SYLLOGISMS

There are three main legal arguments involved in *Ceccarelli vs Town of Cary*. Each argument is a set of three or four syllogisms.

The first argument is for Brian Ceccarelli's intersection of eastbound Cary Towne Blvd at Convention. This case argues that because the actual yellow duration is less than the yellow light duration required by the ITE Yellow Light Change Interval formula, Cary forced Mr. Ceccarelli to run the red light.

The second argument is for Lori Millette's intersection of northbound Kildaire Farms Rd. at Cary Parkway. This case argues that because the yellow duration is less than the yellow light duration required by the ITE Yellow Light Change Interval formula, Cary forced Ms. Millette to run a red light. This case states the point that all drivers, including left turn drivers, may travel legally at the speed limit of 45 mph. But because Cary sets the approach speed to 23 mph, Cary removes the ability from any driver who proceeds at a speed greater than 23 mph to stop safely.

The third argument extends Lori Millette's case. The third case mathematically shows the reality that turning drivers need more time, not less, than the ITE Yellow Light Change Interval formula.

Variable Key

Variable	***Description***
Y	yellow light duration
c	critical distance
t_p	minimum perception/reaction time constant. NCDOT = 1.5 s
v	vehicle's approach speed. Approach speed >= speed limit.
a	maximum safe deceleration constant of vehicle. NCDOT = 11.2 ft/s^2
G	Earth's gravitation acceleration constant = 32.2 ft/s^2
g	grade of the road in %/100. Downhill is negative grade.
a + Gg	effective deceleration of car
1.47	factor converting miles/hour to feet/second

Brian Ceccarelli at Eastbound Cary Town Blvd at Convention

1	**Syllogism**	
Major Premise	Using the NCDOT constants for perception time and deceleration, the critical distance (that is the safe stopping distance) for a 45 mph car on a level road is 294 ft.	294 ft
Show the Work	$$c = v t_p + \left[\frac{v^2}{2(a + Gg)}\right]$$ $$c = 45 * 1.47 * 1.5 + \left[\frac{(45 * 1.47)^2}{2(11.2 + G * 0)}\right]$$ $$c = 99 + 195 = 294\ ft$$ The factor 1.47 converts mph to ft/s. $$\frac{5280\ ft/mile}{3600\ s/hour} = 1.47$$	
Observation	294 ft is about the length of a football field. 300 ft is the length of a football field.	
Minor Premise	Brian is travelling at 45 mph within 294 feet from the intersection.	
Conclusion	Brian cannot stop safely. Brian must proceed and enter the intersection.	True
2	**Syllogism**	
Major Premise	The yellow light is 4.0 seconds long. At a constant speed of 45 mph, Brian can travel 265 ft while the light remains yellow.	265 ft
Show the Work	velocity x time = distance (45 * 1.47) * 4.0 = 265 feet	
Minor Premise	Brian is farther than 265 feet from the intersection that has a 4 second yellow.	
Conclusion	Brian does not have enough yellow time to legally enter the intersection.	True

3	**Syllogism**	
Major Premise	Brian is between 294 ft and 265 ft from the intersection.	
Minor Premise	The green light turns yellow.	
Conclusion	Brian neither has the distance to safely stop nor the time to proceed and enter the intersection legally.	True
Conclusion	A 4.0 second yellow on a 45 mph forced Brian to run a red light.	True

Lori Millette at Northbound Kildaire Farm Rd at Cary Parkway

1	**Syllogism**	
Major Premise	The critical distance formula computes the distance a driver needs to stop safely from initial velocity v.	
Major Premise	The critical distance formula is nothing more than the Yellow Light Change Interval multiplied by the initial velocity.	
Minor Premise	The critical distance is a function of perception time, initial velocity, deceleration constant and the grade of the road.	
Conclusion 1	The critical distance is not a function of what lane a driver is in.	True
Conclusion 2	The critical distance is not a function of whether the driver intends to go straight or whether the driver intends to turn.	True
Conclusion 3	It is legal for a driver to travel at the posted speed limit at 294 feet (the critical distance on a 45 mph road) from the intersection regardless of his intent to turn.	True
2	**Syllogism**	
Major Premise	Using the NCDOT constants for perception time and deceleration, the critical distance for a 45 mph car on a level road is 294 ft.	294 ft

Show the Work	$$c = v t_p + \left[\frac{v^2}{2(a + Gg)}\right]$$ $$c = 45 * 1.47 * 1.5 + \left[\frac{(45 * 1.47)^2}{2(11.2 + G * 0)}\right]$$ $$c = 99 + 195 = 294\ ft$$	
Minor Premise	Lori is travelling at 45 mph within 294 feet from the intersection.	
Conclusion	Lori cannot stop safely.	True
3	**Syllogism**	
Major Premise	The yellow light is 3.0 seconds long. At 45 mph, Lori can travel 198 ft ft while the light is yellow.	198 ft
Show the Work	velocity * time = distance (45 * 1.47) * 3.0 = 198 ft	
Minor Premise	Lori is farther than 198 ft from the intersection that has a 3.0 second yellow.	
Conclusion	Lori does not have enough yellow time to legally enter the intersection.	
4	**Syllogism**	
Major Premise	Lori is between 294 ft and 198 ft from the intersection.	
Minor Premise	The light turns yellow.	
Conclusion	Lori neither has the distance to safely stop nor the time to proceed legally and enter then intersection legally.	True
Conclusion	A 3.0 second yellow on a 45 mph forced Lori to run a red light.	True

Turning Requires More Time than the Formula, not Less

The above arguments are sufficient to win our case, but Cary's expert witnesses may try to convince the judge that left-turning cars need less time than straight-thru movement drivers. There is very basic and obvious principle why turning requires more time than the formula. It all has to do with how long it takes drivers to traverse a fixed distance. Those going slower need more time.

1	**Syllogism**	
Major Premise	Elizabeth Martineau travels through a fixed distance at a constant speed of v.	
Minor Premise	Greg Fuller enters the fixed distance at a speed v but then decelerates while within the fixed distance.	
Conclusion	It takes longer for Greg to traverse the fixed distance than it takes Elizabeth.	True
2	**Syllogism**	
Major Premise	The critical distance is a fixed distance for all drivers moving legally at 45 mph.	
Minor Premise	The drivers enter the fixed distance at the speed limit. Immediately after that the light turns yellow.	
Conclusion	All drivers are *committed* to enter the intersection.	True
3	**Syllogism**	
Major Premise	There is an amount of time required for each driver to traverse the critical distance.	
Major Premise	The ITE Yellow Light Interval Formula provides the time required for a driver to traverse the critical distance at the *constant* velocity of the initial velocity. In Cary, the initial velocity is the posted speed limit. The ITE Yellow Light Interval Formula only gives drivers like Elizabeth Martineau enough time to traverse this fixed distance so long as they move through the entire distance at the speed limit.	
Major Premise	The yellow light duration for a level road for car legally travelling at the speed limit of 45 mph is about 4.5 seconds.	4.5 s

Example		
Show the Work	$$Y = t_p + \left[\frac{v}{2a + 2\mathrm{G}g}\right]$$ $$Y = 1.5 + \left[\frac{45 * 1.4666}{2 * 11.2 + 2\mathrm{G} * 0}\right]$$ $$Y = 1.5 + 2.9464 = 4.4464 \text{ s}$$	
Minor Premise	A driver going a constant 45 mph during the time the light is yellow travels 294 ft.	
Show the Work	velocity * time = distance (45 * 1.4666666) * 4.4464 = 294 ft	294 ft
Conclusion	A yellow duration computed by the ITE Formula gives this driver enough distance to stop and it gives the driver enough time to proceed *so long as the driver proceeds at the constant speed of 45 mph.*	True
4	**Syllogism**	
Major Premise	Most committed drivers who intend to turn need to slow down in order to initiate a turn.	
Major Premise	Lori is committed and is going 45 mph. She slows down to 23 mph in order to execute her left.	
Major Premise	It takes 2.9 seconds from the time Lori's foot hits the brakes to the time she slows down from 45 mph to 23 mph. Lori's braking time is 2.9 s.	2.9 s
Show the work	$$t = \frac{v_0 - v_f}{a}$$ $$t = \frac{(45 - 23) * 1.47}{11.2} = 2.9\ s$$	Eq. 3-12. Halliday and Resnick Physics Part 1, p 40.
Major Premise	It also takes Lori time to travel from the point she entered the critical distance (294 ft) to the point she put her foot on the brake.	
Major Premise	This amount of time plus the Lori's braking is the time it takes Lori to traverse the critical distance.	

Major Premise Example	Lori travels 144.3 ft while her foot is on the brake.	144.3 ft
Show the Work	$$distance = \frac{v_0^2 - v_f^2}{2a}$$ $$distance = \frac{(45 * 1.47)^2 - (23 * 1.47)^2}{2 * 11.2}$$ $$distance = \frac{4375.8 - 1143.1}{2 * 11.2} = 144.3\ ft$$	Eq. 3-16 Halliday & Resnick, Physics 1, p.40
Major Premise	Lori requires 2.3 seconds to travel at a constant 45 mph from the critical distance entry point (294 ft) to 144.3 ft. t = distance/velocity = (294 – 144.3) / (45 * 1.47) = 2.3 s	2.3 s
Major Premise	It takes committed Lori 5.2 seconds to traverse the critical distance. critical distance to brake point time + brake point to intersection time = 2.3 s + 2.9 s = 5.2 s	5.2 s
Minor Premise	Cary set the yellow light to 3.0 seconds.	3.0 s
Conclusion	Lori, who needs to enter the intersection at 23 mph, will be forced to run red light by as much as 2.2 seconds.	True
Observation	Any driver who needs to slow down within the critical distance before entering the intersection has the same problems. Drivers who turn right and do U-turns have the same problem as Lori. Drivers who go straight but have to tap their brakes for cars entering or egressing from nearby business exits have the same problem as Lori. Drivers who go straight but have to slow down for cars at the next close by intersection have a problem. Defensive drivers who slow down to see traffic have a problem. Drivers who slow down for any reason before entering the intersection have a problem.	

Cary's Double Yellow Phases for Left Turn Lanes

There are two durations of yellow at the northbound approach at Kildaire Farms Rd @ Cary Parkway. The first duration is 3.0 seconds. The second duration is 4.5 seconds. Lori was confronted with the 3.0 second duration. For either duration the Town of Cary will force drivers to run a red light. I prove this below.

The 3.0 second duration comes after the protected green arrow phase. When the signal changes from the green arrow to a blinking yellow arrow, the subsequent steady yellow arrow is 3.0 seconds. After the 3.0 second steady yellow, the light changes to red for about 2 seconds then back to a blinking yellow arrow. The 2 second red is like an all-red clearance interval but just for a protected left turn phase. After this second blinking yellow arrow comes a solid yellow arrow for 4.5 seconds. The 4.5 second left turn yellow arrow coincides with all northbound movement yellows.

Approach Speed

Most likely Cary's expert witnesses will bring up "approach speed" in reference to left turn lanes.

Using the term approach speeds in reference to left turn lanes is an oxymoron.

Using the formula for turning motions is also an oxymoron. Denos Gazis only invented it for straight-thru movements where drivers can proceed to the intersection at the constant velocity which is the speed limit. Turning drivers decelerate.

The approach speed is defined as the 85th percentile speed of *freely-flowing* traffic. That speed is usually 1 to 12 mph greater than the posted speed limit. The majority of turning traffic is not freely-flowing but stuck in a queue. It is the turning traffic that is not stuck in queue, that approaches initially at the speed limit, that Cary penalizes.

By violating the 85th percentile rule, it is important to realize that the NCDOT never meets its own NCDOT Design Manual 5.2.2 minimum requirements for yellow lights for any red light camera approach. All the yellow light durations are supposed to be up to 1.5 seconds greater than what they are.

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Cary	Cary's engineers feel that 3.0 seconds is sufficient. Cary engineers feel that cars are approaching at 20 – 30 mph in the left turn lane. Therefore "approach speed" engineers set for left turns lanes is about 23 mph. (Plugging v = 23 mph into the ITE Formula yields a 3.0 second yellow).
Us 1	Show Cary the graph of what happens when Cary decreased an already insufficient 4.0

	seconds to 3.0 seconds. The 1000% spike speaks plainly.
Us 2	By setting v to 23 mph in the ITE Formula, Cary disallows drivers to go the legal speed limit. At 294 feet from the intersection, drivers can and do legally go 45 mph. These drivers are committed to enter the intersection and need *more than* the full formula yellow time to traverse the critical distance for their initial velocity of 45 mph. The full formula yellow time expects drivers to execute their turns at 45 mph, a speed too dangerous to turn. Plugging 45 mph into the Formula forces decelerating drivers (such as Lori), to run a red light. A reduced 3.0 second yellow only exacerbates the problem.
Us 3	The definition of approach speed is the 85th percentile speed of *freely flowing* traffic. Most cars in the left turn lane are decelerating or bottlenecked in a queue. Such cars are not freely-flowing. The NCDOT counts these cars which is incorrect.
Us 4	From the ITE NCSITE Task Force, 20 – 30 mph is for the "v" in the all-red clearance interval, not the "v" in the yellow change interval. 20 – 30 mph is the speed which left turning cars traverse the intersection, not traverse the critical distance on the approach to the intersection.
Us 5	v is not the average velocity of the speed limit and the intersection entry velocity. v in the Yellow Light Formula is the initial velocity—the velocity of vehicles at the entry point of the critical distance. For a 45 mph road, that speed is supposed to be the 85th percentile measured speed of freely flowing vehicles at 294 feet.
Us 7	According to notes at the top of the second column in the NCDOT Spec 5.2.2, sheet 4 of 4, engineers are supposed to set all the yellows durations using the approach speed, not the speed limit, providing that the approach speed is greater than the speed limit. There is not a single intersection in Cary where Cary has done this. All the yellow lights at all intersections do not meet the minimum yellow duration as set in the NCDOT Design Manual.