Time – Distance – Speed Relationships

Time – Distance – Speed

If you know any two you can find the third.

distance traveled	speed	time taken
90 miles	30 mph	3 hrs

$$S = d / t$$

Constant speed:

$$d = S\,t$$

$$t = d / S$$

$$S = d / t$$

In these examples the units of the Time. Distance, and Speed were

Time Distance Speed

HOURS – MILES – MPH

But in collision reconstruction it's a little more complicated

Time Distance Speed

SECONDS – FEET – MPH

But in collision reconstruction
it's a little more complicated

Time Distance Speed
SECONDS – FEET – MPH

We have to convert mph to ft/sec

$$\frac{1\ \text{mile}}{\text{hour}} \rightarrow ? \ \frac{\text{ft}}{\text{sec}}$$

$$\frac{1 \text{ mile}}{\text{hour}} = \frac{5280 \text{ ft}}{3600 \text{ sec}} = 1.466\ldots \frac{\text{ft}}{\text{sec}}$$

$$\frac{1 \text{ mile}}{\text{hour}} = \frac{5280 \text{ ft}}{3600 \text{ sec}} = 1.466\ldots \frac{\text{ft}}{\text{sec}}$$

I use 1.47 for my calculations

30 mph (1.47) = 44.1 ft/sec

ft/sec → mph

divide by 1.47

103 ft/sec ÷ 1.47 = 70 mph

Constant speed:

(speed in mph)

$$d = 1.47\ S\ t$$

$$t = \frac{d}{1.47\ S}$$

$$S = \frac{d}{1.47\ t}$$

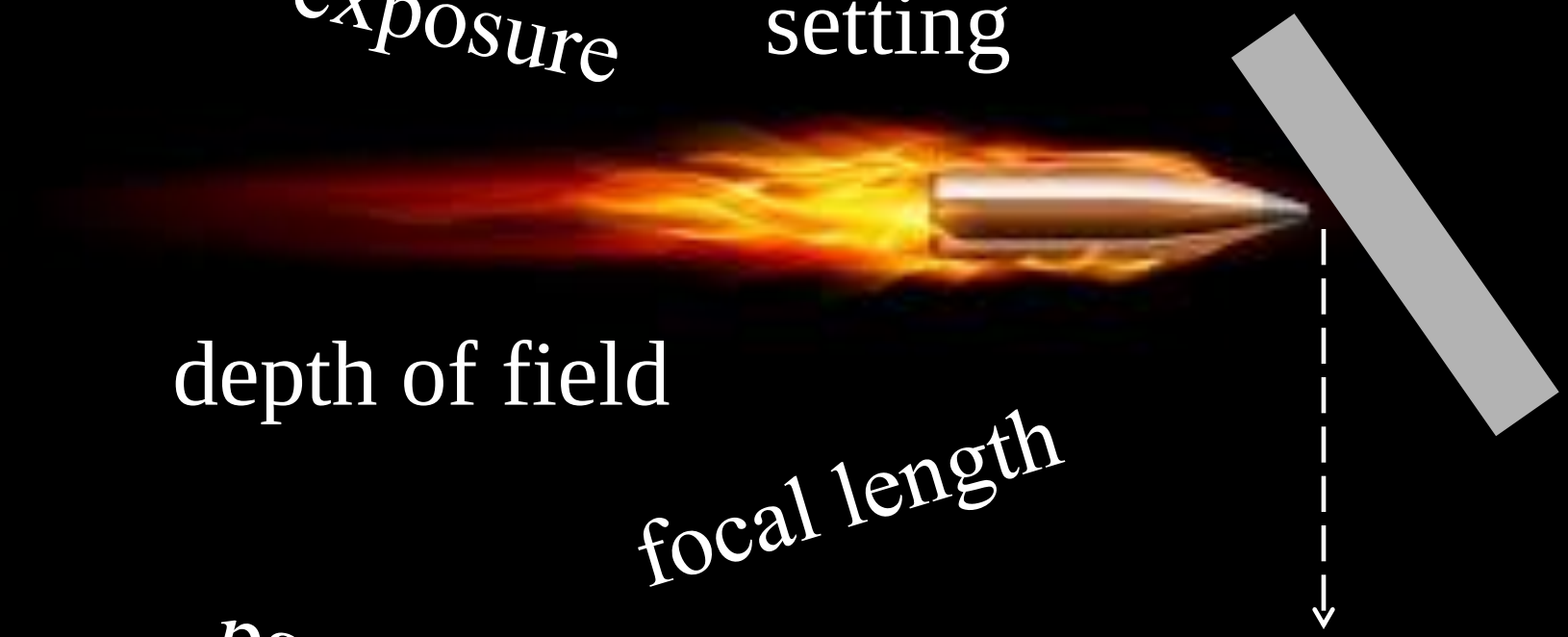

ROH NOCL 01

$$S_{(ft/sec)} = d / t$$

d from landmarks in video

t from frames/sec recording rate

bulletproofing your video analysis



bulletproofing your video analysis

TEST RUN AT KNOWN SPEED (RADAR)

- SAME TIME OF DAY
- SAME VIDEO CAMERA
- SAME RECORDER
- SAME VIDEO DOWNLOAD METHOD
- SAME ANALYSIS METHODOLOGY

OTHER USES OF TDS ANALYSES

TO ESTIMATE VEHICLE SPEED (from GPS, video, etc.)

TO FIND AVAILABLE PRT from sight distance

TIME LAPSE DRAWING OF PRE-IMPACT POSITIONS

TO VERIFY WITNESS STATEMENTS

TO SHOW INCONSISTENCIES IN RECONSTRUCTION

HYPOTHETICALS

How much time would it take for a vehicle to…

Based on CDR data, where was the vehicle at t = …

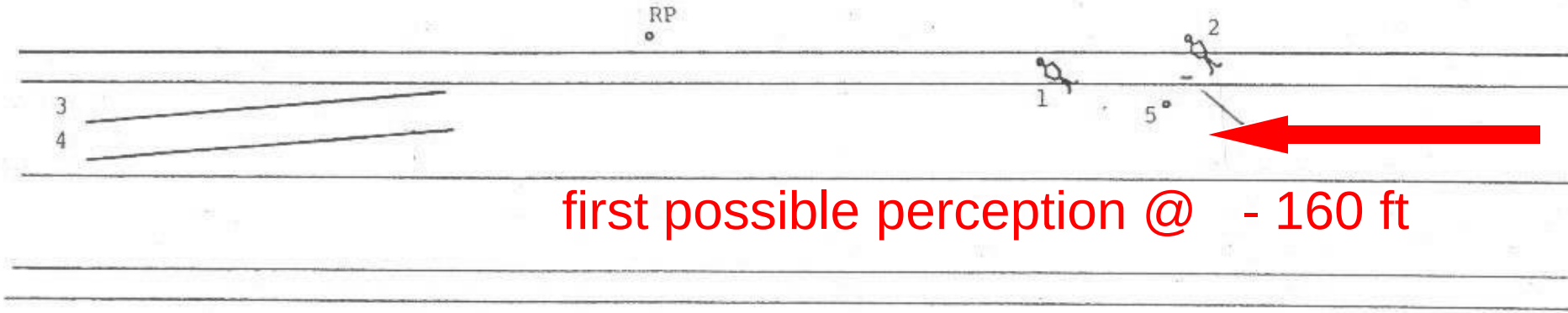
Determining the available PRT
when the visibility distance
is known

(*time available for avoidance*)

Locus: Brick Rd., Adams, AX
Scale: 1:240 (1 inch = 20 feet)

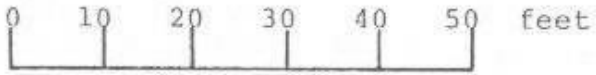
RP: (reference point) utility marker #45/31
Evidence: 1 FRP Brock
2 FRP MacBride
3 skid mark
4 skid mark
5 hood ornament
6 shoe scuff mark
Measurements: R. Bishop
Drawing: R. Bishop
D.O.I. 12/20/XX

State v. Farner



first possible perception @ - 160 ft

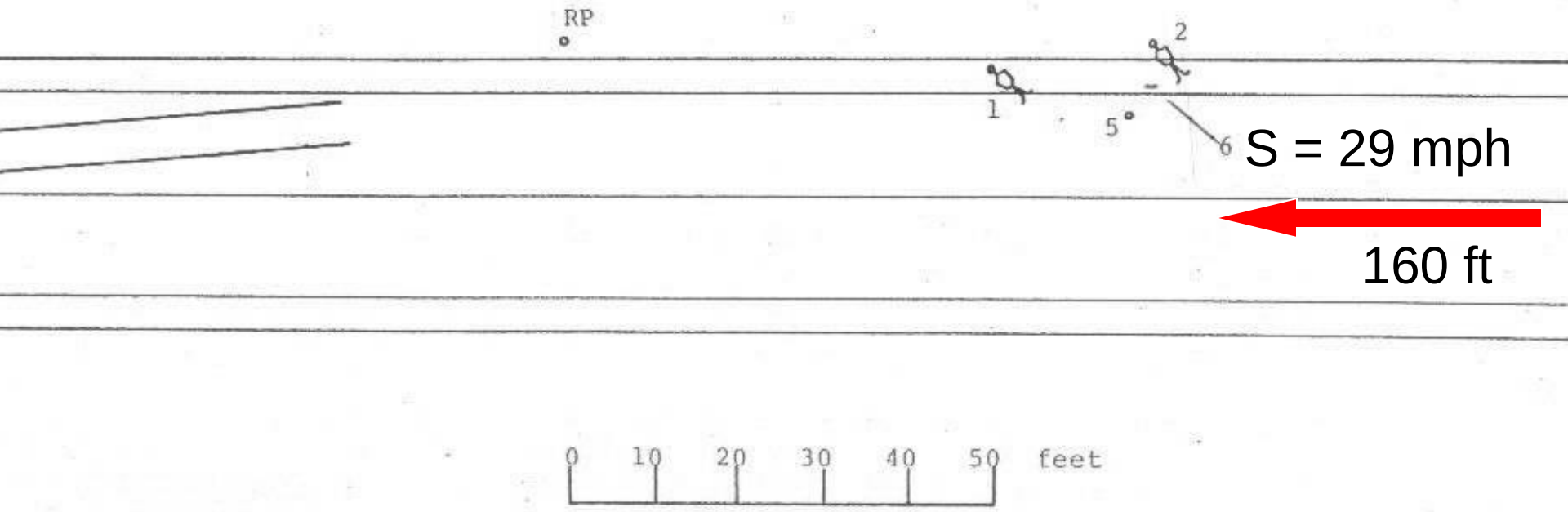
S = 29 mph



RP: (reference point) utility marker #45/31

Evidence:	1	FRP Brock
	2	FRP MacBride
	3	skid mark
	4	skid mark
	5	hood ornament
	6	shoe scuff mark
Measurements:	R. Bishop	
Drawing:	R. Bishop	
D.O.I.	12/20/XX	

$$t = \frac{d}{1.47S}$$



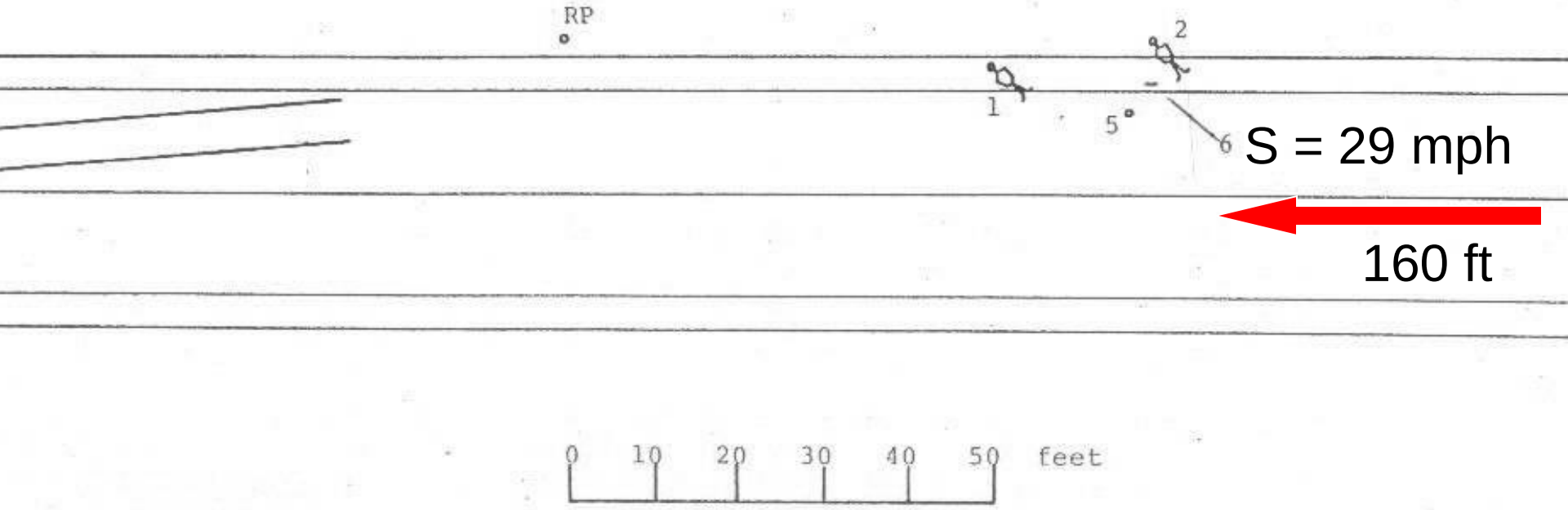
How much time was there to react ?

RP: (reference point) utility marker #45/31

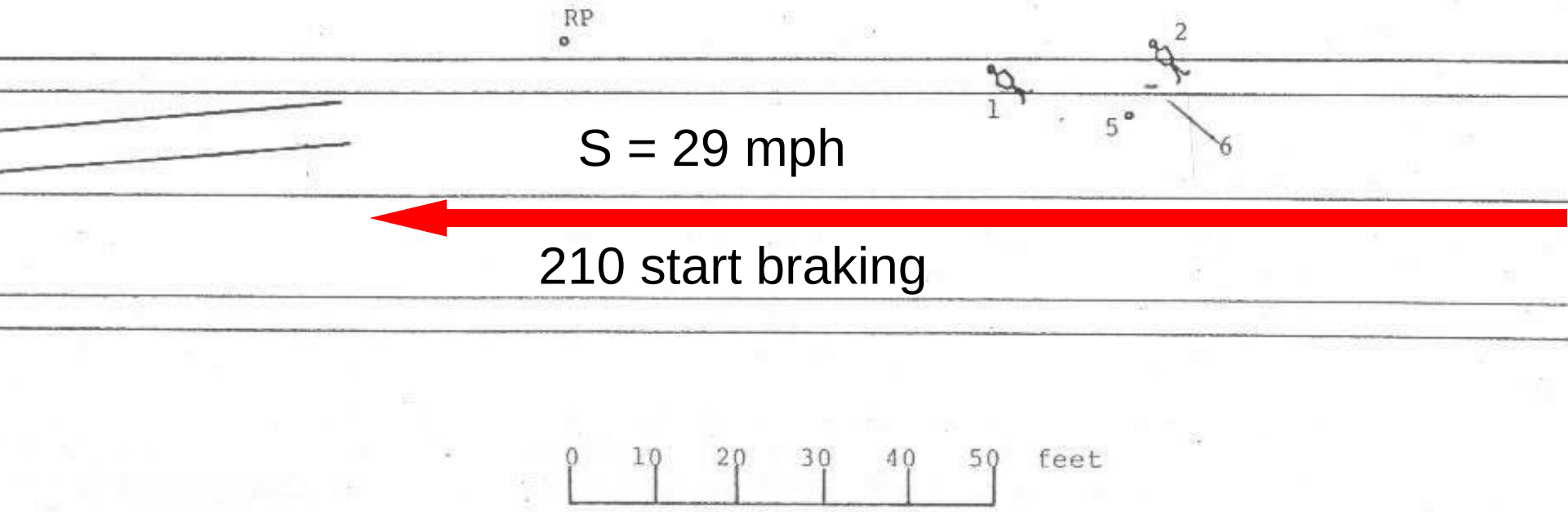
Evidence:
1 FRP Brock
2 FRP MacBride
3 skid mark
4 skid mark
5 hood ornament
6 shoe scuff mark

Measurements: R. Bishop
Drawing: R. Bishop
D.O.I. 12/20/XX

$$t = \frac{d}{1.47S} = 3.75\,\text{sec}$$



RP: (reference point) utility marker #45/31
Evidence: 1 FRP Brock
2 FRP MacBride
3 skid mark
4 skid mark
5 hood ornament
6 shoe scuff mark
Measurements: R. Bishop
Drawing: R. Bishop
D.O.I. 12/20/XX

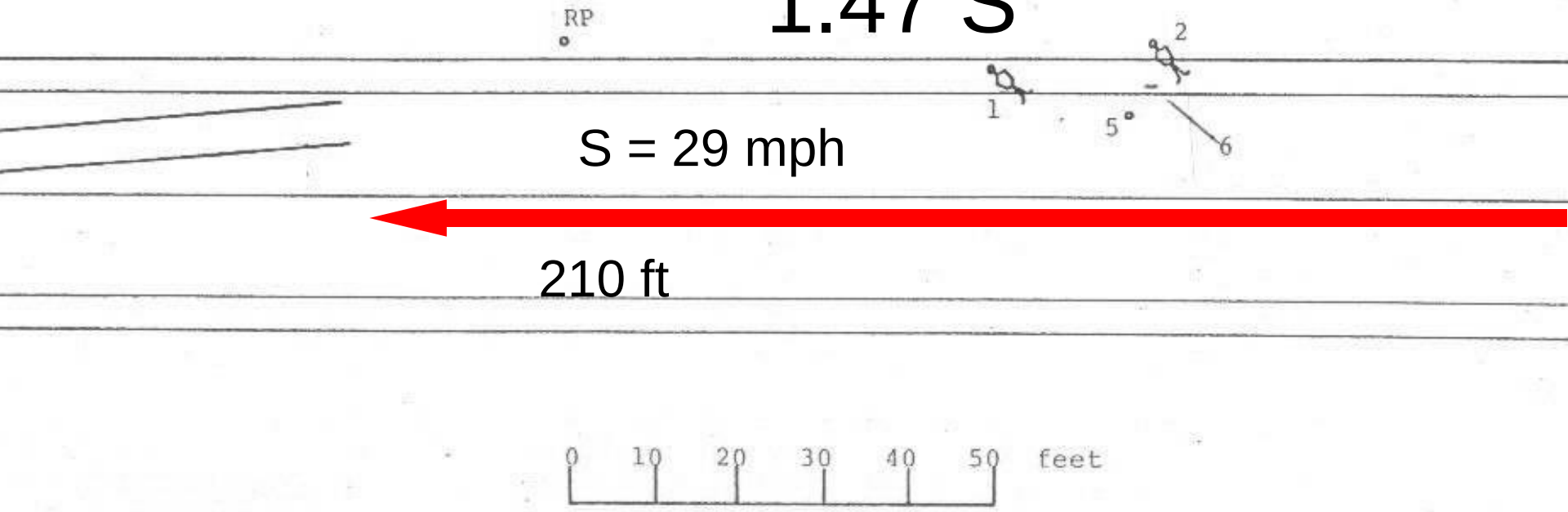


What was the actual PRT?

RP: (reference point) utility marker #45/31
Evidence: 1 FRP Brock
2 FRP MacBride
3 skid mark
4 skid mark
5 hood ornament
6 shoe scuff mark
Measurements: R. Bishop
Drawing: R. Bishop
D.O.I. 12/20/XX

N

$$t = \frac{d}{1.47\,S} = 4.92 \text{ sec}$$

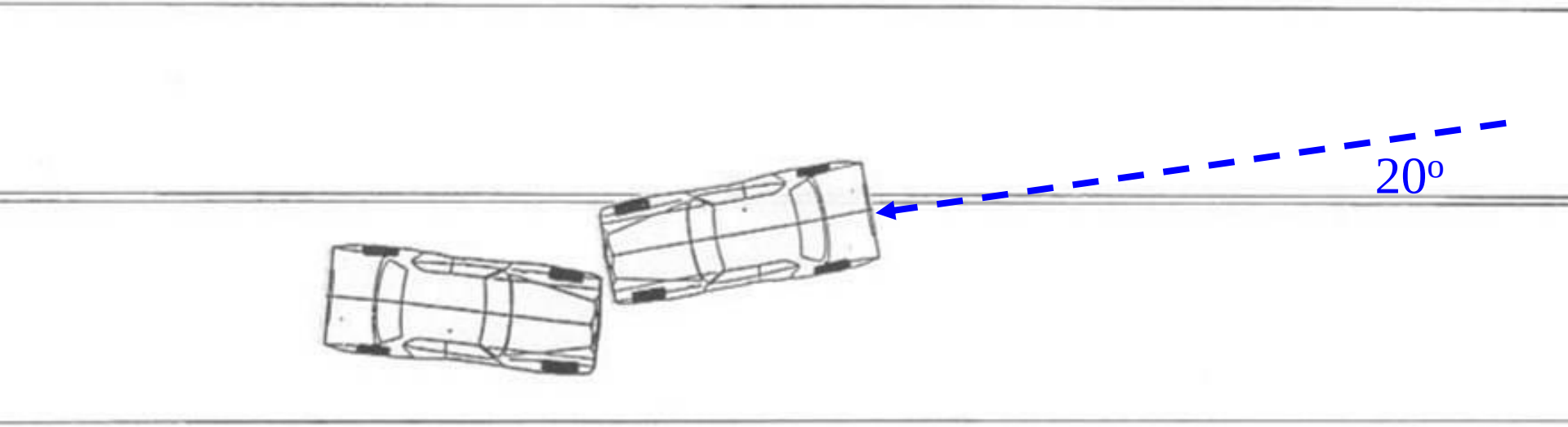


Crossing center line:

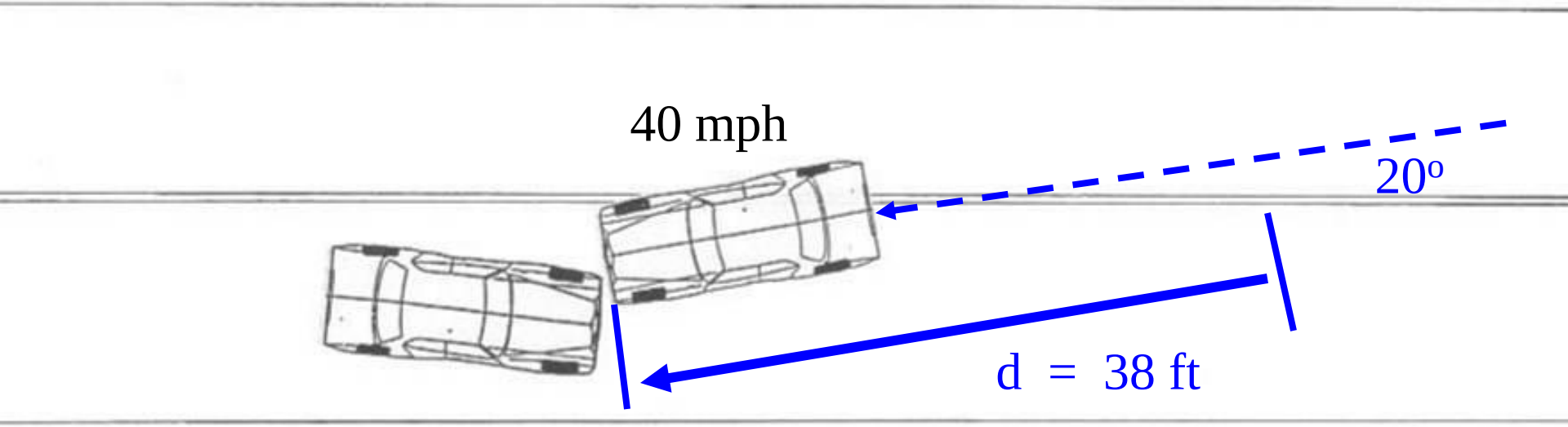
Did victim have enough time to initiate an evasive action ?


CROSSING CENTER LINE

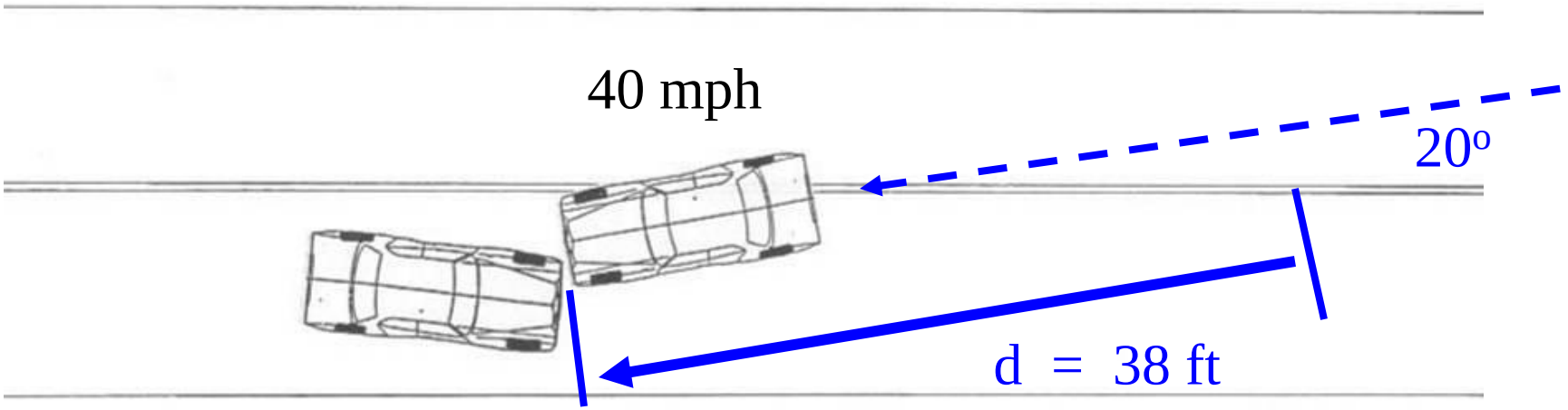
Police report concludes that defendant vehicle, traveling at 40 mph, crossed center line. Victim tried to avoid collision by turning away.



Did victim have enough time to react, and turn away ?

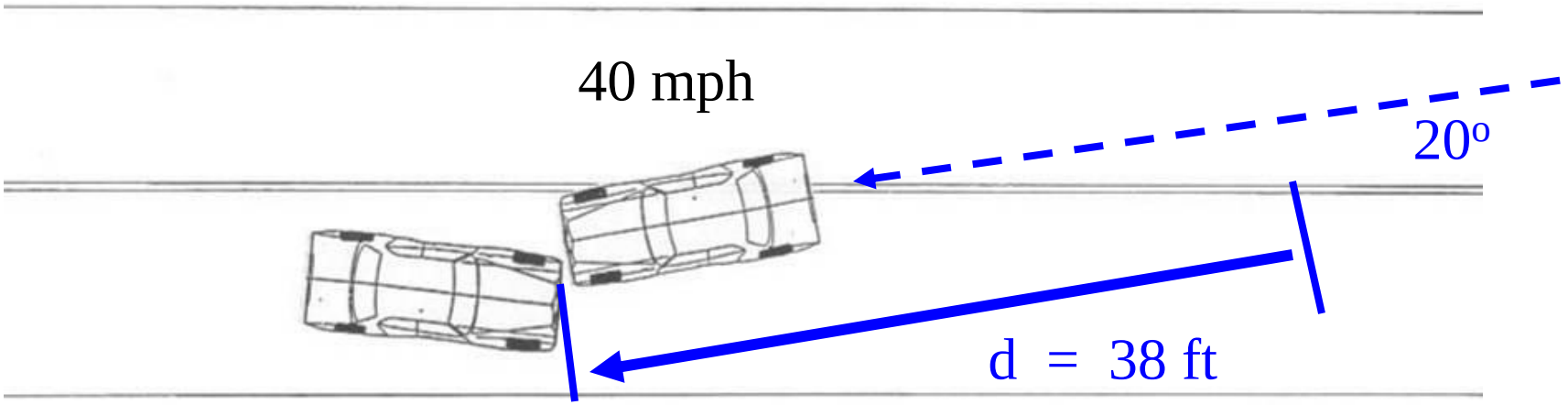


Did victim have enough time to react, and turn away ?



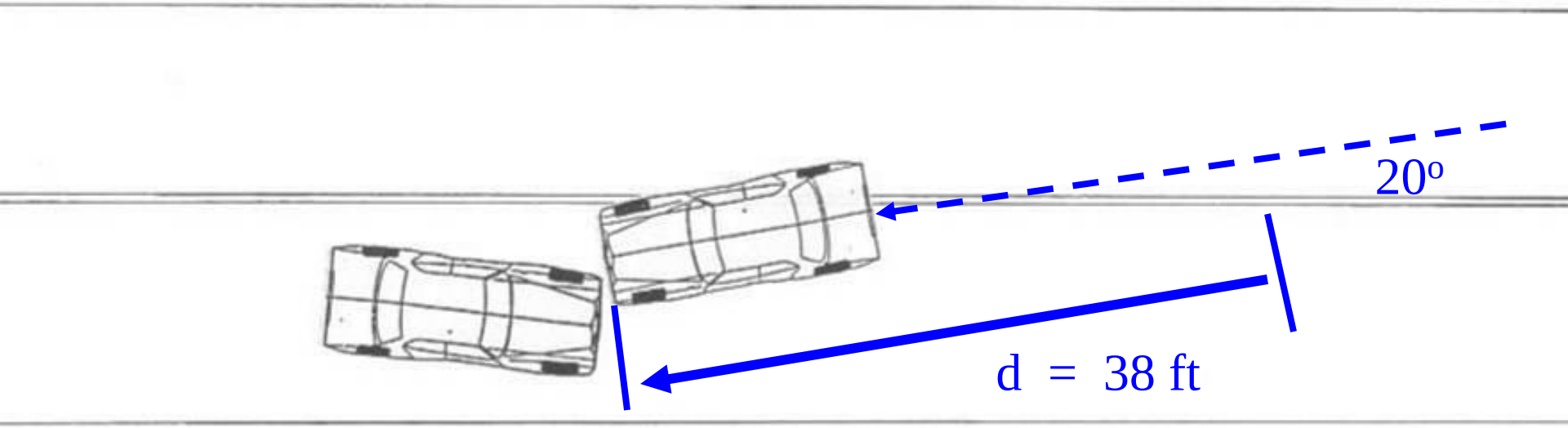
$$t = \frac{d}{1.47S}$$

Did victim have enough time to react, and turn away ?



$$t = \frac{d}{1.47S} = \frac{38}{1.47(40)}$$

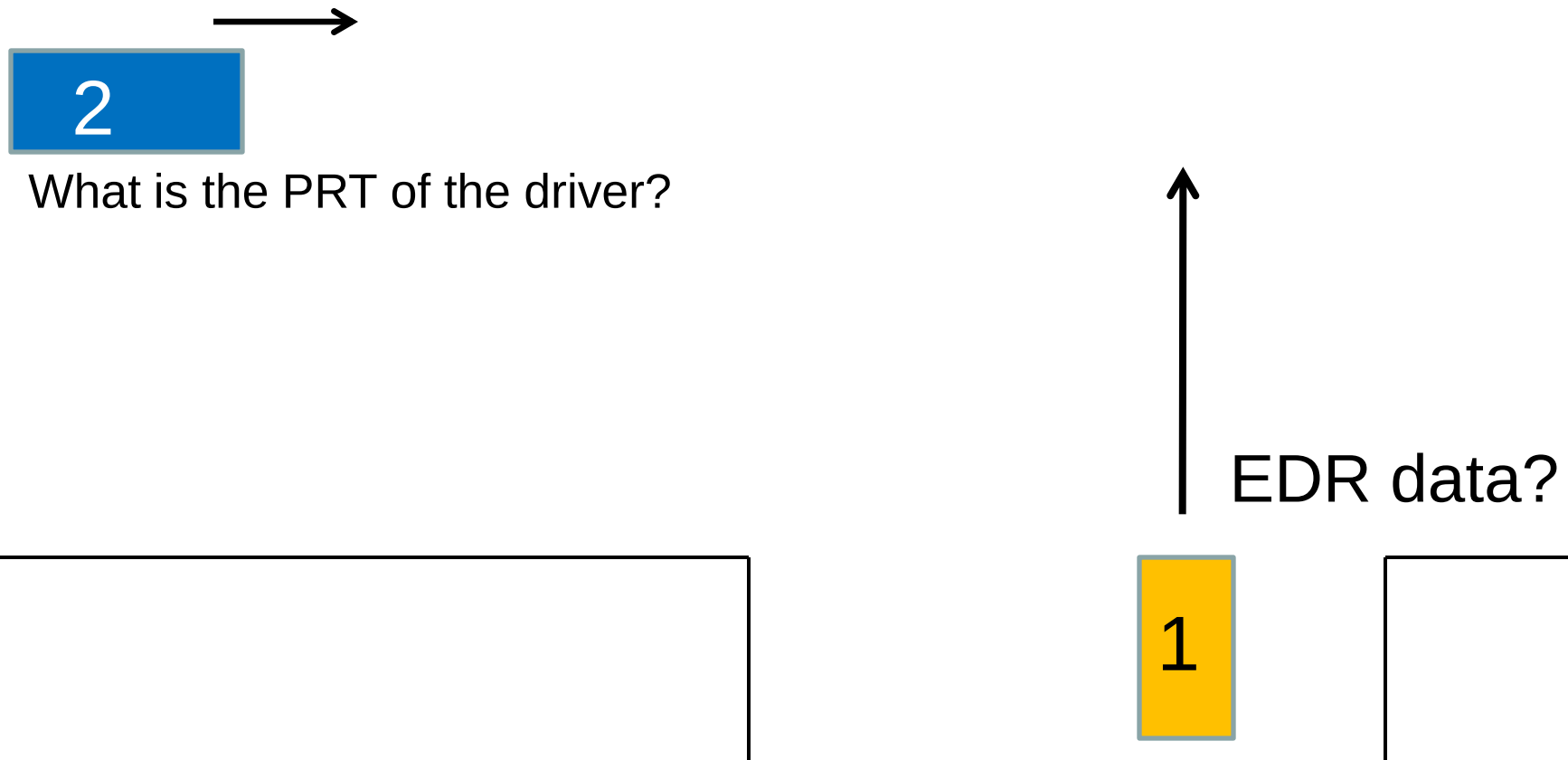
Did victim have enough time to react, and turn away ?



t = .64 sec

Using Data from the EDR Report for T-D-S Calculations

How to know when the danger presented, and the PRT of driver 2



BOSCH

EDR report from MV #1

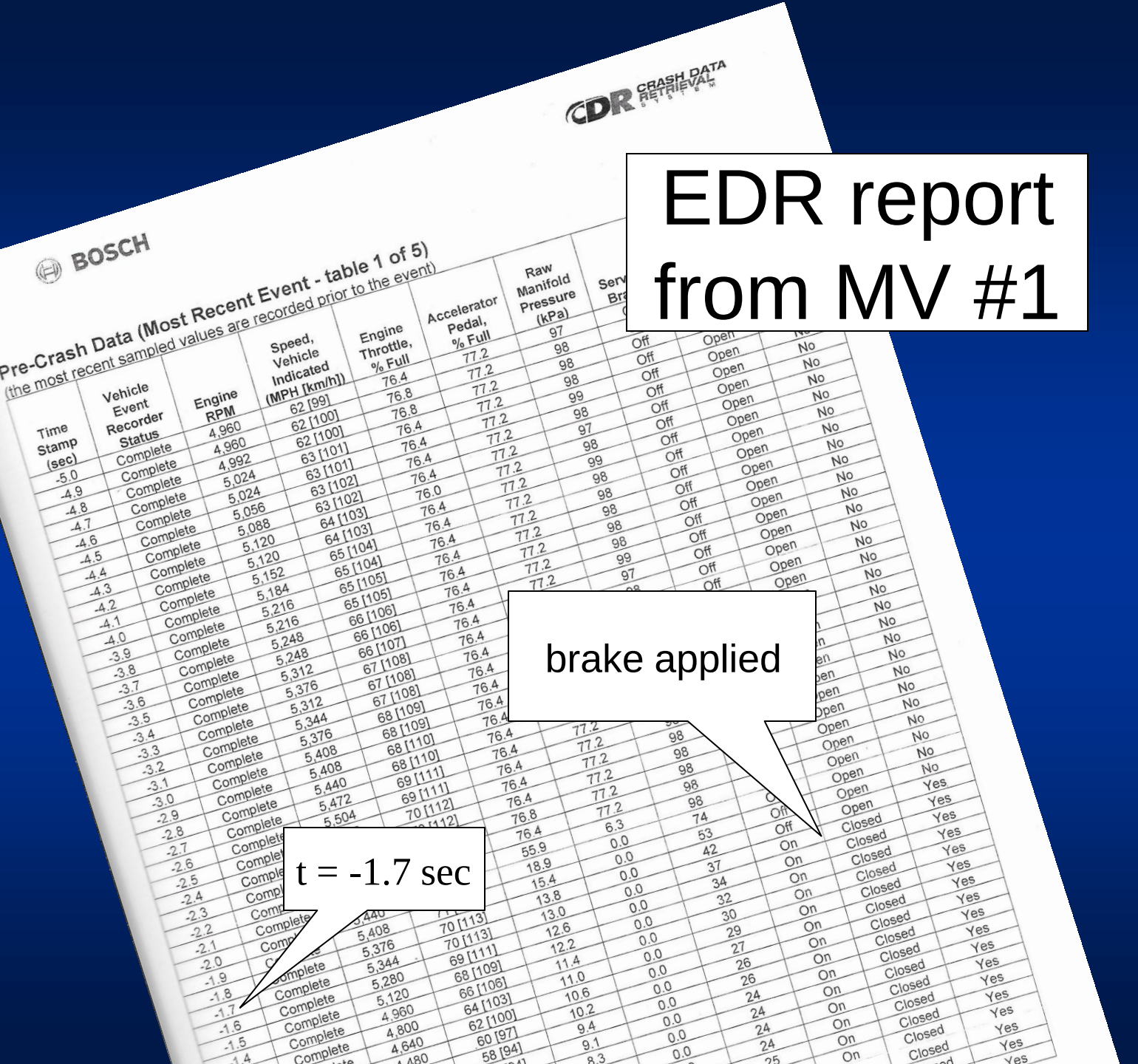
Pre-Crash Data -5 to 0 Seconds (1st Pri

Time (sec)	Vehicle Speed (MPH [km/h])	Accelerator Pedal, % Full (%)	Perce Eng Thro (%)	jection Quantity (mm^3/st)	Engine (RP
-5.00	0.0 [0]	0.0	0.0	Invalid	60
-4.50	0.0 [0]	0.0	0.0	Invalid	60
-4.00	0.0 [0]	0.0	0.0	Invalid	60
-3.50	0.0 [0]		4.0	Invalid	60
-3.00	1.9 [3]	25.5	10.0	Invalid	1,1
-2.50	5.0 [8]	34.5	15.0	Invalid	1,4
-2.00	8.1 [13]	34.5	15.0	Invalid	1,5
-1.50	10.6 [17]	36.5	17.0	Invalid	1,8
-1.00	12.4 [20]	39.0	19.0	Invalid	2,1
-0.50	13.7 [22]	0.0	3.5	Invalid	2,1
TRG(0)	Invalid	Invalid	Invalid	Invalid	Inva

Pre-Crash Data -5 to 0 Seconds (1st Prior Event) - Table 2 of 4

Time (sec)	ABS Control Status	BOS Control Status	Brake Oil Pressure (Mpa)	Longitudinal Acceleration , VSC Sensor (m/s^2)	Yaw R (deg
-5.00	OFF	OFF	1.97	0.072	0.0

EDR report from MV #1



Driver 2's PRT = 3.5 – 1.7 = 1.8 sec

Accelerated motions:

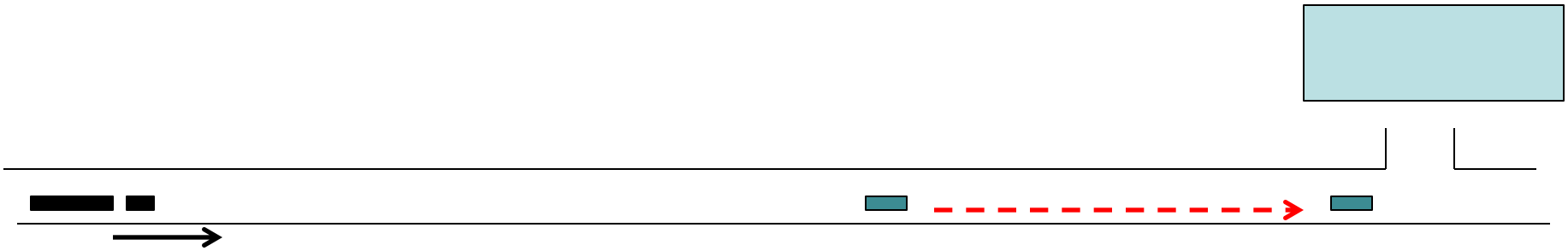
non-constant speed

These calculations will include the rate at which the speed was changing, called acceleration.

The units of acceleration are $\frac{ft/sec}{sec}$ or ft/sec^2

People of NY v. Munise

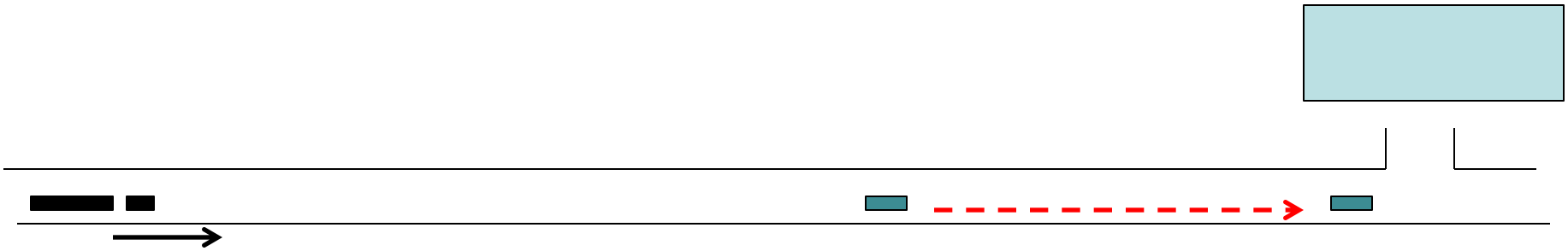
NYSP Trooper killed



State's theory: driver inattention (cell phone) caused crash.

People of NY v. Munise

NYSP Trooper killed



Defense theory: Automatic alert system in truck malfunctioned.

Making an assumption in one part of the analysis often creates a problem somewhere else.

Using the expert's assumptions to construct a request for a concession.

BRAKING TIME

$$t = (V - Vo) / 32.2\, f$$

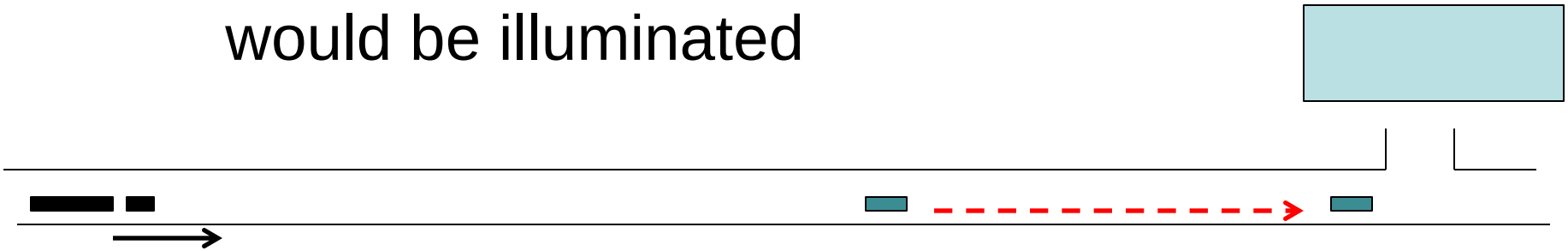
time for vehicle to brake from one speed to another

People of NY v. Munise: NYSP Trooper killed

Δ expert opines about victim's speed(s)

Δ expert assumes a slowing rate for victim's car

State calculates the time the brake lights would be illuminated



State asks Δ expert for a concession:

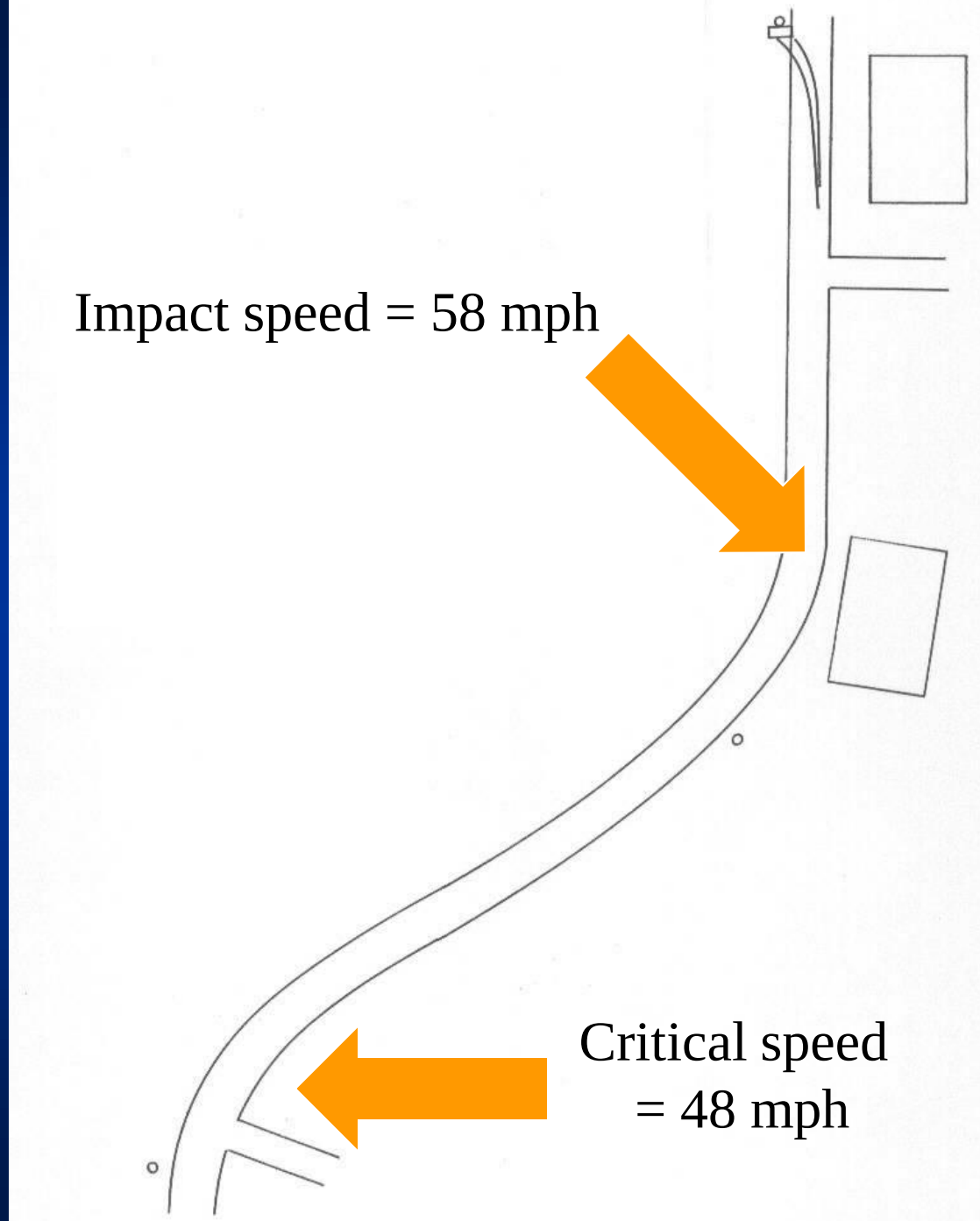
Based on the numbers in your own report the time the defendant had to start an evasive action was at least 13 seconds, correct?

Acceleration after traversing a curve

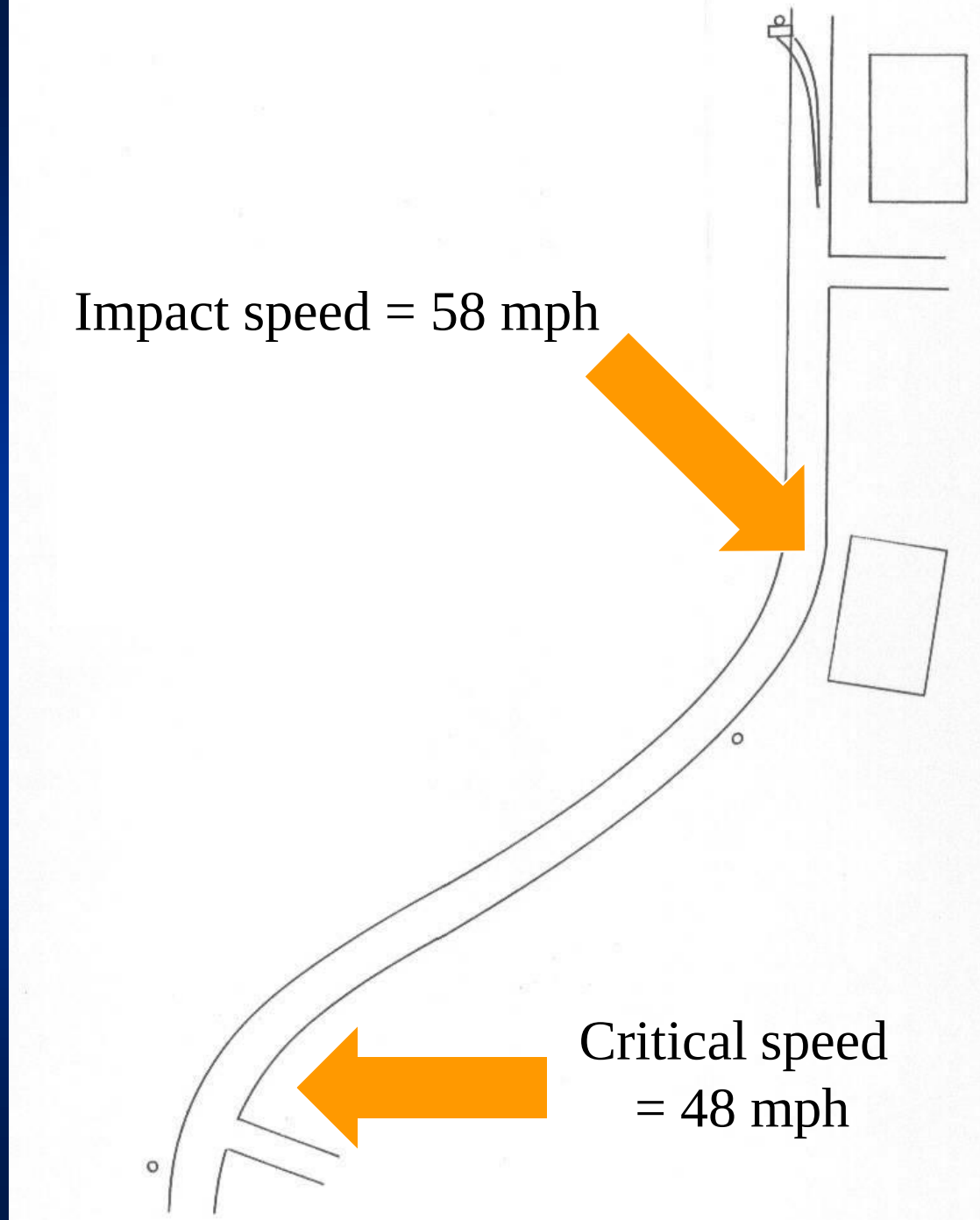
What is the critical speed of a curve?

How is the critical speed determined?

Impact speed calculated to be 58 mph



Critical speed in prior curve was determined.



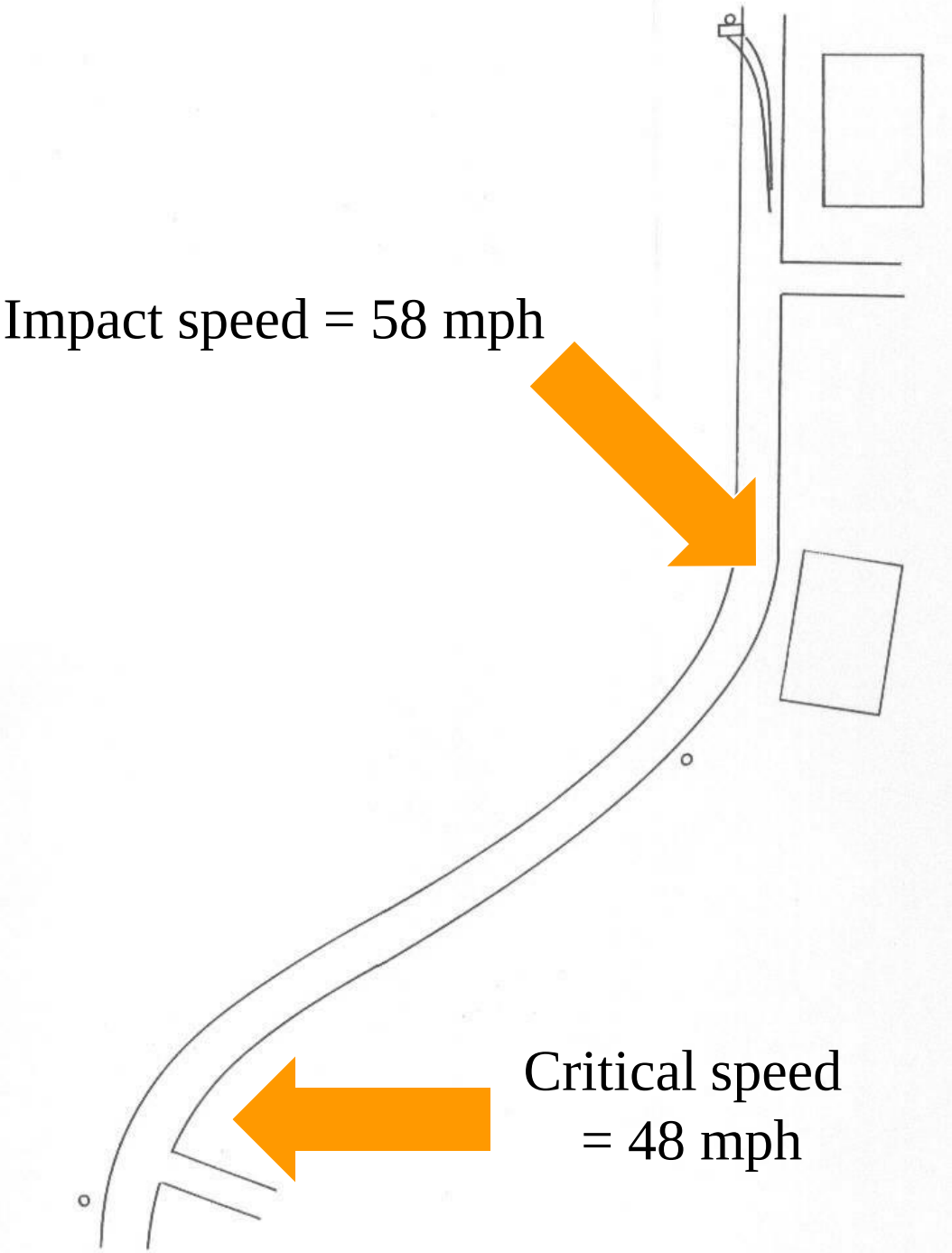
Could the vehicle traverse the prior curve at a speed of 48 mph and accelerate to a speed of 58 mph?

Accelerated motion:

Speed at any distance after start of acceleration:

$$v = \sqrt{v_o^{\,2} + 2ad}$$

What information is needed to calculate the maximum possible speed at impact?



$$\mathbf{V_{max} = \sqrt{(V_o^2 + 2ad)}}$$

$V_o = 48(1.47)$ ft/sec

a = 7.8 ft/sec/sec *

d = 320 ft

* Auto Stats

$$\mathbf{V_{max} = \sqrt{(V_o^2 + 2ad)}}$$

V_o = 48(1.47) ft/sec

a = 7.8 ft/sec/sec *

d = 320 ft

* Auto Stats

$$\mathbf{V_{max} = 67.9\ mph}$$

(reconstructed speed = 58 mph)

DID THE VEHICLE STOP BEFORE ENTERING THE INTERSECTION ?

SPEED AT POI WAS DETERMINED TO BE 13 mph

A car has different possible acceleration rates ?

To determine the maximum speed that could be reached, the maximum acceleration rate should be used in this calculation.

Condition	Speed range	Acceleration, a		
		Drag factor $f=a/g$	Meters per sec^2	Feet per sec^2
Free fall		+1.00	+9.81	+32.2
Normal acceleration of passenger car	Less than 20 mph (30kph)	+0.15	+1.47	+ 4.8
	20 to 40 mph (30 – 60 kph)	+0.10	+0.98	+ 3.2
	More than 40 mph (60kph)	+0.05	+0.48	+ 1.6
Rapid acceleration of passenger car	Less than 20 mph (30kph)	+0.30	+2.94	+ 9.7
	20 to 40 mph (30 – 60 kph)	+0.15	+1.47	+ 4.8
	More than 40 mph (60kph)	+0.10	+0.98	+ 3.2

"Using an accepted acceleration, the speed could not be reached if the defendant had stopped !"

EXPERT TESTIMONY:

"The operator did not stop prior to entering the intersection."

SPEC SHEET FOR DEFENDANT'S VEHICLE

ACCELERATION:

0->30 mph	*t =*	*3.8 sec.*	*a =*	*11.6 ft/sec/sec*	*G-force =*	*0.36*
0->60 mph	*t =*	*9.8 sec.*	*a =*	*9.0 ft/sec/sec*	*G-force =*	*0.28*
45->65 mph	*t =*	*5.9 sec.*	*a =*	*3.7 ft/sec/sec*	*G-force =*	*0.12*

SPEC SHEET FOR DEFENDANT'S VEHICLE

ACCELERATION:

0->30 mph	*t =*	*3.8 sec.*	*a =*	*11.6 ft/sec/sec*	*G-force = 0.36*
0->60 mph	*t =*	*9.8 sec.*	*a =*	*9.0 ft/sec/sec*	*G-force = 0.28*
45->65 mph	*t =*	*5.9 sec.*	*a =*	*3.7 ft/sec/sec*	*G-force = 0.12*

Using the maximum acceleration, the speed attainable for MV #1, if it stopped, is ***16.9 mph***

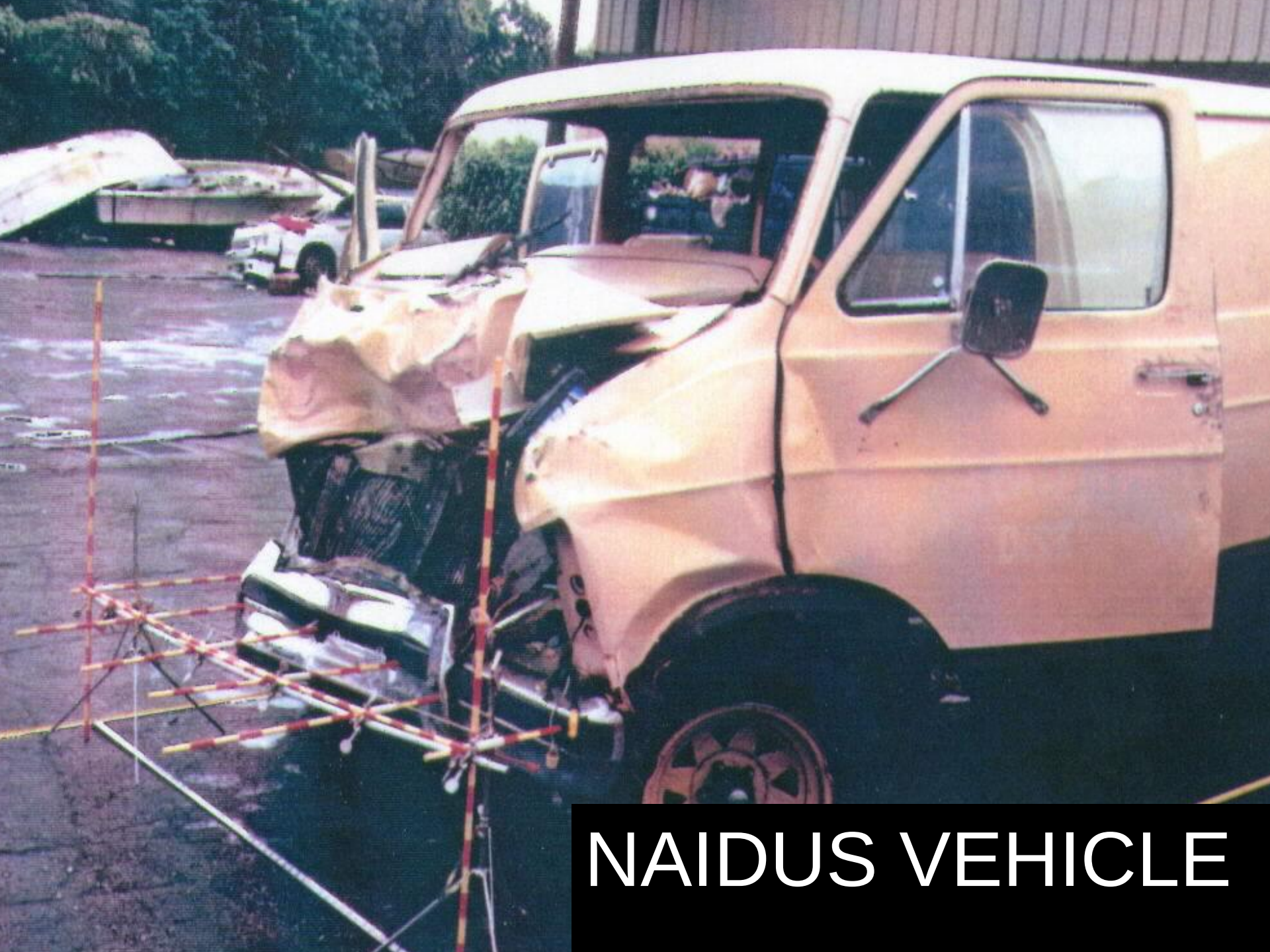
Correct conclusion:

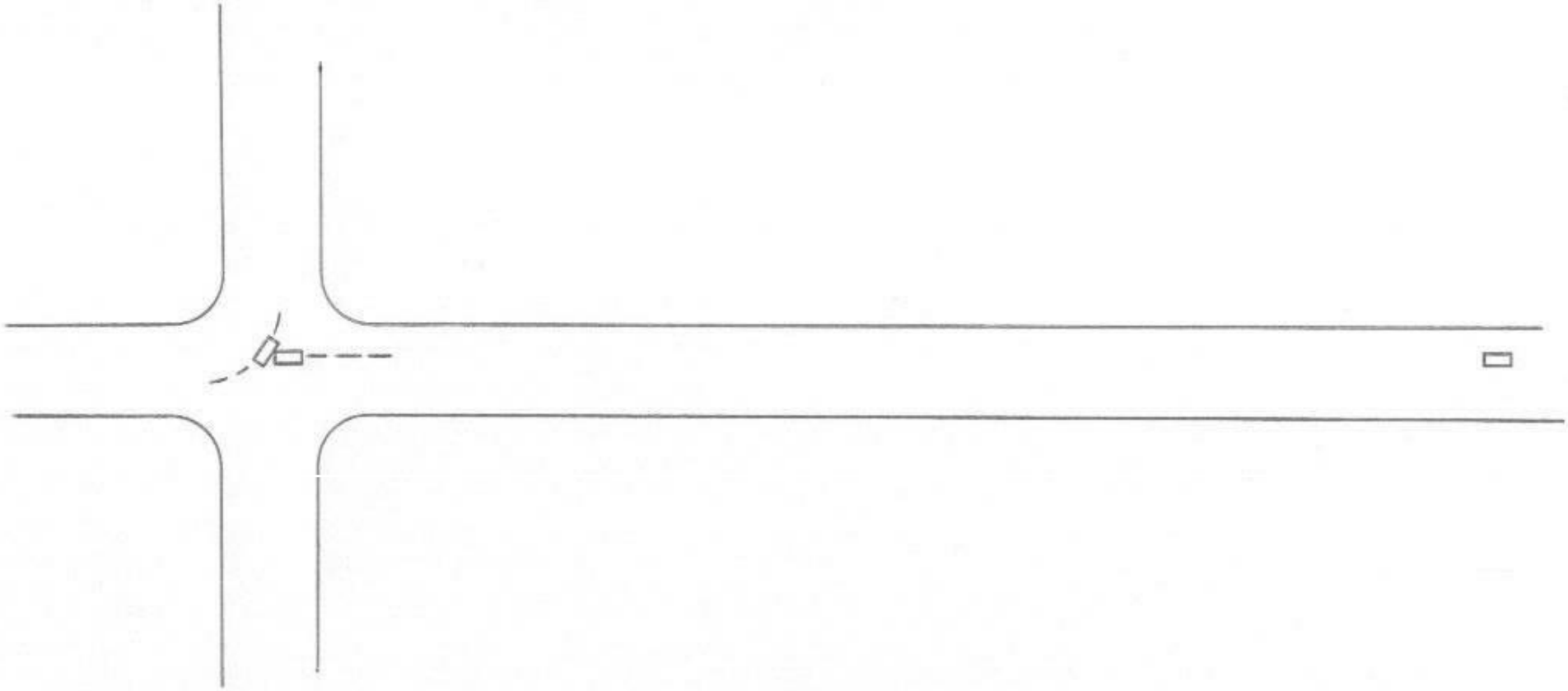
"It is inconclusive whether the vehicle stopped before entering the intersection."

FL v. SCOTT NAIDUS

- VICTIM TURNS LEFT IN FRONT OF ONCOMING DEFENDANT
- NAIDUS CHARGED - DWI HOMICIDE
- ALEXANDER VEHICLE
  - MOTHER AND THREE CHILDREN KILLED


VICTIM'S VEHICLE

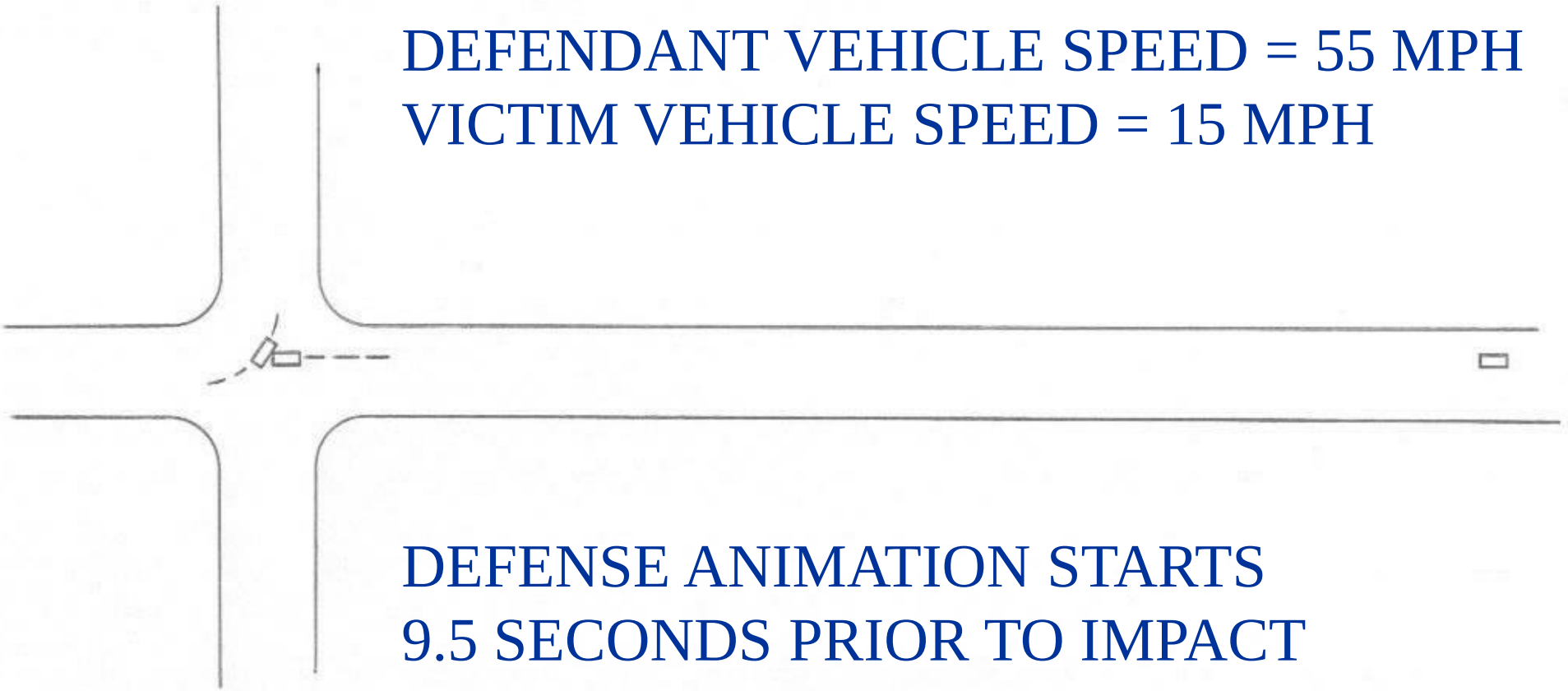

NAIDUS VEHICLE



CROSS EXAMINING THE DEFENSE ANIMATION

SOMETIMES THE DEFENSE EXPERT DOES THE PROSECUTOR A FAVOR BY GENERATING A VIDEO ANIMATION

DEFENSE ANIMATION



DEFENDANT VEHICLE SPEED = 55 MPH
VICTIM VEHICLE SPEED = 15 MPH

DEFENSE ANIMATION STARTS
9.5 SECONDS PRIOR TO IMPACT

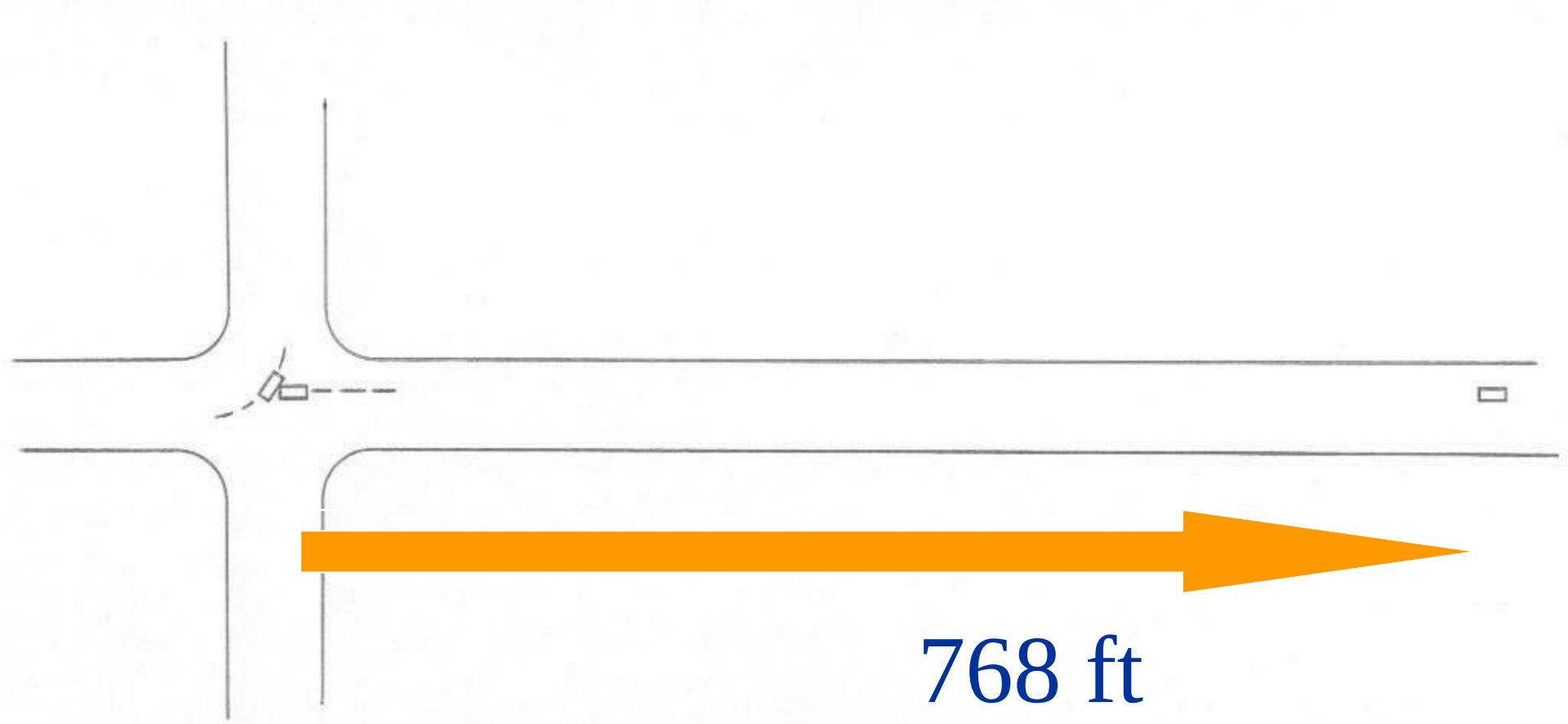
Locking the expert in :

- Speed of Naidus vehicle at all times
- Time from start of video to POI
- Lack of pre-impact braking
- Speed of turning vehicle
- Posted speed
- Naidus' ability to control speed
- No mechanical defect

Using the defense expert's animation to prove negligence

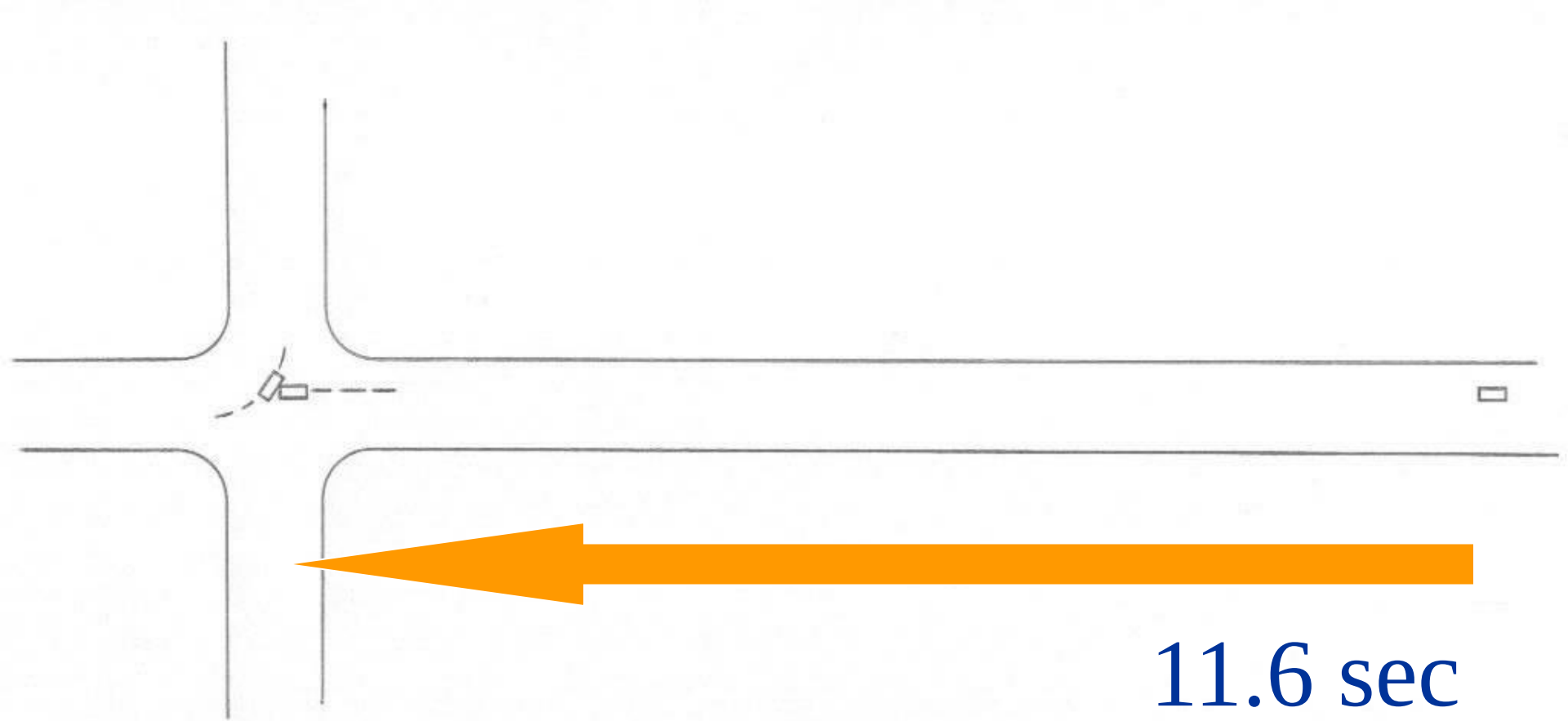
How far was defendant's vehicle from poi when animation starts ?

$d = 1.47(55)(9.5) = 768$ FT


768 ft

If defendant were traveling at 45 mph (posted speed) rather than 55 mph how much time would it take defendant's vehicle to travel 768 ft ?

t = 768 / 1.47(45) = 11.6 SECONDS



11.6 sec

If defendant were traveling at 45 mph (posted speed) rather than 55 mph he would have reached the POI 2.1 seconds later than he did. Correct ?

YES

If defendant vehicle reached POI 2.1 seconds later, where would victim's vehicle have been ?

$d = 1.47(15)(2.1) = 46$ ft

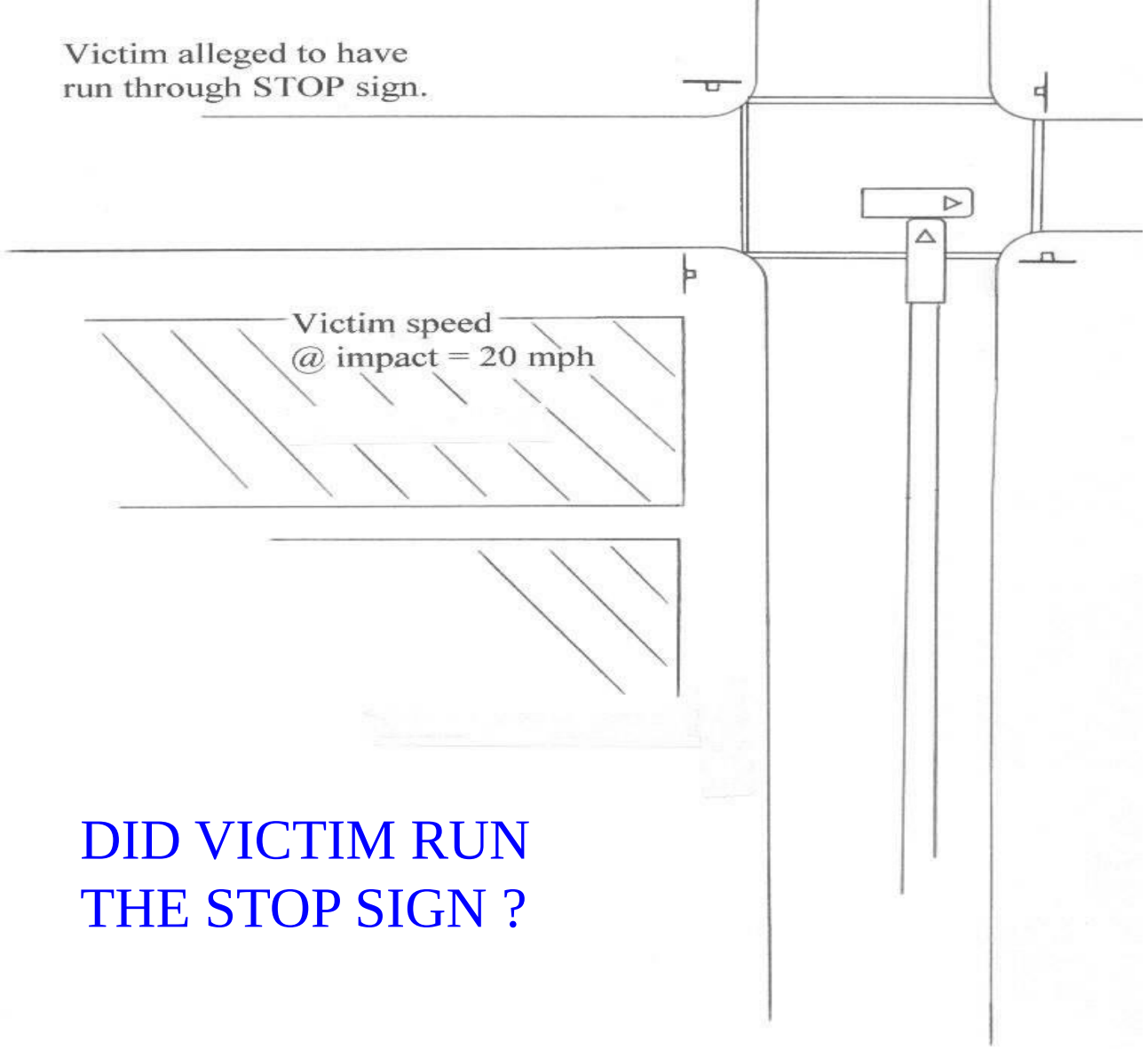
CLEAR OF THE INTERSECTION

If defendant had been operating at the posted speed of 45 mph would there have been a crash ?

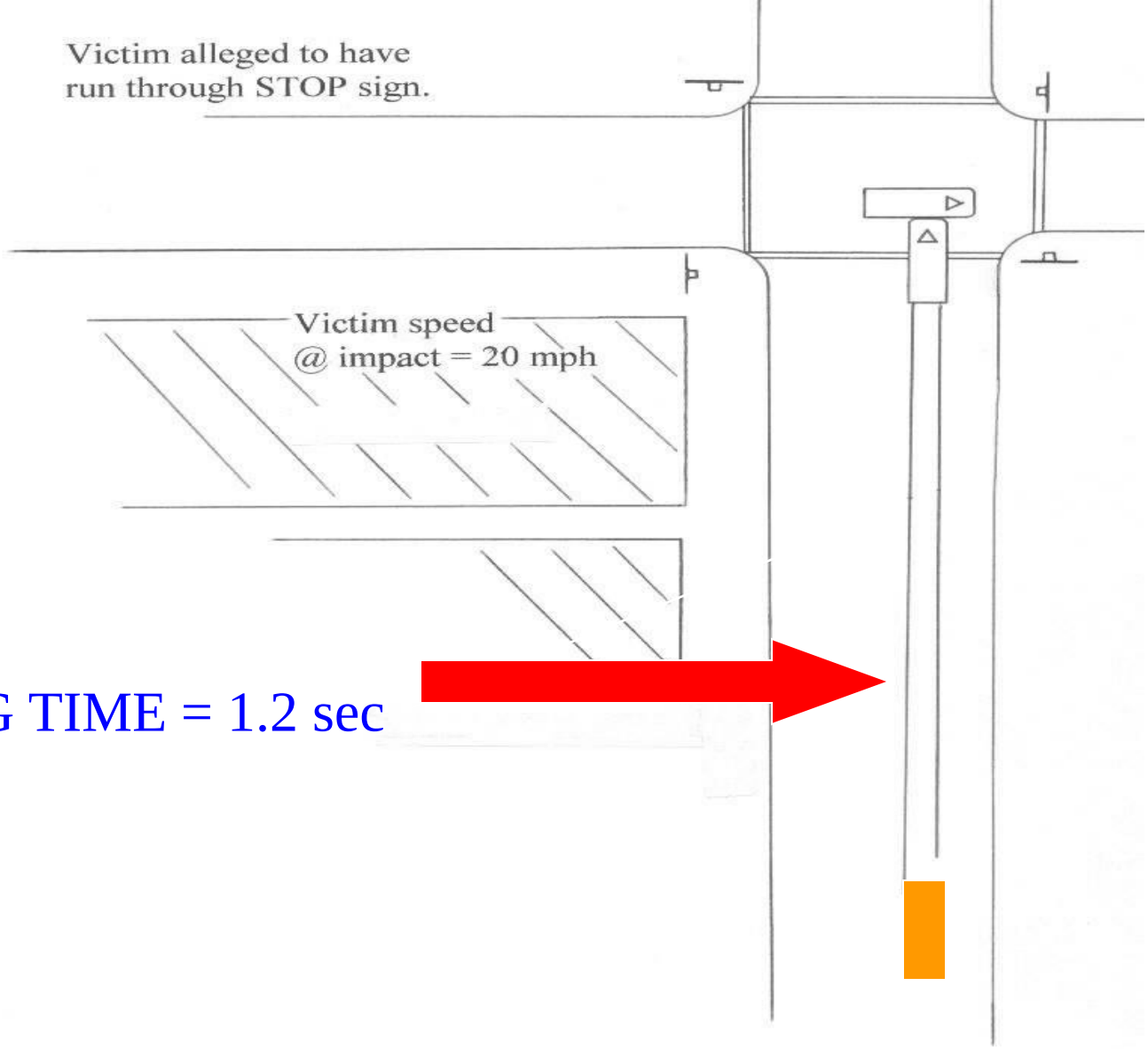
NO

Intersection collision,
Manchester, NH

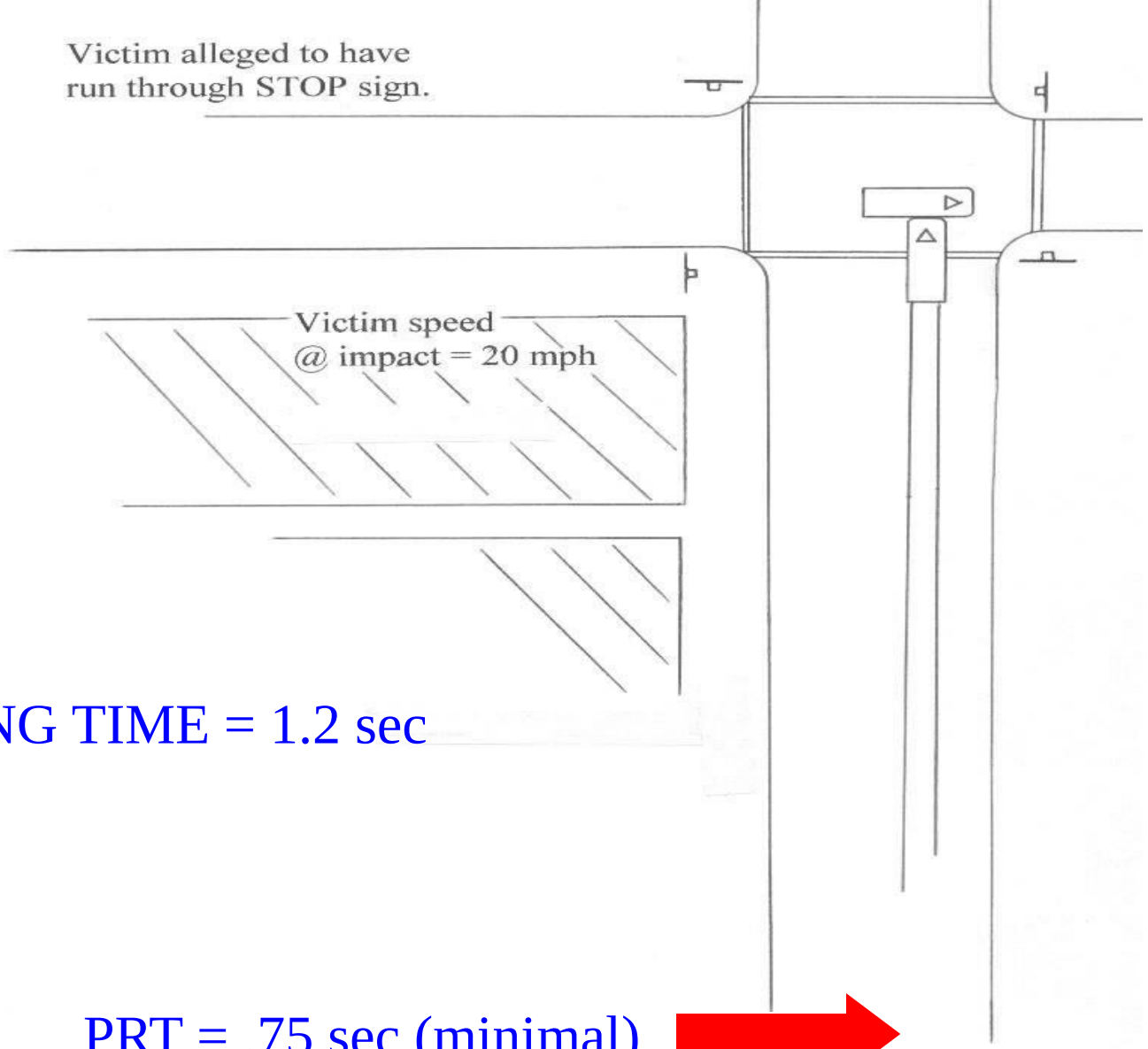
Defendant asserts that the victim ran the stop and caused the crash.



DID VICTIM RUN
THE STOP SIGN ?

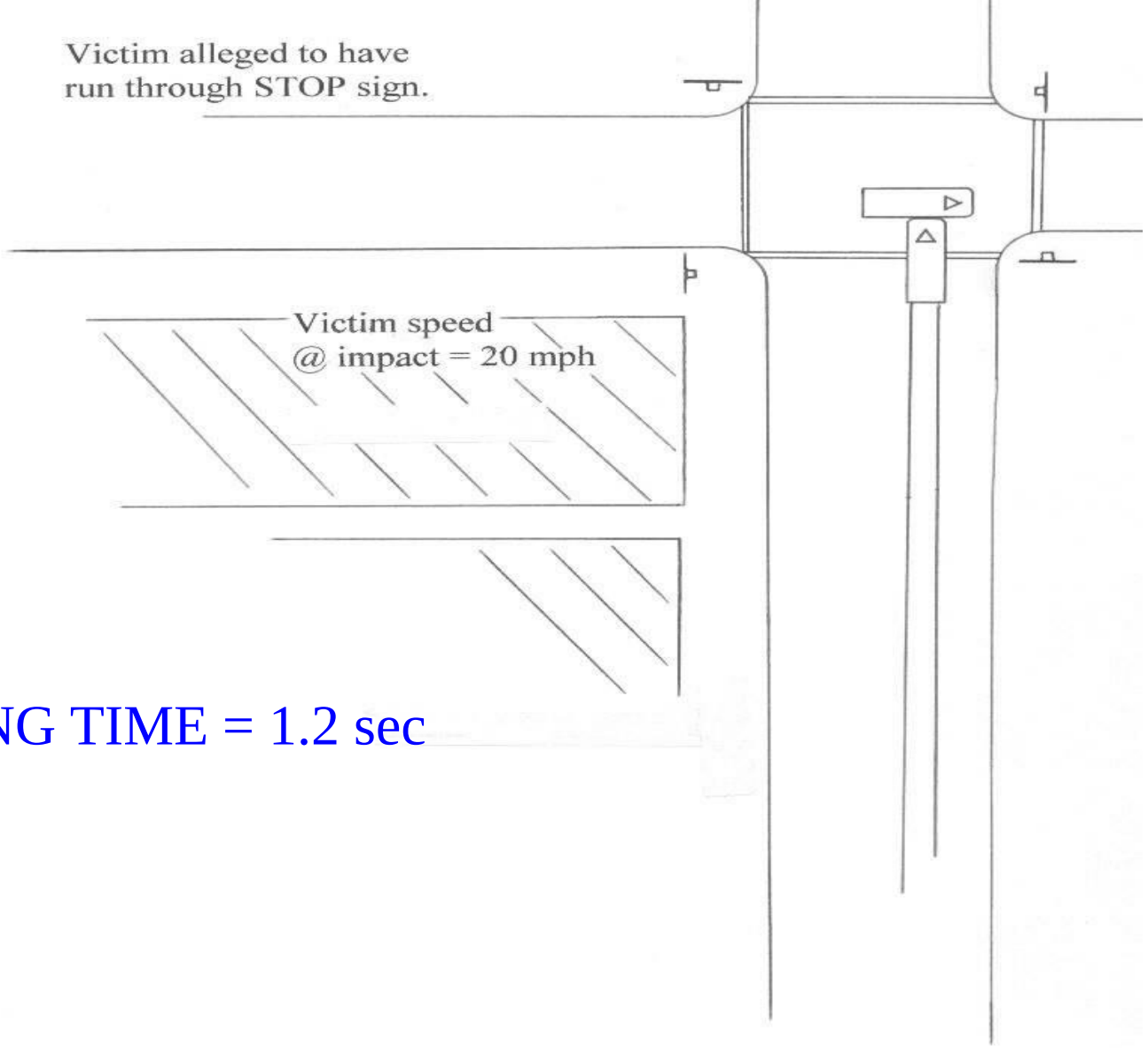


BRAKING TIME = 1.2 sec



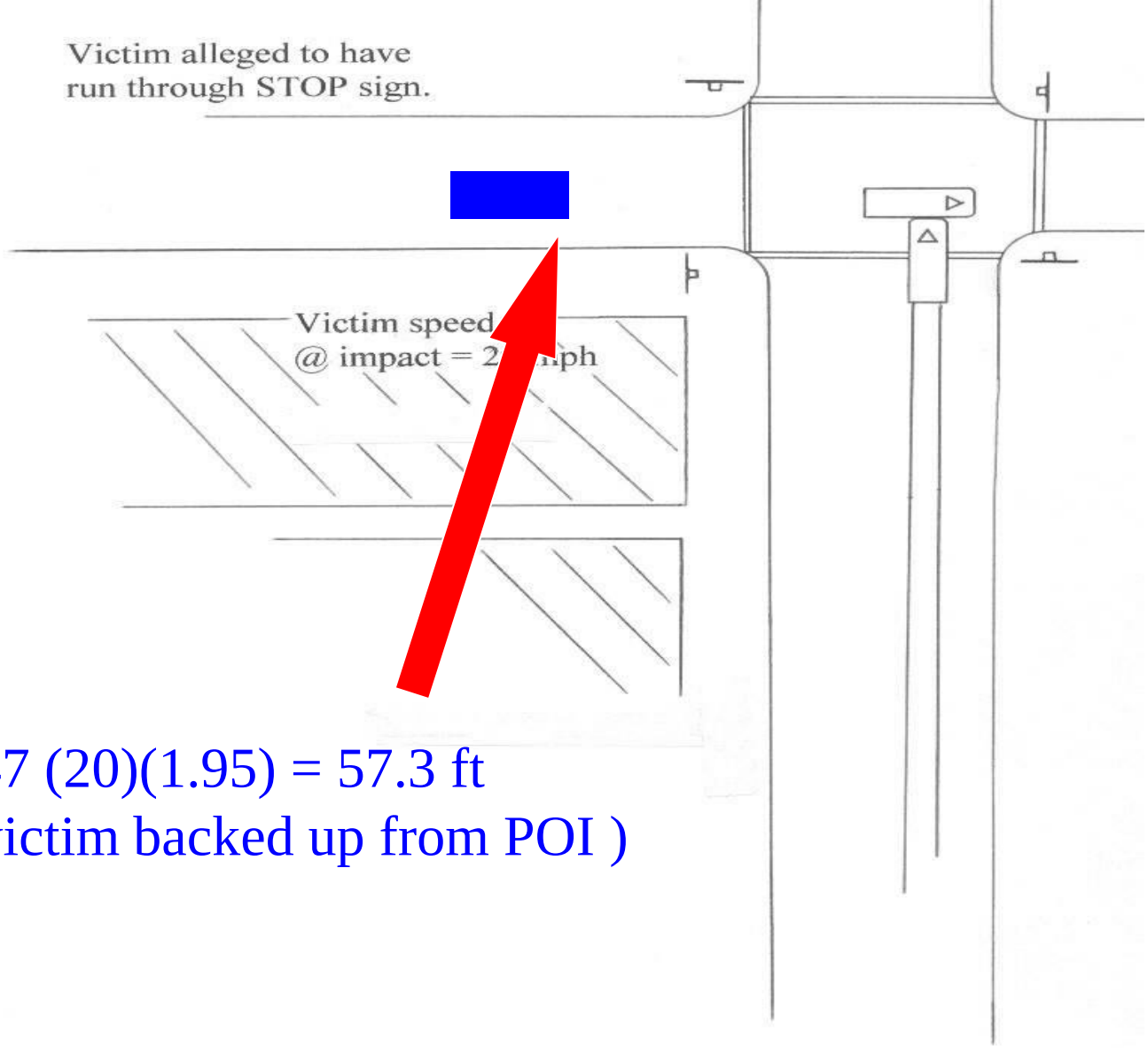
BRAKING TIME = 1.2 sec

PRT = .75 sec (minimal)



BRAKING TIME = 1.2 sec

defendant at start of PRT



d = 1.47 (20)(1.95) = 57.3 ft

(victim backed up from POI)

TDS checklist

Can you defend any *assumptions* ?

- starting point for accelerated motion
- acceleration rate
- operator behavior
- pedestrian walking speed

Was a range of values used ?

TDS checklist

Have human factors been considered ?

Visibility or conspicuity issues ?

PRT value – was a range of values used ?

Can TDS be used to develop additional facts ?

Is a hypothetical useful ?