowing is an aspect that can result in undeserved citations. Large vehicles will return a stronger radar signal than small vehicles. Tractor trailer rigs, with their large, flat forward surfaces send back very strong signals. A car, in front, behind or to the side of a tractor trailer rig can be moving along faster than the truck but will not be detected by a radar unit until it gets well in front of the truck. On the other hand, a speeding truck coming up from behind a slower moving car will cause a strong signal to be returned, overshadowing the car's speed which could be much lower. Even though the car is out front, the truck's larger surface area and speed returns a stronger signal than is reflected from the car. The radar operator has to be aware of all traffic in the immediate vicinity of the targeted vehicle. Sudden shifts or changes in the audio doppler tone indicates the radar unit is processing numerous signals. The return of numerous short, differentiated signals in the audio tone makes the radar readings questionable.

Stationary and Moving radar --

Traffic radar works in two modes, stationary, when the radar unit is not moving, and moving mode, both the radar unit and the target vehicle are moving. It is almost impossible for stationary radar to provide a strong audio doppler tone in error. Of the two modes, stationary radar is the easiest to use. Moving mode is most often used by highway patrols on high speed roads and requires greater care to target the right vehicle. If a radar gun is set to the stationary mode and the patrol vehicle is moving, the radar will pick up the relative motion of the car over the earth and display the patrol vehicle's speed. Should another vehicle approach, it will calculate the closing speed between the two cars and display that. For instance, if the patrol vehicle is going along at 30 m.p.h., and another car is approaching from ahead at 40 m.p.h., then the radar display will read 70 m.p.h. (30 + 40 = 70).

The mode of most radar guns can be changed by the operator just by pressing a button. The radar guns have indicator lights to show which mode they are in. In stationary mode, only one speed, a target speed is displayed, the patrol speed display window will always be blank.

Both stationary and moving mode radar sends out one signal but moving radar reads two returns. One is called the low doppler shift. The low doppler shift is a return from the surrounding terrain, the speed the patrol car is moving relative to the earth. The other return is the high doppler shift, the speed of a target vehicle.

The radar computer reads the low doppler shift and then reads the high doppler shift. The high doppler shift is the relative closing speed between the two cars. If the patrol is going along at 55 m.p.h. and the approaching car is traveling at 75 m.p.h., then the closing speed is 130 m.p.h. The radar's computer subtracts the low doppler shift from the high doppler shift and displays this as the approaching vehicle speed (130 - 55 = 75). So far, so good.

There is a unique possibility for error when using moving radar. The audio doppler tone will only reflect the approaching vehicle's computed speed, not the patrol vehicle speed. The patrol speed is displayed but without a tone. If for any reason, such as outside interference or equipment failure, the patrol speed reading on the radar is lower than the actual patrol speed, then the residual speed computed from the closing rate will be given to the approaching vehicle.

For example, a patrol car is traveling along at 55 m.p.h. but the low doppler shift on the radar unit is reading 25 m.p.h. as a patrol speed because there is a large truck going 30 m.p.h. in front of the patrol car. The back end of the truck is reflecting a strong low doppler shift. The radar unit is reading the closing speed of the patrol car on the truck going in the same direction in front. (55 - 30 = 25). From the opposite direction comes a car, traveling at 60 m.p.h. Since the radar unit "thinks" it is moving over the earth at 25 m.p.h., and is closing on the approaching car at 115 m.p.h., then it shows the speed of the approaching vehicle as 90 m.p.h. (115 - 25 = 90). This is 30 m.p.h. over the actual speed of the target vehicle.

The only way for the officer to avoid writing an undeserved citation in this situation is to check the radar displayed patrol speed against the patrol car's speedometer. They must match whenever moving mode radar is being used.

Another phenomena associated with moving radar is batching. Batching occurs when the patrol car speeds up or slows down suddenly. The radar unit cannot keep up with the sudden changes in speed using the low doppler shift. This will cause momentary speed readings inconsistent with the vehicle's actual speed. Radar operators are taught to maintain roughly even speeds when running moving radar. Sudden shifts in speed from a vehicle being tracked on the high doppler shift will not cause this type of error.

Some radar units have two transmitter heads, one pointing to the front and one to the rear. Either one can be operated in a stationary or moving mode as explained earlier. The one in the front operates in the standard moving radar mode, it calculates the closing speed of the two vehicles and subtracts the patrol vehicle speed. The one in the rear does it a little differently. A car, coming up behind a patrol car, must be closing on the patrol, that is going faster. As it enters the radar's operational beam, the radar's computer uses readings from both transmitter heads to determine the target speed. The front transmitter is used to determine the patrol vehicle speed while the rear transmitter reads the closing speed of the target vehicle behind.

If a patrol vehicle is traveling at 30 m.p.h., and is being approached from behind by another car going 60 m.p.h., then the car from behind is closing on the patrol car at 30 m.p.h. The radar's computer add the two speeds and displays the result as the speed of the closing vehicle (30 + 30 = 60). It is difficult to estimate the speed of a car approaching from the rear using your rear-view mirrors but this must be done for the officer to issue a citation in this scenario.

The mode of the radar, moving checking vehicles coming from behind, moving checking vehicles approaching from the front or stationary is selected by the radar operator using a series of buttons on the radar unit. The officer must know which mode the radar is in at all times.

Radar, due to the wide fan pattern of the radar beam, is not lane selective on multi-lane roads. The operator cannot pick out a target vehicle when there is another vehicle going in the same direction in the immediate vicinity of the target. To a certain extent, two vehicles going in opposite directions can also affect the returns. If the operator claims his radar is lane selective, then he is not competent to operate traffic radar and any citations he issues are questionable.

When you are stopped --

When you first see those pretty lights in your rear-view mirror, turn on your four-way flashers. This lets the officer know you see him and will stop at the first safe place. This shows the officer you are cooperative and they like that. Slow down and pull well off to the side of the road, on the right if practical. Do not slam on the brakes suddenly as the officer does not want to rear-end your car.

Once you have pulled over, turn off the engine, put it in park and get your driver's license, registration and insurance papers out and ready to hand the officer. If everything is in order, current address on the license and registration and the insurance is valid, things will go much smoother.

If you have a legitimate emergency, tell the officer at once. He will either escort you to where you need to be or call an ambulance. Don't try to lie about this as the officer has all the time necessary to check it out. If he finds you were trying to fool him, the consequences can be dire. Police officer's do not like being lied to by speeding motorists.

Stay in your car unless the officer instructs you to get out. If you have passengers, they must stay in their seats unless told to get out by the officer. Follow directions, do not argue, get angry or feign a lack of understanding. Don't get excited. If you are not sure what the officer said, calmly and clearly ask for clarification.

If the officer approaches your car while you are still in it, keep your eyes forward and your hands high on the steering wheel where he can see them. He is more afraid of you at this point than you are of him. Do not reach for anything inside the car unless the officer asks you. A suspect, which is what you are at this point, reaching for something unexpectedly makes them very nervous. Passengers should remain still with their hands in plain view. A few yes, sirs and no, sirs will not hurt but don't over do it.

Answer questions of where you were coming from or going to clearly and calmly. If asked if you knew how fast you were going, and you know, tell him. If you don't know, say so. When an officer is asking what appears to be irrelevant questions like this, he is fishing for additional information. He is listening, looking and smelling for evidence of intoxication or other criminal activities. He is on the job, working, and not exchanging pleasantries or trying to win friends. If he finds something, the last thing you need to worry about is a speeding citation.

Don't ask for his name or badge number, it will be on the citation should you get one. Don't threaten to have his badge, flirt with him, offer a bribe, call his boss, your brother the mayor or anything else of this ilk. It does not work and could cost you later in court. On the issue of offering a bribe, attaching a $100 bill to your driver's license with a paper clip and then denying knowing it was there is a very bad idea. No police officer is going to let you threaten his career like this. You could end up in jail facing felony charges. Never, under any circumstances, argue with a patrol officer on the side of the road. You will lose this argument and at the very least give the officer even more ammunition to use against you in court. Avoid acknowledging you were speeding and do not offer some lame excuse, they have heard them all. Accept the citation graciously and drive off carefully. It is not a good idea to inform the officer that you are an attorney. It does not matter if your area of practice is real estate, personal injury, maritime law or criminal defense. Some police officers have an outright hatred for the profession. Those that consider attorneys "the other side" will take great personal pleasure in writing a citation to you. And they will show up for court. Basically, to avoid getting a citation when you have been stopped, cooperate and be pleasant. The officer may be having a bad day but more likely, he is just doing his job as he sees fit. At least make this traffic stop as clean, quick and unmemorable as possible. You just might get out of a ticket because you were nice.

Be very careful of what you say and do during a traffic stop. Many police cars are now equipped with video cameras that come on automatically when the overhead lights are activated. The police officer may also have a microphone on his uniform that picks up the entire conversation. This is all recorded on a video tape in the trunk of the patrol car. Should an officer become abusive or rude, immediately file a formal complaint with his department so any video tape can be recovered by his superiors.

The officer is not required to, and probably could not in any event, show you any readings that were made with the radar gun when you were clocked. First, there is nothing to see. A radar "lock" does not mean he froze a reading on the display. It means he achieved a good track and saw the readings on the display. They will change as the target speed changes. It is his interpretation of the readings that matters. You could look at the radar gun but the display will be showing any targets currently in range or nothing at all. It does not record past displays.

Many states have laws on the books that prohibit the use of any type of readout locking device or automatic locking system that freezes the display with the highest reading when speeds above a certain level are indicated. Only the oldest radar units currently in service have these locks installed and manufacturers disable them when the units come in for repair.

In court --

Should you decide to contest a speeding citation, you have to go to court. If the officer does not show up, you win by default. If the officer does show up, have your defense ready.

One defense tactic that sometimes works is to obtain as many delays in your court appearance as possible. The more time that passes between the day you were issued a citation and the day the officer actually has to show up for court, the fainter his memory of the traffic stop. Since many officers issue hundreds of citations in a single month, there is a good possibility he will not remember your stop at all.

The court will give greater credence to the officer in a simple contest of he says you were speeding and you say you were not. You will lose.

You can and should question the radar operator on the traffic and weather conditions at the time the stop was made. Ask about terrain, bushes, trees, obscured speed limit signs, other vehicles, pedestrians and bicycles that were in the area. If there were any overhead wires and it was windy, it is possible the radar gun picked up the movement of the overhead wires whipping in the wind. Ask about businesses in the area that may have burglar alarms with microwave motion sensors. This could affect the reliability of the radar reading.

Make the officer dig deep in his memory for details. This is your opportunity to put him on the defensive and go fishing for information just like he did on the side of the road.

Some operators have just enough knowledge of traffic radar to impress the unknowing with their direct testimony. Call the bluff. Have all your background materials at hand and be thoroughly familiar with them. Be ready to cross-examine the officer on qualifications and procedures to the tiniest detail. A collection of small errors in procedure can add up to a very impressive list and make the radar readings questionable. The police have very specific procedures that must be followed when running radar. These procedures should be contained in standard operating instructions maintained by the department. Copies of operating manuals should also be on file with the department for every make and model of radar in use. Most of the standard operating instructions state the police officer must satisfy certain criteria before issuing a citation based on a radar reading. The first item is certification as a radar operator by the state. The officer should be able to produce a certificate indicating he completed a radar operator's course. Some states also require refresher training at specific intervals.

The second item is the testing and calibration of the radar unit. When was it tested, who tested it and what was the procedure? Did the procedure exactly match the one in the manufacturer's manual? Does the officer know the correct procedure? Were the correct tuning forks used? Check to make sure the tuning forks used were the ones issued with the radar gun by obtaining the serial numbers from the tuning forks and the serial number from the radar unit. Then contact the radar manufacturer to determine if these are the right tuning forks for that particular radar unit.

Did the officer make a visual speed estimate? Was the targeted vehicle out front and by itself? Was it well separated from any other vehicles? Was there an audio doppler tone consistent with the speed displayed and his visual estimate? For judicial notes on these requirements, see Honeycutt v. Commonwealth.

An easy way to determine if an officer knows his basic radar procedure is to ask, "Did you complete a tracking history checklist before issuing this citation?" If the officer does not even know what it is, he needs to go back to radar school. The tracking history checklist is not written down but is a standardized method to eliminate most questionable radar readings. The checklist is detailed in the N.H.T.S.A. radar operator's training manual.

For stationary radar the checklist is:

1. Was a visual speed estimate made of the suspect vehicle?

2. Was the speed reading displayed consistent with the visual estimate?

3. Did the audio doppler tone match the speed reading and visual estimate?

4. Was the suspect vehicle out front and by itself when the speed readings were made?

For moving radar operations, add

5. Did the radar displayed patrol speed match the vehicle's speedometer reading at the time the suspect vehicle was tracked?

The basic premise is the radar unit is a tool, as smart as a hammer. It cannot testify for itself. Traffic radar is only as good as the operator and the operator must be able to testify as to the accuracy of the readings and the accuracy of the unit at the time the violation was observed.

It is on this point that photo radar has come under fire. A photograph alone cannot show what outside influences were affecting a radar beam at the time the photo was taken. It can only show vehicles within the camera's range. What if there is more than one car within the radar's range? Which car was speeding and which is cited? There is no record of the audio doppler tone which is essential to radar operation. There is no person to testify as to the accuracy of the unit at the time the photo was taken even though the camera is connected to the radar's computer. Finally, there is no person to testify that they saw the pictured vehicle speeding.

Laser timing devices and airborne officers have one thing in common when it comes to going to court. Two officers have to show up. As most laser units are run by one officer and the actual citation written by the other, both have to appear to testify to their respective contributions to the citation. Same thing goes for police officers timing cars from aircraft using a stop watch. He sees the violation and informs another officer on the ground who issues the ticket.

Radar detectors --

Recall that when a radar beam is transmitted, it goes out in a fan pattern and will go on forever unless it hits something. The operational range of a radar beam is about one-half mile. Radar receivers require a fairly strong signal to produce a reading. Radar detectors will pick up a very weak signal, far away from the radar gun, parts that are too faint for the radar receiver to analyze. Basically, a radar detector is an extremely sensitive radar receiver. When it receives a radar signal, it buzzes or lights up to alert the driver. The driver is supposed to slow down in time to avoid a citation. Great in theory, lousy in reality.

The first problem with radar detectors is sensitivity. They tend to give out false warnings. Radio signals can be sent out from burglar alarm motion detectors, radio station transmitters, and even automatic door openers. They all use high frequency radio to detect motion and some infringe into the radar bands. Radar detectors, being necessarily sensitive to work at all, often give out false warnings because of these types of transmitters.

With the production of Ka band radar guns, operating within a very wide band, the work of radar detectors became much more difficult. To provide a warning, they have to search a very large area of the radar frequency spectrum. This slows their response time down as they try to tune out possibly false signals. To add to the confusion, radar gun makers now have a large area in which to tune their radar guns.

All radar units have a "hold transmission" switch. Sometimes this is called "instant on radar" or "pulsed radar". Both terms are misnomers. The unit is powered up but no signal is being sent out. As long as no signal is going out, there is nothing for the radar detector to detect. An officer, sitting on the side of a road, simply waits until he has a vehicle in sight and well within his radar operational range. If you are not paying attention, you won't see him. Then he hits the switch and starts getting speed readings in milliseconds.

Let's assume you are going along at 75 m.p.h. in a 55 m.p.h. zone. The police have radar set-up but with the "hold transmission" button set. No signal is going out, your radar detector is quiet. The radar operator sees you in his range, visually estimates your speed and turns on the radar gun. You radar detector starts screaming wildly and you hit the brakes. Too late. The officer got your highest speed reading as soon as he turned on the radar gun. Then he tracked your speed down from 75 to a more sedate 50, all the while watching the nose of your car dive as it decelerated. While he was watching you madly trying to slow down, he was getting speed readings equal to your deceleration. Just a little more confirmation that he has the right car with the very high initial speed reading. Say hello to the nice police officer.

Another way the police thwart radar detectors is to use terrain to their advantage. If a radar unit is set up on the far side of a hill, facing up the hill, the extraneous radar signal, the part radar detectors depend on to give early warnings, will be absorbed by the earth or head off into space. Once your car crests the hill approaching the radar unit, you are being tracked. Now your radar detector will start sounding off. About 30 seconds too late.

Some radar detectors boast of the ability to locate radar to the side. This is of absolutely no value. Radar only detects relative motion, either coming in or going away. If a car is going along perpendicular to a radar unit, then there is very little relative movement. The only readings the radar would display would be extremely low. This is called Cosine Error, a function of geometry. For the most accurate readings, radar must be within 10 degrees of the travel path of the target vehicle. The farther off to the side of the road, the greater the angle. The greater the angle, the more the closing speed decreases and a radar reading below the target's true speed is presented in the display. Cosine Error always works in the motorist's favor.

Never even mention Cosine Error in court. It only works against the defense by suggesting your actual speed was higher than the radar's display.

If you like to drive fast and purchased a radar detector to give you ample warning of the presence of traffic radar, then be prepared to pay extra for fines and increased insurance rates. You are going to get caught. The author has yet to see any radar detector manufacturer provide a guarantee that offers to pay the fine of anyone caught speeding on radar while using one of these devices. They cannot get around the fact that traffic radar operates under some very basic laws of physics and this is what governs their actual performance. More than one police officer has found amusement in annoying drivers with radar detectors. Many detectors mount high on the windshield with small flashing lights. These lights can be seen out the back window at night. Imagine your frustration when your radar detector keeps going off intermittently with no police in sight. What's going on? Look in your rear-view mirror and see if there is a patrol car back there. The officer just might be following you while turning his radar on and off watching the lights through your rear window.

Radar detectors are illegal to operate in some states. There is a "radar detector detector" in use by the police in those states. Radar detector detectors work because all electronic devices emit radio frequencies when in use. Radar detector detectors scan for emissions in certain bands from these devices. There is probably a "radar detector

detector detector" on the market. A few other ways people have tried to defeat radar includes hanging chains from the car's body so they drag on the ground. The theory is this grounds out the car and the radar signals are directed to the ground and not back towards the radar unit. This does not work. Radar does not "energize" a car body, it is merely reflected like light from a mirror.

Placing foil in the hubcaps will do nothing more than cause the wheels to go out of balance and give you a rough ride. Frantically honking the horn has been put forth as a means to defeat radar. This is done under the mistaken impression that the rapid oscillation of the horn's speaker will interfere with the radar signal. No. Not even close. The oscillation is so small, and the horn so buried under sheet metal, it has absolutely no affect. Except to get the attention of the police officer as you go by.

Radar jammers are sometimes advertised. These devices are sold in kit form, not as complete, ready-to-install units and for a very good reason. They are illegal to sell, own or operate without a license from the Federal Communications Commission because they are radio transmitters. It's a misdemeanor. Radar manufacturers have licenses for the units they sell, individual licenses are not required for each operator. The FCC will not issue you a license for a traffic radar jammer.

Radar jammers are supposed to transmit a signal on the same frequency and wavelength as the radar gun pointing at you. The signal sent out by the jammer either causes a blank display on the police unit or a lower speed reading. Of course, this assumes your jammer matches the exact frequency of the police unit and with all the radar bands now available, this would be a neat trick.

There are often repeated stories of someone having built a traffic radar jammer that will cause a radar gun to instantly burn out. Pure fairy tale. The signal strength required to cause a circuit burn out from an outside transmission would be so strong everything within a 5 mile radius of the jammer would begin to glow. No automotive electrical system could possibly produce this much power.

Some police traffic radar units even have a jamming indicator/locator so they can track you down, confiscate the jammer and take the matter to federal court. This can be much more serious, and costly, than a speeding ticket. Should they decide not to prosecute, do you really think they are going to give that expensive piece of contraband back to you?

A few states have specifically outlawed the possession of radar jammers in vehicles. Tests conducted by various auto enthusiast magazines have consistently shown radar jammers do not provide the protection from police radar they claim. They are all made by very small electronics firms, hobbyists really, usually in a backyard garage. To top it all off, they are expensive. Sometimes as much as $2000 for a basic kit with a few critical parts missing that you have to track down and install yourself.

By not providing a complete unit, the manufacturer can skirt federal laws regarding the licensing of radio transmitters.

Laser radar --

Laser timing devices have become the latest addition to the traffic speed enforcement arsenal. "Laser radar" is a misnomer as there is no radar in the laser devices. Laser timing devices, also known as Lidar, use light instead of radio signals. The basis is a little different from radar in that lasers send out pulses of light and measures the time it takes for the reflection to return.

Laser timing devices, unlike radar, have not received judicial notice and it is possible to challenge laser devices on operating principles. This means the state would have to bring in experts to support their case. Be warned, however, that any discussion of the physics of lasers and how they work is going to be extremely technical with very intense math. Since lasers are still fairly new in traffic enforcement, there are major differences in the way each unit works.

Lidar has a very narrow beam compared to radar. At 1000 feet, the beam is less than four feet wide. Lidar can pick out a single vehicle from a group of cars as long as there are no vehicles in a straight line between the Lidar transmitter and the reflecting surface. To run Lidar, the operator must have a visual line of sight to the targeted vehicle. Any reflective surface on the target vehicle is sufficient for a Lidar return although operators are instructed to aim for the front license plate.

At present, Lidar is restricted to the stationary mode, it cannot be run from a moving vehicle. It is typically used in the "wolf pack" scenario where one officer runs the Lidar while several others up the road pull over vehicles he has identified. The identification process includes make, color, type and sometimes model of the targeted vehicle. Most often, the officer running the Lidar can see which vehicles his cohorts are pulling over and provides confirmation via radio when he sees they have the right one.

Lidar is not subject to radio interference because it does not use radio signals. It is subject to failures in inclement weather but very few departments would risk destroying an expensive laser unit in the rain. Laser detectors are on the market but they have no value in reality. Laser beams are detectable, in the same way the sound of a guillotine is detectable to the condemned -- he hears it just before his head is lopped off. Lasers do not emit a broad, fan type beam over great distances. The laser is not turned on until the operator has a target vehicle in sight so there is nothing for a laser detector to detect until it is too late. Lidar, like radar, gives readings instantly and any sudden deceleration simply adds to the operator's tracking history checklist.

Car and Driver Magazine reported in their November 1993 issue that the use of powerful lights may reduce -- and sometimes defeat -- lidar's effectiveness and buy time for drivers to slow down after their lidar detectors go off. Every state has laws on how bright and how many lights you can have on the front of your car. What's allowed, typically no more than 300 candlepower total, is far below that required to defeat police lasers.

Lasers could be jammed if your car was equipped with extremely powerful lights covered with an infrared band filter. All lights produce some infrared light, but this filter blocks all light except that in the 904 nanometer range, which is that of police laser. The FCC does not govern this part of the spectrum either, so laser jammers are legal from this aspect. By sending out an infrared light similar to that of the laser gun, the receiving diode in the laser gun can't make a determination between reflected laser gun light and "jamming" light from the car. The laser gun would not get a reading. This would be a practical solution if the power requirements for lights bright enough to have any effect would not burn out your car's electrical system.

Covering the headlights with the filter has several problems -- it is illegal because by law you cannot drive with the headlights covered, standard headlights will not produce nearly a strong enough jamming light and the filters just might melt from the heat of the lamps. Of course, you could always tow around a small diesel generator to power a few 1000 watt lamps with the appropriate heat shields and filters.

A car can be made to be less visible, but not invisible, to lasers. Cover all the reflective surfaces, headlights, taillights, windows and chrome, with light refracting covers and paint the entire body with flat, not glossy, black paint. Do not apply wax. If you have been clocked with a laser, defend on operator training, qualification, vehicle identification and the tracking history checklist.

There are two other ways commonly used to detect speeding vehicles; airborne officers and pacing. Pacing requires the patrol officer to get behind a car and travel along with it for a sufficient distance to determine cruising speed. Police vehicles should have calibrated speedometers. Just because the auto maker put a placard on the dash saying the speedometer was calibrated does not mean it will remain that way forever. It is a mechanical device subject to wear and tear. Speedometers need to be calibrated regularly.

It is not hard to calibrate a speedometer, a radar unit in stationary mode can be used. A card indicating when the speedometer was calibrated, who did it and how it was done should be in the patrol car at all times. Any differences between the speedometer speed indications and the calibration device speed readings should be noted in not more than 10 m.p.h. increments. A speedometer can be off by several miles per hour and still be accurate as long as this difference is taken into account.

Police vehicles are subject to hard use, sudden accelerations and decelerations. A speedometer is controlled by a series of small cogs in the speedometer head, the part you see on the dash, connected by a cable to the transmission. Any wear or damage to the cogs or cable can put the speedometer off true. Changes in tire or wheel rim size from the original manufacturer's specifications can also cause a change in accuracy.

When in court, if you have been paced, ask the officer when the speedometer was last calibrated, who did it, and what was the recorded error ratio? How many miles, weeks, months or years have passed since it was last calibrated? If more than 90 days or 10,000 miles have passed between the last test and the day the citation was issued, then the accuracy is questionable. Check the department's standard operating procedures to see if they have a set schedule for calibration testing and if it was complied with. Ask to see the calibration records.

To achieve a good speed reading while pacing, a steady speed must be achieved for some distance. Sudden bursts of speed can cause speedometers to show a momentary high speed that does not accurately reflect the actual speed achieved. A pacing distance of 1/10th mile at a relatively steady speed is generally considered sufficient. How far and for how long did the officer pace you? Did he have you in sight the entire time? Was he able to maintain a constant distance between the vehicles during the pacing? What were the traffic conditions at the time? Were there any other cars similar to yours in the immediate vicinity?

Airborne officers watch traffic from a light aircraft flying along a highway. Painted on the road are white bars, ground markers, spaced at specific distances. The officer in the aircraft starts a stopwatch when a car crosses the first of a series of bars then stops it when the same car crosses the next in the series.

A quick check of a timing sheet shows that if it took a car 10 seconds to travel the one-quarter mile between the two bars, then it is traveling at 90 m.p.h. He radios to another officer on the ground some distance ahead of the offending vehicle and then watches to make sure he stops the right one.

The police tend to calibrate those stopwatches regularly. If you go to court to challenge this type of ticket, the prosecution must present both officers to testify.

One other type of timing device in very limited use is Vascar. Vascar is a trade name for a simple, visual, stopwatch arrangement that is entirely dependent unpon the officer's observations. The officer starts a stop watch when a vehicle passes a reference point and stops it when the vehicle reaches another reference point. The time it takes to pass between the two points is used to calculate your speed.

There are even more timing devices in use including electric eyes or air hoses spaced across a road. Both of these arrangements are connected to a timer that measures the time it takes a car to break two sequential beams or hoses. They are in extremely limited use. How to defend against a ticket received in this situation would depend upon the device.

Quotas and speed traps --

Just because you were caught speeding with radar does not mean you were caught in a speed trap. To entrap someone, some kind of bait must be set or something to entice the person to do something illegal that they would not have otherwise done. A classic speed trap involves the removal of speed limit signs along a stretch of road where the speed limit has just dropped. Since a driver did not see a speed reduction sign, they continue on at highway speed. Somewhere in this area is a patrol with radar, a ticket book and very fast pen. Once a number of citations are issued, the signs are put back up. Variations on this scheme involve defacing, obscuring or in some cases temporarily changing the signs.

Speed traps have been used by less than scrupulous politicians as a means to raise money for local city coffers. Citations issued by state highway patrols must be written against state statutes. The states assign very little of the citation fine, usually one dollar, to the enforcement agency that wrote the citation. The rest is doled out in percentages to a broad range of government service providers, almost none of which have any connection to law enforcement. Small towns, using local ordinances to write the citations against instead of the state statutes, can receive the lion's share of the fine. This is not a common practice but should you get caught in one just pay the fine. The local judge will be in on the game and will have no tolerance for your cross-examination of the officer that wrote the citation.

It may feel good to give a parting remark to an officer that just wrote you a ticket about him meeting his quota. Reality check. Police do not have ticket quotas. At least, not in the literal sense. A police officer is an employee performing a job and, like any other job, he has to meet certain performance goals to keep his job or get promoted.

Larger departments do not track who wrote how many tickets in any given time frame. They do track how many public contacts the patrol has made during a shift. They do this with the dispatcher's log. Every traffic stop, or any other contact for that matter, is called in via radio. A supervisor can check to see that his patrolmen are making contacts and not out there sleeping through the shift. Traffic stops are just one part of a police function. Traffic officers also must handle more mundane things like truck inspections and accidents.

A group of patrol officers all working in one area do not constitute a speed trap. Intense local enforcement can be ordered because of a real or perceived problem with speeding cars in a certain area. The intense enforcement is to remind all drivers, not just those that are stopped, of the presence of the enforcement community. A group of patrols working like this are called wolf packs.

Summary --

Police traffic radar enforcement is not perfect. It was invented by humans and is, for the most part, operated by humans. Always challenge the operator's qualifications, training and procedures.

Laser devices are extremely accurate but their use is limited by current technology and cost. Other forms of detecting speeding vehicles are simple and have been around since cars first went on the road but can be defended if counsel has the right information at hand.

There are other aspects of traffic radar operation that will result in lower than actual speed readings (Cosine Error) but this is not a matter of concern to the motorist. It is addressed extensively in the radar operator's courses.

To quote the N.H.T.S.A. radar operator's training manual:

Statement of Overall Goal -

To improve the effectiveness of enforcement, we must:

Observe more speeding violations, apprehend more violators, secure more convictions.

As a final note -- there is one sure fire, absolutely, unconditionally, your satisfaction or money back, iron clad, no exceptions, no excuses, guaranteed way to avoid a speeding ticket. Slow down.

Drive safely. Your life depends on it.