U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

Basic Training Program in RADAR Speed Measurement

Trainee Instructional Manual

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

Basic Training Program in RADAR Speed Measurement

Trainee Instructional Manual

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

Contents

Unit 1—Overview and Introduction

This opening unit introduces the topics to be covered during the Basic Training Program in RADAR Speed Measurement. The introduction describes the course's overall goal and lists specific training objectives. It also outlines the contents of subsequent chapters and indicates how they relate to the course's goal. After carefully reviewing this first unit, the reader should be able to:

- *Describe the course's objectives.*
- *Describe the course's technical scope and contents.*

This is the principal study guide and reference source for the Basic Training Program in RADAR Speed Measurement. This information will be expanded and supplemented by your instructor's presentations as well as classroom discussions, sample exercises, and hands-on practice sessions. Included with each unit are study topics, consisting of sample problems and questions about the unit's content and suggestions for reviewing the material covered. Your knowledge of the material and achievement of the unit's training objectives can be tested through the study topics.

This *Trainee Instructional Manual* is a basic reference, but it is not a complete text for the course. Some of the essential information for this training comes from State and local law enforcement agencies. This "local" information includes statutes and regulations concerning speed violations, policies and procedures affecting enforcement, and the specific role of RADAR devices in enforcement. Such information will be provided through lectures, handouts, and additional suggested reference sources.

It is expected that this Manual will be useful in three different ways. First, before the course is conducted, it will allow a preview of the contents, structure, and sequence of units. This should make it easier to follow the presentations and discussions and provide a solid preparation for a good learning experience. Second, while the course is underway, the Manual will be the principal source of the reference material required in class. It is **not** intended to be read along with the instructor in class, as it will not follow the classroom lectures and presentations. From time to time, though, your instructor may point to specific sections of material contained in the Manual. When the instructor gives a formal test of the knowledge and skill acquired, the Manual plus your class notes will help you prepare for that test. In order to be certified to use RADAR in actual speed enforcement, you will have to have a period of field practice. During that period, this Manual can be a useful reference, especially if any operational problems or unusual readings are encountered. Finally, when applying what has been learned in this course to RADAR speed enforcement, you may encounter instances where your memory will need refreshing. This Manual is suited to all of these needs.

Overall Course Goal

The goal of all police work is to protect the lives, property, safety, and well-being of the public. Traffic law enforcement is no exception. Generally, traffic laws arise from safety-related needs. Preventing accidents requires well-designed roads and vehicles and well-regulated driving behavior. If there were no traffic laws or traffic law enforcement, there would be no regulation of driving behavior. The result would probably be chaos, confusion, frequent accidents, and many injuries and deaths. In general, the most important traffic laws are those that regulate the most dangerous driving behaviors.

Vehicle speed laws belong to this "most important" class. Research shows that excessive speed is a major contributing factor to motor vehicle accidents. Further, excessive speed increases the severity of the accidents that do occur: A high-speed crash is much more likely to produce death or serious injury than a low-speed crash. Research also shows that vehicle speeds **can** be reduced and that thousands of American lives **can** be saved each year.

Where does RADAR fit into all this?

RADAR is an important and effective means of establishing vehicle speed. It is not the only means available, and it may not be the best means in certain cases, but it has numerous advantages that make it perhaps the most widely used method. In recent decades RADAR technology has been advanced significantly. Its cost-effectiveness has continued to improve as well. RADAR has made a major contribution to our speed enforcement capability.

The National Highway Traffic Safety Administration believes that police traffic RADAR is an effective enforcement tool. The role of police RADAR in traffic safety enforcement continues to be of critical importance, especially in view of the safety and fuel conservation benefits of the 55-mph speed limit. Police traffic RADAR provides a means of increasing enforcement effectiveness and permits police administrators to make better use of scarce personnel and increasingly costly fuel.

The overall goal of this training program is to improve the effectiveness of speed enforcement through the proper and efficient use of police traffic RADAR speed measurement instruments. It is hoped that every officer who completes this course will become a better enforcer of the traffic laws governing vehicle speed—that is, the officer will detect more speed violations, apprehend more violators, and secure more convictions.

Specific Training Objectives

This course is designed to help you, the police officer, become a more effective speed enforcer. The knowledge and skills needed to accomplish this not only relate to proper RADAR speed measurement, but also carry over into successful speed enforcement in general.

By the time this course is completed, you should be able to:

(1) Describe the association between excessive speed and accidents, deaths, and injuries as well as the highway safety benefits of effective speed control.

(It has already been stated that excessive speed can cause accidents. Knowing how excessive speed contributes to highway safety problems and how speed enforcement can effectively solve these problems will enable you to better understand your function in the overall traffic safety scheme.)

(2) Describe the basic principles of RADAR speed measurement.

(This course certainly won't make you an expert in electronics or physics. That kind of expertise is not necessary to operate police traffic RADAR. These basic principles are discussed only to give you an understanding of RADAR's strengths and weaknesses and the kinds of problems that can occur if it is not operated properly. People usually adhere to precribed procedures more faithfully if they know why those procedures are needed; this is certainly true of RADAR operators.)

(3) Demonstrate basic skills in testing and operating specific RADAR instrument(s).

("Practice makes perfect." RADAR instruments are fairly simple to operate, but practice is needed before an operator's skills become sharp enough to result in confident RADAR speed readings.)

(4) Identify the specific RADAR instrument(s) used by your agency and describe their major components and functions.

(Before a specific RADAR device is used, the operator must understand its specific control functions, characteristics, advantages, and limitations.)

(5) Identify and describe the laws, court rulings, regulations, policies, and procedures affecting RADAR speed measurement and speed enforcement in general.

(Laws cannot be enforced unless they are known. What constitutes a speed violation? What are the elements of the offense? What special rules of evidence apply to the offense? What special rules apply to RADAR evidence? Until these and similar questions can be answered, an officer is not ready to enforce speed laws or use RADAR instruments.)

(6) Demonstrate the ability to prepare and present records and courtroom testimony relating to RADAR speed measurement.

(The job doesn't end when a citation is issued. Evidence must be gathered and presented to support adjudication of the charge.)

At the end of the course, tests will be administered to determine how well the six objectives listed above have been reached. As the course progresses, try to keep them in mind to see how the various topics covered fit into the total learning experience.

Course Content

This course consists of a series of units that address the six objectives just discussed. The topics covered include:

- Speed offenses and speed enforcement. (Speed in relation to highway safety; types and benefits of speed regulation.)
- Basic principles of RADAR speed measurement. (Origin and history of RADAR; wave theory; the Doppler Principle; principles of stationary and moving RADAR; target identification considerations; factors affecting RADAR operation.)
- Legal and operational considerations. (Laws, court rulings, policies, etc., affecting

RADAR operations; instrument licensing, general operating procedures.)

- Operation of specific RADAR instruments. (Instrument components and their functions; operating procedures; operational demonstrations.)
- Moot Court. (Case preparation, testimony, and cross-examination.)

The content outlined above represents a complete course of training in RADAR speed enforcement. Some agencies may decide that some of this content has been adequately covered in other courses and thus may delete or deemphasize certain items. If used as "refresher" training for more experienced officers, parts also may be deleted. It will be up to the RADAR instructor to advise you of just what local adaptations have been made.

Some Final Words of Introduction

Before the actual training begins, some questions that have been asked recently by many motorists (as well as police officers and judges) must be considered. Just how good is RADAR? Is it really accurate? Can it be trusted? Or, as some have claimed, is RADAR liable to "clock" trees at 85 mph, houses at 28 mph, and law-abiding motorists at all kinds of false speeds? What are the facts?

One fact is that, more and more, RADAR instruments and the people who operate them are being challenged in court. One of the best-known recent challengers to RADAR occurred in Dade County, Florida, early in 1979. It resulted in the rejection of RADAR evidence in 80 pending speeding cases. Other attacks on RADAR will undoubtedly be made in the future. Does this mean that RADAR instruments are simply no good?

Quite the contrary: unbiased, scientific tests have consistently shown that the RADAR instruments used in traffic enforcement are reliable tools when properly installed and operated by skilled and knowledgeable operators.

The lack of proper operator training has been at the root of almost all the successful challenges to RADAR. The Dade County incident is a good case in point. Contrary to widespread belief, the Florida challenges did not prove that RADAR will "detect" 85-mph trees, 28-mph houses, or cars traveling much faster than they actually were. What they did show was that if certain basic operating procedures are violated those kinds of absurd speed measurements can **appear** to have been made. There is a logical and obvious explanation for each of the speed measurements that were cited in Dade County. Each of these absurdities is discussed and explained in this course.

Speed enforcement based on RADAR is not difficult to learn, but is complex enough that shortcuts in training can result in less than effective performance. The courts are aware of this, and many are now demanding evidence that the RADAR operator has had sufficient training and experience.

So, finally, just how good is RADAR? It is only as good as you, the operator, make it. If the specific training objectives cited in this course are met, you will be an effective police traffic RADAR operator.

Study Topics:

a. Become familiar with the course objectives.

b. Become familiar with the topics to be covered in later units.

c. Be prepared to answer the following questions:

1. What is the overall goal of this course?
2. What are the six specific training objectives of the course?
3. What are the ultimate purposes of speed enforcement?
4. If the courts do not expect or require that police officers be experts in RADAR technology, why does this course include training in RADAR's basic scientific principles?
5. If your proper basic concern is with speed enforcement, why does the course include training in preparing and presenting courtroom testimony?

Unit 2—Speed Offenses and Speed Enforcement

Excessive vehicle speed is a major cause of death and injury on our highways. Thus, the control of excessive speed has long been of paramount interest to traffic law enforcement. Effective regulation of vehicle speed requires first that police officers have a thorough knowledge of the various types of speed laws, as well as where and when they apply; next, that the officers enforce these statutes.

This unit will discuss the problem in general and the existing laws created to deal with that problem. By the completion of the unit, you are expected to be able to:

- *Describe the association between speed offenses and motor vehicle accidents and injuries.*
- *Describe the major types of speed regulations, including their origin, development, and scope.*
- *Describe the safety benefits of effective speed enforcement in general and enforcement of the 55-mph speed limit in particular.*

Speed in Society

Since the earliest days of the automobile, speed has been its most controversial feature. Historically, manufacturers have had little trouble in finding a ready market for fast cars. Concern over the public's fascination with speed was voiced by the Supreme Court of Pennsylvania as early as 1906. In affirming a conviction under a city ordinance for speeding over 7 mph, the Court 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.**
>
> *Brazier* v. *City of Philadelphia*, 215 Pa. 297, 64A. 508, 510 (1906)

This preoccupation with speed seems to be even more prevalent today, with our highly-mechanized society. People rush to work and rush to play. The automobile provides the means to maintain this harried existence. For some, it also serves as a means to relieve the tensions brought about by living at so rapid a pace. These individuals turn their automobiles into weapons—tools of aggression. This is not to say that most drivers are obsessed with speed. It is important, however, not to lose sight of the dangers inherent in high speeds. High speeds affect all three elements of driving:

a. **The operator**—Increased speeds tax the driver's basic capabilities, such as reaction time (the time required to respond to a situation).

b. **The vehicle**—Increased speeds also tax the automobile's capabilities (the brakes, steering, etc.).

c. **The roadway**—Increased speeds increase the potential hazards of any deficiencies in the road surface (potholes, construction, etc.) or situational conditions resulting from weather (ice, snow, rain).

High speed interacting with one or more of these elements can result in an accident. To grasp the dramatic impact excessive speed can have, let's examine a simple task, stopping a vehicle. This simple task incorporates the three elements above and is, therefore, greatly affected by increased speeds.

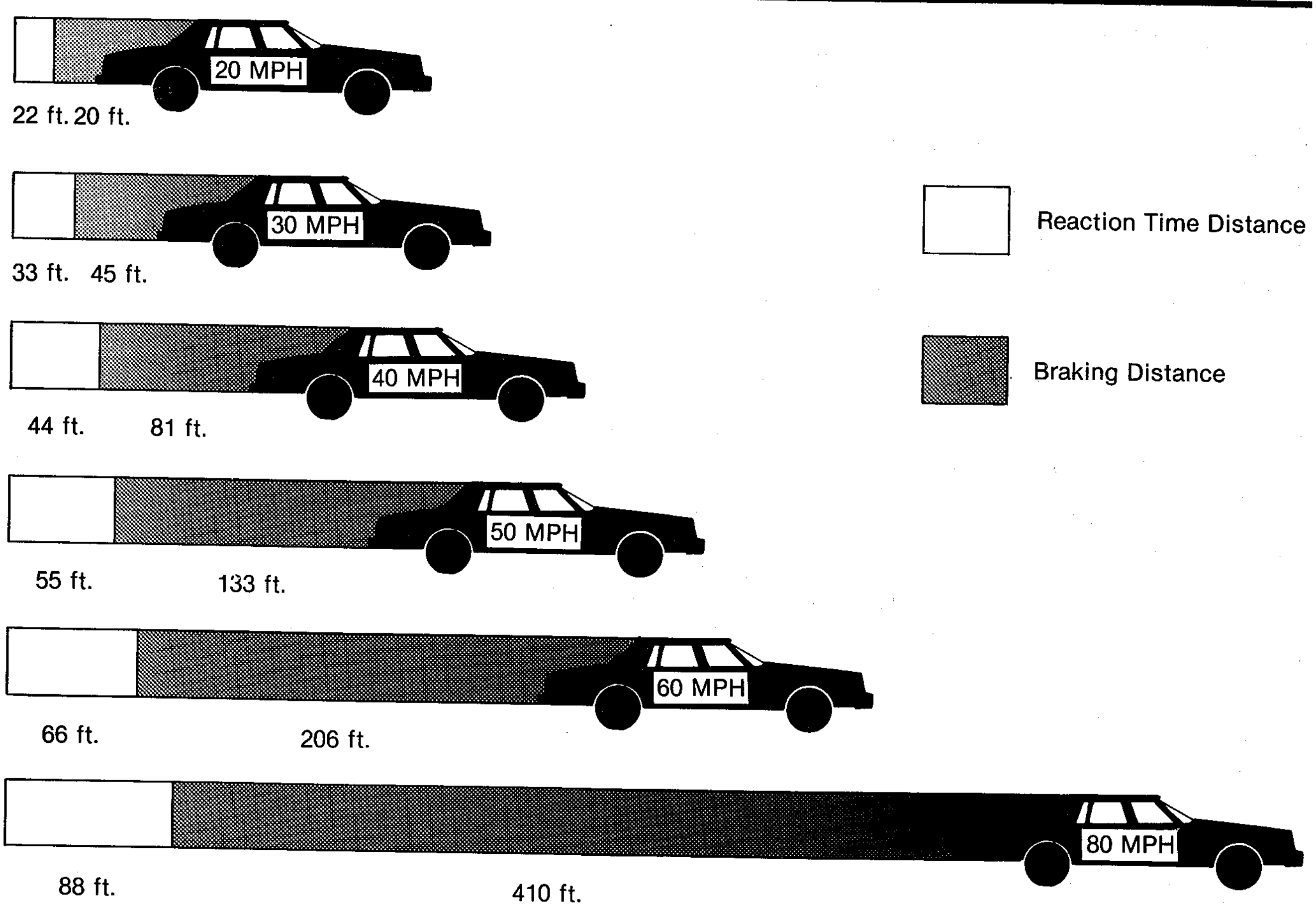
The average person has a reaction time of about three fourths of a second. Suppose our average motorist is proceeding along a typical road clear of any snow, ice, or other surface problems. Driving at about 20 mph, the motorist notices a hazard ahead and reacts normally. At 20 mph, the car moves 22 feet during this three-fourths of a second. Assuming that the automobile is in proper working order, an **additional** 20 feet of braking distance is required to bring the car to a complete stop. In total, it has taken the car 42 feet to stop.

Suppose the driver was proceeding at 40 mph. Reacting to a hazard within the same reaction time span, the car will have traveled 44 feet before the driver begins to brake. However, the braking distance is now 81 feet. (Remember, at 20 mph the braking distance was only 20 feet.) **The braking distance at 40 mph is not twice the distance required at 20 mph, but four times the distance.** Now a total of 125 feet is required to bring the vehicle to a halt.

Similarly, **the braking distance at 80 mph would not be four times the distance required at 20 mph, but more than 20 times the distance—410 feet.** The chart on the following page graphically illustrates the distance needed to stop a vehicle at speeds from 20 to 80 mph.

Remember, this example was based on an average driver with average reaction time, driving a car in good working order, under good road conditions. As speeds increase, a driver maintains less and less real control over the vehicle. Increased speeds tax the effectiveness of the driver's reaction time and the vehicle's stopping capabilities. Additionally, if there had been any deficiencies in our hypothetical driver's reaction time, (the condition of the car, or the condition of the roadway,) increased speed would have magnified those deficiencies.

Technical advances can increase an automobile's capabilities or improve the design of roadways to allow for greater and greater speeds. It is much more difficult to "redesign" or improve a driver's capabilities!



Distance required to bring vehicle to a complete stop.

A Short History of Speed Regulation

Various types of legislation to control speed have been introduced throughout our country's history. The primary purpose of this speed regulation has not been to restrict the flow of traffic, but to make traffic movement more efficient with minimum danger to people and property.

According to Joseph Nathan's *Famous Firsts,* the first traffic law in America was passed on June 12, 1652, by New Amsterdam (now New York), and prohibited the riding or driving of horses at a gallop within city limits. Hartford, Connecticut, lays claim to the distinction of having the first automobile speed regulation. This law was enacted in 1901 and limited automobile speeds to 12 mph in the country and 8 mph within city limits.

As the number of automobiles increased, so did the number of laws governing their use. This volume of statutes and ordinances was based on the assumption that no one should drive a vehicle at a speed greater than is reasonable and prudent under existing conditions. This assumption became known as the "basic speed law."

Enforcing the basic speed law involves procedures different from enforcing speed limits. Under the basic speed law, it must be shown that the violator's speed was unreasonable or imprudent given the existing conditions. This is not easy, since any basic speed law includes such ambiguous terms as:

- "Reasonable"—What is "reasonable"?
- "Prudent"—Just what is a "prudent" speed?
- "Under existing conditions"—This term can refer to the condition of the road (whether there are wet or slippery conditions), the condition of the vehicle (whether it is in proper working order), or the condition of the driver (is the person fatigued, intoxicated, etc.?).

Early efforts to enforce this somewhat ambiguous law resulted in some confusion. These enforcement efforts caused two major schools of thought regarding speed enforcement to emerge: those advocating "*prima facie*" speed limits and those advocating "absolute" speed limits.

Loosely translated, "*prima facie*" means "at first glance," or "in the absence of further proof." *Prima facie* speed limits are those stated as a specific rate and posted on the highway, e.g., "**Speed Limit 35 mph.**" However, the **basic** speed law is the one that has to be enforced and adjudicated. In other words, a speed limit is posted to tell the motorist what is considered a reasonable speed for that area. If a motorist exceeds this speed, the motorist is said to have violated the basic speed law "*prima facie.*"

However, speed in excess of the *prima facie* limit is only an **indication** that the speed was unreasonable and imprudent. The accused is entitled to produce evidence in court to show that the speed was reasonable and prudent for the conditions and circumstances at the time in question. A court or jury provides the final decision.

Proponents of this type of law insist that it permits greater flexibility in practice. Not every speed exceeding the stated limits should be considered dangerous. *Prima facie* limits are not arbitrary and it is contended that most drivers use good judgment and adjust their speed according to the conditions encountered.

"Absolute" speed limits are based on laws that simply prohibit driving faster than a specified speed, no matter what "the existing conditions." This school of thought insists that the basic speed law alone leaves too much room for individual interpretation by motorists—many of whom aren't reliable enough to make correct decisions as to reasonable speeds. It is also maintained that *prima facie* limits are practically unenforceable, since questions arise in almost every case as to the rate of speed in relation to environmental conditions and what a reasonable speed really is for those conditions. Driving in excess of that absolute limit, **regardless of conditions**, is a violation. The only proof required is that the motorist exceeded the limit; circumstances and conditions have no bearing on the driver's guilt or innocence.

Speed limits can include both maximum and minimum speed restrictions. Different limits can be set for different conditions, such as:

- Time of day—Speeds are sometimes lowered during night or rush hours;
- Type of roadway—Highway or urban routes can have different limits than roads in residential areas; and
- Type of vehicle or equipment—Lower maximums are often set for buses or trucks.

In the early versions of the *Uniform Vehicle Code, prima facie* limits were recommended, and a majority of States adopted *prima facie* speed provisions. Meanwhile, the absolute type of law fell into disfavor. In the 1950s more and more States began to adopt absolute limits and abandon the *prima facie* approach. In fact, the *1956 Uniform Vehicle Code* was revised to provide absolute maximum limits and all mention of *prima facie* was eliminated.

Current systems of speed control acknowledge that the speed control system must permit motorists to reach their destinations as rapidly as possible while giving all due consideration to safety, reason, and prudence. Rapid movement of vehicular traffic is essential to efficient highway transportation.

Elements of the Offense

Successful enforcement of speed regulations—whether *prima facie* limit, basic speed limit, or absolute speed limit—involves more than simply detecting and apprehending violators. Speeding, just as any other offense, can only be successfully prosecuted when certain specific elements of the offense stipulated in each statute are established. The elements of the speeding offense are driver identification, location, speed, and conditions. These elements are specified in general in Table 1. It should be noted that the elements of the different types of regulations are essentially the same, except for "speed," which is defined differently under each type of law. The "location" element in some jurisdictions may include only public highways and roads and in others, parking lots, public driveways, and private roads.

Table 1

Elements of the Speeding Offense

Elements	Absolute Speed Law	Basic Speed Law	Prima Facie
Driver Identification	Accused must be shown to have been the driver at time of the infraction.	(Same)	(Same)
Location	Any place to which the public has right of access for vehicular use.	(Same)	(Same)
Speed	In excess of specified limit.	Unreasonable or imprudent.	In excess of posted limit and thus presumed unreasonable or imprudent.
Conditions	(Not applicable)	Having regard to actual and potential hazards.	Same as Basic.

Driver Identification

There are two aspects to driver identification. The officer must be able to quickly identify the driver of the vehicle at the time of the initial stop and then later identify the same driver in court.

Upon making the initial stop, the officer should make an immediate visual identification of the driver. Other vehicle occupants may attempt to change places with the driver in an effort to confuse the investigation. An alert officer can counter these activities by initially noting driver characteristics such as clothing colors, hats, beards, or other distinguishing characteristics that can be observed at a quick glance. When the officer has completed this first identification of the driver, more specific details that will aid the officer in identifying the suspect in court.

Location

Establishing where the defendant's vehicle was being driven when the infraction occurred is usually not difficult. The officer's testimony that the violation was observed to have taken place on a certain street or highway is sufficient. If there is doubt as to whether the location of a particular roadway is considered public or private, look it up under State statutes or check with a supervisor. If the offense occurred off-highway and is included under your statute, the location can be defined by reference to permanent landmarks.

Speed

Establishing a defendant's speed has differing degrees of importance depending on which type of speed law covers the location of the infraction.

National Maximum Speed Law

As indicated in previous sections, safety officials have long been aware of the relationship between speed and safety. They have also been aware of the relationship between speed and fuel consumption. It took a national emergency in the form of an energy shortage to provide the impetus for lowering highway speeds nationwide. In the following sections, the reasons for adopting the national 55-mph maximum speed limit and its subsequent impact on motorist safety and fuel consumption will be discussed.

Relationship of the 55-mph Limit to Energy Conservation

With the 1973 oil embargo, States quickly began to take measures to conserve fuel. Since highway transportation accounts for about 44 percent of our gasoline consumption, Congress imposed a national 55-mph maximum speed limit in 1974. Fifty-five mph was chosen because it is the median energy-efficiency speed. This has been determined by studying factors of wind resistance and engine efficiency.

The energy required to move the mass of air before a moving motor vehicle is called "wind resistance." Wind resistance increases in geometric proportion to the velocity of the vehicle. In other words, the energy required to move an air mass at 65 mph is 40 percent greater than that required to move it at 55 mph, even though the velocity is increased only 18 percent. Thus, at 65 mph more energy is required, and therefore more fuel is needed, than at 55 mph.

When absolute limits are involved, an officer need only establish that an accurate measure of the defendant's speed was obtained and that the speed was in excess of the established absolute limit.

In the case of the basic speed law, the measurement of speed alone will not establish the element of "speed." Remember that the basic speed law states that it shall be unlawful to operate a motor vehicle at an unreasonable or imprudent speed. There are no clear definitions of just what an "unreasonable" speed is, so a measurement of speed is useless without some indication that the speed was excessive.

Prima facie limits suggest what speeds may be **presumed** to be excessive. The courts will ultimately decide whether a particular speed was unreasonable or imprudent. It is incumbent upon the officer to produce more detailed information to show the courts that the defendant's speed was excessive.

Conditions

In establishing that a defendant's speed was unreasonable or imprudent, the officer must gather information to show it was so **in light of existing conditions.** Such conditions include:

1. weather—rain, snow, sleet;
2. roadway characteristics—traffic volume, road surface conditions;
3. the vehicle—brakes, tires, or such vision obstructors as a dirty windshield.

(Obviously this type of information does not have to be established in cases involving absolute limits.)

While the relationship between speed and fuel economy is obvious for passenger cars, some truck and bus companies maintained that they would suffer with the 55-mph limit, claiming that trucks and buses operate more efficiently at 60 mph. Data from various studies disprove this assumption. Continental Trailways, a bus company that operates nationwide, showed a direct savings of about 1.2 million gallons of diesel fuel in 1976 as a result of reducing speed. Other studies by the Federal Government indicate that about a 2 percent fuel savings results for each mile per hour of truck/bus slowdown between 60 and 55 mph.

When the oil embargo ended on April 29, 1974, many drivers expected the 55-mph limit to be lifted. Instead, the temporary law became permanent. While it was impossible to determine the exact number of gallons of fuel saved as a result of the 55-mph limit (a conservative estimate is 3.6 billion gallons per year), another statistic became glaringly obvious: The number of traffic fatalities had been reduced.

Relationship Between Speed and Safety

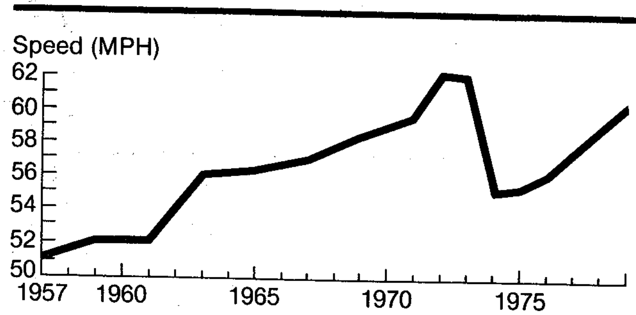
When the 55-mph speed limit was enacted, its sole purpose was to save fuel and help reduce our dependence on foreign fuel sources. At the end of 1974 a more important effect was noticed: There were 8,856 fewer fatalities than in 1973.

The first graph on the following page shows yearly increases in speeds, which reached a high point in 1973 and then dropped sharply after passage of 55-mph speed limit. The second graph shows yearly traffic fatalities. When compared, the two graphs appear almost identical. Wherever speeds have increased significantly, so have fatalities. Conversely, wherever speeds decreased, so did fatalities. In fact, in 1974, the first year of the 55-mph speed limit, traffic fatalities decreased 16.8 percent — the largest annual absolute reduction since 1942.*

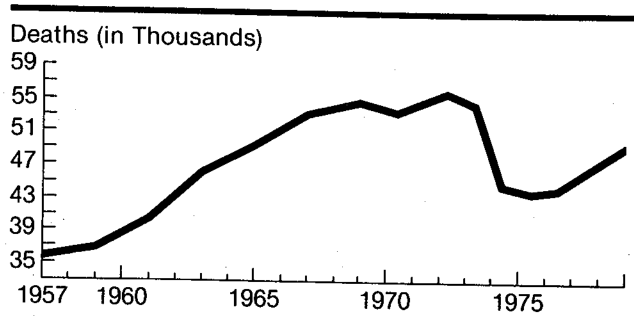
One might, at first, argue that the dramatic reduction in fatalities in 1974 were simply a result of a reduction in travel during the fuel shortage—the less time in traffic, the less chance of being in a traffic accident. This argument can be refuted with one look at the "fatality rate." The fatality rate measures the number of fatalities reported against the number of miles actually traveled (fatalities per 100 million miles). Since the early 1970s, the fatality rate had been declining by about three percent a year because of better engineering and such other

* "Absolute" indicates the **total** number of fatalities reported.

safety factors as increased use of seat belts. However, the fatality rate plunged from 4.2 in 1973 to 3.6 in 1974. This represented a very significant decrease of 14 percent! Obviously, reduced speed has saved lives.



Average Free Moving Vehicle Speed on Main Rural Roads in the U.S. 1957-1979.



Reported Motor Vehicle Deaths in the U.S. 1957-1978.

* Data based on *55 MPH Fact Book*, U.S. Dept. of Transportation, Sept. 1979.

Not only has the 55-mph speed limit reduced the number of fatalities, it has also reduced the number of significant injuries. The reported number of spinal cord injuries caused by auto accidents has dropped as much as 60 to 70 percent in some parts of the country. In all, disabling injuries resulting from traffic accidents dropped 10 percent after 1973, when two million people were severely injured.

That speed has such a tremendous effect on fatality and accident severity rates should come as no great surprise. As we discussed earlier, increased speeds tax the operating limitations of both vehicle and driver. Speeding increases the stress on tires, steering, and braking systems. It also stresses a driver's physical limitations, such as vision and reaction time. Moreover, when crashes occur, the higher the speed the greater the structural damage to the auto will be and the more tragic the consequences for the occupants. The probability of a fatality in a crash roughly **doubles** as traveling speed increases from 45 to 60 mph, and **doubles** again at 70 mph.

Why Not Raise the Speed Limit to 60 mph?

Fifty-five mph has been proven to be a relatively safe and economical speed. Higher speeds, such as 70 and 80 mph, are considerably more dangerous. But what about 60 mph? Can a 5-mph increase in speed have that great an impact on accident and fatality rates? And aren't most people driving at 60 mph anyway?

One study that clearly demonstrates the possible effects of raising the national speed limit was conducted by the National Highway Traffic Safety Administration (NHTSA) in 1977. The study estimated the increase in the number of motor vehicle accidents, injuries, and fatalities that would result from an increase in the national speed limit to 60 mph. NHTSA determined that raising the speed limit would have a relatively small effect on the number of accidents and injuries (approximately 1 percent and 2 percent, respectively)—but it would raise **fatalities** 9 percent. In other words, a 5-mph increase in speed limit would not significantly change the frequency with which accidents happen, but rather the severity of these accidents.

The projected 9-percent fatality increase mentioned above translates into about 3,500 lives. In effect, raising the speed limit to 60 mph could offset most of the safety benefits achieved by the 55 mph speed limit.

Speed Limit Compliance

Passage of the 55-mph speed limit in 1974 had an immediate and dramatic impact on U.S. driving patterns. Looking at the years following 1974, it is also obvious that after two successful years of speed reduction, average driving speeds began to creep up again. The average highway speeds per State for 1977, 1978, and 1979 are listed in Table 2 these data reflect traffic on roads with a speed limit of 55-mph.

Looking at Table 2, it is clear that many motorists are violating the 55-mph speed limit. Further, it indicates that:

- Average speeds by State ranged from 51.0 to 58.7 mph during 1979. Only 15 States encountered average speeds of 55 mph or below; 35 States averaged speeds of 55 mph or more.

Table 2

Average Highway Speeds for 1977, 1978, and 1979, by State

US Department of Transportation
Federal Highway Administration

Comparison of selected free-flow traffic data from the 1979 55 MPH NMSL Enforcement Certification, with values from previous year certifications.

State	Percent Exceeding 55 MPH			Average Speed (MPH)		
	1979 (1)	1978	1977	1979	1978	1977
Alabama	56	59	58	55.8	56.1	56.2
Alaska	39	38	40	53.8	53.7	53.8
Arizona	66*	67	68	57.9	58.2	58.1
Arkansas	50	55	51	55.4	56.1	55.5
California	55*	56	52	55.8*	56.0	55.3
Colorado	43	41	41	54.6	54.3	54.0
Connecticut	61	68	74	56.9	58.1	59.3
Delaware	58	62	62	56.1	56.7	56.7
Florida	57	57	58	55.7	56.4	56.6
Georgia	55*	62	60	57.3*	58.7	57.4
Hawaii	41	32	34	53.4	52.3	52.6
Idaho	39	47	44	54.5	55.5	55.1
Illinois	44	56	59	54.6	56.7	56.6
Indiana	64	69	65	57.2	57.9	57.5
Iowa	61	62	61	56.7	56.8	56.5
Kansas	65*	72	65	57.3*	58.1	57.5
Kentucky	32	33	40	52.5	52.9	53.4
Louisiana	40	42	38	54.4	55.0	54.1
Maine	46	63	70	55.0	57.4	58.5
Maryland	44	55	52	54.7	56.1	55.9
Massachusetts	53*	52	58	55.8*	55.9	56.6
Michigan	56	55	57	56.1	56.0	56.1
Minnesota	60	59	56	56.6	56.6	56.2
Mississippi	56	65	59	56.6	58.0	57.5
Missouri	65	71	77	57.4	58.0	57.7

(1) These figures are for trend comparison only and will differ from the official certification figures for percent exceeding 55. They reflect "free-flow" base data rather than "all traffic" base data now required by 23 USC 154. In those cases where free-flow data were not included with the annual certifications, an average of the quarterly values for FY 79 was used.

*Indicates a quarterly average based figure.

(Extracted from Federal Highway Administration Summary Information for FY 1979)

Table 2 (Continued)

Average Highway Speeds for 1977, 1978, and 1979, by State

State	Percent Exceeding 55 MPH			Average Speed (MPH)		
	1979 (1)	1978	1977	1979	1978	1977
Montana	52*	62	57	56.0	57.4	56.6
Nebraska	61	63	59	56.7	56.9	56.5
Nevada	62	64	64	57.7	57.7	57.4
New Hampshire	42	53	45	55.0	56.5	55.4
New Jersey	52	51	52	55.6	55.5	54.0
New Mexico	64	64	62	57.9	57.7	57.6
New York	41	43	42	53.4	53.7	52.7
North Carolina	55	56	61	55.7	55.8	56.3
North Dakota	57*	62	66	55.7*	56.8	58.2
Ohio	65	62	58	56.9	56.7	56.0
Oklahoma	51	61	63	55.0	56.9	57.5
Oregon	52	54	53	55.7	56.0	55.6
Pennsylvania	48	50	47	54.3	54.9	54.7
Rhode Island	57	58	49	56.3	56.4	54.7
South Carolina	49	67	58	54.6	57.2	56.1
South Dakota	55	55	64	56.7	56.6	57.2
Tennessee	49	53	58	54.7	54.8	55.4
Texas	72	77	71	58.7	59.7	58.5
Utah	62	63	62	56.4	56.7	56.5
Vermont	64	73	66	57.2	58.4	58.1
Virginia	28*	30	28	51.1*	51.4	50.6
Washington	56	61	62	56.2	56.7	56.8
West Virginia	55	54	55	55.5	55.4	55.7
Wisconsin	54	54	57	55.2	55.3	55.7
Wyoming	67*	74	77	58.5	58.7	59.3
District of Columbia	—	—	—	—	—	—
Puerto Rico	27	32	29	51.0	51.7	51.2

(1) These figures are for trend comparison only and will differ from the official certification figures for percent exceeding 55. They reflect "free-flow" base data rather than "all traffic" base data now required by 23 USC 154. In those cases where free-flow data were not included with the annual certifications, an average of the quarterly values for FY 79 was used.

*Indicates a quarterly average based figure.

(Extracted from Federal Highway Administration Summary Information for FY 1979)

- Between 27 and 72 percent of the drivers in each State exceeded the 55-mph limit in 1979.

The goal of the 55-mph program is to achieve voluntary compliance with the law. It is fairly obvious from the above figures that (with the exception of 1974) this has not been the case.

The strange thing is that public support of the 55-mph program is still high even as fewer and fewer people adhere to it. A Gallup Poll taken in February 1979 indicates that 71 percent of the population still favors keeping the 55-mph limit. Though this represents a slight decline in the percentage of persons supporting 55 mph from earlier polls, 71 percent still represents a large majority. Further, when asked specifically about changing the law to raise the present speed limit to 65 mph, only 34 percent of those polled favored such a move. The majority (62 percent) were opposed.

Given the support indicated by these surveys, it is difficult to determine why there is a growing disregard for the 55-mph limit. Three possible explanations might be:

- **Seeing other motorists speeding.** A motorist on the highway sees everyone else exceeding the speed limit and getting away with it, and figures, "Why shouldn't I?"
- **Skepticism over the energy crisis.** Many people seem to have little faith in the reports and announcements made by the major oil companies, feeling that there really isn't any fuel shortage.
- **It only applies to someone else.** Many drivers seem to feel laws and speed limits are more for other drivers, who "just can't drive as well as I can."

Whatever the explanation for the noncompliance occurring on our highways, it is clear that there is at least the potential for voluntary cooperation. One key to increased cooperation lies with law enforcement. Motorists must simply be reminded that the laws are there and will be enforced.

State vs. Local Speed Enforcement

The preceding discussion has emphasized the national maximum speed limit of 55-mph—which, of course, applies essentially to the interstate highway system and to major State highways. Does the enforcement of local speed limits (State, county, or municipal) have a benefit comparable to that realized from enforcement of the highway speed limits? The answer is an unqualified "yes."

At any speed, the factors discussed earlier—driver reaction time, total stopping time, the severity of an accident, the likelihood of a fatal accident, and fuel usage—are operative. The faster a car is driven, the greater the impact of each of these factors. As we discussed earlier, the change is geometric. The changes in these factors between say, 30 mph and 40 mph, are not as dramatic as the changes between 55 mph and 65 mph. Nevertheless, they are significant. Effective speed enforcement will help reduce both the frequency of accidents and their severity.

Perhaps the most important reason for stressing enforcement of lower speed limits is simply that a very substantial number of fatal accidents occur in low-speed-limit zones as indicated in the following table:

Table 3. **Percent of Fatal Accidents by Type of Roadway (1978)**

Interstate	Other U.S. Route	Other State Route	County Road	Local Street	Other
8.8	16.0	32.4	15.9	19.7	7.2

The last three locations (county, local, other) together account for over 42 percent of all fatalities. That fact alone argues eloquently for improved effectiveness of local speed enforcement.

Study Topics:

a. Review the statute(s) governing vehicle speed along a typical patrol route. Which statute(s) govern speed there?

b. Be prepared to answer the following questions:

1. Distinguish between *prima facie* speed limits, the basic speed law, and absolute speed laws.
2. What are the elements of a speeding offense?
3. Since many drivers now exceed the 55-mph speed limit, why not raise the maximum speed to 60 mph?
4. What was the original reason for the 55-mph limit?
5. What would be an appropriate response to this statement: "Local speed limits are so low that enforcing them isn't really worthwhile."

Unit 3—Basic Principles of RADAR Speed Measurement

This unit deals with one of the principal tools of law enforcement in the detection of speeders: police traffic RADAR. It will present the basic operating principles of present-day police traffic RADAR. By being acquainted with these principles, the enforcement potential of these devices can be maximized and factors that can affect their accuracy can be recognized and avoided.

On completing this unit, you will be expected to:

- *Explain RADAR and describe the origin and history of RADAR equipment.*
- *Explain what is meant by frequency and wavelength of a RADAR signal and describe the relationship between frequency, wavelength, and RADAR signal speed.*
- *Explain the Doppler Principle by describing how a RADAR signal is changed by reflection off a moving object.*
- *Describe the basic operation of a stationary RADAR instrument.*
- *Describe the basic operation of a moving RADAR instrument.*
- *Describe the factors that can affect RADAR's accuracy and effectiveness.*

NOTE: *Some of the terms and technical descriptions contained in this unit have been simplified to aid student understanding.*

Fundamental Concept

The word "RADAR" is an abbreviation of the phrase RAdio Detection And Ranging. This acronym implies that all RADARs are capable of finding a target (detection) and calculating its distance (range). The acronym, as defined, does not exactly fit the description of police traffic RADARs. Police traffic RADARs can provide a speed reading on a detected target, but they cannot measure the range to the target.

Actually, the inventors of RADAR did not make a mistake in their acronym. The concept of "ranging" is correct for about 90 percent of the RADARs in use today. It is police traffic RADAR that is in the 10 percent of RADARs that provides no range information.

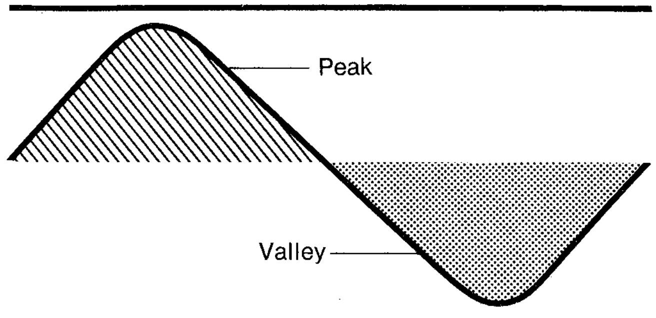
It is important to recognize that many types of RADARs exist. Some are complex, while others, like the police unit, are simpler. Even though there are many variations and different features among types and families of RADARs, the underlying principle remains the same: Radio-frequency energy is generated by a transmitter; an antenna forms the energy into a beam; and the beam is transmitted into space. When the energy, or signal, 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 detected. This is how the RADAR operator learns that a target is present in the beam.

The way that the energy reflected from the target is processed by the receiver determines what information will be available to the operator. If the RADAR is to compute range to the target, timing circuits in the set will time the round-trip travel period of the signal—starting at the time the signal is transmitted and ending when the receiver detects the reflected signal. Timing circuits are made possible by the fact that radio energy always travels at 186,000 miles per second—the speed of light. The speed of radio energy is, therefore, a constant in all computations performed in any RADAR set.

Police traffic RADARs use another characteristic of radio energy to measure speed. A radio signal's frequency (waves per second) is changed when the signal is reflected from a target that is moving at a speed different from that of the RADAR set. This change or shift in frequency is known as the Doppler shift and will be explained in more detail later.

The Wave Concept

To examine how reflected radio signals are changed by relative motion requires an understanding of their wave nature. Everyone is familiar with waves occurring in water: Each water wave consists of a peak and a valley, as shown in the illustration below:



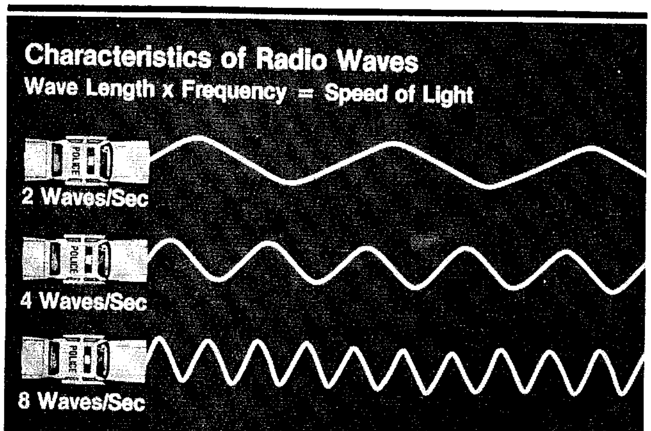
Waves can also be observed on a tightly held string or rope. If one end of the rope is tied to a pole and the other is given a sharp upward snap, a wave will travel down the rope toward the pole: a distinct peak followed by a distinct valley. If the rope is snapped steadily, a regular stream of waves—a continuing series of peaks and valleys—will be generated.

Sound, light, and radio energy can each be described as a distinctive form of wave. Each police traffic RADAR device transmits a continuous series of radio waves, which have three characteristics:

- *The signal speed—constant.*
  All RADAR signals travel at the speed of light. This is equivalent to 186,000 miles per second, or 30 billion centimeters per second. Both transmitted and received RADAR signals always travel at that speed.
- *The wavelength—variable.*
  The distance from the beginning of the peak to the end of the valley of a wave may vary.
- *The frequency—variable.*
  The number of waves transmitted in one second of time may vary.

Frequency is usually measured in cycles per second. A cycle is the same as a wave. Scientists and engineers often use the term hertz (abbreviated Hz) instead of cycles per second. All these terms have the same meaning: One hertz equals one cycle per second, which is the same as one wave per second. "Waves per second" will be the term most often used, since this will help you keep in mind the wave nature of RADAR signals.

Because the speed of radio waves is constant at 186,000 miles per second, wavelength and frequency have an inverse relationship. As the number of radio waves transmitted each second (frequency) increases, the length of the waves (wavelength) must decrease. The reverse is also true. If frequency decreases, wavelength must increase.



There is an inverse relationship between wavelength and frequency.

Theoretically, if a radio were to transmit only one wave per second, the length of that wave would have to be 186,000 miles. Conversely, a radio transmitting 186,000 waves per second would produce a wavelength of one mile. It is obvious then that any given radio frequency must be associated with a specific wavelength.

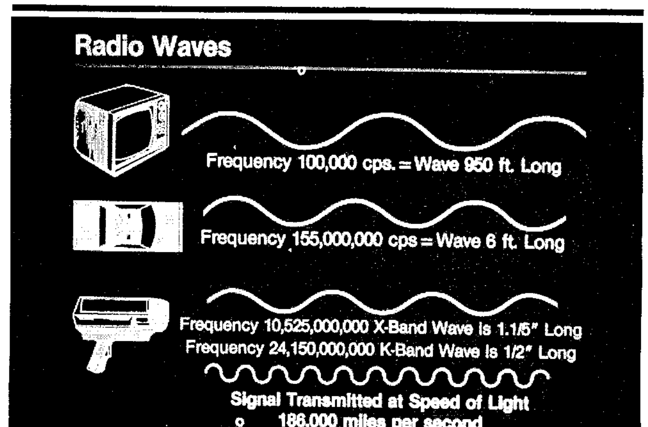
Police Traffic RADAR Assigned Frequencies

Police traffic RADAR devices operate in the microwave frequency band; they transmit billions of waves per second. The wavelength involved is therefore very short (hence microwave). Almost all police traffic RADARs operate on one of two Federal Communications Commission (FCC) assigned frequencies.

Currently most RADARs operate within the so-called **X-band**, at a frequency of approximately 10.525 billion waves per second, or 10.525 gigahertz (giga=billion). This RADAR signal has a wavelength of approximately three centimeters or about 1⅕ inches.

Similarly, so-called **K-band** RADARs operate at a frequency of 24.15 billion waves per second (24.15 gigahertz). The wavelength is approximately 1¼ centimeters, or about half an inch.

In either case, the frequency times the wavelength **always** equals the speed of light (186,000 miles per second). This relationship exists for **all** radio signals and is fundamental to understanding how the Doppler Principle is used to obtain a valid speed measurement.



RADAR wavelengths are much shorter than most kinds of radio waves and the frequency much higher.

The Doppler Principle

Christian Johann Doppler, an Austrian physicist, is credited with having discovered that relative motion causes a signal's frequency to change. We now honor his memory by referring to this basic scientific fact as the **Doppler Principle**. Doppler actually studied sound waves but it was later found that the principle applies to all wave energy, including light waves and radio waves.

Almost everyone has had the opportunity to hear how the Doppler Principle affects sound waves. An observer standing by the side of a railroad track will notice that an approaching train makes a *high-pitched* sound. (Pitch is another word for frequency.) As the train passes the observer, an immediate drop in pitch occurs. The frequency of the wavelengths that carry the train's sound has changed because the train's motion, relative to the observer, has changed. The same thing can be heard alongside a road listening to the sounds of passing cars and trucks.

The Doppler Principle can be expressed as follows:

- 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.
- If the relative motion brings the objects closer together, the frequency will be increased.
- If the relative motion takes the objects farther apart, the frequency will be decreased.
- How much the frequency is increased or decreased is determined by the exact speed of the relative motion.

What is most important about the Doppler Principle is that the frequency change happens only when there is *relative motion* between the objects. If both objects are standing still, there is no relative motion, and the received signal has the same frequency as the transmitted signal. There is also no relative motion between two objects if they are moving in the same direction at the same speed. Relative motion requires that the distance between the transmission source and the receiver of the wave energy must be changing in some way.

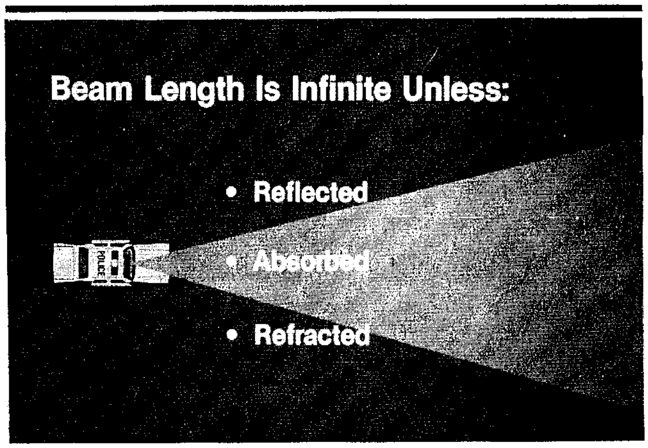
Relative motion will occur:

- If the object receiving the energy stands still and the transmission source moves.
- If the transmission source stands still and the object receiving the energy moves.
- Or, if both the transmission source and the object receiving the energy move, as long as they do so at different speeds or in different directions (so that the distance between them changes).

In each case, the Doppler Principle says that the transmitted signal, as perceived by the receiver, will have a different frequency. Police traffic RADAR merely measures this change in frequency and converts it to a speed reading. In order to operate police traffic RADAR, you don't need a complete understanding of how or why the Doppler Principle works. It is enough for you to be aware that there is a valid scientific basis for RADAR speed measurement.

The RADAR Beam

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 get farther away from or off to the side of the main beam.



The length of a RADAR beam is infinite unless reflected, absorbed, or refracted by an object in its path.

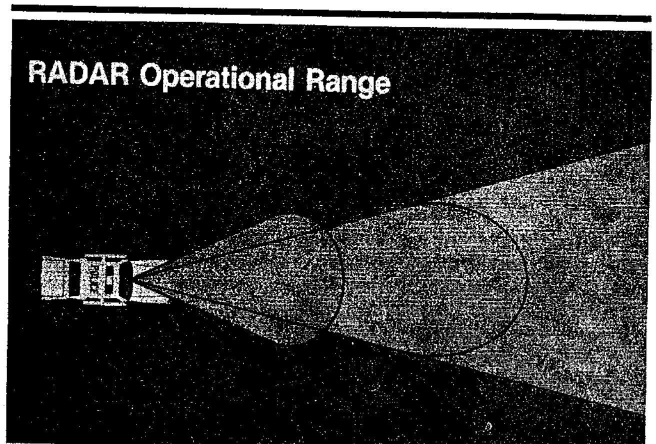
Once transmitted, the length of the beam is infinite unless it is **reflected, absorbed,** or **refracted** by some object in its path. The typical objects from which the beam is reflected are made of metal, concrete, or stone. The beam is largely absorbed by grass, dirt, and leaves, with little energy being reflected back to the antenna.

The term **refraction** refers to the radio waves that may pass completely through some substances and continue on infinitely. As they do, though, their direction or velocity may be changed slightly. Almost all forms of glass and many plastics will refract the RADAR beam. (An example of light waves being refracted can be seen when a straight object that's been put partway into water appears suddenly to be bent.)

RADAR Range

The range, or maximum distance, at which a reflected signal can be interpreted by the RADAR is dependent on the sensitivity of the antenna receiver. In other words, the RADAR antenna will not respond to every signal it receives. It can only respond to those signals that are strong enough to be recognized.

If a RADAR beam's operational range could be seen, it might take on the appearance of an elongated cigar. While this cigar shape is not the entire transmission of RADAR energy, it does represent that area of the beam from which usable reflections back to the antenna can normally be achieved. Most police traffic RADAR now in use is capable of receiving and displaying reflected signals from targets more than half a mile away. Under some conditions, this distance may extend to well over a mile.

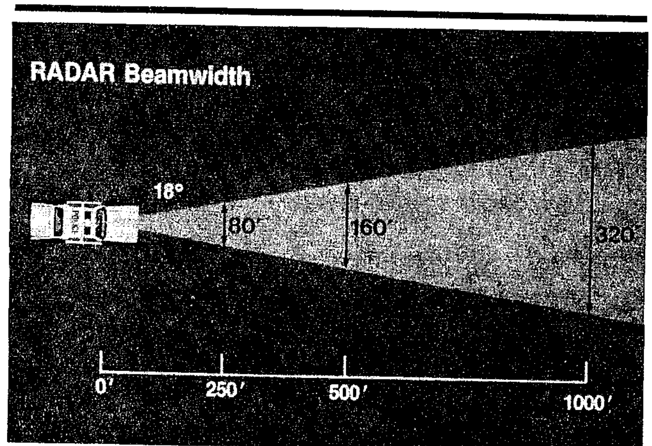


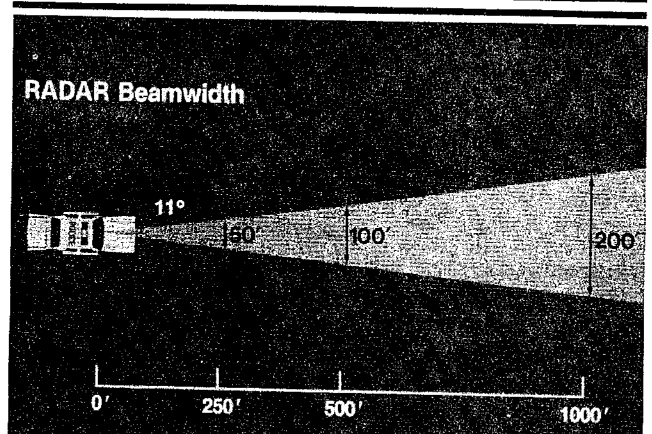
The operational area, or "range," of a RADAR beam normally exceeds one-half mile.

Located close to the antenna are much smaller cone-shaped beams. These beams, or side lobes, are a byproduct of the RADAR antenna and are so reduced in power that they normally don't affect RADAR operation.

RADAR Beam Width

The initial angle of the emitted RADAR beam will determine the relative beam width. This initial angle may vary from 11° to over 18° depending on the manufacturer. For example, a beam emitted at an 18° angle will be approximately 80 feet wide at a distance of 250 feet from the source; 160 feet wide at a distance of 500 feet; and 320 feet wide at a distance of 1,000 feet. Even with a device that emits a beam with a relatively narrow angle of 11°, the beam width would be approximately 50 feet at a distance of 250 feet; approximately 100 feet wide at a distance of 500 feet; and approximately 200 feet wide at a distance of 1,000 feet.





Standard RADAR beam widths vary from about 11° to about 18°. No police traffic RADAR is lane selective.

This makes it impossible for RADAR to select or focus in on one particular traffic vehicle at any significant distance. **It is vital that the operator understand 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 RADAR's operational range. Other criteria must be used to determine which vehicle's speed the RADAR is displaying. These criteria will be discussed in the target identification section of this Manual.

The operator, it is also vital to note, does not have to know the beam width of the RADAR wherever it is being aimed. The beam width at any **significant** distance is much wider than the roadway being focused on. In other words, the operator must acknowledge that lane selection is virtually non-existent with current RADAR devices.

All of the transmitted energy is not contained within a specific designated beam width. A small amount may be emitted at a much greater angle. The operator should not be alarmed when a vehicle's speed is displayed from an approach angle in excess of the prescribed beam width. This will occur most often when a single vehicle is approaching the RADAR. Because the beam's strength decreases dramatically outside its main area, vehicles within the main beam normally will be displayed by the RADAR over vehicles outside of it.

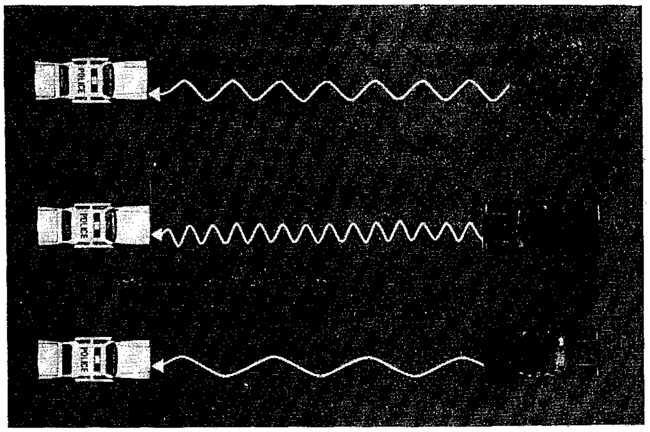
Principles of Stationary RADAR

Stationary RADAR operation, like all police traffic RADAR, is based on the Doppler Principle. Remember, the Doppler Principle involves a transmission source (for example, a train) and a wave-energy receiver (for example, a human observer), one or both of which are moving.

To relate the Doppler Principle to police traffic RADAR, the theory must be modified to include a transmission source that is also a receiver (e.g., RADAR antenna) and an object that can **reflect** the transmitted radio waves back to the transmission source (e.g., a target vehicle), one or both of which are moving.

Radio waves transmitted from a stationary RADAR antenna striking a motionless object will reflect off that object back to the transmission source at the same frequency and wavelength as those transmitted. There is no relative motion by the object to produce a Doppler shift in frequency. If the object is in motion toward or away from the RADAR source, the Doppler Principle comes into effect.

If the object is moving toward the RADAR source, the reflected waves will be shortened in wavelength and therefore the frequency of the waves will be increased. If the object is moving away, the reflected RADAR waves will be lengthened and the frequency of the waves will decrease. It is this change in frequency—produced by the object's motion, or Doppler shift—that the RADAR measures against the original transmission frequency to arrive at the object's speed.



Moving objects in the path of RADAR will change the frequency and wavelengths of signals reflected from them.

As previously stated, X-band and K-band are the primary frequencies used today for police traffic RADAR. With the X-band frequency, an increase or decrease of 31.4 waves per second, or Hertz, is equal to 1 mph in speed for a target vehicle. Therefore, a shift of 314 hertz exists for each 10 mph and 3,140 hertz for each 100 mph. For the K-band frequency, an increase or decrease of about 72 waves per second, or hertz, is equal to a 1-mph change in speed.

Doppler Shift

72 waves/sec.	1 mph	31.4 waves/sec.
720 waves/sec.	10 mph	314 waves/sec.
7200 waves/sec.	100 mph	3140 waves/sec.

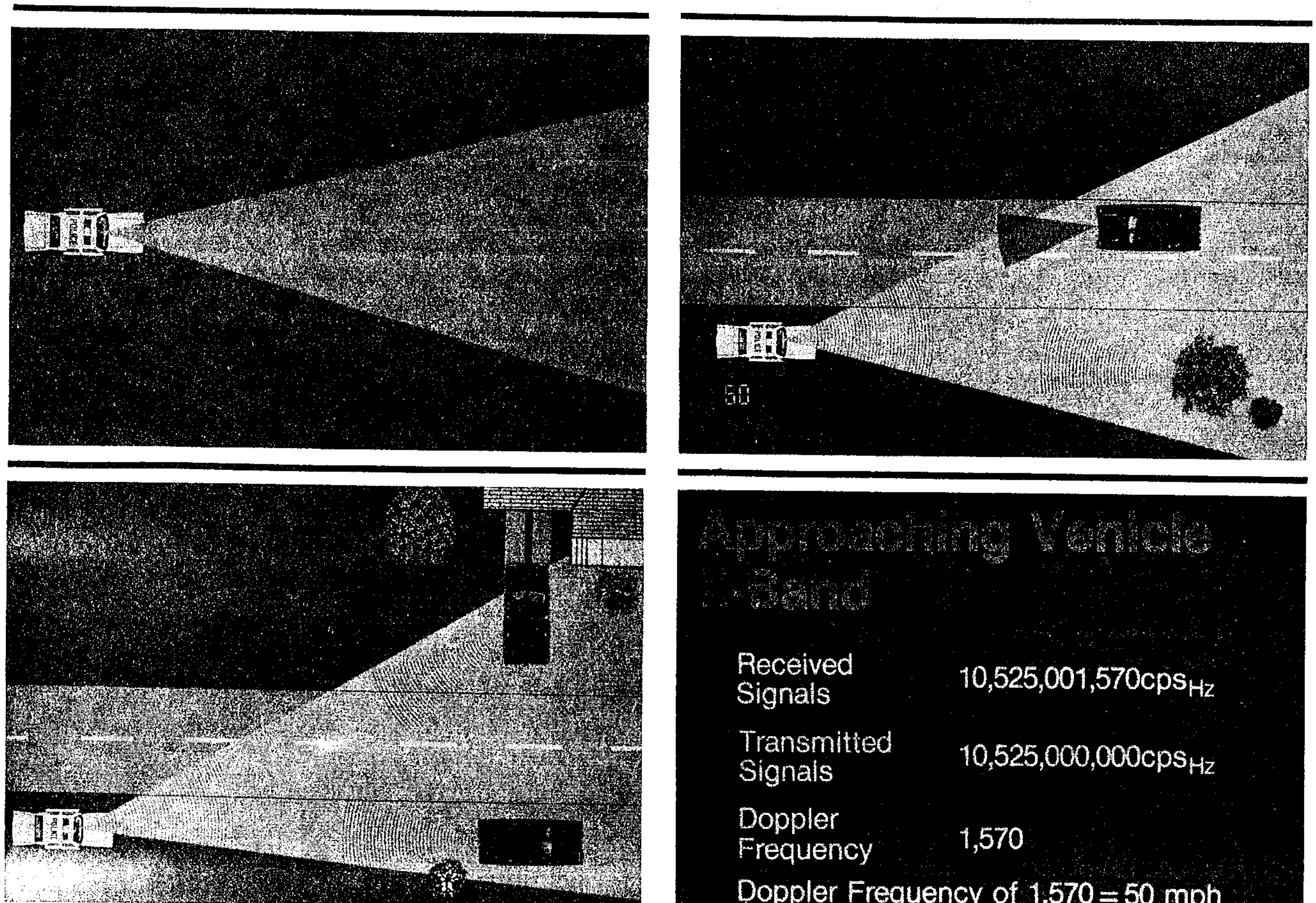
The number of waves-per-second for each mile-per-hour change in speed is a constant.

These changes in frequency produced by a moving vehicle are very small compared with the original transmitted frequencies, which consist of billions of waves per second. Nevertheless, RADAR is sensitive to these small changes and automatically computes them many times each second. In the case of stationary RADAR, the following examples characterize this process.

Example 1. A stationary RADAR beam is transmitted into empty space with no object in its path. It will continue on forever without being reflected back to the antenna. There will, of course, be no reading obtained.

Example 2. A stationary RADAR beam is transmitted down a roadway around which there are a number of large stationary objects—parked vehicles, trees, and the roadway itself. Because these objects are reflective, a small portion of the original transmission beam will be bounced back to the antenna. Since none of the objects are moving, the same frequency that was transmitted will be returned to the antenna. Since there is no change in frequency, there will be no reading displayed on the RADAR.

Example 3. A stationary RADAR beam is transmitted down the same roadway on which there is a moving vehicle. If the vehicle is **approaching** at a relative speed of 50 mph, the **increase** in frequency due to the Doppler shift would be received by the antenna and converted by the counting unit to exhibit the speed of 50 mph on the RADAR. The same would apply if the target is **moving away** from the stationary RADAR. In that case, though, the RADAR would receive a **decrease** in frequency equal to 50 mph. Computations made by the RADAR unit are show below.



Although the change produced by the Doppler shift is very small as compared to the transmitted frequency, it is still measurable.

These examples describe how stationary RADAR functions. When applying the Doppler Principle to police traffic RADAR, remember that the transmitted and reflected signals are compared to determine only the relative motion of the target vehicle to the antenna. Doppler RADAR cannot tell the operator whether the target, the RADAR unit, or both are moving. All that can be determined is how fast they are moving **relative to one another.** The RADAR instrument cannot tell whether the target is getting closer or farther away but only how fast the distance between them is changing.

A stationary RADAR in a moving patrol car will, therefore, display the relative speed of the patrol car to the stationary terrain, or in other words, the patrol car's own speed and if a target vehicle approaches, display the relative (or closing) speed of the two vehicles.

Stationary RADAR Angular (Cosine) Effect

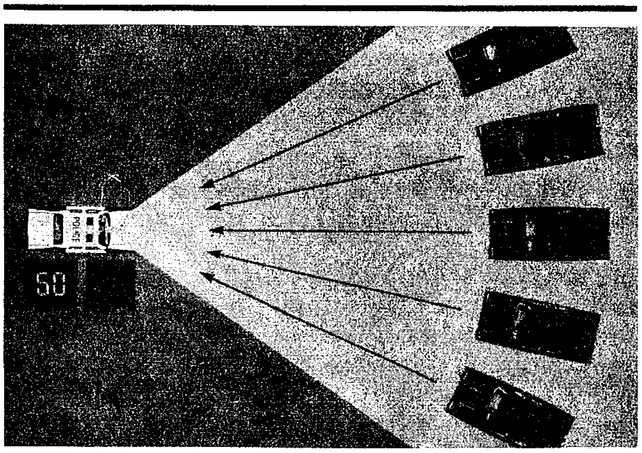
If a target vehicle is moving directly toward or away from the RADAR, the relative motion as measured by the RADAR should be equal to the target vehicle's true speed. Very often, however, this is not the case. For safety reasons, a stationary RADAR is usually set up a short distance from the travelled portion of the road. Therefore, cars travelling along the roadway will not be heading directly toward or away from the stationary RADAR—in other words, some angle between the car's direction of travel and the RADAR's position is created.

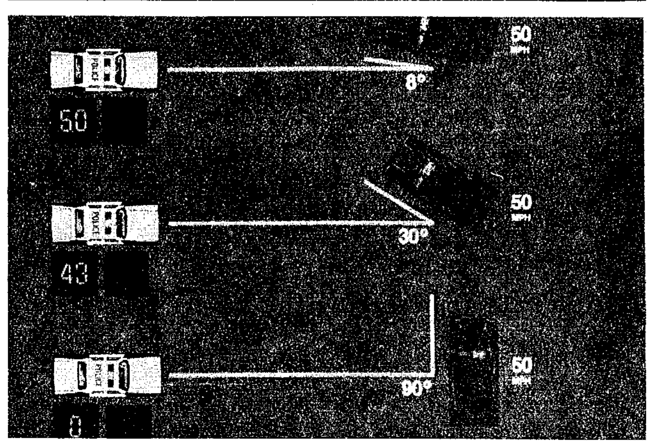
When a target vehicle's direction of travel creates a significant angle with the position of the stationary RADAR, the relative speed will be less than the true speed. Since the change in the signal's frequency is based on the relative speed, the RADAR speed measurement may be less than the car's true speed. This is known as the angular, or cosine, effect. (Cosine is a trigonometric function related to this principle.)

The difference between the measured and true speeds depends upon the angle between the object's motion and the RADAR's position: The larger the angle, the lower the measured speed. This effect **always** works to the motorist's advantage when the RADAR is **stationary.**

Loosely speaking, the angular effect is not significant as long as the angle itself remains small. Table 4 indicates how a stationary RADAR speed measurement can differ from true speed as a function of angle.

As can be seen in this table, the angular effect does not become a factor until the angle reaches about 10°. When a target vehicle passes by at a 90° angle, the RADAR is unable to perceive any of the vehicle's speed because at an angle of 90° the target is getting neither closer to nor farther away from the RADAR. This can best be understood by imagining a target vehicle being driven in a perfect circle around a RADAR unit. Because the vehicle is getting neither closer to or farther from the RADAR, there is no relative motion and no possibility of a Doppler shift. Therefore, no speed can be displayed on the RADAR.





Unless a vehicle comes directly at it, RADAR cannot "see" all of a vehicle's speed due to a cosine effect.

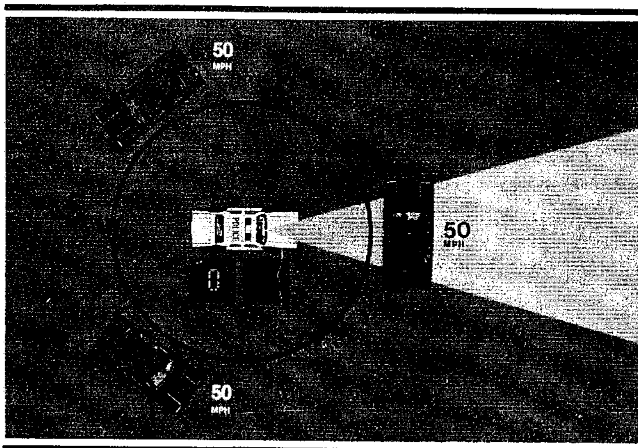
Table 4

True Speed as Affected by Angular Effect

	TRUE SPEED					
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

Example: If an automobile traveling 70 mph moves in a direction that makes an angle of 15° with the RADAR antenna, the RADAR speed measurement could be 67.61 mph. (See bold entry in the above table.)

Because current police traffic RADARs only display speeds in whole numbers, the speed actually displayed is rounded *down* to the nearest whole number (e.g. 67 mph).



A vehicle travelling in a perfect circle around a RADAR unit will result in no reading at all.

The angular effect on stationary RADAR manifests itself in two ways.

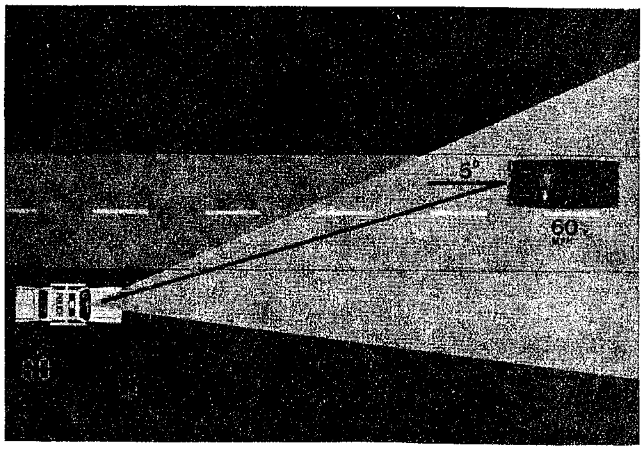
The most common is the most recognizable to the operator. The antenna on a parked patrol car is pointed directly down an adjacent roadway. Well down the road, a target vehicle enters the RADAR's operational area. A speed reading is displayed on the unit. Because the target vehicle is so far away, the angle that exists between it and the RADAR unit is very small and thus the RADAR's perception of the target speed is identical to its true speed. As the target vehicle approaches the RADAR unit, though, the angle between them increases. As soon as this angle becomes large enough, the RADAR unit will perceive the target's speed as less than it really is. The operator may notice that the target vehicle's speed drops several mph on the RADAR unit before it passes by.

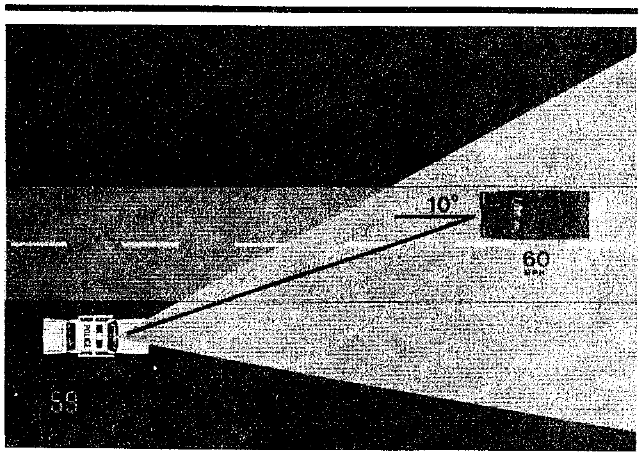
The second way is less recognizable. In this case, the RADAR antenna is pointed sharply across the adjacent roadway. This delays the RADAR unit's perception of an approaching target vehicle, so that speed reading will not be displayed by the unit until the target is relatively close. At that point the existing angle of the target in relation to the RADAR unit is already significant and the RADAR may display a target speed less than the true speed. Pointing the antenna across the roadway in this fashion gives away too much speed to the motorist and should be avoided.

To minimize the angular effect on stationary

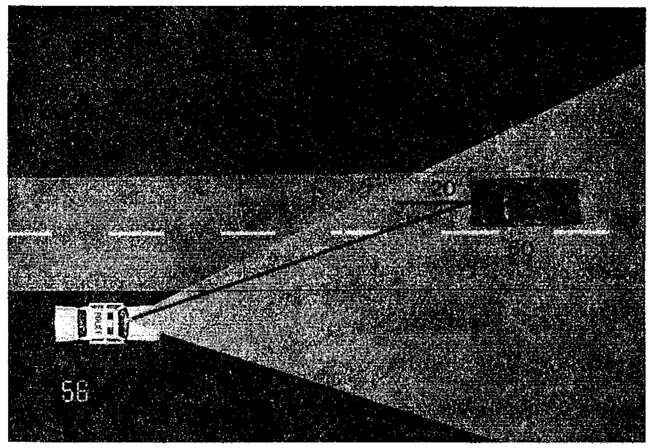
RADAR, the angle should be kept small by setting up the RADAR as close to the road as possible without creating safety risks. The antenna should be aligned straight down the adjacent roadway so that target vehicles can be perceived and displayed by the RADAR before they get close enough to create an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

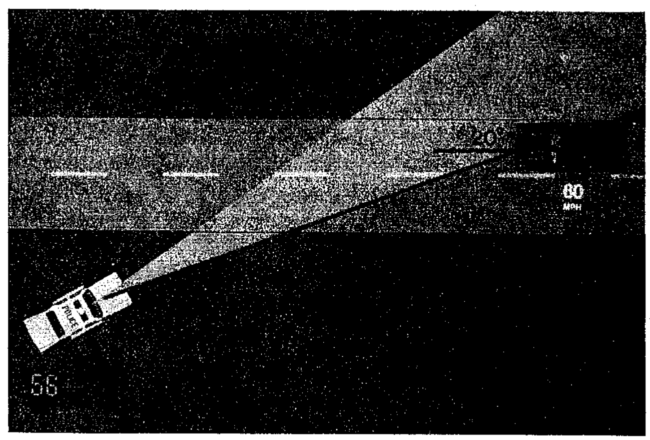
It should be stressed again that with stationary RADAR, **the angular or cosine effect is always in the motorist's favor.** With moving RADAR, this is not always the case. The angular effect on moving RADAR will be discussed in detail next.





The closer a vehicle gets to RADAR, the greater will be the angle created and the lesser amount of speed perceived.





"Shooting" RADAR across a road delays its perception of an approaching vehicle until a significant angle exists.

Principles of Moving RADAR

So far, we have only focused on stationary RADAR. While stationary RADAR has its uses, in recent years police have more and more been using traffic RADAR that can be operated from a **moving** patrol car.

The most important thing to remember about a moving RADAR device is that it uses the same RADAR beam to acquire **two** different speeds.

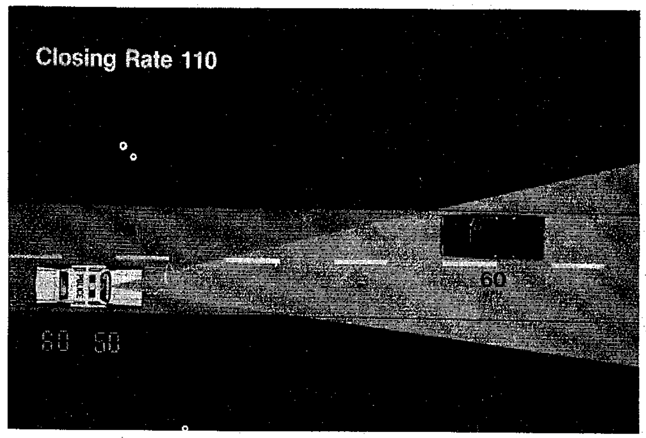
- The speed of the target vehicle in relation to the patrol vehicle.
- The speed of the patrol vehicle in relation to the stationary terrain around it.

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.

The moving RADAR's antenna is able to detect and process two reflected signals **simultaneously**—one from the stationary terrain, the other from an approaching target vehicle. The signal coming back from the target vehicle has undergone a frequency change known as a high Doppler shift—a change caused by the relatively fast closing speed between the patrol car and the target vehicle. The signal returning from the stationary terrain has undergone a so-called low Doppler shift—a lesser frequency change caused by the patrol car's lower relative speed in respect to the stationary terrain. The moving RADAR then computes the difference between the low and high Doppler shifts and translates that difference into a displayed target vehicle speed measurement.

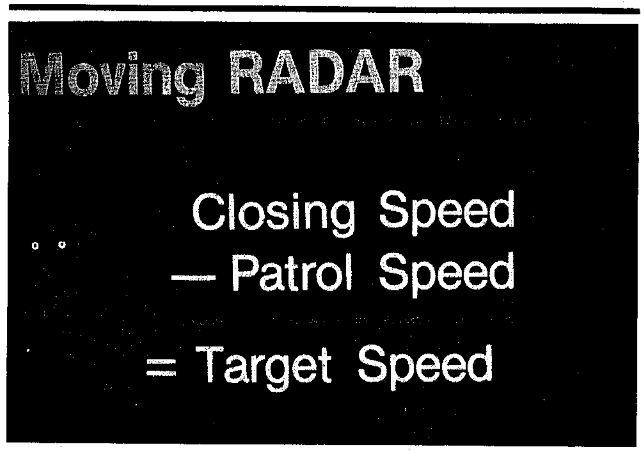
For example, a patrol car is traveling upon a roadway at 50 mph while a target vehicle is approaching it at 70 mph. The two vehicles then are closing in on each other at a relative speed of 120 mph. The moving RADAR receives a high Doppler frequency change equal to that relative speed of 120 mph and a low Doppler frequency change equal to the patrol car speed of 50 mph. The RADAR subtracts the relative patrol car speed from the closing speed, and the relative target speed of 70 mph appears on the RADAR display. This process can be summarized as:

Target Speed = Closing Speed − Patrol Speed
TS = CS − PS



Moving RADAR simultaneously processes the patrol speed signal and the closing speed signal.

This double signal-gathering from a single transmitted RADAR beam and the computing of the target speed are performed continuously and automatically by the moving RADAR unit.

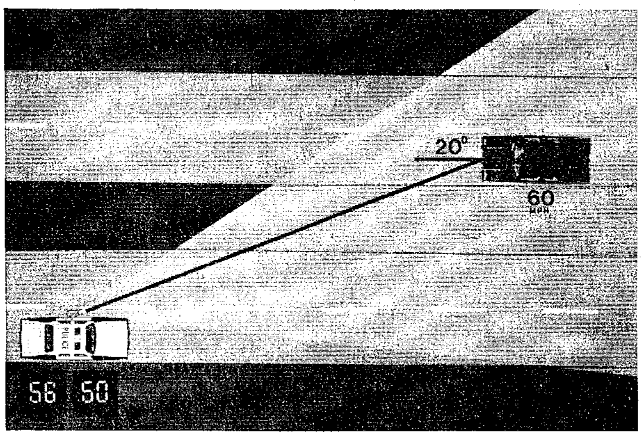


The target speed is computed continuously and automatically.

Moving RADAR Angular (Cosine) Effect

With moving RADAR, just as with stationary RADAR, angular effect can produce RADAR displayed speeds less than the target's actual speed. In order for this to occur the patrol speed must be accurate.

This occurs most frequently when an approaching target vehicle gets close enough to the antenna to create a significant angle. The RADAR may momentarily display a target speed that is less then true. This happens most often on expressways where the median is wide enough to create a large angle between the RADAR antenna and the target vehicle.



As with stationary RADAR, moving RADAR Angular Effect can produce target-speed perception.

A curve in the road can cause a similar situation. If a target vehicle is approaching a moving patrol unit from around a curve, it is unlikely to be moving straight at the antenna. Again, the RADAR may perceive the target's speed as less than it really is.

In examples of moving RADAR cosine or angular effect, RADAR readings **in favor** of the motorist can result **only** if the RADAR unit is correctly computing the patrol car speed.

An improperly high RADAR target display can result due to the angular effect through conditions that exist naturally or are created by the officer. It is critical that the officer know how to avoid these situations when possible and, when they are unavoidable, to recognize that the speed displayed is artificially high.

Certain unavoidable road conditions can result in the RADAR making it seem that the patrol car is traveling more slowly than it actually is. If a less-than-true patrol speed measurement is taken by the RADAR, the calculation of TS=CS−PS will produce an incorrectly **high** target speed. For example, suppose the target vehicle's true speed is 55 mph, and the patrol vehicle's true speed is 50 mph. The true closing speed between the two vehicles would be 105 mph. If an angular effect produces a **low** patrol speed measurement—for example, an apparent patrol speed of only 45 mph—the following computation would be made:

TS = CS − PS

TS = 105 − 45

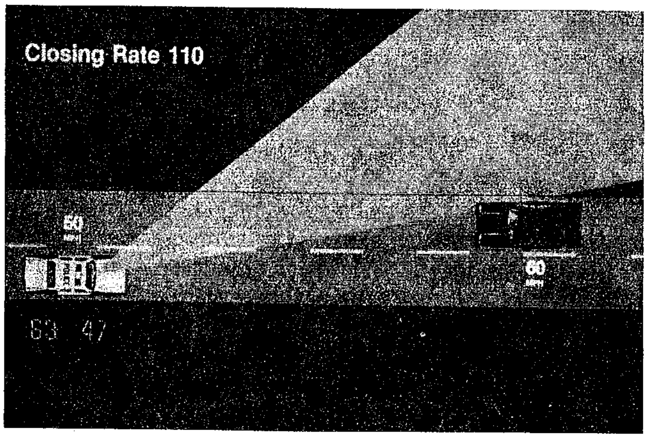
TS = 60 mph

The target speed displayed to the operator would be 5 mph **higher** than the target's true speed. Any enforcement action taken due to this displayed speed would, of course, be improper.

Conditions that create a low RADAR perception of the patrol car speed sometimes are beyond the operator's control. The patrol car speed signal is received primarily from the stationary terrain **in front** of the patrol car. A parked vehicle, a building, a large metal sign, or some other highly reflective stationary object **alongside** the road may sometimes send a stronger signal back to the RADAR than the roadway directly ahead. The reflected signal could actually then be coming from an object that is at a significant angle to the RADAR unit. Because of the angular effect, the relative motion between the patrol car and the roadside object would be less than the patrol car's true speed. Therefore, the patrol speed may be **briefly perceived** as less than the patrol car's true speed. A high target speed may then be **briefly** displayed.

Roadways that have large buildings or many reflective objects close to the roadside are most susceptible to this. Wet or icy roads are less reflective than dry ones and may enhance the RADAR's susceptibility to angular effect.

This factor can become a severe problem if the moving RADAR antenna is not aimed properly. If the antenna is significantly out of alignment with the patrol car's direction of travel, the effect will be immediate and significant on the patrol car's low Doppler signal. The target closing speed high Doppler signal will normally be unaffected. Because the low Doppler reflected signal is being **continuously** received from stationary terrain not directly in front of the patrol car, the patrol speed may **continuously** be perceived as less than it really is. The resulting target vehicle speeds could then **continuously** be displayed as higher than actual. This condition is very recognizable to the operator when the displayed patrol speed is compared to the calibrated speedometer (to be discussed shortly). However, deliberately misaligning the antenna is unnecessary and extremely undesirable.



Misaligning the antenna can cause a high-target speed.

It is important that the operator point the moving RADAR's antenna as straight as possible into the patrol vehicle's direction of travel. The operator can obtain an alignment very close to 0° by merely "eyeballing" the antenna in relation to the patrol vehicle.

It is true that the mathematical potential for angular effect causing an improper target reading is not likely until there is about 10° angle present (see Table 5). However, the operator should not deliberately misalign the antenna of the moving RADAR because:

- Even a slight alignment of the antenna out of the patrol car's direction of travel may increase the susceptibility of the RADAR to receiving a low Doppler signal from objects on the side of the roadway. This problem probably will not be continuous, but may be more frequent than is necessary or desirable.
- It may harm the operator's credibility in court. Because few RADAR antennas are provided with mounting brackets with degree markings on them, it is difficult for the operator to testify that the antenna was aligned only 1°, 2°, or 9° off center. (Where RADAR units possess antenna brackets with such markings, testimony probably would have to be given showing that the brackets had been properly installed.) On the other hand, everyone is familiar with the term "straight ahead." The burden on the operator to disprove the existence of a low patrol speed angular effect is much less if it is concerned only with pointing the antenna straight ahead. Even a defense argument alleging the RADAR could be a few degrees off can be refuted because a few degrees has no appreciable effect on the RADAR target reading.

It should be stressed that, with proper antenna alignment, the angular effect on moving RADAR does not often produce speed measurements that lead to high target speed readings. Most often the angular effect will produce low readings. **The point is that the angular effect can work either way when moving RADAR is involved.** The possibility that the angular effect may produce a low patrol speed measurement and give a higher-than-true target speed is of most concern.

Even properly operated, the RADAR can perceive a less-than-true patrol speed when certain unavoidable conditions exist. The operator must have some way of recognizing these conditions so that the resulting improper target speed reading can be disregarded. This is why all moving RADAR units now on the market have both a target speed display window and a patrol car speed display window.

Vitally important to the operation of moving RADAR is the close monitoring and comparison of the patrol car calibrated speedometer with the patrol speed displayed on the RADAR. This safeguard will be discussed shortly.

Target Vehicle Identification

Up until now the discussion has dealt with obtaining a speed reading from a single target vehicle. When more than one vehicle is present, RADAR operations must include the accurate identification of a **specific** target vehicle. In such cases, the operator must:

- Understand how a RADAR unit "decides" which target vehicle's speed to display.
- Realize that the RADAR is only one piece 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."

The RADAR "Decision" Process

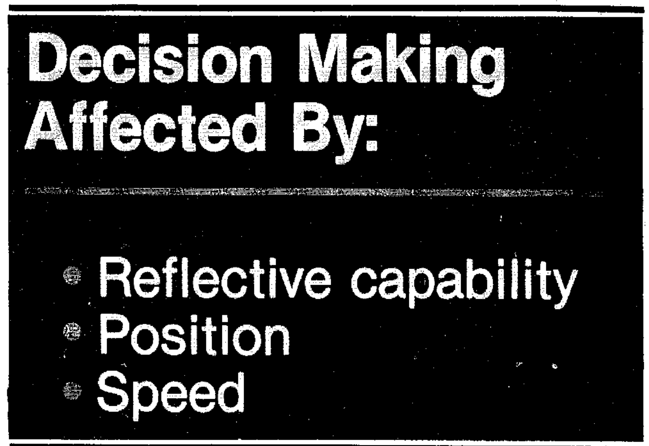
A considerable effort has been made to explain how police traffic RADAR works in relation to the Doppler Principle. When multiple targets are present in the RADAR beam, additional factors must be considered.

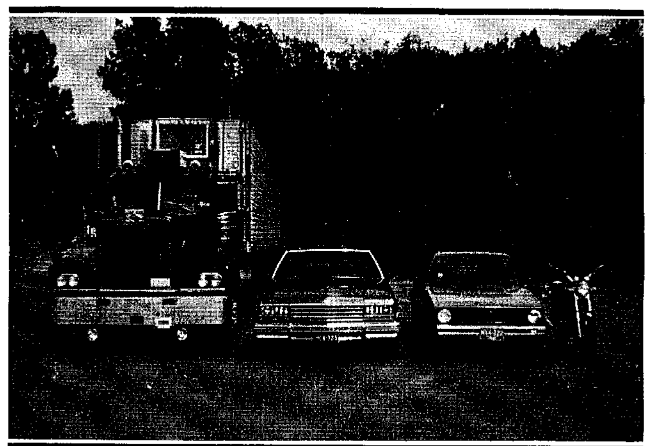
A RADAR beam may be only a few inches wide at the antenna but several hundred feet wide at its maximum operational range. The antenna may receive reflected signals from many vehicles. Most RADAR now in use in this country is designed to display the strongest of the multiple signals available.

The RADAR unit's operation is affected by three factors: the **reflective capability** of the various targets; their **position** in relation to each other and the RADAR; and, occasionally, their actual **speed.**

Reflective Capability—Most of the vehicles on a given road will be of different sizes. A large truck will obviously have a larger reflective area than a smaller passenger vehicle will. Thus, a truck can create a stronger reflected signal than a passenger vehicle. By the same token, a passenger car can have a stronger reflected signal than a motorcycle.

The shape and physical makeup of a target vehicle will also affect its reflective capability. Low-profile, streamlined vehicles have less surface area to reflect a RADAR signal than vehicles of the same relative size that aren't streamlined. Vehicles containing a large amount of plastic materials or those made of fiberglass are generally less reflective than those of metal. Streamlined vehicles, or those made of fiberglass, **will** reflect a RADAR signal. However, the distance at which the RADAR displays a reading for such vehicles will be reduced.





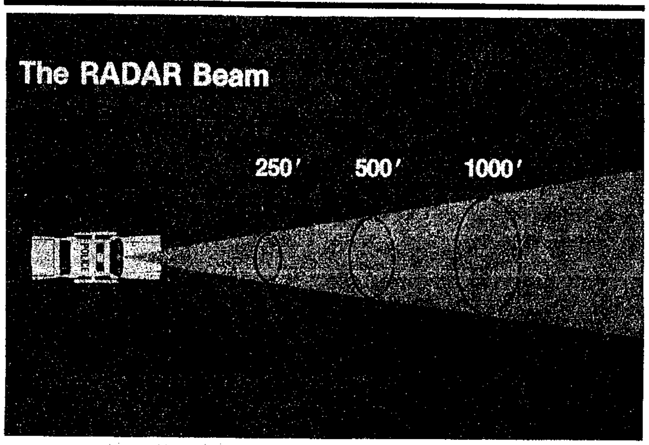
The reflectivity of a vehicle is affected by its size, shape, and composition.

Position—The position of a target vehicle relative to other vehicles and the RADAR antenna is important in regard to which vehicle's speed the RADAR unit will display. Normally, the closer a vehicle is to the antenna, the stronger the reflected signal. In other words, the closer a vehicle is to the antenna, the larger the portion of the cone-shaped beam it occupies. If vehicles of comparable size are in question, the target vehicle closest to the antenna will most often be the one displayed by the RADAR unit.

Speed—The speed of a target vehicle is the last factor affecting how a RADAR unit will operate. How much a target vehicle's actual speed will affect the RADAR unit's "decision" depends on the make and model of RADAR being used. Generally speaking, speed is usually the **least** dominant of the three primary factors. Some specific circumstances where speed may be a factor will be described later.

Understanding the RADAR "Decision"-Making Process—When multiple targets of **unequal** size are present, either reflective capability or position will most often be the determining factor. It is vital that the operator understand that reflective capability and position are completely different. With this understanding, the operator will be better able to tell which factor is governing any particular multiple-target situation. To illustrate this, an explanation of what actually happens to the radio energy wave after leaving the antenna is in order.

If a slice of the cone-shaped RADAR beam could be observed 250 feet from the antenna, you would find that almost all of the energy originally transmitted is still there. However, instead of being contained in a circle a few inches in diameter, as originally transmitted, the energy would be dispersed over a circle approximately 70 feet in diameter.

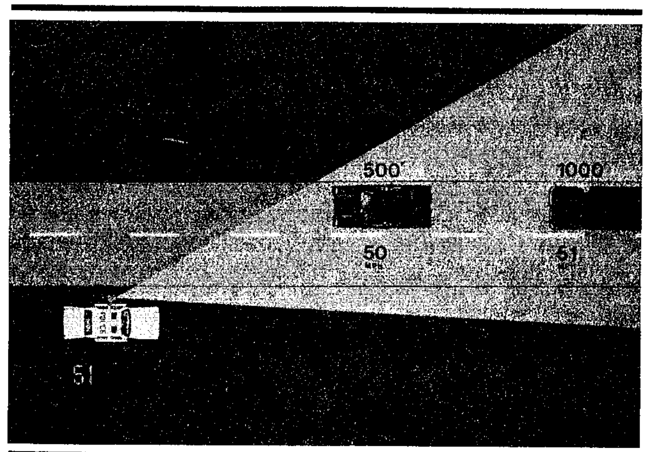


Due to the Inverse Square Rule, each time the distance from the antenna is doubled, the strength of the signal is reduced by a factor of four times.

If this distance is now doubled to 500 feet, the energy would be spread over an area **four times** as large as at 250 feet. If the distance is again doubled to 1,000 feet, the energy would be spread over an area four times as large as at 500 feet, but **16 times** as large as at 250 feet.

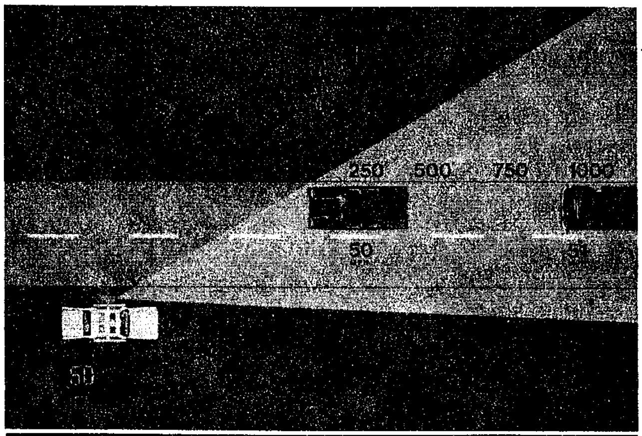
It is apparent the farther a target vehicle is from the RADAR unit, the lesser the amount of energy available to be reflected back to the antenna. This relationship between energy and the distance from its source is called the **inverse square rule.**

The Inverse Square Rule and Target Identification—To understand the impact of **reflective capability**, imagine a full-sized passenger vehicle 500 feet away and approaching the RADAR unit. At the same instant, a truck is also approaching the RADAR unit, 1,000 feet from the antenna. Given these relative positions, there is four times less RADAR energy per square foot to be reflected from the truck at 1,000 feet than there is to be reflected from the car at 500 feet. However, if the truck has **five times the reflective surface of the car,** its reflected signal will probably be stronger. In this case reflective capability would probably determine which vehicle's speed is displayed by the RADAR unit.



Though twice as far away, if the truck has five times as much reflectivity, its speed would probably be displayed.

To illustrate the impact of **position,** it is necessary to advance the positions of these imaginary vehicles to where passenger vehicle is 250 feet from the antenna and the truck 750 feet. At 250 feet the passenger car now has four times as much RADAR energy being reflected from each square foot of surface area as it did at 500 feet. The truck also has more reflected RADAR energy per square foot at 750 feet than it did at 1,000 feet, but proportionally hasn't increased nearly as much as the car. In this case, position would probably determine which vehicle's speed the RADAR unit would display.



By moving both the car and the truck 250 feet closer, the car's speed would probably be displayed due to position.

It should be noted that with each of the examples cited, the reflective **capability** of the vehicles'—size, shape, and composition—remained the same. The position of the vehicles relative to the RADAR antenna was the factor changed.

Under certain circumstances, RADAR devices can select which vehicle to display on the basis of speed. The most common instance involves multiple target vehicles of comparable size on an expressway. If a vehicle approaching the RADAR unit is being overtaken by a similar-sized vehicle at a significantly greater speed, the faster vehicle's speed may be displayed. This normally will not occur, however, until the faster vehicle is reasonably near the lead vehicle. The RADAR unit is less likely to be speed-selective on two-lane roadways because the front vehicle is likely to block the radio waves from striking the following vehicles. Operators should be aware that with most RADAR units currently in use, the individual speeds of approaching target vehicles do not normally determine which vehicle will be displayed.

The possible combinations of these factors—reflective capability, position, and speed—are infinite. You are not expected to have to compute the relative sizes or positions of target vehicles mathematically. It is enough for you to have a general understanding of the impact these factors have on how the RADAR unit selects which target vehicle's speed to display.

The interpretive process that results in valid target identification is generally easy for the trained operator because a RADAR reading is only one part of the evidence the operator has to have to establish a speed violation.

The Role of Supportive Evidence—The Tracking History

Several elements are involved in the valid identification of a target vehicle.* Together these elements comprise what is referred to as a complete "tracking history" and are listed below:

Visual estimation of target speed: This is the most critical element. Testimony must substantiate that the vehicle in question was *observed* to be speeding. An officer's ability to estimate speeds is established separately from the RADAR evidence. The officer should be able to testify that a target vehicle was traveling faster than the speed limit even if no RADAR or similar device was used.

Audio tracking: The audio feature common on many police traffic RADARs allows the operator to hear the incoming Doppler signal. A stable target signal will result in a single pure, clear audio tone. The higher the pitch of the signal, the faster the speed of the target producing the signal. With experience, an operator can correlate this pitch with actual speeds.

Interference that could affect the RADAR is heard as static or buzzing and is **not consistent** with the pure, clear Doppler return from valid target vehicles.

Target Speed Display: The target speed displayed by the RADAR must correspond reasonably with the visual and audio estimations. Each of the three must reinforce the other. If any of them is incompatible, the reading must be disregarded.

With stationary RADAR, these three elements would be enough to constitute a valid tracking history. One additional element is required for moving RADAR.

Patrol Speed Verification (Moving RADAR Only): Current moving RADARs, as previously noted, possess not only a target-vehicle, speed-display window but also a patrol-car, speed-display window. The patrol speed indicated on the RADAR must correspond with the reading on the patrol vehicle's speedometer, which must be certified as well. This verification ensures that the RADAR computation of the target speed is based on a valid patrol car speed. This additional element has been mandated by case law for moving RADAR and is to be considered essential for a valid moving-RADAR case.

---

*The additional elements inherently involved with every traffic violation—location, vehicle make and color, driver identification, etc.—will be covered in *Unit 4: Legal and General Operational Considerations.*

A tracking history must be obtained for each RADAR-based enforcement action. Whenever RADAR speed measurements are conducted, two points must be kept in mind:

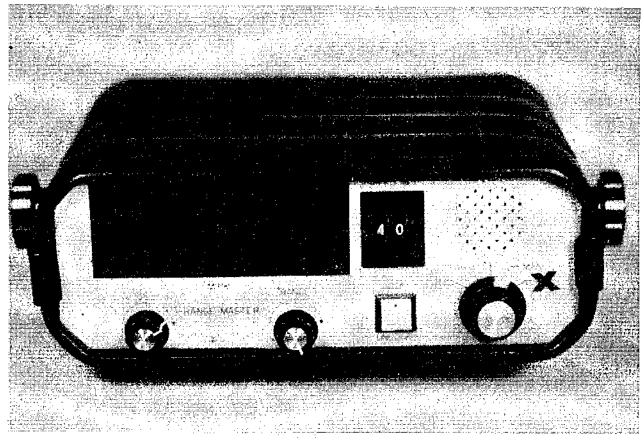
- The RADAR-displayed speed measurement is only one part of the evidence and cannot be the sole basis for any enforcement action.
- In order to be valid and admissible, the RADAR speed measurement must be obtained in strict compliance with all applicable case law.

These two points have significant implications for the manner in which RADAR operations are conducted. Related to the first is the officer's need for the good judgment and experience in making visual estimates of a vehicle's speed. Almost everyone can estimate speeds visually: It would be impossible to drive a motor vehicle or walk across a busy street without some understanding of how fast traffic is moving. Because observing traffic is a major part of their job, traffic law enforcement officers in particular can and do become very good at estimating speeds.

Never base a decision on instant RADAR measurement. Instead, watch speed measurement and listen to the audio output for at least a few seconds to make sure that the signal received is from a real, identifiable vehicle.

The biggest impediment to obtaining a valid traffic history is the locking feature that most current RADAR instruments have. This feature allows the operator to press a button or pull a trigger and cause whatever speed measurement is appearing at that instant to freeze on the display. Many RADARs, have an automatic locking feature that causes this freeze to occur as soon as some specified speed is exceeded.

The idea behind the locking feature is to preserve the evidence. Whatever the idea's merits might be, locking the speed measurement can prevent the operator from correlating changes seen or heard in the target vehicle's speed with the speed on the RADAR display. If a good, complete tracking history has been obtained, the RADAR speed reading may be manually locked—if that is compatible with your agency's procedures. **However, the automatic locking feature should never be used for enforcement purposes.**



Auto-locks or auto-alerts should never be used.

When multiple targets are present, it is often preferable to continue observing the target speed measurement, paying close attention to what happens when the suspect vehicle passes out of the beam. The display might suddenly either blank out or abruptly change to another speed. If that happens, the implication is that the speed measurement obtained was from the suspect vehicle.

On the other hand, the display might hold steady after the suspect vehicle passed out of the beam. The implication in that case would be that the RADAR was displaying some other vehicle's speed. The Doppler audio feature present on many units is also very useful in this respect. If there is no change in the Doppler sound, you can infer that the suspect vehicle was not being displayed.

The burden of proof is obviously less if the operator can show that there were no other vehicles between the RADAR and the target vehicle. Remember, however, that other vehicles farther away can produce a stronger reflected signal. Again, good visual and auditory observations validate the speed reading and complete the tracking history.

RADAR operations should be conducted only at the appropriate times and places. If traffic flow builds up to the point where target identification becomes problematic, stop using the RADAR. RADAR is not the only speed measurement method available, nor are speed violations so uncommon that they can only be found in one place. RADAR is a very effective tool. Like any tool it has to be used properly and only for the job that it has been designed.

Finally, and perhaps most important, if any doubt exists, take no enforcement action.

Effect of Terrain on Target Identification

Road terrain may affect the RADAR unit's ability to process and display target vehicle readings. The best areas for RADAR operation are straight, level roadways. When traffic RADAR is operated on hilly or curved roadways, you must take their effect on the RADAR into account. Police traffic RADAR units are designed to function on a "line of sight" basis and will seldom display a vehicle behind a hill or around a curve.

Hilly terrain creates the worst problems in target identification. For example, if the patrol vehicle is positioned on the crest of a hill, with the RADAR antenna focused straight ahead rather than down, the RADAR beam may "overshoot" the approaching lead vehicle and display a vehicle behind it. A dip in the roadway may also affect the RADAR 's ability to display the lead vehicle. In this case, the roadway itself may shield most of the reflective surface of the lead vehicle and again cause the RADAR to pick up a following vehicle. When roadway terrain problems exist, you must exercise discretion in using RADAR, tracking the target vehicle long enough to be certain of target identification.

Operational Range Control

Some RADAR instruments have a control that permits the adjustment of operational range. The range control allows an adjustment to the RADAR instrument's sensitivity to reflected signals, and can be used to reduce target identification problems. It must be stressed that the RADAR transmission remains steady and unaffected by this range control. **This control only affects the RADAR's ability to receive and process a signal.**

Thus, a low sensitivity setting means that the RADAR will only perceive fairly strong signals—the RADAR won't "see" a vehicle until it is fairly close. A high sensitivity setting means that the instrument will perceive even fairly weak signals from vehicles that are quite far away. Atmosphere and other environmental conditions can affect the RADAR's sensitivity to target vehicle signals. Try experimenting with the range control to find the most appropriate setting each time you use the RADAR unit.

When using stationary RADAR, the recommended procedure is to first turn the range control to its **minimum** setting (i.e., its lowest sensitivity) and then slowly increase the RADAR's sensitivity.

By observing when and where approaching target vehicles begin being displayed on the RADAR, you can establish an effective operational range.* This range must be long enough to allow a target vehicle to be displayed for the time necessary to complete a proper tracking history, but not so long as to create unnecessary identification problems.

For moving RADAR, the sensitivity setting must be significantly higher, because both vehicles are moving, and the distance between the patrol car and the target vehicle changes very rapidly. This means that moving RADAR must be more sensitive to targets at longer ranges than stationary RADAR to achieve a proper tracking history.

It is important for you to understand that a RADAR unit's range setting is approximate, not precise. Most range control units are designed so that the average automobile will be displayed when it is in the selected range. Small vehicles may not reflect a signal strong enough to be displayed until they are close to the transmitter. Larger vehicles, of course, may be displayed even though the vehicles are farther away.

In the past, operators often attempted to control RADAR sensitivity by tilting the antenna up or down. This tilting is **not** recommended, since it may cause or worsen interference. **If your RADAR unit has no range control, keep the antenna pointed straight ahead and stay alert—don't tamper with the antenna.**

One final point should be mentioned: Adjusting the beam's range control will have absolutely no effect on RADAR detectors (i.e., devices used to give speeders advance warning of a RADAR's presence). You can't outwit a RADAR detector by turning down your range setting, because the power in the beam remains constant regardless of the range control setting.

* This description assumes that the antenna is directed toward approaching traffic. If you are measuring the speeds of receding traffic, the proper procedure would be to note how far away the vehicles are when their speed measurements **disappear** from the RADAR's display window.

Factors Affecting RADAR Operation

It is sometimes alleged that police traffic RADARs often display "false" target readings. In fact, certain factors can affect RADAR devices. Many of these factors can be avoided, provided you operate the RADAR unit properly. Some are unavoidable, the result of natural causes. All of them should be recognizable to the trained, experienced operator.

Police traffic RADAR, like any measurement instrument, has inherent and logical limitations. When a false reading is displayed, the RADAR unit is not making an error—it has simply been subjected to conditions beyond its capabilities. As a rule, though, it is more likely that the operator, rather than the RADAR, will make an error. This can happen if the operator forces the device to operate beyond its limitations or fails to recognize when its limitations have been passed.

The following discussion is broken down between factors that affect police traffic RADAR as a whole and those that apply only to moving RADAR operation. Often a false reading is directly attributable to an operator's inaction or inappropriate action. Where avoidable factors can arise to give false readings, the discussion will describe them and note how to avoid them. Where a cause is unavoidable, the discussion will show how to recognize it. Only those factors affecting RADAR that possess some credence or those that have received a lot of publicity will be addressed.

Interference

"Interference" encompasses a wide range of natural and artificial phenomena. For this manual, the term "interference" will refer to RADAR effects that happen unintentionally. Purposeful attempts to subvert or otherwise affect RADAR will be discussed later.

Generally, interference can be attributed to two primary sources:

Harmonics—The first source of interference, harmonics, refers to RADAR's tendency to occasionally process the wrong radio frequency. Harmonics may include radio energy released by airport RADAR, mercury vapor and neon lights, high-tension powerlines, high-output microwave transmission towers, and transmissions from CB and police radios.

Moving objects—The second source of interference results because Doppler RADAR is designed to measure the relative motion of moving objects. This can mean any moving object, not just motor vehicles. The most common moving objects that may interfere with RADAR are vibrating or rotating signs near the roadway and fan blades moving either inside or outside the patrol car.

A RADAR antenna's sensitivity or capability to receive and process a signal depends on the number and relative strengths of the reflected signals it is receiving. Strong signals received from bona fide target vehicles will almost always override weaker interference.

Interference caused some of the more bizarre and highly publicized "inaccuracies" that surfaced in Dade County, Florida and other places where RADAR has been challenged. The infamous "85-mph tree" is a case in point.

The news has been well circulated that a RADAR antenna was pointed at a banyan tree (which obviously was not moving) and that a reading of approximately 85 mph appeared on the display. Not so widely reported was the fact that a CB radio transmitter located in the same vehicle as the RADAR had been turned on and that at the instant the reading was made a reporter whistled into the microphone. Feedback from the CB was picked up by the RADAR, and **that** caused the 85-mph reading. It did not matter that the RADAR was pointed toward a tree; it could have been pointed at the ground, a house, the sky, anything. The actual source of the 85-mph reading was the CB's interference, **not** the tree. Ordinarily, RADAR will not pick up a CB signal. But when the CB and the RADAR are extremely close together (as in the same vehicle), interference can result.

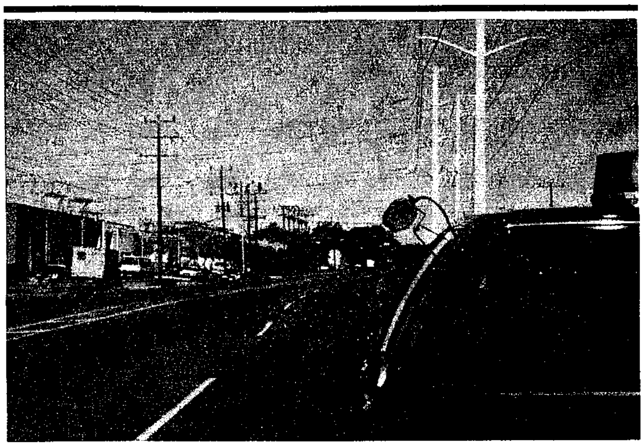
Most types of interference that may affect RADAR originate from within patrol cars.

Another well-reported incident from Dade County was the "28-mph house." Here again, interference was the culprit. The RADAR antenna was aimed at the house through the car's front windshield. Meanwhile, within the antenna's range the window defroster had been turned on and its fan blades were spinning. What the RADAR actually measured was the speed of the defroster fan's blades.

Most interference will come from inside the patrol vehicle. Radio transmissions from within the patrol car and, occasionally, faulty ignition wires may cause harmonic disturbances; air conditioning and heater fans may cause moving interference.

Citizen Band radios have largely been a positive contribution to traffic safety.

Outside the patrol vehicle it is less likely that moving objects will cause interference with RADAR. However, proximity to such harmonic sources as airport RADAR, high-tension powerlines, and high-output microwave transmission towers may create readings.



Parking directly beneath high-voltage power lines may affect the RADAR.

Having a Doppler audio feature on the RADAR unit will help a lot in recognizing interference—instead of a clear, pure tone, the audio will emit fluttering or buzzing sounds.

The trained operator will ignore interference-induced readings, since:

- There is generally no vehicle within the operational range of the RADAR and, therefore, no visual clue on which to make a speed determination.
- Interference is usually weak, and when a bona fide target vehicle enters the RADAR's operational range it will almost always override the interference reading.
- The Doppler audio effect caused by interference will be scratchy and inconsistent, unlike the good, clear tones of a true Doppler target signal.
- Usually interference is momentary, not lasting for the several seconds necessary for a valid tracking history.

The operator must be careful to avoid known interference sources and not to make radio transmissions while actually tracking a vehicle on RADAR. If the RADAR antenna is inside the patrol vehicle, dash-mounting the antenna and aligning it away from fan vents will minimize movement-related interference.

Inclement weather (e.g., rain or snow) does not affect RADAR's accuracy as often as is alleged. Inclement weather may, however, decrease the unit's operational range sensitivity. Moisture-laden air tends to scatter the RADAR beam slightly, thus reducing its effective range.

Multi-Path Beam Cancellation Effect

Multi-path beam cancellation refers to the RADAR blind spots produced by occasional oddities in roadway terrain. The RADAR operator may be monitoring the speed of an approaching vehicle when suddenly the speed displayed will disappear for a few seconds and then, just as suddenly, reappear. All this happens while the vehicle remains constantly in sight.

Technically, multi-path beam cancellation results when a 180-degree phase inversion occurs between the direct path signal from the target vehicle and the signal from the reflected path. The signals, in effect, cancel each other out as far as the RADAR is concerned. During this brief period the RADAR display goes blank. However, the operator must be alert to the possibility that a vehicle **behind** the lead target vehicle may briefly display a speed on the RADAR when the lead vehicle's signal has momentarily been cancelled. Obtaining a good complete tracking history will minimize the problem of multi-path beam cancellation.

Scanning Effect

A hand-held RADAR antenna that is swung swiftly or "scanned" past the side of a parked car, a brick wall, or some other stationary object is alleged to produce a speed measurement. The idea behind this charge is if the antenna moves, the relative motion will be registered by the RADAR.

This effect is extremely difficult to produce. However, by not moving the RADAR antenna while making a speed measurement, you will eliminate any (faint) possibility of its contributing to a false reading. In any case, swinging an antenna around does not help obtain a valid tracking history.

The Scanning Effect is difficult to produce and constitutes improper operation.

Panning Effect

The panning effect can occur only with two-piece RADAR units—instruments whose antenna and counting units are physically separate. If the antenna is pointed at its own counting unit, a speed reading may appear on the display because of electronic feedback between the two components. When this is done, the Doppler audio becomes a very inconsistent squeal. To avoid the panning effect, don't point the antenna at the counting unit.

Panning Effect can only occur with two-piece RADARs.

Turn-On Power Surge Effect

Suddenly turning on the RADAR unit's power may result in a speed reading displayed because of the sudden surge of voltage to the unit. Operators are said to do this with the idea of outwitting illegal RADAR detectors.

Many newer-model RADAR units have a "transmission-hold" switch that keeps the power turned on in the computer module but prevents the transmission of the RADAR signal until the target vehicle is within range. These "anti-fuzzbuster" switches are considerably more effective than flipping the unit off and on—and they don't constitute misoperation.

Allegations that using the transmission-hold switch may also cause a power surge affecting the speed display is spurious. Extensive testing by the National Bureau of Standards on various makes of RADAR indicates no support for this charge.

Mirror Switching Effect

Some hand held-type RADARs can have the numerals of the readout displayed backwards when a switch is thrown. This lets the operator point the RADAR rearwards and read the numbers correctly through the rearview mirror. The claim here is that the operator may forget to switch the display back again when the unit is pointed forward and mistake the reversed reading for a proper reading. For example, a reversed speed reading of 18 mph may be observed as 81 mph by the operator. If the operator stays normally alert the mirror switching effect should not be a problem.

Factors Affecting Moving RADAR Operation

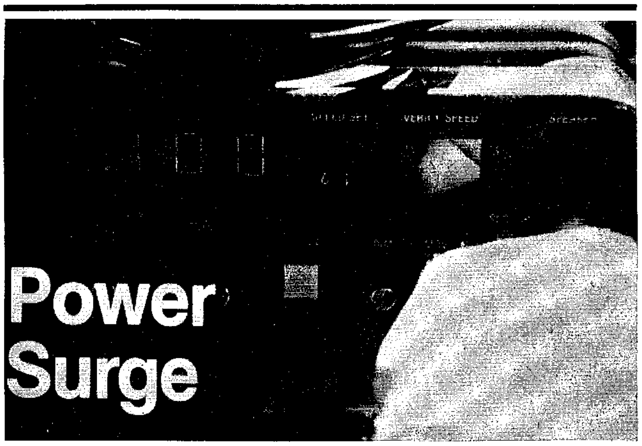
The operator should be aware that moving RADAR is susceptible to some special problems that do not affect stationary RADAR. Like the moving RADAR angular effect, these can produce a lower-than-actual patrol speed measurement and thus a higher-than-actual target speed calculation.

Patrol Speed Shadow Effect

Remember that moving RADAR depends on two speed readings, that of the target vehicle and that of the patrol vehicle itself. A shadow effect may be caused if the beam that is supposed to determine the patrol car speed by tracking the stationary terrain locks instead onto a large moving vehicle in front of the patrol car. This large vehicle (usually a truck) must be close enough to the RADAR unit to effectively reflect a major portion of the normal beam.

If this occurs, the patrol car's speed will be displayed as the difference in speeds between the patrol car and truck rather than the patrol car and the stationary terrain. If a target vehicle is approaching at this time, the remainder of the patrol car's speed could be added to the target's speed by the RADAR. (Target Speed=Closing Speed−Patrol Speed.) It should be noted that there must be a significant difference in speed between the truck and the patrol car to produce this effect.

Most RADAR units can be made to shadow, under the right conditions. During normal moving-RADAR operations, this effect is largely unavoidable; but luckily it is reasonably rare; and most importantly, is extremely noticeable to the operator.

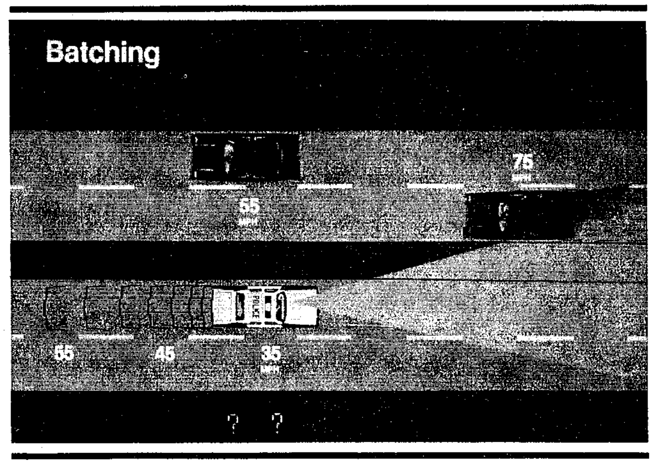


The Patrol Speed Shadow Effect is instantly recognizable if a Tracking History is followed.

There will be two glaring inconsistencies. One, the target speed displayed will be in excess of the visual estimation of the target as perceived by the operator. Two, when the operator checks the patrol car displayed speed after the false target reading is obtained, it will in no way correspond to the calibrated patrol car speedometer speed. For example, if a patrol car is actually driving at 55 mph and has locked onto a truck doing 40, the radar may display a target vehicle supposedly doing 100 while the patrol car is supposedly doing 15. The reading obtained should then be ignored as it lacks the necessary supportive evidence for complete tracking history.

Batching Effect

Another problem unique to moving RADAR is known as the batching effect. This is caused by slight time lags in the moving RADAR's sensing/computing cycle. Like the angular effect on moving RADAR, the batching effect can lead to the display of erroneously low or high target speeds.



Batching Effect can occur if the partrol car changes speed suddenly.

The batching effect may occur if the patrol car is rapidly changing its speed while the RADAR speed measurements are being made. Some RADAR counting units may not be able to keep up with drastic changes in speed. Instead of using the true speed of the patrol car to measure closing speed, the counting unit may use the speed that the patrol car was traveling a few fractions of a second earlier. If the patrol car is rapidly accelerating, then its earlier speed was lower than its present true speed, and the target speed calculation may be higher than the target's true speed. If the patrol car is rapidly decelerating, then its speed a fraction of a second before was higher than its present speed, and the target speed calculation may be lower than its true speed.

Most RADAR units are fast enough to keep up with the significant speed changes, thus avoiding the batching effect, and/or blank out when such changes occur. **You can avoid even the possibility of an improper speed reading due to the batching effect by maintaining a relatively steady speed when taking speed measurements.**

Conclusions on Factors Affecting RADAR

Looking at all of the factors alleged to affect RADAR operation, several conclusions can be reached:

- Many of them arise only through blatant misoperation of the RADAR instrument.
- Some have no basis in fact.
- Many will almost never occur when the RADAR is being operated properly.
- Most will only affect the RADAR unit momentarily.
- ALL OF THEM WILL LACK THE NECESSARY SUPPORTIVE EVIDENCE FOR A VALID TARGET READING.

RADAR's proper operation requires supportive evidence: a significant period of visual and audio tracking of the target vehicle, the verification of the patrol car speed against the calibrated patrol car speedometer (if moving), and a RADAR reading that is consistent with the visual and audio estimation. If all of these elements of the tracking history exist, the likelihood of any of these factors affecting RADAR causing an improper traffic citation to be issued will be negligible.

Provided you understand its capabilities and limitations, RADAR will remain a valid tool in the police arsenal for speed enforcement, resulting in both accident reduction and energy conservation.

Jamming and Detection of Police Traffic RADAR

In recent years, a small percentage of the motoring public has used increasingly sophisticated means to try to sidestep police traffic RADAR, offering rationales like, "RADAR is unfair!" and "Maybe **some** people can't, but I can drive safely and fuel-efficiently at higher-than-allowable speeds." Whatever reasons are offered, they all sound foolish when compared to the documented evidence that speed wastes energy—and speed kills.

Jamming Devices

Purposeful attempts to create false or distorted RADAR signals are called "jamming." This is not yet a widespread problem (jamming devices are illegal, and tend to be expensive and complicated), but various agencies are encountering it more and more.

The most effective jamming device is a radio transmitter that sends out a relatively strong signal with a frequency close to that of police traffic RADAR. The RADAR receiver "sees" that signal rather than (or in addition to) the signal reflected from the speeding vehicle, with the result that the RADAR displays either a false speed or no speed at all. The Federal Communications Commission (FCC) will not license a device whose purpose is to jam police RADARs. Even using an already-licensed radio transmitter would violate Federal regulations if the use were to purposely jam police RADARs.

It is easy to tell when a RADAR jammer is being used, because most of the jamming devices now in use are crude. When a jammer is being used close by, your Doppler audio should be inconsistent and uneven in tone. The speeds displayed on a RADAR being jammed tend to fluctuate, even though you can see no obvious change in the speeds of approaching vehicles. The best tipoff that a jammer is around occurs with the RADAR units that have transmission-hold switches. Some RADAR devices are capable, when on transmission-hold, of receiving and processing incoming signals. If the RADAR is displaying a speed and the audio is emitting a tone even when the RADAR is not transmitting a RADAR signal, a jammer is almost certainly being used nearby.

If you encounter a jamming device, you can contact the nearest FCC regional office for assistance. In addition, some States and local governments have language in their statutes outlawing the use of jamming devices similar to that in Federal law. In any event, be sure of what laws apply before actually confiscating the device or arresting its owner.

One will occasionally encounter or hear of other "techniques" for jamming police RADARs. These usually range from the laughable to the ridiculous. Among the more common "jammers" based on pseudo-scientific superstitions, one will find:

- Aluminum paint stripes or metal foil strips on the outer side of a violator's vehicle. (If anything, this only increases the vehicle's ability to reflect the RADAR beam and makes it easier to measure its speed.)
- Hanging chains under a vehicle. (This might help keep static electricity from building up on the vehicle, but it certainly will not distort or reduce the RADAR the vehicle reflects.)

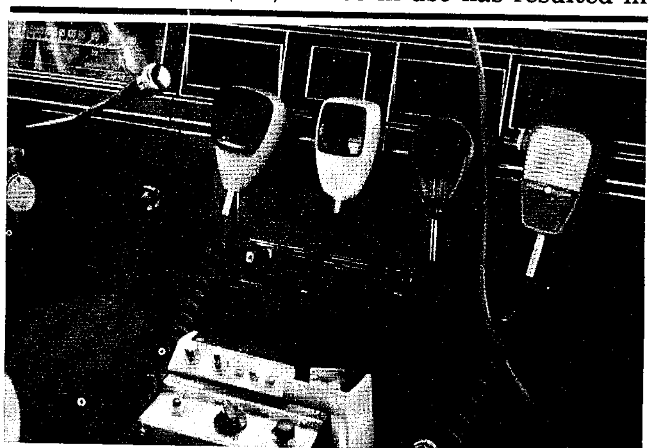
- Hiding small metal objects or strips of metal foil inside a vehicle's hubcaps. (The only thing this can do is create unpleasant rattling sounds; the RADAR beam will not penetrate the hubcap.)
- Furious honking of the horn in short beeps, long bursts, or whatever. (The vibrating diaphragm of the horn could modulate a RADAR signal—but since the horn is under the hood, these vibrations are not detected.)

In short, none of these "techniques" have any effect at all on police traffic RADAR.

Detection Techniques

Getting advance warning of the presence of a police RADAR is probably the oldest method used by speed violators to avoid getting caught. The most common means of getting advance warning involves cooperation among violators. Soon after RADAR was first introduced for speed enforcement, violators acquired the habit of flashing their headlights to warn one another when it was around. People still do this, and undoubtedly it does reduce the number of enforcement actions taken. However, the flashing-headlight method probably has a positive influence on highway safety. The headlight-flashers tend to send out their warnings for several miles around the RADAR site, since they cannot inform the oncoming traffic of the exact location of the transmitter. The result is that traffic typically slows down to legal speeds for several miles each way.

In recent years the proliferation in the number of citizens' band (CB) radios in use has resulted in some motorists' using them to warn others that "Smokey" is "taking pictures." Unlike the headlight-flashers, CB users can tell their listeners exactly where the RADAR patrols are located, thus helping some motorists escape the law. However, CB's positive applications in terms of assistance to law enforcement agencies, and to motorists themselves when emergency situations exist, far outweigh this negative aspect.



Citizen Band radios have largely been a positive contribution to traffic safety.

A third major method of obtaining advance warning of RADAR operation is the RADAR detector. These instruments are nothing more than RADAR frequency receivers, designed to give off an audible and/or visible signal when exposed to a transmitted RADAR signal.

RADAR detectors have been on the market for many years. Early models were generally ineffective and suffered frequently from false alarms (buzzing when there actually was no RADAR in operation). Typically, they did not detect the RADAR until it was too late. However, recent improvements have resulted in models that can detect RADAR transmitters while still out of range of speed measurement, so there has been some increase in the number of drivers who use RADAR detectors.

A few States have legislation that bars the possession or use of such devices. A number of other States have introduced similar legislation. It is because of RADAR detectors that many recent police traffic RADARs have been equipped with "anti-fuzzbusters," switches that delay the RADAR transmission until the target vehicle is well in range. Using this feature, along with completing a proper traffic history, is an effective way to defeat RADAR detectors.

The experience of recent years proves that it is possible for police to do a very effective job of speed enforcement, despite some drivers' attempts to avoid getting caught. Violators **can** be apprehended, speed **can** be reduced, and lives **can** be saved. Neither the modern nor the old-fashioned methods of RADAR detection have significantly reduced the impact of a much-needed and effective speed control tool: police traffic RADAR.

Study Topics

a. Assemble a list of possible sources of interference to RADAR. (Such a list can help in future selections of appropriate, relatively interference-free RADAR sites.)

b. What kind of readings should you obtain from a motionless object in the RADAR beam? How would you explain such readings if they did occur?

c. Be prepared to answer the following questions:
   1. Radar is an acronym for what?
   2. What is meant by a RADAR signal's **wavelength?**
   3. What is meant by a RADAR signal's **frequency?**
   4. When you adjust a RADAR's **beam range,** what are you adjusting?
   5. What is meant by the angular effect for stationary RADAR? For moving RADAR?
   6. What frequencies do the X- and K-bands represent? Give answers in both hertz and giga-hertz.
   7. What are the three primary factors involved in the RADAR "**decision**" **process?**
   8. What pieces of supportive evidence make-up a stationary tracking history? Moving tracking history?
   9. What factors may affect RADAR operation in general?
   10. What factors may affect moving RADAR specifically?

Unit 4—Legal and General Operational Considerations

The previous unit dealt with RADAR's basic operating principles. This unit examines how these principles have gained acceptance in the courts. As with any new concept or device in law enforcement, the courts did not take "judicial notice" quickly or without reservation. This unit presents the process through which RADAR evidence has gradually come to be accepted in our courts.

In accepting RADAR evidence, the courts have also spelled out certain procedural requirements. As you will see, obtaining a speed reading with RADAR does not necessarily ensure a successful prosecution. The officer must ensure that he or she has followed those procedures outlined by the courts to specify the proper methods of RADAR operation and rules of evidence.

Upon completion of this unit, you are expected to be able to:

- *Identify and describe the fundamental case law affecting the use of RADAR for speed measurement and enforcement.*
- *Demonstrate basic skills in preparing and presenting evidence and testimony concerning speed enforcement and RADAR speed measurement.*
- *Describe the accepted testing procedures and general operating considerations for police traffic RADAR.*

Legal and Operational Considerations

Ever since the automobile appeared on the American scene, we have had problems with speed and speed regulation. In order to deal with these problems, law enforcement officers have continually sought to develop newer, more efficient methods to measure vehicle speed accurately.

Perhaps the earliest mechanical device for measuring speed was the stopwatch. Police officers would time a motorist over a measured distance and establish vehicle speed by calculating distance over elapsed time. If they found that the motorist was driving over the speed limit, they took action. However, in 1903 the major pursuit vehicle used by law enforcement was the bicycle; police officers found it rather difficult to pursue motor vehicles that were traveling at up to 40 mph.

To solve this problem, police in Westchester County, New York, introduced another application of the stopwatch. New York City Police Commissioner William McAdoo set up series of three dummy tree trunks at 1-mile intervals along the Hudson drive. A police officer equipped with a stopwatch and a telephone was concealed inside each fake tree. When a car sped past the first station, the police officer inside telephoned the exact time to the officer in the next tree. The second officer set his watch accordingly. When the car passed his post he computed its speed for the mile. If the speed was above the posted limit, he telephoned the officer in the third tree, who lowered a pole across the road and stopped the car.

The year 1910 saw the introduction of another new scientific advance in speed detection, the "Photo-Speed Recorder." It consisted of a camera synchronized with a stopwatch and operated by taking pictures of a speeding car at set times (for example, 3 seconds apart). The photographic image of a vehicle, of course, becomes smaller the farther away from the camera the vehicle goes. By taking pictures of a receding vehicle at specified intervals and then comparing the images in each photograph, a mathematical formula could be applied to determine the vehicle's speed. William S. Buxton was the first driver found guilty of violating the speed limit on the basis of evidence obtained through the use of a Photo-Speed Recorder.*

Foundational Elements and Requirements for Introduction of Scientific Evidence

As just stated, evidence derived from complex mechanical devices is typically challenged by the defense as to its accuracy and reliability *(Commonwealth* v. *Buxton).* The burden then rests on the prosecution to demonstrate to the court that these devices are capable of performing their function accurately. To do this, the prosecution must introduce testimony by recognized experts in that particular field. Such expert testimony is required every time a case involving a new principle comes to court. The process of expert testimony is long and tedious, and often bogs down the judicial process.

The court can dispense with the need for expert testimony only if the scientific principle underlying the new device has been given judicial notice. Judicial notice indicates that a particular fact or principle is so generally known as to be familiar to all reasonably well-informed persons. When the courts feel that a particular principle is commonly understood and accepted, they will take judicial notice of it; thereafter, expert testimony is no longer required. This approach by the courts has in the past been applied to such (at the time) new principles as clocks, chronometers, motion pictures, x-rays, fingerprinting, and television.

*To bring up a point that will be found interesting later in this unit: At his trial, the defendant objected to the introduction of the speed-recorder evidence, contending that its accuracy and reliability had not been established. The court eventually ruled against Mr. Buxton.

Bear in mind that judicial notice extends only to the scientific accuracy of the principle upon which a particular device operates. It does not extend to the accuracy or efficiency of any given device designed to employ that principle. Judicial notice has also been taken of certain methods of techniques for determining the accuracy and reliability of a particular device.

Once the courts accept a certain scientific principle and take judicial notice of certain tests for the accuracy of devices that employ the principle, it must still be established that the individuals who used the device were qualified to do so and that the specific device used was operating properly at the time in question.

Fundamental Case Law Affecting Doppler RADAR

Below we will see how the courts have dealt with:

- Judicial notice of the scientific principle underlying Doppler RADAR.
- Judicial notice of the tests for the accuracy and reliability of devices employing the Doppler Principle.
- The qualification required of Doppler RADAR operators.

You should be aware that case laws, i.e., fundamental court rulings, apply directly only in the jurisdictions where they were handed down. However, a fundamental ruling in one State will often be offered as precedent in another State's court.

Judicial Notice of the RADAR Principle

Before June 1955, the soundness of the Doppler Principle was the central issue in virtually all court cases involving the admissibility of speed measurement evidence obtained by RADAR. The issues of the reliability and accuracy of RADAR devices were subsidiary questions. In case after case, the prosecution had to prove the Doppler Principle through the long, involved testimony of expert witnesses.

In 1955, the Supreme Court of New Jersey finally took judicial notice of the principle behind Doppler RADAR. The case in question, *State* v. *Dantonio,* proved a landmark. In deciding this case, the court drew a parallel between RADAR meter readings and those registered on more well-known instrumentation, such as fingerprints, x-rays, cardiographs, etc., saying:

> "The law does not hesitate to adopt scientific aids to the discovery of truth which have achieved such recognition. . . . Since World War II members of the public have become generally aware of the widespread use of RADAR methods in detecting the presence of objects and their distance and speed. . . ."

With this, the court affirmed that the RADAR concept was generally known and understood by all reasonably well-informed individuals: The court extended judicial notice.

Other States quickly followed suit. The Supreme Court of Arkansas, in *Everight* v. *City of Little Rock,* reaffirmed the New Jersey court's decision, saying:

> "We are of the opinion that the usefulness of RADAR equipment for testing [the] speed of vehicles has now become so well established that the testimony of an expert to prove the reliability of RADAR 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 equipment used in testing the speed involved in the case being tried."

To repeat the important point emphasized by the Arkansas court: While judicial notice had been extended to the RADAR principle, it was still necessary to prove the accuracy of the particular device employing that principle.

Judicial Notice of Tests for Accuracy

The accuracy of a particular RADAR unit, as distinguished from the accuracy of the RADAR principle, is not a proper subject for judicial notice. No court can accept every RADAR device as always completely accurate. The prosecution must prove that a particular 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 particular device was checked for accuracy at various established intervals and through accepted methods, that device's readings would be accepted as accurate. In a Virginia case, *Royals* v. *Commonwealth,* 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 a highway and at the end of the period. In scientific work it is usual to assume that if a given instrument 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 car with a calibrated 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 mph greater. As the test car 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 RADAR 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 car. If such a procedure is carried out each time the RADAR meter is set up, the check measurements made with the automobile speedometer become supporting evidence."

These steps, however, represented the extreme in precautionary testing. The courts tended to relax them as the use and understanding of RADAR increased. In *Thomas* v. *City of Norfolk,* the court indicated that it would be sufficient to test the RADAR unit at the beginning and end of each duty shift: If the unit tested properly at these times, it could be presumed to have functioned properly between times.

The court had now established guidelines for when RADAR equipment should be tested. However, the issue of the best method of testing remained.

An efficient, convenient, and popular method of testing a RADAR device's accuracy uses a tuning fork. 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 of the accuracy of the instrument 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 RADAR instrument 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 RADAR instrument. 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 RADAR unit 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 RADAR device properly tested by that tuning fork.

Operator Qualifications

The courts seemed to have had little difficulty in outlining the RADAR 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 instrument; it is not required that he understand the scientific principles of RADAR or be able to 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 RADAR repairman and had operated RADAR equipment 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 instrument."

The courts thus established that a RADAR operator need be neither technician nor physicist. Whether or not the operator fully understands all of a RADAR unit's internal workings is unimportant.

Vehicle Identification

As discussed in Units 2 and 3, certain elements of the speeding offense must be established for prosecution to be successful. Beyond establishing the vehicle's speed, the officer must also be able to prove that a particular speed law was violated; that the defendant was the driver of the vehicle at the time of the offense; and that the offense occurred on a public thoroughfare. In cases where RADAR has been used to obtain the speed measurement, the officer must also be able to identify the violator's vehicle.

Identifying a vehicle does not mean just saying that it was, for example, a yellow Mercedes (although physical descriptions are important). In cases involving RADAR, vehicle identification refers to the operator's ability to tell which vehicle's speed registered on the instrument.

For example: An officer on RADAR patrol is monitoring a section of highway at a time of moderate traffic flow (i.e., fairly steady). The officer discovers a speed violator and obtains a RADAR reading on that vehicle. Naturally, the defense will maintain that the officer couldn't possibly have singled out the defendant's vehicle from all the others on the road.

How then can the RADAR officer assume that the violator was properly identified? In *Honeycutt* v. *Commonwealth*, the Kentucky Court of Appeals dealt with this problem:

> "The RADAR device used in the instant case simply registered a speed reading on a speedometer dial. It did not show a "blip" on a screen or by any other means undertake to show location or direction of a vehicle in its field. The testimony of the policeman was that he had set up the instrument to cover northbound traffic on the four-lane, two-way street in question. He said that he observed, in the rearview mirror of the cruiser, several vehicles approaching from the south. One of them was passing the others. The RADAR speedometer registered an unstable reading, with a top of 50 mph. Directly, the reading stabilized at 50 mph and he observed in the mirror that one car had passed the others and was itself out in front of the others. The fact that the one car was by itself, away from the others, and closest to the RADAR unit, enabled the RADAR unit to make a stable reading of its speed. The policeman pursued the car in question, in [his] cruiser, and caused it to stop. The car was being driven by the appellant.
>
> "The appellant argues that there was insufficient evidence that his car was the one which caused the RADAR unit to show a 50 mph reading; that a southbound car in the other lane could have caused it. In our opinion the reasonable import of the policeman's testimony is that he observed the appellant's car passing others at the same time the RADAR dial showed a fluctuating reading with a 50-mph maximum. When the dial stabilized at 50 mph the car was in front by itself, nearest to the unit. The policeman's estimate of its speed, by visual observation alone, was from 40 to 45 mph. This evidence reasonably points to the appellant's car as the offending vehicle, and we do not think that the evidence is reduced to worthlessness by the remote chance of coincidence that a southbound vehicle broke clear from a passing situation, at 50 mph, at the same moment that the appellant's car got out in front of the northbound lanes. Furthermore, the testimony indicates with reasonable certainty that a southbound car, when it entered the range field of the RADAR, would have been beyond the north bound cars and therefore would not have registered a stabilized reading."

In dealing with the question of vehicle identification, the courts have in effect outlined the proper procedures to be employed. The officer must first establish that a vehicle's speed represents a potential violation through direct visual observation. This initial estimate is next verified by checking the speed displayed on the RADAR unit. If these two pieces of evidence agree, the operator has sufficient cause to believe the target vehicle is the violator. The visual estimate must be considered the primary evidence, with the RADAR speed reading secondary and supportive. The operator should watch the vehicle as long as possible and get a complete tracking history before taking enforcement action. Using the audio Doppler feature available on many RADAR devices can provide strong supportive evidence. While not mandated by case law, its use is strongly recommended as an integral part of tracking history.

Special Requirements of Moving RADAR

Moving RADAR presents special problems in vehicle identification because the speed of the patrol car itself enters the picture. **In effect, when moving RADAR is used the courts demand that the officer verify both the defendant's vehicle speed and that of the patrol car 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 RADAR. As with earlier case law, *Hanson* affirmed that:

- The operator must have sufficient training and experience in the operation of moving RADAR.
- The moving RADAR instrument 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 RADAR device was used where road conditions would distort readings as little as possible.
- The patrol car's speed was verified.
- The instrument's accuracy was tested within a reasonable time before and after the arrest.

Case Preparation and Presentation

We have, to this point, discussed several elements essential to the successful prosecution of a speeding offense. When preparing a case presentation, it may be helpful for you to keep in mind that:

A. The officer must establish the time, place, and location of the RADAR device; the location of the offending vehicle when the violation took place; that the defendant was driving the vehicle; and that State law regarding the posting of speed limits and RADAR signs had been complied with.

B. The officer must state his qualifications and training.

C. The officer must establish that the RADAR device was operating normally.

D. The officer must establish that the RADAR device was tested for accuracy, both before and after its use, using a certified tuning fork or other accepted method.

E. The officer must accurately identify the vehicle.

F. The officer must have *seen* that the vehicle appeared to be speeding and estimated how fast.

G. The officer must have gotten a RADAR reading that agreed with the visual estimate of the target vehicle's speed.

H. If a Doppler audio feature is present on the RADAR device, the officer is **strongly** encouraged to establish that the audio Doppler pitch emitted correlated with both the visual estimate and the RADAR reading.

I. If moving RADAR is used, the officer must testify that the patrol vehicle's speed was verified at the time the speed measurement was obtained.

These elements should be incorporated into a clear and concise account of the incident. A sample of in-court testimony that includes all these elements is shown on the following page.

When testifying, an officer should say only what she or he is sure is true. Under no circumstances should an officer be drawn into a technical discussion of the Doppler Principle or a RADAR unit's internal workings. Remember, the *Honeycutt* case established that an officer need only be familiar with the operating procedures of a RADAR unit, not be an expert on RADAR.

Instrument Licensing

A RADAR unit is composed of a radio transmitter and a receiver; as such it must be licensed by the FCC. A RADAR instrument for vehicle speed measurement is classified by the FCC as a "pushbutton" device, and therefore only a "station license" is required. This means that the police agency owning the RADAR unit(s) is issued the license and the actual RADAR operators do not need to be licensed individually.

If the police agency possesses both X- and K-band RADAR units, the license must specify both frequencies. The license will also state the number of RADAR units which may be operated at any one time. A police agency may own as many RADAR units as it wishes, but may not operate **at any one time** more RADAR units than authorized on the FCC station license. This FCC license must be renewed periodically (usually every 5 years).

Preparation and Use

General Operational Considerations

Most of the RADAR devices currently on the market require similar preparatory procedures: The device components are assembled and installed, and the required tests for accuracy are performed. Unit 5 will detail the exact procedures for the specific RADAR(s) you will use (there are differences among the various manufacturers' units in the exact procedures involved). However, certain procedures are common for all RADAR devices; this section will deal with those procedures.

Instrument Component Assembly

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

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

Two-piece units require some component assembly. First, the antenna must be attached to

A Model of Testimony Concerning RADAR Speed Measurement

"My name is John B. Smith. I am a trooper assigned to the Traffic Unit of the Connecticut State Police Department. As part of my duties for the past year, I have operated police traffic RADAR for this department. I have successfully completed a basic training program for RADAR speed measurement, and I currently hold a Certificate of Competency issued by my department.

"On the afternoon of June 2, 1981, I was operating a stationary RADAR unit on Post Road at the corner of Old Kings Highway. The RADAR unit, a model manufactured by Acme RADAR Instruments, was operating in a normal manner. Tests for calibration had been performed when the unit was first set up at 2:15 p.m., and again at the end of my duty tour at 6:20 p.m.

"At approximately 4:25 p.m. a 1978 Alfa Romeo, Connecticut Registration Number 1A-1750 (later found to be driven by the defendant, Paul A. Branless), was observed approaching from the south at what appeared to be a high rate of speed. From visual observation, I judged the speed to be approximately 60 mph. The audio pitch emitted by the RADAR correlated with this speed estimate.

"At the corner of Post Road and Old Kings Highway, when the defendant's vehicle was out front of other traffic, a stable RADAR target speed reading was obtained. The speed reading obtained was 55 mph. The posted speed limit on Old Kings Highway at the intersection of Post Road is 35 mph. [At this point, if the basic speed law applies the officer should state that the speed was unreasonable in light of the conditions of the roadway, traffic, and/or visibility. If a prima facie limit or absolute speed law applies, the officer should also state that RADAR warning signs were in place as required by law.]

"I pursued the suspect for about a block, at which point the suspect's vehicle pulled to the curb. When I approached the vehicle, I discovered the defendant, Mr. Branless [here the officer should point out the defendant], to be the operator of the vehicle."

the counting unit. This in turn is connected to the power source. The RADAR device may then be turned on. As with one-piece units, failure to follow this sequence can result in a blown fuse or possible instrument damage. A good method to recall this procedure is to think of it as the "A-B-C" of RADAR assembly:

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

It then becomes Antenna to Box to Current.

RADAR Installation Considerations

Police traffic RADAR comes in a variety of shapes and sizes. The RADAR unit's structure (one-piece, two-piece) and the manufacturer's recommendations will in large part determine how and where it will be installed in the patrol car. The safety of the patrol car driver and passengers should be the paramount consideration: A poorly secured RADAR unit can become a dangerous missile in the event of any sudden change of patrol car speed or direction. Since a two-piece RADAR unit creates the most problems in installation, some time must be spent discussing proper mounting of the counting unit and antenna.

Mounting the Box Counting Unit

The size and shape of the counting unit component is likely to dictate where in the patrol car 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 RADAR speed display(s), and whether or not the counting unit is obstructing the operator's vision are all factors to consider in mounting.

Antenna Mounting

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 antennna outside is that it is away from the potential areas of interference that may be generated inside the patrol car. 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. Deviations in temperature do not affect the antenna significantly. 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 accident damage are also minimized. The disadvantage of mounting the antenna inside is that there is more potential for interference within the patrol car. **Dash-mounting the RADAR 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 RADAR unit (hand-held or two-piece), the mounting brackets available, the manufacturers' recommendations, and your agency's policies, will generally govern how you mount the antenna. There are three basic guidelines:

- Avoid mounting the antenna so that it unnecessarily exposes the operator or passengers to microwave radiation (i.e., 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 RADAR beam (i.e., avoid the panning effect).
- Avoid directing the RADAR beam at nearby large metallic surfaces (e.g., the car door). Over time, strongly reflected signals from close surfaces may damage the RADAR's antenna.

Antenna Direction

With stationary RADAR, the antenna can be directed toward vehicles either **approaching** or **going away** from the RADAR. When the antenna is directed 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 is allowed to pass the RADAR's position and the idea is to make a speed measurement before it gets out of range.

Either antenna direction has its merits and there will be times and places where either one will be advantageous. It is important to understand that the stationary RADAR instrument will work equally well either way. Whether a target is approaching or receding has no effect on its speed relative to the RADAR. With moving RADAR, on the other hand, the antenna is most often directed toward oncoming traffic.

Instrument Tests for Calibration

Over the years, a number of procedures have evolved to test the accuracy and calibration of police traffic RADAR. Some of these methods are now mandated by case law.

Internal Circuit Test

Testing typically begins with an internal circuit test. These circuit tests vary from device to device and therefore will be discussed in subsequent sections. In essence, the internal circuit test checks the circuits inside the counting unit by means of either crystal(s) or internal electronic tuning fork(s). It should be noted that the internal circuit test checks only the counting unit, not the antenna. On most RADAR instruments, the internal circuit test is performed by pressing a button and checking the speed display to verify that a particular number appears (the number differs from one make and model of RADAR to another). **In all cases, the internal test is passed only if the proper number appears exactly. If any other number appears, do not use the instrument.**

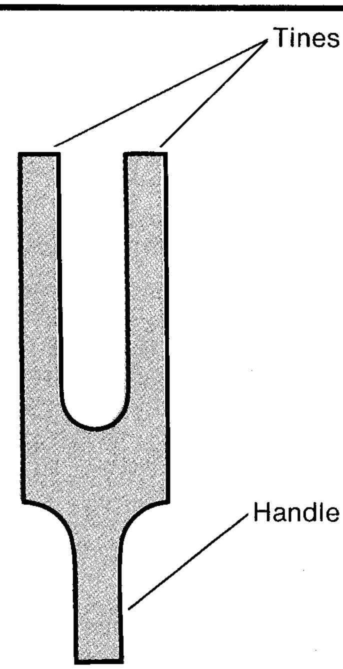
Light Segment Test

Many police traffic RADARs have a feature that allows the operator to make sure all the individual light segments on the RADAR speed display(s) are working. A burned-out light segment could cause the operator to make a mistaken speed reading. If a burned-out segment is discovered, the RADAR unit should be taken out of service and repaired.

External Tuning Fork Test

Next comes a test of the RADAR's calibration. The tuning forks used in this test should not be confused with those used for tuning musical instruments. The RADAR tuning fork is specially calibrated for use with a RADAR device. The external tuning fork test checks the ability of both antenna and counting unit to process and display a simulated target speed properly.

Below is a diagram of a typical tuning fork. To use the fork, grasp its handle and strike one of the tines against the 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, might chip or break the fork. Tests by the National Bureau of Standards have shown that even a badly chipped fork will probably continue to vibrate properly and give valid results; but there is no reason to needlessly abuse any piece of equipment.



Typical RADAR tuning fork.

It is also generally better to avoid striking the fork when the fork is extremely hot or cold. Extreme variations in temperature might cause a reading to be displayed other than the one desired. However, you can assume that if you can hold the tuning fork comfortably in your bare hand, its temperature will not affect the reading it displays. (The allegation that a tuning fork being wet can affect the speed it displays on a RADAR device is without scientific basis.)

In preparing to make a tuning fork test, point the RADAR antenna upwards. If the antenna is pointed horizontally (i.e., toward any traffic) there may be interference with the test.

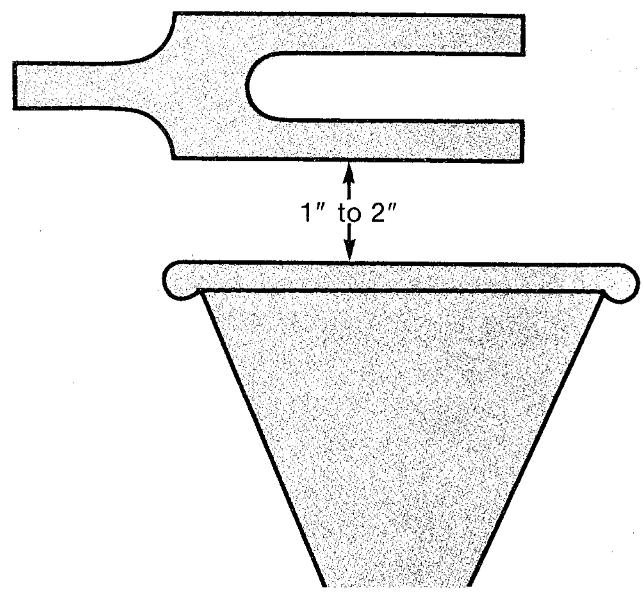
The actual distance the tuning fork is held from the antenna face is not critical, but 1 to 2 inches is generally accepted as optimum. The recommended procedure is to hold the fork so that the two tines line up one behind the other and only the tine faces the antenna. It is **not** incorrect to hold the fork in some other way and it will not invalidate the test if you do. However, experience shows that the recommended method seems to facilitate the RADAR's ability to measure the fork's vibrations.

If you perform the tuning fork test properly, a speed measurement will appear on the RADAR instrument's display window. **The speed measurement cannot differ from the fork's certified value by more than 1 mph.** For example, if you use a 65-mph fork to test the instrument's calibration, the test will be passed as long as 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 mph, the test should be repeated. If the deviation persists, **do not use the RADAR instrument.**

Case law over the years has affirmed that using tuning forks is a vital and reliable way to check a RADAR unit's accuracy. Traditionally, only one tuning fork has been needed to check a stationary RADAR unit (although local case law or departmental policy may dictate using two or more forks).

For moving RADAR, two forks are necessary because of the RADAR's additional circuitry. One tuning fork usually simulates a low speed, 30 to 50 mph. The second tuning fork is usually a high-speed fork, simulating a speed of between 60 and 90 mph.

Moving RADAR is checked by first striking the low-speed tuning fork and holding it in front of the antenna. This simulates a patrol car speed in the patrol speed display window. A second, high-speed fork is then struck and also held before the antenna. This second fork, presented in conjunction with the first fork, will simulate a target closing speed. The speed displayed in the target display window should show the difference between the high- and low-speed forks, in other words a simulated moving target speed. This process checks the RADAR unit's ability to properly subtract the patrol car speed from the closing speed (remember, TS=CS−PS).



Recommended method for holding tuning fork over antenna.

RADAR tuning forks **must not** be mixed between X-band and K-band RADARs. An X-band fork used to test a K-band RADAR (and vice versa) will **not** yield accurate results.

Patrol Speed Verification Test

The RADAR tests for accuracy discussed so far (internal circuit test, light segment test, and external tuning fork test) apply to all traffic RADAR units, moving and stationary. The final test, verification of the RADAR patrol speed readout against the patrol car calibrated speedometer, is required only for moving RADAR units.

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

While not mandated by case law, this test can also be applied to stationary RADAR devices. Running a stationary RADAR in a moving patrol vehicle (without approaching traffic) should result in a RADAR speed reading consistent with that of the calibrated speedometer.

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

Subsequent Tests for Accuracy

It can only be assumed that the RADAR was working properly when a speed measurement was made if it can be proved that the RADAR was working properly both before and after the measurement was made. An important procedural question is: How soon before and after a speed measurement must the RADAR's accuracy be tested?

Each law enforcement agency determines its minimum requirements for retesting the RADAR device as part of its own standard practices and in response to case law applicable to its own jurisdiction. Some general guidelines and suggestions can be offered here.

Most agencies require that these tests be performed **at least twice**, at the beginning and end of the duty shift in which the RADAR is operated; usually they are made even more frequently. Many agencies instruct their RADAR operators to conduct the tests as part of both the setup and teardown at each place they make RADAR measurements. This ensures that the before-and-after tests are made within a reasonable time of any speed measurements and enforcement action. It also eliminates any possibility that the RADAR might malfunction in transit between locations.

General RADAR Operating Procedures

Site Selection Considerations

You should keep several considerations in mind when selecting an appropriate place for RADAR operations. Some of these are general considerations; others apply specifically to moving RADAR or to stationary RADAR.

First, there should be a demonstrated need for speed enforcement at any location chosen for RADAR (or any other speed measurement operation). Locations should not be chosen just because they are convenient. A need for RADAR speed enforcement might be shown in locations where:

- There have been a lot of motor vehicle accidents involving speed.
- Many speed violations have previously occurred.
- Citizens have made a lot of complaints about speed violations.
- Special speed regulations or other characteristics (e.g., school zones, construction sites, etc.) require selective or special speed enforcement.
- Planning and allocating enforcement resources call for conducting a speed survey.

These are not the only reasons for choosing a particular location. This list is just to illustrate that there must be some good reason for selecting a RADAR site.

Safety is a major consideration in RADAR site selection. RADAR's whole purpose is to improve traffic safety, so it is clearly undesirable to conduct RADAR operations where the patrol car's presence will worsen the safety situation. For stationary operations, this implies that the chosen site must be far enough off the road that it does not impede the flow of traffic. The site should also give you enough of an unobstructed view that you can enter the traffic stream safely to conduct pursuits. With moving RADAR, you should be very safety-conscious when initiating pursuit, especially since it may involve a U-turn against oncoming traffic. With both stationary and moving RADAR, you must also consider the safety aspects of actually stopping a speed violator. The shoulders of the road or other potential stopping places must be broad enough to ensure that the traffic flow is not obstructed by either the violator's vehicle or the patrol car. Of course, you should observe all basic safety procedures when approaching and investigating an apprehended speed violator, as with any citizen contact.

Traffic and roadway conditions should also influence the selection of RADAR sites. The flow of traffic should not be so heavy that problems with target identification become insurmountable. When operating either stationary or moving RADAR, the operator must be alert to potential distortion sources. In all cases, you should be able to see target vehicles clearly. Therefore, the roadway should not be excessively hilly or curved, or otherwise severely obstructed.

Some States stipulate that when there are two patrol cars at a RADAR site they must remain in visual contact with each other. This is intended to ensure that both the spotter car (the car with the RADAR unit) and the chase car keep the target vehicle in sight, and thereby that enforcement action is taken against the appropriate vehicle. If you are not sure whether your State has such a stipulation, check with a supervisor.

General Record Keeping Requirements

Many departments provide a form for recording RADAR activity. The types of form and contents vary greatly among police departments.

A typical RADAR operation form usually contains the following points:

A. Site Information:

(1) Date of log (day, month, year).

(2) Location of surveillance site.

(3) Type of road (highway, urban street, rural road, etc.).

(4) Speed limit (based on posted or unposted limits).

(5) Traffic conditions (light, heavy, medium).

(6) Weather conditions.

(7) Road conditions (construction, slippery conditions).

B. Device Information:

(1) Tests of calibration (stating speeds of tuning forks used).

(2) Time of tests.

(3) Device manufacturer, model number, serial number.

C. Enforcement action:

(1) Citation type and number.

(2) Vehicle registration.

(3) Time of stop.

(4) Recorded speed.

D. Notes:

Included here would be any specific comments relative to the investigation. These notes may help in subsequent court testimony.

As discussed in the section on the legal aspects of RADAR use, a log can establish the accuracy of the RADAR device and the conditions that may affect its use. Examples of RADAR logs are presented on the following three pages.

RADAR Log

Radar # ____________________

Calibration Record

	Begin Shift							End Shift								Activity	
Date	Time	Int. (64)	Tune 65	35	Fork 30	Vfy	Other Squad	Time	Int. (64)	Tune 65	35	Fork 30	Vfy	Other Squad	Trooper	Citations	Warnings

RADAR Arrest Data

Barrack ____________ Date ____________ Time Started ____________ Time Stopped ____________

Test ____________M.P.H. MSP Car No. ____________ Tuning Fork No. ____________
Traffic - Direction of Travel - N. S. E. W.

Locations: Unit - Rt. No. ____________

Signs - Rt. No. ____________ Type - Perm - Type

Stop Point - Rt. No. ______ ____________ Sight of Unit - Yes No

Intersecting Roads - Unit to Stop Point ____________

Conditions:

Road Character:	☐ Upgrade	☐ Downgrade	☐ Level
	☐ Macadam	☐ Concrete	☐ Dirt-Gravel
Road Condition:	☐ Dry	☐ Wet	☐ Snow-Ice
Traffic Condition:	☐ Heavy	☐ Medium	☐ Light
Weather Condition:	☐ Clear	☐ Foggy	☐ Raining
	☐ Snow-Sleet		

Arrest # ____________ Summons # ____________ Arrest # ____________ Summons # ____________
Color ____________ Make/Model ____________ Color ____________ Make/Model ____________
Regis. ____________ State ____________ Regis. ____________ State ____________
Speed ____________ TPR. ____________ Speed ____________ TPR. ____________
Remarks: ____________ Remarks: ____________

Arrest # ____________ Summons # ____________ Arrest # ____________ Summons # ____________
Color ____________ Make/Model ____________ Color ____________ Make/Model ____________
Regis. ____________ State ____________ Regis. ____________ State ____________
Speed ____________ TPR. ____________ Speed ____________ TPR. ____________
Remarks: ____________ Remarks: ____________

Arrest # ____________ Summons # ____________ Arrest # ____________ Summons # ____________
Color ____________ Make/Model ____________ Color ____________ Make/Model ____________
Regis. ____________ State ____________ Regis. ____________ State ____________
Speed ____________ TPR. ____________ Speed ____________ TPR. ____________
Remarks: ____________ Remarks: ____________

Arrest # ____________ Summons # ____________ Arrest # ____________ Summons # ____________
Color ____________ Make/Model ____________ Color ____________ Make/Model ____________
Regis. ____________ State ____________ Regis. ____________ State ____________
Speed ____________ TPR. ____________ Speed ____________ TPR. ____________
Remarks: ____________ Remarks: ____________

Unit Operator ____________

RADAR Log

Date ______________ Vehicle No. ______________ Officer(s) ______________

Tests: CAL/STA-Reads ______________ L/T-Reads Yes ________ No ________

Tuning Forks: No. ________ , ________ MPH; and No. ________ , ________ MPH

Start STA: MPH/ ______ MPH MPH/ ______ MPH MOV: MPH ______ MPH Time ______

End STA: MPH/ ______ MPH MPH/ ______ MPH MOV: MPH ______ MPH Time ______

Speed Limit	Radar Speed	Summons Number	Time	Vehicle Reg.	Year	Make	Color	Location

Remarks:

Study Topics:

a. Review some of the major court decisions affecting RADAR within your own State.

b. On your own, or with other members of the class, practice preparing for a court appearance. Rehearse the testimony you would present. Remember, your testimony should be concise and it should include those elements that have been discussed as being essential to a successful prosecution.

c. Summarize the procedures involved in conducting typical tests of calibration.

d. Be prepared to answer the following:

1. *State* v. *Dantonio* and *Honeycutt* v. *Commonwealth* are considered to be two landmark RADAR cases. Briefly explain what each established.

2. What is the "A-B-C" of RADAR assembly?

3. When should you test a RADAR unit's calibration?

4. Does RADAR have to be licensed? Why or why not?

5. Why is it important to obtain a RADAR tracking history on a speeding vehicle?

6. Briefly list the major considerations involved in RADAR site selection.

7. When performing tuning fork tests, a discrepancy between the RADAR readout and the speed stamped on the tuning fork is allowable. What is this tolerance?

Unit 5—Operation of Specific RADAR Devices

This unit will introduce you to the RADAR device(s) used by your own police department.

After completion of this unit you are expected to be able to:

- *Describe the functional components of the RADAR device(s) used by your department.*
- *Be able to describe the devices' setup, testing, and operating procedures.*
- *Operate the device and meet all the procedural requirements of actual patrol.*

1. Operation of Specific RADAR device(s).

This unit's "study materials" consist of the direct examination of the instructions provided by the manufacturer of the particular RADAR device(s) used in your police department. Specific information on the assembly of the components, nomenclature, power supply considerations, device test procedures, etc. must be gleaned from the manufacturer-supplied materials. Because modifications are constantly being made to both new and existing RADAR devices, it would be impossible to provide truly up-to-date materials with this course.

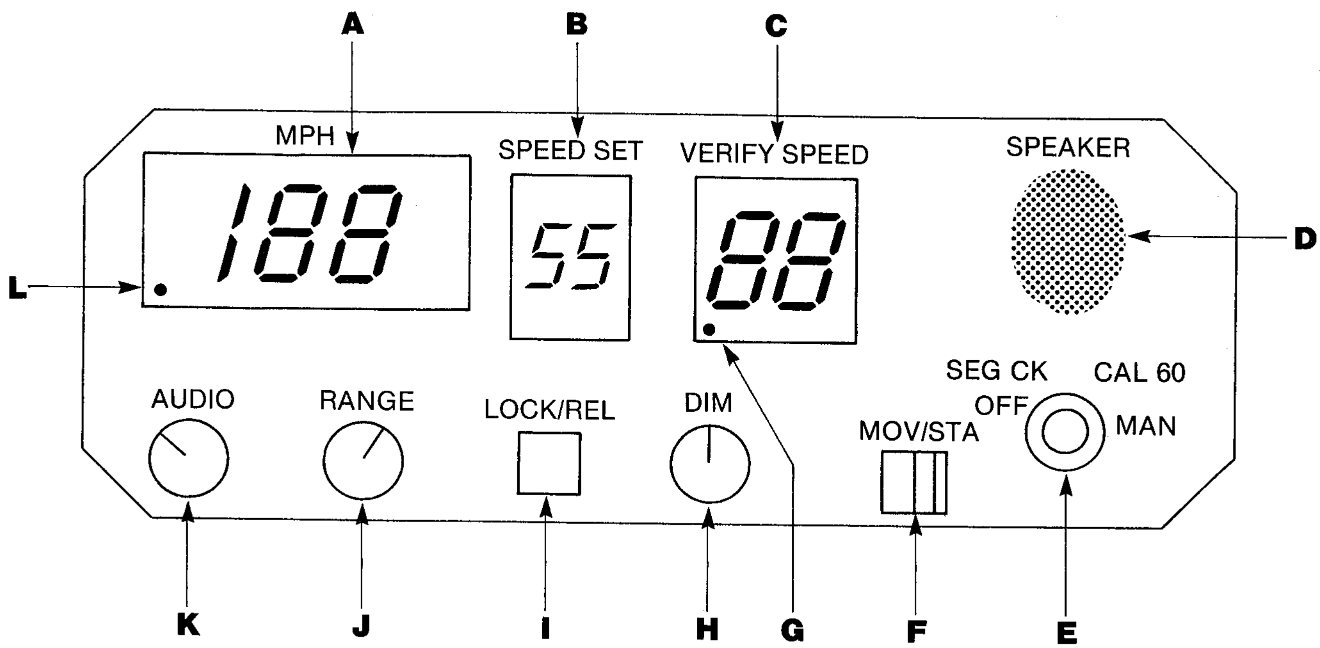
Your instructor has been recommended to present a brief synopsis of the specific operating instructions for your department's RADARs. This will give you a quick overview of the specific features, characteristics, and limitations of your RADAR device(s).

It is possible that the terminology and, in some cases, the operating procedures described by the manufacturer may conflict with what you have been taught in this course. Wherever possible, your instructor should try to ensure that both terminology and procedures conform as closely as possible with those recommended with this program.

Attached is a sample format that your instructor may use in preparing this outline.

A typical two-piece Doppler RADAR unit operates within the X-band frequency at about 10.525 GHz, in both moving and stationary modes.

NOMENCLATURE



A **Target Vehicle Display Screen**—Displays target vehicle speeds via lighted seven-segment Numitrons. 0-199 mph.

B **"Speed Set" Thumbwheels**—This control is present on devices which still have auto lock or auto alarm feature.

C **"Verify Speed" Display Screen**—Displays the patrol vehicle speed via lighted seven-segment Numitrons. 0-199 mph.

D **"Speaker"**—Provides an audio reproduction of the Doppler signal being monitored.

E **Selector Switch**—Five positions:

1. "OFF"—No power is supplied to the unit.
2. "SEG CK" (Segment Check)—Displays the lighted Numitron segments of the two display screens, A & C above.
3. "CAL 60"—Verifies the internal circuitry of the display module. If any number other than 60 appears in the displays when the circuitry is checked, the unit must be removed from service. Different devices may use another number for internal circuit check.

F **"Mov/Sta"**—This switch position allows the selection of moving or stationary mode operation.

G **Low-Power Indicator**—A lighted dot appears in the lower left corner of the "verify speed" display screen (C, above) when power drops below the manufacturer's specifications.

H **"Dim"**—This control allows adjustment in the brightness of the readout displays.

I **"Lock/Rel"**—Permits the lock-in or release of readings on the display screens.

J **"Range"**—Permits adjustment of the sensitivity of the RADAR receiver.

K **"Audio"**—Permits adjustment of the volume of the audio reproduction of the Doppler signals being monitored.

L **Power-On Indicator**—A small lighted dot will appear in the lower left corner of the target vehicle display screen when the unit is receiving operational power.

TEST PROCEDURE—Decatur MV-A Rangemaster 715

1. **Connect Unit:**

   With the selector switch (E) in the "off" position, connect the antenna and power cables to the rear of the readout module. Plug the power cable into the cigarette lighter.

2. **Perform Light Segment Check:**

   Set "Mov/Sta" switch (F) to "Mov."

   Set the selector switch (E) to "Seg Ck." A lighted dot will appear in the lower left corner of the target vehicle display screen (L). "188" will appear in the target vehicle display screen and "88" will appear in the "verify speed" display screen (C).

   After checking the light segments, adjust the brightness of the readouts by using the "Dim" control (H).

   If any numerical segment fails to light up, remove the unit from service.

3. **Perform Internal Circuit Test:**

   Set the selector switch (E) to "Cal 60."

   Set the "Mov/Sta" switch (F) to "Sta." The number "60" should appear in the target vehicle display screen.

   Set the "Mov/Sta" switch to "Mov." The number "60" should appear in the "verify speed" display screen.

   If any number other than "60" appears on either screen, remove the unit from service.

4. **External Tuning Fork Tests:**

Set the selector switch (E) to "Man."

Set the "Mov/Sta" switch (F) to "Sta" (stationary).

Strike the low-speed fork and hold it in front of antenna as described in Unit 4. The speed stamped on the tuning fork will appear in the target vehicle display.

Strike the high-speed fork and hold it in front of antenna. The speed stamped on the tuning fork will appear in the target vehicle display.

Set the "Mov/Sta" switch (F) to "Mov."

Repeat the individual low- and high-speed fork tests. The forks' stamped speeds will now appear in the "verify speed" display window.

Strike the low-speed fork and hold it in front of the antenna. When the appropriate reading appears in the "verify speed" display, immediately strike and hold the high-speed fork in front of the antenna. A speed reading reflecting the difference between the two forks will now appear in the target vehicle display screen.

If the proper speeds are not displayed, remove the unit from service.

NOTE: Only the forks supplied by Decatur for MV-A 715 units may be used.

5. **Patrol Speed Verification Test:**

With the RADAR unit properly mounted, accelerate the patrol vehicle to a steady speed. Compare the "verify speed" display reading with the calibrated speedometer—the two readings should closely correspond.

If there is a noticeable deviation, remove the RADAR unit from service. A determination must be made whether the speedometer, the RADAR unit, or both are in error.

6. **Removal of Unit from Service:**

If the RADAR unit fails any of the prescribed tests, the unit is not to be used.

Unit 6—Moot Court

In Unit 4, you were provided with a sample statement of direct testimony for a typical RADAR speed measurement case. This unit is designed to help you prepare further for the courtroom. In this, you will be required to prepare a similar statement of direct testimony based upon specific case descriptions. Some trainees will also be given the opportunity, in class, to participate in a moot court, giving testimony and later submitting to cross-examination by the defense. After the exercise there will be a group discussion of the good and bad points of the testimony heard.

After completion of this unit, you should be better able to:

- *Prepare complete, concise and effective direct testimony for RADAR cases.*
- *Respond properly and effectively to cross-examination.*

Requirements and Procedures

In preparation for the moot-court segment of this course, you are expected to prepare a complete set of direct testimony for a hypothetical case in which a speeding offense was alleged to have occurred. Think of this as writing a script for a courtroom drama. You will not only be the playwright, but you will also assume the role of the arresting officer.

The script you prepare might include two speaking roles: the Officer and the Prosecutor. The prosecutor's role will be to ask a series of questions, and the officer's role will be to respond to those questions. Alternatively, the script may be written without a prosecutor, consisting only of a monologue by the officer. The choice must be based on the traffic offense adjudication procedures.

In either case, it's expected that your script will be good, realistic, and well thought out, since the officer's testimony is the principal body of evidence that will be introduced to establish the elements of the offense.

The script you prepare can be based on one of the hypothetical cases described on the following pages. Each case description includes a sketch of the scene of the alleged violation and an outline description of the various circumstances and conditions alleged to have characterized the incident.

There are a number of ground rules governing how you use the pictorial and narrative information in preparing your script:

(1) Feel free to introduce or not introduce the sketch into evidence. It is there primarily to help you visualize the scene.

(2) The trainee is **not** free to change the sketch. (With the sole exception discussed in Item 3.)

(3) You are, however, expected to complete the sketch by indicating on it the exact position of the patrol car with its RADAR unit. That information was purposely left out of each sketch because it is felt to be of considerable importance to both the prosecution and the defense. The vehicle's location, for example, may have a major bearing on the likelihood that interference may have occurred.

(4) The type, make, and model of RADAR used in the case will be the one used by your agency.

(5) The circumstances, characteristics, and conditions listed in the narrative information cannot be changed.

(6) Included in the testimony may be any or all of the circumstances and conditions listed in the narrative description. You do not have to include any item if you do not feel it is relevant to the case. For example, it might be that in some jurisdictions you may not mention a suspect's age; in other instances, age may be irrelevant. However, if you are questioned about any of the "facts" described in the sample cases, you may not change any of the information presented in the narrative.

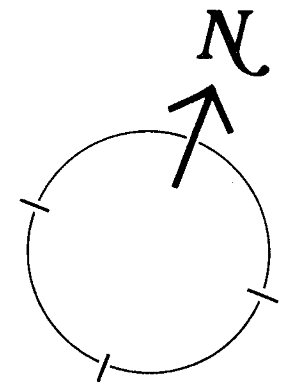
(7) You may, however, make up any "facts" not covered in the narrative description. For example, there is nothing in any of the narrative descriptions that pertains to the physical condition of the subject vehicles; you may raise that point if it strengthens your testimony. Any such "facts" added must not contradict or change in any way the information in the narrative description.

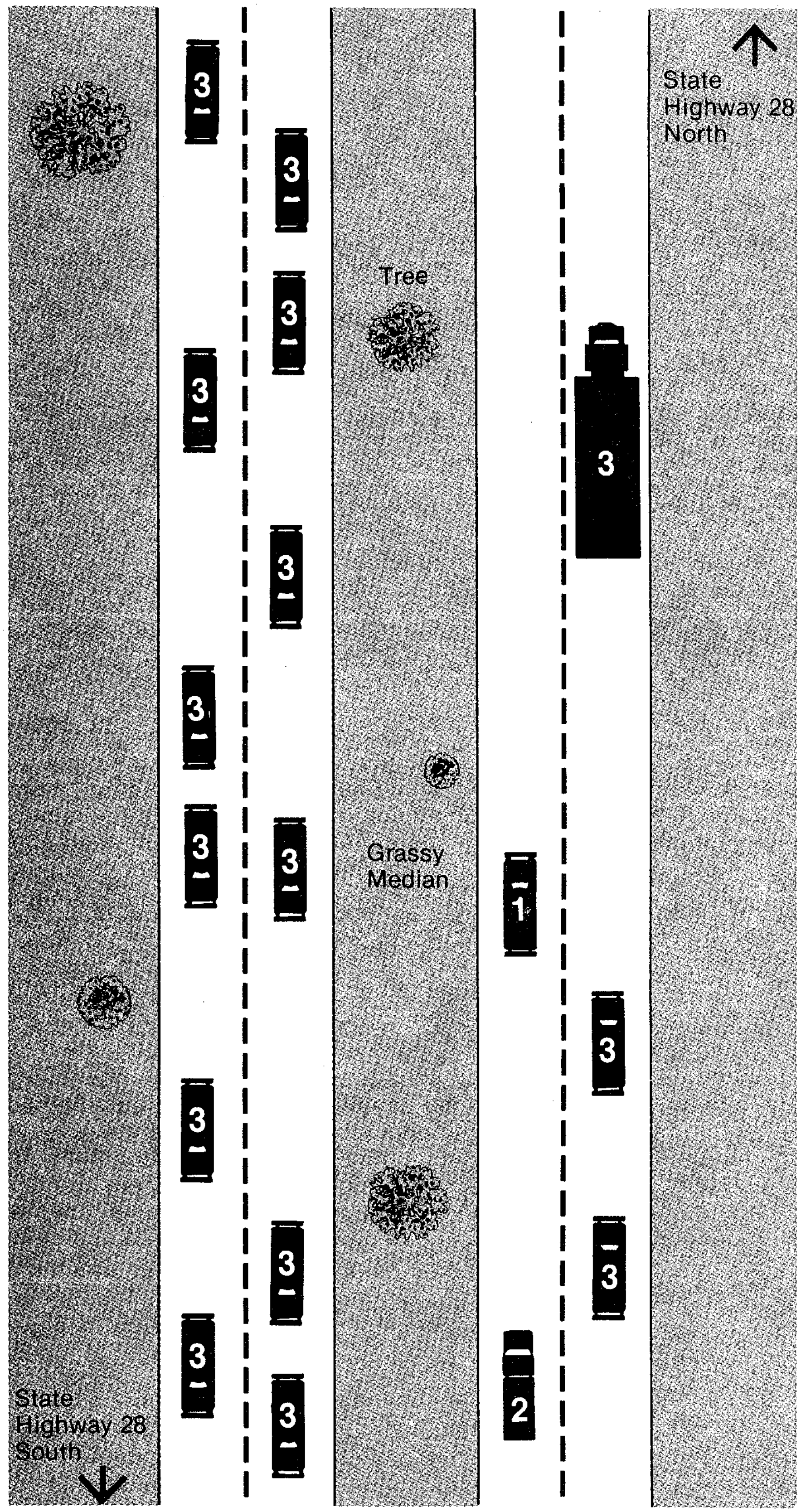
Sample scripts of direct testimony for a similar hypothetical case will be presented in class to illustrate the type of material that you will be expected to produce.

Case Number 1 Description

Accused:	John J. Able Male Age 16
Vehicle 1:	1977 Chevrolet Nova Color: white-on-green Registration Number: AC 6429 Registered to: Mrs. Martha P. Able (mother of accused)
Date/Time of Alleged Offense:	Friday, July 17 6:15 p.m.
Location of Alleged Offense:	State Highway 28 (limited access) Northbound lanes Two miles south of Bakerstown exit
Traffic Conditions:	Moderate, free-flowing in northbound lanes Heavy, constricted in southbound lanes
Weather Conditions:	Daytime Overcast/light mist Light, easterly breeze
Persons in Vehicle (other than accused):	Fred J. Able Male Age 15 (brother of accused) Tina B. Brandt Female Age 16
Situation Description:	The subject vehicle is alleged to have been traveling at 67 mph. A speed limit of 55 mph is in force at the subject location. The subject location is a four-lane (two-north, two-south) divided, limited-access highway in a suburban, residential neighborhood. A 15-yard-wide grassy median devides northbound and southbound traffic. The subject vehicle is alleged to have been in the left-hand (inside) northbound lane and passing a series of slower moving vehicles in the right-hand (outside) lane when the speed measurement was made. A late model Ford pickup truck, approximately 150 feet behind the subject vehicle, was the only other vehicle in the left-hand northbound lane within a quarter mile of the subject vehicle. Three persons, including the driver, were observed to be in the front seat of the subject vehicle.

Case Number 1 Illustration





Vehicles In Vicinity

Vehicle 1:
1977 Chevrolet Nova (Registered to Martha P. Able)

Vehicle 2:
Late-Model Ford Pick-Up Truck

Vehicles 3:
Surrounding traffic

Case Number 2 Description

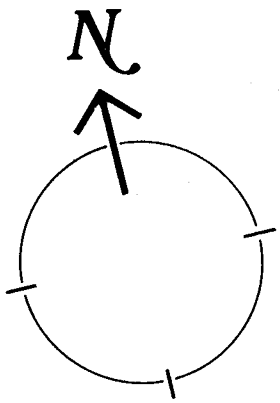
Accused:	Frank H. Dawes Male Age 37
Vehicle 1:	1978 Dodge Aspen Color: blue Registration Number: KT 1292 Registered to: Frank H. Dawes
Date/Time of Alleged Offense:	Tuesday, March 31 7:50 a.m.
Location of Alleged Offense:	Highland Avenue Southbound lane Approximately 500 feet south of intersection with Smith Street
Traffic Conditions:	Moderate-to-heavy, free-flowing in southbound lane Light, free-flowing in northbound lane
Weather Conditions:	Daytime Clear Brisk, westerly wind
Persons in Vehicle (other than accused):	Peter G. Hale Male Age 42

Situation Description:

In response to several complaints of speeding traffic by Highland Avenue residents, police were conducting speed measurement and selective enforcement along a straight stretch of that two-lane road (one northbound, one southbound lane), roughly between the intersections with Smith Street and Chambers Place. Highland Avenue is a residential road with a posted speed limit of 30 mph. It is the most direct north-south route between State Highway Number 28 and the commercial district of Bakerstown. A good deal of morning and afternoon rush hour commuter traffic passes along Highland Avenue. Citizen complaints of speeding focused on the morning rush hour, since it coincides with the departure of neighborhood students to the nearby junior high school.

Subject vehicle is alleged to have been traveling at 43 mph and to have been in front of a closely packed cluster of roughly 4 southbound vehicles. Two persons, including the driver, were observed to be in the front seat of the subject vehicle. No vehicles other than the patrol vehicle were parked on either side of Highland Avenue in the vicinity of the alleged violation. Moderate pedestrian traffic was moving along the sidewalks on either side of Highland Avenue; virtually all pedestrians appeared to be students heading south toward the junior high school, which was approximately one mile from the scene of the alleged violation on Highland Avenue.

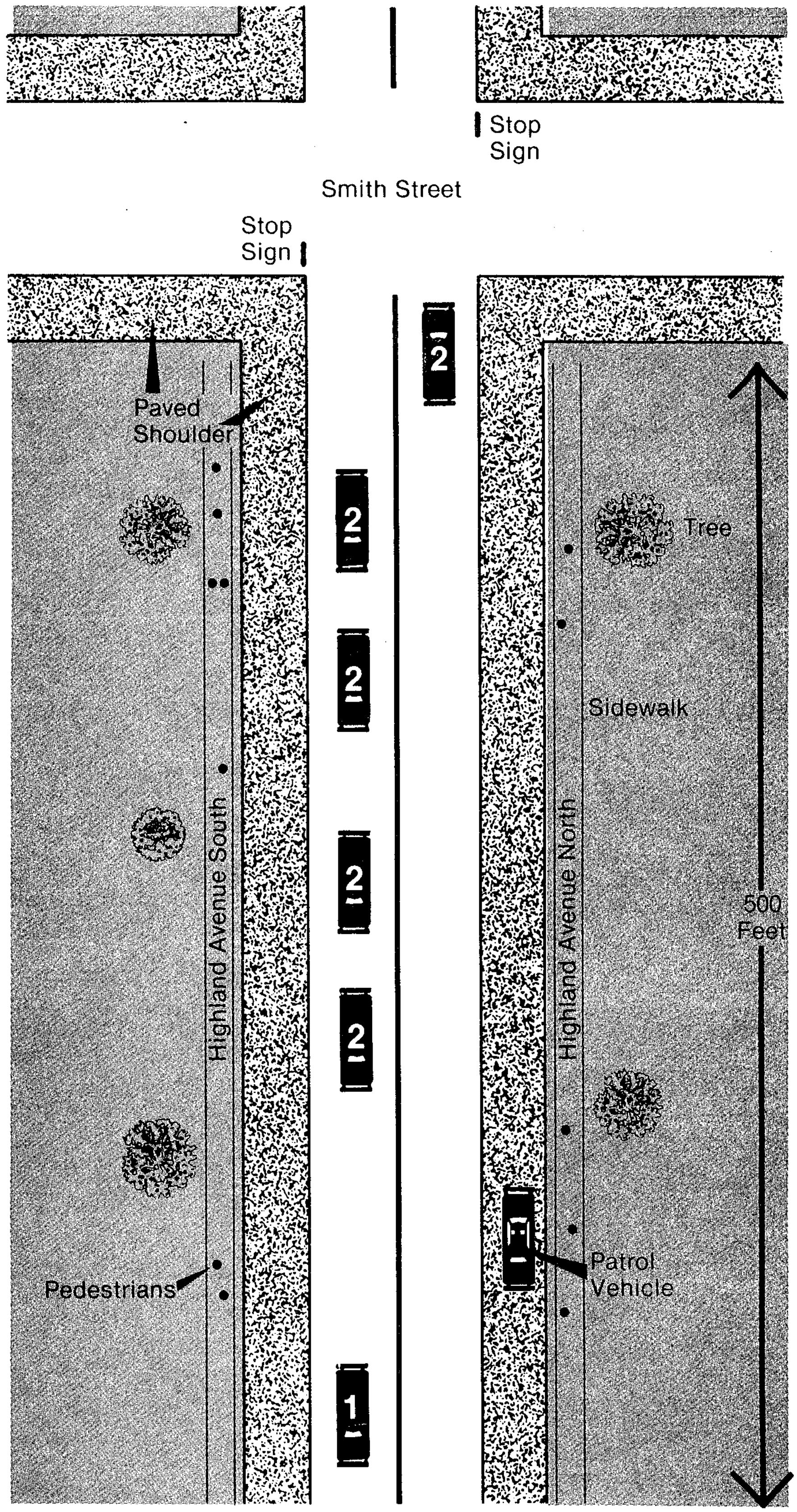
Case Number 2 Illustration



Vehicles In Vicinity

Vehicle 1:
1978 Dodge Aspen (Registered to Frank H. Dawes)

Vehicle 2:
Surrounding traffic



Case Number 3 Description

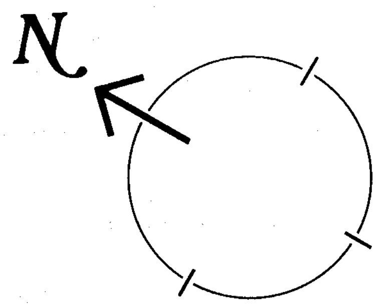
Accused:	Mary J. Smith Female Age 32
Vehicle 1:	1975 Ford Pinto Station Wagon Color: tan Registration Number: PT 7377 Registered to: Francis P. Smith (husband of accused)
Date/Time of Alleged Offense:	Wednesday, April 11 3:15 p.m.
Location of Alleged Offense:	Park Avenue Northbound Lanes At intersection with Fillow Road
Traffic Conditions:	Light-to-moderate, free-flowing in both directions
Weather Conditions:	Daytime Clear Light, variable breeze
Persons in Vehicle (other than accused):	Maryrose Smith Female Age 10 Thomas Smith Male Age 8

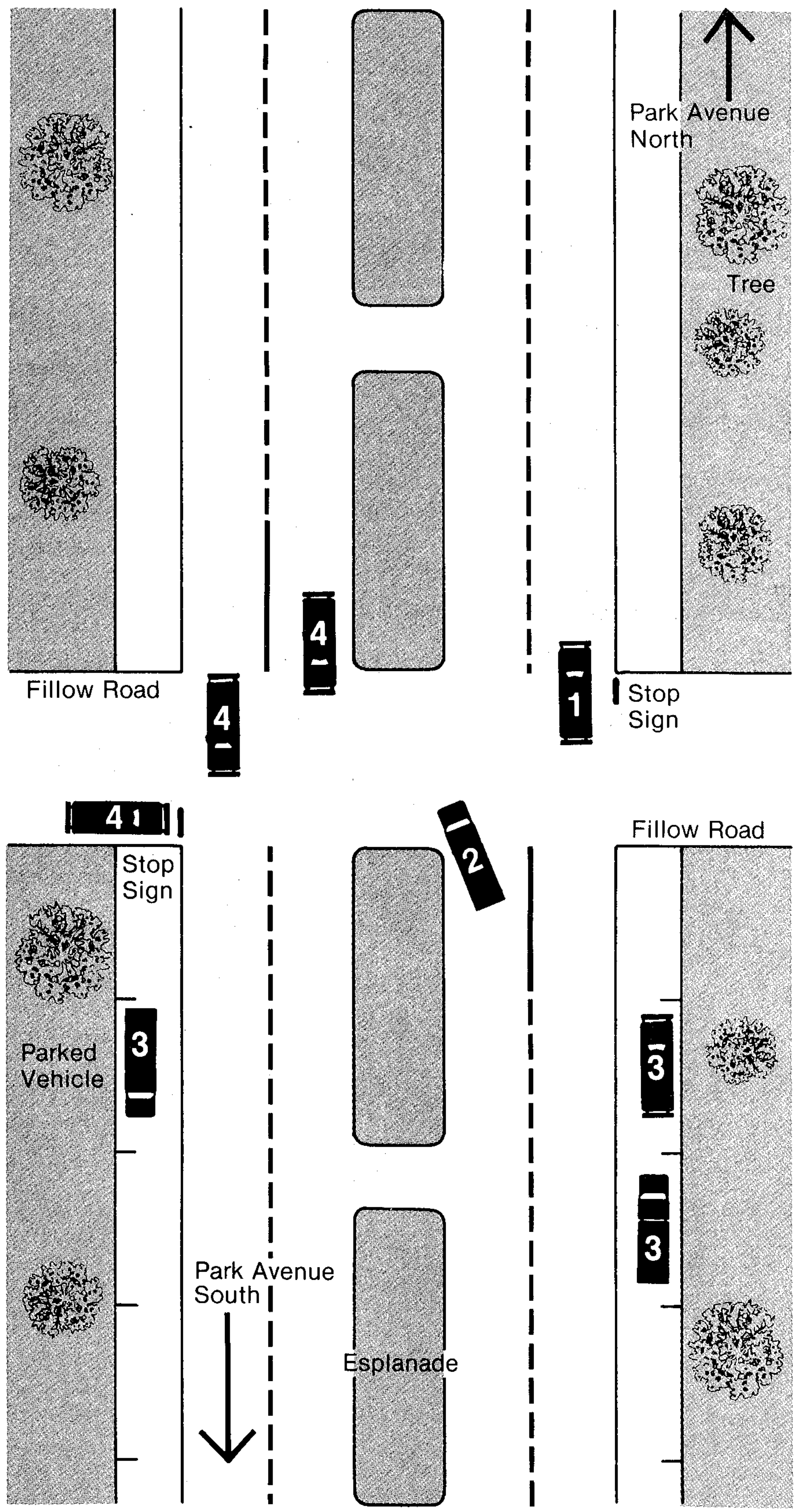
Situation Description:

Park Avenue is a tree-lined, four-lane roadway with a narrow esplanade separating its southbound lanes from its northbound lanes. A speed limit of 30 mph is posted along the avenue. The neighborhood in the vicinity of the intersection of Park Avenue with Fillow Road is mixed commercial-residential. Parking is permitted along both sides of the avenue. Stop signs are situated on Fillow Road to control the intersection. The intersection is located at the crest of a slight hill on Park Avenue. Several accidents have occurred at or near the intersection in recent months; one of these accidents resulted in a pedestrian fatality.

The Subject vehicle is alleged to have been traveling at 40 mph, in the right-hand, northbound lane, adjacent to a few, scattered, parked vehicles. When crossing through the intersection, the subject vehicle is alleged to have passed (on the right) a Dodge van that was stopped in the left-hand northbound lane and preparing to turn left on Fillow Road. Only the driver was observed to be in the front seat of the subject vehicle.

Case Number 3 Illustration





Vehicles In Vicinity

Vehicle 1:
1975 Ford Pinto Wagon (Reg. to F.P. Smith)

Vehicle 2:
Dodge Van (not in motion)

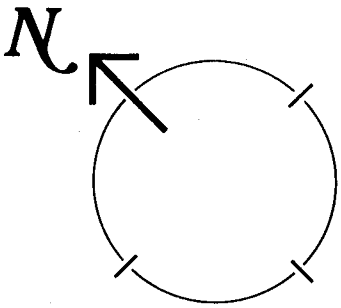
Vehicle 3:
Parked cars

Vehicle 4:
Surrounding traffic

Case Number 4 Description

Accused:	Edward C. Lee Male Age 24
Vehicle 1:	1977 Honda Motorcycle Color: blue Registration Number: 320028 Registered to: Edward C. Lee
Date/Time of Alleged Offense:	Saturday, July 18 10:20 a.m.
Location of Alleged Offense:	State Highway 28 (limited access) Northbound lanes One mile north of Bakerstown Exit
Traffic Conditions:	Light-to-moderate, free-flowing in both directions
Weather Conditions:	Daytime Partly cloudy, no precipitation Brisk easterly wind
Persons in Vehicle (other than accused):	None
Situation Description:	The subject vehicle is alleged to have been traveling at 64 mph. A speed limit of 55 mph is in force at the subject location, which is a four-lane, divided, limited-access highway in a suburban-residential neighborhood. A 15-yard-wide grassy median separates the northbound lanes from the southbound lanes. The subject vehicle is alleged to have been in the right-hand northbound lane when the speed measurement was made. No other vehicles were in the northbound lanes within a quarter-mile of the subject vehicle. One passenger car was in the right-hand, southbound lane.

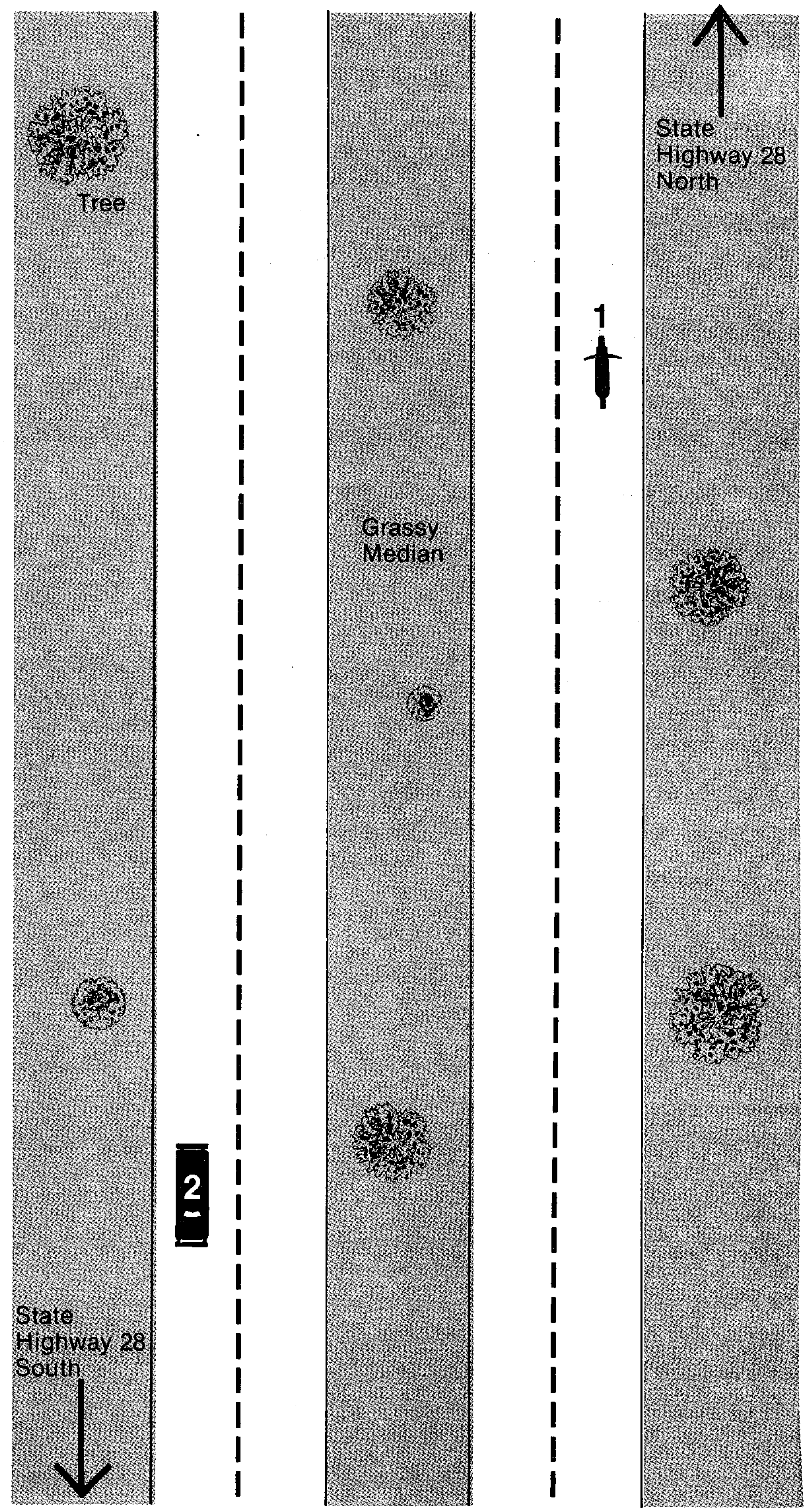
Case Number 4 Illustration



Vehicles In Vicinity

Vehicle 1:
1977 Honda Motorcycle
(Registered to Edward C. Lee)

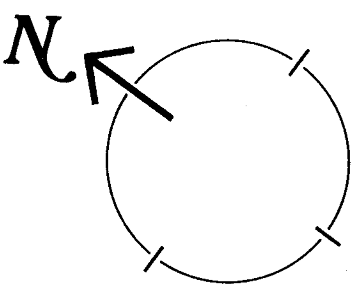
Vehicle 2:
Surrounding traffic



Case Number 5 Description

Accused:	Harold P. Hutchins Male Age 31
Vehicle 1:	1972 Kenworth Tractor with Fruehauf Trailer Colors: Tractor, green; Trailer, white Tractor Registration Number: 175376 Registered to: Allied Fast Freight, Inc.
Date/Time of Alleged Offense:	Monday, July 20 7:10 a.m.
Location of Alleged Offense:	State Highway Number 28 (limited access) Northbound lanes Three miles east of Bakerstown exit
Traffic Conditions:	Moderate, free-flowing in both directions
Weather Conditions:	Daytime Clear Light, variable breeze
Persons in Vehicle (other than accused):	None
Situation Description:	The subject vehicle is alleged to have been traveling at 65 mph. A speed limit of 55 mph is in force at the subject location, which is a four-lane, divided, limited-access highway in a suburban-residential neighborhood. A 15-yard-wide grassy median separates the two northbound lanes from the southbound lanes. The subject vehicle is alleged to have been traveling in the left-hand northbound lane, and to have been passing another tractor-trailer in the right-hand northbound lane when the speed measurement was made.

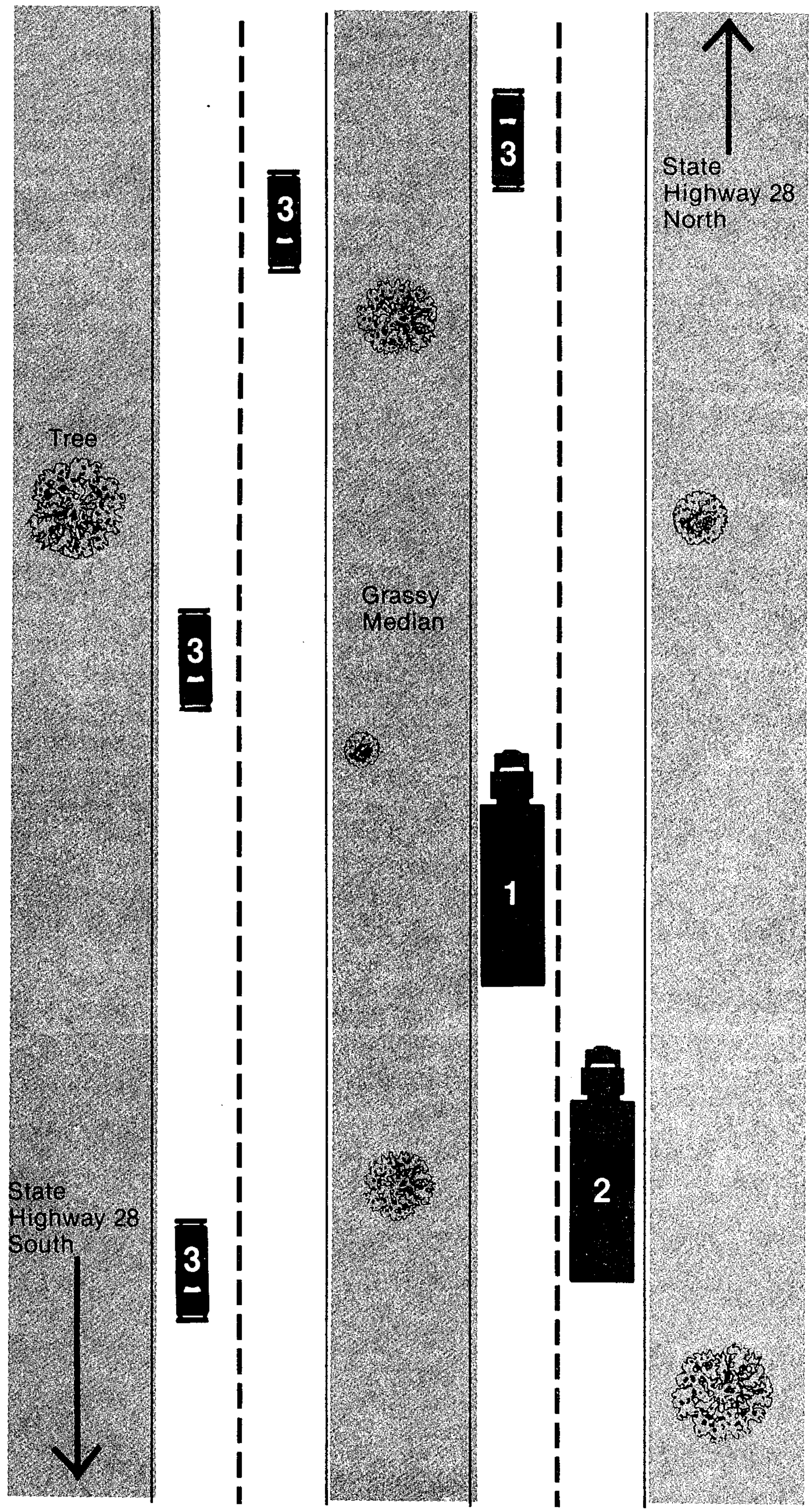
Case Number 5 Illustration



Vehicle 1:
Kenworth Tractor/Fruehauf Trl.
(Reg. to Allied Fast Freight Inc.)

Vehicle 2:
Another Tractor-Trailer

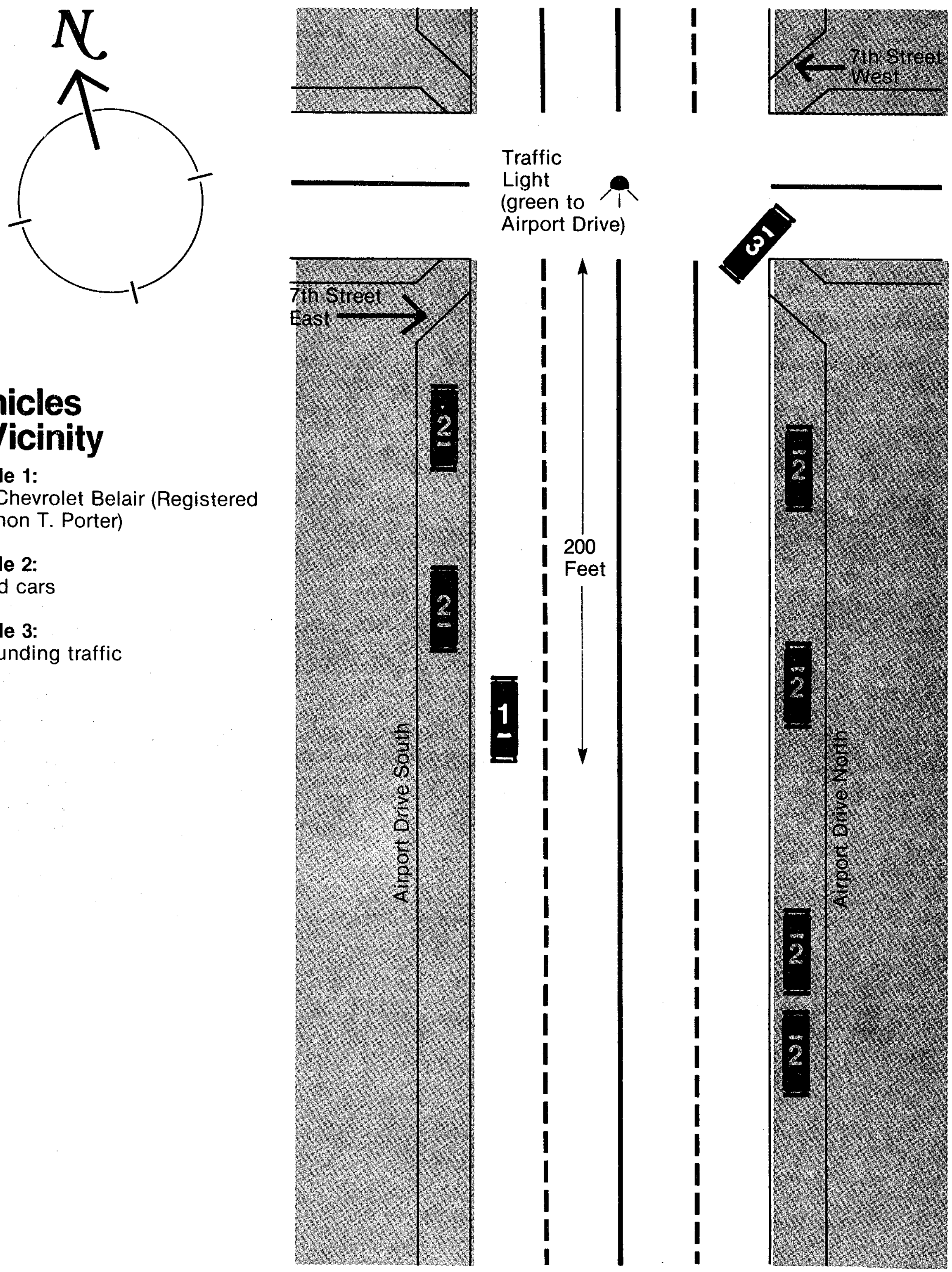
Vehicle 3:
Surrounding traffic



Case Number 6 Description

Accused:	Simon T. Porter Male Age 18
Vehicle 1:	1957 Chevrolet Belair Color: Two-tone green Registration Number: IG 213 Registered to: Simon T. Porter
Date/Time of Alleged Offense:	Monday, July 20 7:55 p.m.
Location of Alleged Offense:	Airport Drive Southbound lanes 200 feet south of intersection with Seventh Street
Traffic Conditions:	Very light, free-flowing in both directions
Weather Conditions:	Dusk (sunset was at 7:40 p.m.) Clear No breeze
Persons in Vehicle (other than accused):	Jane H. Gilman Female Age 16
Situation Description:	The subject vehicle is alleged to have executed a turn from the east bound lane of Seventh Street onto the right-hand, southbound lane to Airport Drive. The traffic control light at the intersection of Seventh and Airport is alleged to have been "RED" to Airport Drive traffic as the subject vehicle entered the intersection from Seventh Street and is alleged to have turned "GREEN" as the subject vehicle completed its turn. Airport Drive is a four-lane, non-divided roadway (two northbound lanes separated from two southbound lanes by solid yellow lines). A speed limit of 35 mph is posted along Airport Drive. The subject vehicle is alleged to have been traveling at 45 mph after turning onto Airport Drive. No other vehicular or pedestrian traffic was present in the southbound lanes of Airport Drive south of the intersection with Seventh Street. A few widely scattered vehicles were parked on the right shoulder of the southbound lanes. Two persons, including the driver, were observed to be in the front seat of the subject vehicle.

Case Number 6 Illustration



Vehicles In Vicinity

Vehicle 1:
1957 Chevrolet Belair (Registered to Simon T. Porter)

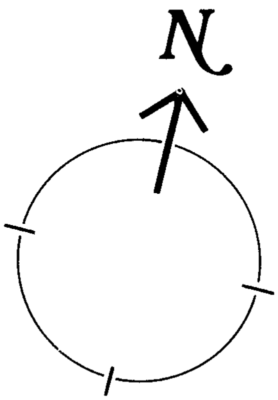
Vehicle 2:
Parked cars

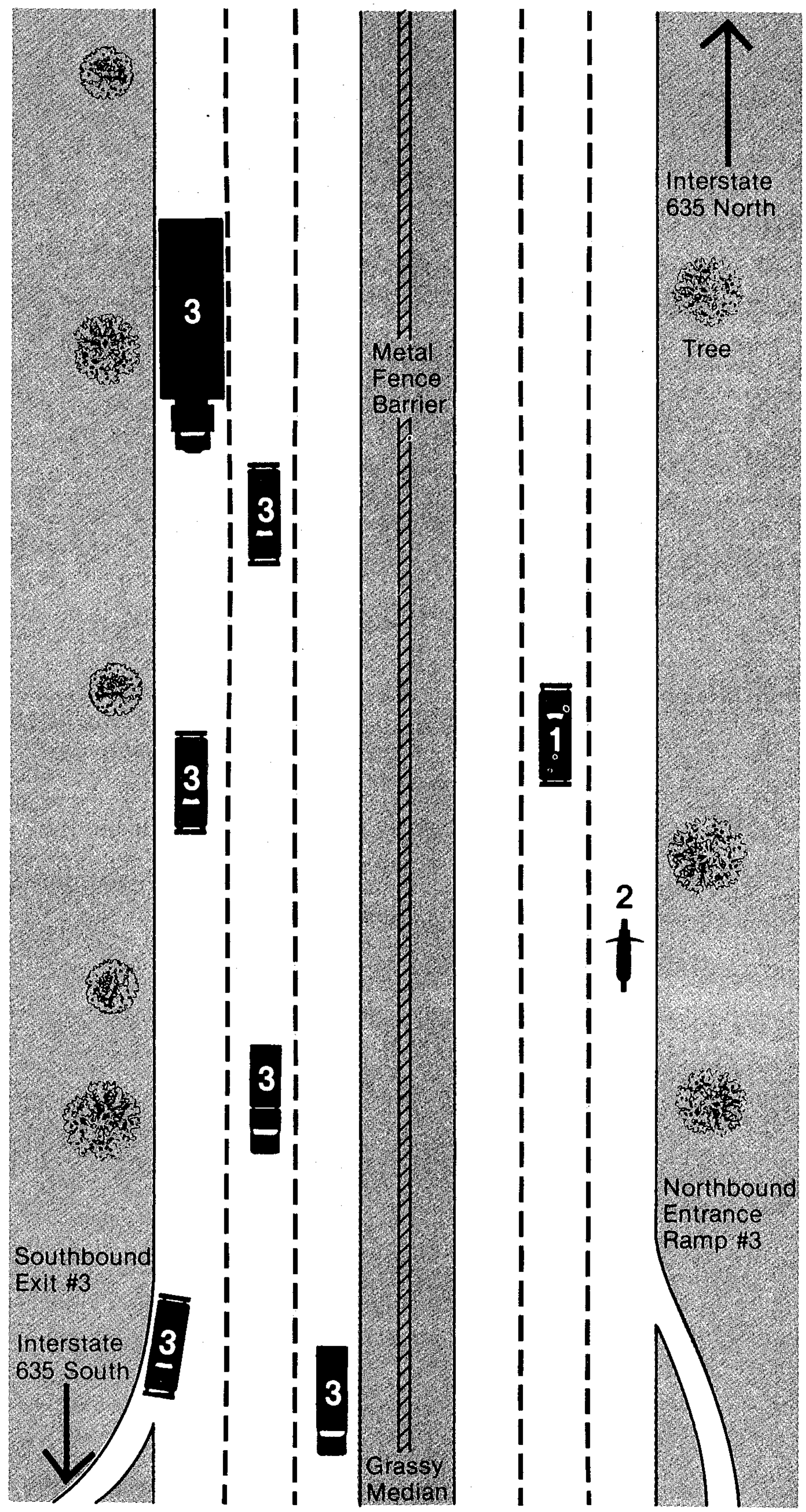
Vehicle 3:
Surrounding traffic

Case Number 7 Description

Accused:	Joan F. Johnson Female Age 22
Vehicle 1:	1979 Fiat Lancia Color: blue Registration Number: TH 2082 Registered to: Stephen B. Holcom
Date/Time of Alleged Offense:	Friday, July 24 7:30 p.m.
Location of Alleged Offense:	Interstate 635 (limited access) Northbound lanes Milepost 11.3 (500 feet north of entrance ramp No. 3)
Traffic Conditions:	Light, free-flowing in northbound lanes Moderate-to-heavy in southbound lanes
Weather Conditions:	Sunset Clear Light, variable breeze
Persons in Vehicle (other than accused):	Stephen B. Holcom Male Age 22
Situation Description:	The subject vehicle is alleged to have entered the northbound lanes of Interstate 635 via entrance ramp No. 3, directly behind a motorcycle. Both vehicles initially entered the extreme right-hand lane of the three northbound lanes; the subject vehicle then moved to the center lane and proceeded to pass the motorcycle. At the time the speed measurement was made, the subject vehicle is alleged to have been traveling at 68 mph. The speed limit on Interstate 635 is 55 mph. Other than the subject vehicle and the motorcycle, no other vehicles or pedestrians were present in the northbound lanes at that time. Two persons, including the driver, were observed to be in the front seat of the subject vehicle.

Case Number 7 Illustration





Vehicles In Vicinity

Vehicle 1:
1979 Fiat Lancia (Registered to Stephen B. Holcom)

Vehicle 2:
Motorcycle

Vehicle 3:
Surrounding traffic

Case Number 8 Description

Accused:

John Jones
Male
Age 25

Vehicle 1:

1978 AMC Pacer
Color: red
Registration Number: 318537
Registered to: John Jones

Date/Time of Alleged Offense:

Saturday, July 18
11:15 a.m.

Location of Alleged Offense:

Interstate 827 (limited access)
Northbound lanes
Milepost 57.5

Traffic Conditions:

Light, free-flowing in northbound and southbound lanes

Weather Conditions:

Daytime
Clear
No breeze

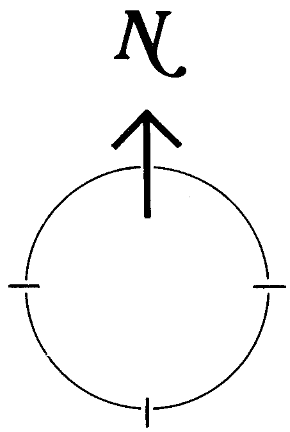
Persons in Vehicle (other than accused):

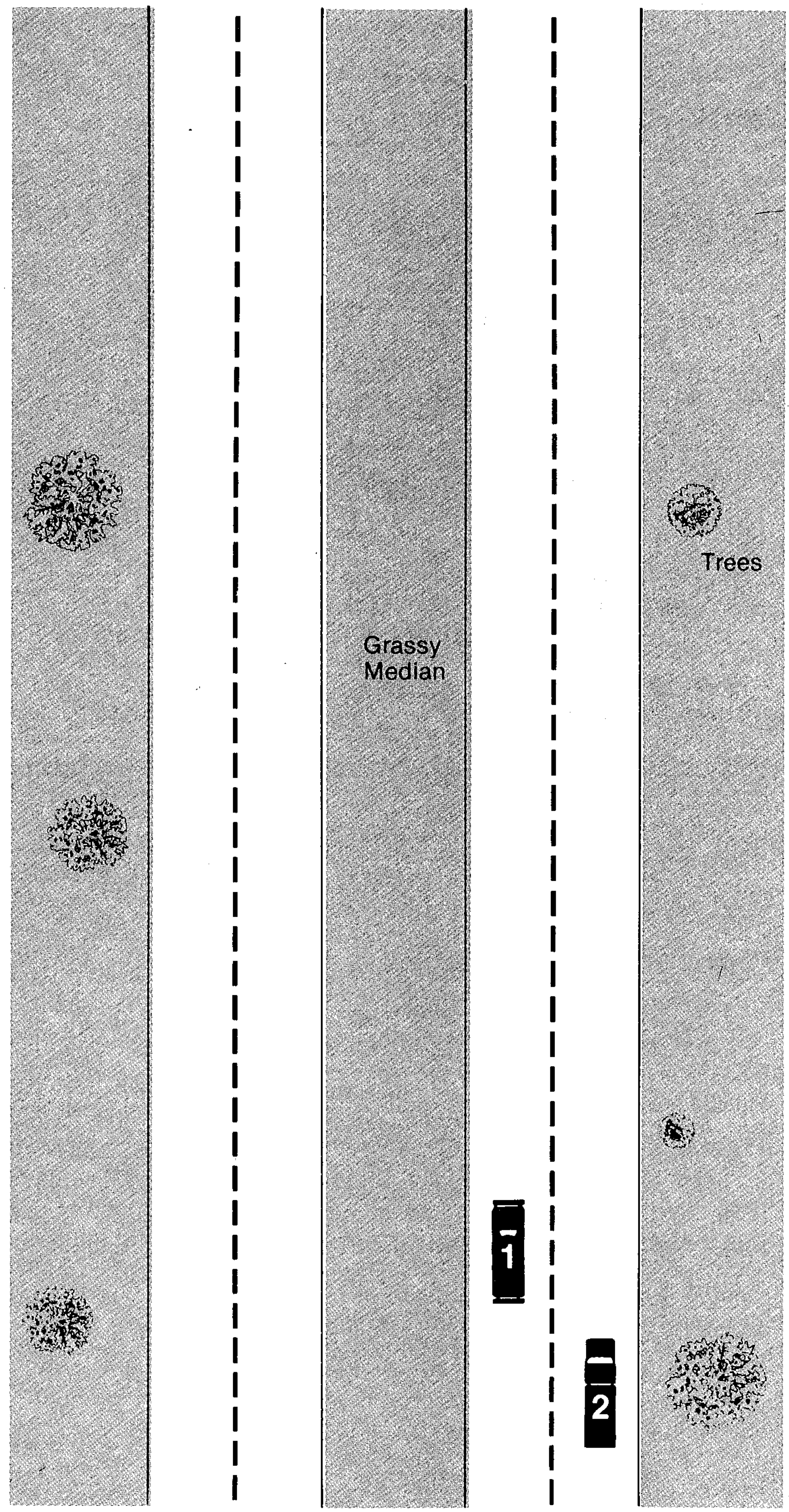
Thomas Smith
Male
Age 26

Situation Description:

Subject vehicle is alleged to have been traveling at 65 mph. Absolute speed limit of 55 mph is in force at subject location, which is a divided four-lane, limited-access highway in a heavily wooded rural area. A 15-yard-wide grassy median separates the two northbound and southbound lanes. Subject vehicle is alleged to have been traveling in the left-hand northbound lane and to have just completed passing a pickup truck when the speed measurement was made. Two persons, including the driver, were observed to be in the front seat of the subject vehicle.

Case Number 8 Illustration





Vehicles In Vicinity

Vehicle 1:
1978 AMC Pacer (Registered to John Jones)

Vehicle 2:
Pickup truck

☆U.S. GOVERNMENT PRINTING OFFICE. 1983 381 428 3014

DOT HS 900 072
September 1982