NORTH CAROLINA | IN THE GENERAL COURT OF JUSTICE

WAKE COUNTY | SUPERIOR COURT DIVISION

BRIAN CECCARELLI and LORI MILLETTE, individually and as class representatives,

Plaintiffs,

v.

No. 10-CvS-019930

TOWN OF CARY,

Defendant.

DEPOSITION OF LISA MOON, P.E.

TUESDAY, OCTOBER 9, 2012

Conference Room

Town of Cary Town Hall

316 North Academy Street

Cary, North Carolina

2:00 p.m.

Volume 1 of 1

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A P P E A R A N C E S

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Also Present:

Brian Ceccarelli

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(continued)

P R O C E E D I N G S 2:22 p.m.

(This deposition was taken pursuant to the North Carolina Rules of Civil Procedure.)

(Whereupon,

LISA MOON, P.E.

was called as a witness, duly sworn, and testified as follows:)

D I R E C T E X A M I N A T I O N 2:22 p.m.

By Mr. Stam:

Q I'm Paul Stam. I represent Mr. Ceccarelli and Ms. Millette.

A Okay.

Q State your name and address.

A My name is Lisa Moon. I live at 923 Madison Avenue, Cary, North Carolina.

Q Among other things, do you design traffic signals for a living?

A Yes, I do.

Q Have you done it for a long time?

A 20 years.

Q Suppose there was an intersection and you concluded that based on all factors involved, there should be a five second interval from one direction before you let the other direction go.

A Uh-huh.

Q Hypothetically.

A Okay.

Q Would it be okay just to have no yellow light and let it go straight from green to red and then wait five seconds before you turned on the green at the perpendicular direction?

Ms. Martineau: Objection to the form of the question. You can answer it if you understand it. It's a hypothetical question.

A If I understand your question correctly, you're saying basically get rid of the yellow altogether?

Q Yeah, yeah.

A No. I would not get rid of the yellow altogether in any situation.

Q Okay. Why not? What---

A (interposing) Because it's a warning that the opposing traffic is going to be getting the right of way.

Q Okay. But if the red--if the opposing traffic, the lane coming in from a perpendicular direction---

A (interposing) A main street, side street.

Q Do you call that opposing---

A (interposing) I was---

Q ---the side street?

A ---trying to---

Q (interposing) Whatever you call it.

Ms. Martineau: Just for the benefit of the court reporter, if you two could try not to talk over each other, that would be helpful.

The Witness: Okay.

Q If you could keep both lights red for five seconds, which you've already determined would be sufficient time to clear the intersection, what would be the problem with doing away with the yellow light and just maintaining it all red for five seconds before letting the opposing traffic through?

Ms. Martineau: You can answer if you understand the question.

A I'm not sure I completely understand the question, partially because I have never debated in my head about eliminating the yellow because you don't, so---

Q (interposing) Why not?

A Because the yellow is the warning that it's going to be red and that the side street is going to be--or the perpendicular---

Q (interposing) Why does the driver need that warning?

A Because you can't stop on a dime.

Q Well, if you are going to control the opposing traffic for a sufficient length of time, why do you need to warn the driver to stop?

Ms. Martineau: Are you asking about her opinion or whether there are requirements for yellow times? I mean those are two separate questions.

Mr. Stam: I'm asking her her opinion.

Ms. Martineau: Okay.

A All right. My opinion--I can answer this the only way I know how to answer this, and I don't know if this directly answers your question.

Q Okay.

A But in traffic engineering we've always had a yellow and red. The yellow is a clearance interval, or a change interval, and the red is the clearance, or the--yeah, the clearance interval. The yellow is the amount of time that we use to warn people of conflicting movements. The red is the amount of time that you use to actually clear the vehicles through the intersection.

Q Would it be the yellow plus the red is the actual clearance time?

A The yellow plus the red is the total clearance change interval time. If they have two separate grids, it gets a little--but they are two different functions.

Q Sure.

A The red is to clear the traffic after they're in the intersection. The yellow is to help the driver know that something's coming so that they can make a decision whether they need to stop or go.

Q So suppose at this intersection you would propose a four second yellow light signal and then a one second all-red clearance interval, a total of five seconds.

A Uh-huh.

Q Would there be any problem with just having it all red both ways for five seconds from a traffic point of view?

A You're taking away the yellow, which is the intent to warn the other people, so it feels wrong.

Q It feels wrong. I---

A (interposing) It feels wrong.

Q ---grant you that. But if you have some other way to control the opposing traffic--let's suppose this. Suppose that there was an actual gate for the opposing traffic. They could not go through even if they wanted to, but after that five seconds they could. Would there be any problem then in not even having a yellow light for the direction you're designing for?

Ms. Martineau: Objection to the form of the question. Answer if you can.

A I don't feel like I'm understanding the intent of the question to give you an answer.

Q Okay. All right. What is--so you say the yellow light is to warn the driver?

A Uh-huh.

Q What is it warning the driver of?

A Conflicting traffic movements, that their light is going--they're going to lose their right of way to the perpendicular traffic.

Q At some point in the future?

A In the near future.

Q In the near future. And that near future ranges from what time to what time?

A It depends on the situation. It depends on the intersection, the speed, grade.

Q Does it range between three and six seconds?

A Yellow time typically ranges between three and six seconds, a minimum of three.

Q Okay.

A And then the red on top of that is a clearance space on top of the yellow to actually clear the intersection.

Q Right. So you're warning them that there will be another phase. In your opinion, in the typical traffic signal that you design--have you ever designed any in Cary?

A Yes.

Q Okay. So let's just take the ones you've designed for Cary.

A Uh-huh.

Q Does the yellow light last 50 percent of the time it takes a driver to stop, 100 percent, or 150 percent of the time it takes a driver to stop?

Ms. Martineau: Objection to the form of the

question. Answer if you can.
Q Or some other figure?
A We don't calculate the yellow time based on how long it takes to stop.
Q Why not?
A Because when you make the decision to stop or go, you either need the time that it takes to go and pass the stop bar, or if you're going to stop, it does not matter when you stop in relation to the stop bar because you're stopping before you enter the intersection and you're avoiding the conflicting traffic.
Q When does a driver--I'll withdraw that question. If a driver no longer has the distance to stop, how fast must the driver proceed toward the intersection, toward the light, so the light is still yellow when the driver enters the inter-section?
A Can you repeat the question because I don't want to answer---
Q (interposing) Right.
A ---incorrectly.
Q If a driver approaching an intersection no longer has the distance to stop, how fast must that driver proceed toward the intersection for the light to still be yellow when the driver enters the intersection?
A I can't give you a--because there are too many

variables in that question to answer it, because once they decide that they need to stop or if they don't have enough room to stop, that's a varying distance depending on their rate of decel and all of that other stuff. They could be right on top of it. They could be--so I don't think there's one answer to that question.

Q But by definition in that case, if the driver no longer has the distance to stop, that driver cannot slow down; is that correct?

A No. I think what I'm hearing you ask me is you're talking about the point of decision, where they decide that they do not have enough room to stop, and our formula is based on a comfortable stopping distance. So when you say cannot stop, there's a wide range in there between cannot stop and what we calculate. And I'm still---

Q (interposing) Let me clarify: cannot stop within a reasonable deceleration rate, which you-all assume to be 11.2 feet per second.

A We assume a comfortable deceleration rate, not a reasonable deceleration rate.

Q What do you mean by comfortable deceleration rate?

A Comfortable as an average driver comfortably stops, and there is a range between a comfortable stop and a slamming on the brake stop. There are all the variations in the middle, plus like there's variations on acceleration and

there's variations on deceleration.
Q Does a typical driver have a right to assume that other drivers will be decelerating at a reasonable rate?
A Reasonable--I just don't want to--I don't want to say that comfortable and reasonable necessarily are always equal.
Q I agree. But does a driver have a right to assume that the drivers fore and aft, before him or her, after him or her, would be decelerating at a reasonable rate?
A Most people are going to assume that other people are going to drive similar to them and stop at a reasonable rate, yes.
Q All right. Let's talk about left-turning drivers---
A Okay.
Q ---as opposed to drivers who are going to take a right turn. Do left-turning drivers who have to--they would have to go a little farther than the right-turning drivers?
A Uh-huh.
Q Would they have to be going faster or slower than right-turning drivers?
Ms. Martineau: Objection to the form of the question.
Q In order to---
Mr. Stam: I'll continue.
Q In order to make the turn safely within the law?
Ms. Martineau: Well, object to the question.

A In what parameters?
Q Okay, in general. There are a lot of different parameters.
A Lots of different parameters.
Q But the only difference in my scenario is whether the driver is turning left or right.
A Okay.
Q So would a driver turning left as opposed to a driver turning right have to have more time--more distance to stop or less distance to stop?
Ms. Martineau: Are you asking her the distance through the intersection, because---
A (interposing) Basically a right turn, in making the actual movement, typically makes that turning movement slower than a left turn. But on the approach, I can't tell you exactly how they're going to decel. That's a driver characteristic.
But yes, they're both going to have to slow down to make those right and left turns. I have not studied it to know how fast, you know, one is going particularly on the approach as compared to the other.
Q And I don't have a videographer, but I do have a magnetic board. If that would help you explain anything, feel free to go to the board if you want to.
A Okay.

Q Let me ask you this. Two cars approaching an intersection, the same intersection, the same speed limit, I'm assuming--I'm going to assume 45 miles an hour because that's the speed limit in the cases in controversy in this case.

A Okay.

Q Does the straight--the car that is going straight through the intersection compared to the vehicle that is going to turn left, which one of them needs more time to make the turn reasonably and lawfully through the intersection, the one going straight or the one turning left?

Ms. Martineau: Objection to the form of the question. Answer if you can.

A Once again, it depends on where you're at. If you're talking about a point in time, if you're starting from the same point, somebody going through at a faster speed is going get through an intersection faster than somebody who is making a left to go this way (indicating) because they are slowing down to make this turn at a slower movement. So if you are starting at the same point, a left turn would generally need more overall time.

Q Time, more time, the left-turning, okay. In general, for the intersections that you've designed--for which you've designed traffic signals in Cary--I'm trying to get my prepositions in correct English--is more time allowed for the

vehicles going straight through the intersection or the vehicles turning left at an intersection, in general?
A Once again, as a traffic engineer, I want to know what time you're talking about. Are you talking about the minimum green, the maximum green, the yellow, the red? When you say time, time is generic and can include all of those, and so---
Q (interposing) Good point. Here's my--let me clarify. I'm talking about the time of the yellow change interval.
A The time of the yellow change interval is based on the speed and the grade. And because you are going slower going through a left turn than you are going through a through, you generally need less time to be able to stop, if you choose to stop.
Q Now, my recollection is that about two minutes ago you said that the left-turning vehicle would need more time.
A But that time, once again, is green, yellow, red. That was not talking about specific yellow time. That was talking about how much time in space would it take for a car going from point A to point B. That was not in regards to green, yellow, or red.
Q Okay. So if two cars traveling north on Kildaire Farm Road---
A (interposing) North is which--okay, north on Kildaire Farm Road, got it.
Q I'm not testifying. I'm just clarifying my question.

We don't have a videographer, so the jury won't even know what we are doing here. Two vehicles going 45 miles an hour, okay?
A Uh-huh.
Q The one in red is planning to turn left.
A Correct.
Q The one in white is planning to go straight through.
A Correct.
Q All right. The yellow light goes on right when they're there. Which one of them needs more time to get through the intersection safely and lawfully, the one on the left or the one on the right, the one turning left or the---
A (interposing) And we're assuming the one going straight through continues at 45 miles an hour and the one on the left is going to slow down in order to make the turn?
Q I would assume that, yes. Which one of them is going to need more---
A (interposing) Yellow time.
Q ---yellow time?
A The through movement because they are going at a faster rate, which means they are approaching a dilemma zone. And to clear them past that dilemma zone to get through the intersection, they're going to need more time.
When you're going slower, you eliminate--there's argument about how much elimination, but there's a lot less

critical distance for the left turn, and therefore you're going slower. You're already upon your brake. It takes you less time to stop if you need to.

Q So the vehicle turning left going north on Kildaire Farm--and under my hypothetical they're both going 45 miles an hour.

A At that point in time.

Q At that point.

A Uh-huh. But you cannot be going 45 as you hit that stop bar to make an average turn of 20 miles an hour through the intersection.

Q Correct, but can you be going 45 294 feet away from the intersection?

A Yes, you can, but at that point if you're slowing down to stop, then you should have plenty of distance to stop.

Q What if you want to go through the intersection?

A You're still slowing down.

Q Right, so you need more time?

A If you're slowing down and it turns yellow, then you stop. You don't speed up and go through the intersection. At 45 miles an hour, you're going to have to slow down to make the turn. And if you're going a slower speed, it takes you less time to stop.

(Plaintiffs Exhibit A was marked for identification.)

Q Okay. I show you what's been marked for identification as Plaintiffs Exhibit A, three pages, which is the civil engineering curriculum at North Carolina State University for July 2010.
A Okay.
Q I guess you graduated a while before then.
A 20 years ago.
Q Okay. But if you would just take a look at that, and I'm going to just ask you a couple of questions about it. Is that--after you've had a chance to take a look at it, does that appear to be sort of a typical curriculum for civil engineering? Take a minute to take a look at it.
A It has been so long since I was there I cannot honestly tell you.
Q Well, just a couple things: in your degree, did you take physics for engineers and science?
A Yes, I did.
Q Did you take mechanics?
A Yes, I did.
Q Hydraulics?
A Yes, I did.
Q Engineer mechanics--engineering mechanics?
A I'm not sure exactly what that one is--statics, yes.
Q Okay. Applied differential equations?
A Yes.

Q Okay. Would you say that a basic knowledge of physics is basic to sound engineering?

Ms. Martineau: Objection to the form of the question. You can answer if you can.

A I can tell you that I got a degree and I learned how to learn in school, but I learned a lot about my job doing my job.

Q You need to know a lot more than what you learned in school to be a good engineer. Is that what you're saying?

A There are things that you learn in school that teach you how to learn and apply things but aren't necessarily what I use on a day-to-day basis.

Q What would be your definition of what engineering is?

A To tell you the truth, I don't have a definition of what engineering is.

Q I'm not looking for a dictionary definition, but a more common language definition.

Ms. Martineau: Well, she just answered your question. If you want to know what are her job responsi- bilities, her duties, or what she does, she can tell you, but she's answered the question.

Q Do you--would you agree that engineering, among other things, is applying the principles of physics, math, chemistry, and other sciences to the real world?

A There are so many different kinds of engineers. What you say sounds reasonable, but I don't know that I would have defined it particularly that way.

Q Would what I say apply to traffic engineering, that it's the application of principles of physics, mathematics, chemistry?

A Partially, but not in its entirety by any means.

Q It requires more than that, but at least that, physics, math, science?

A It requires some common sense understanding of those applications, yes.

Q Okay. 2 plus 2 equals 4, and if I said 3 plus 4 equals 8, I would be wrong; is that correct? By the definition---

A (interposing) Correct.

Q ---of 3, 4, and 8, I would be wrong.

A Correct.

Q Could an engineer design anything who could not add or subtract accurately and multiply and divide?

Ms. Martineau: Objection to the form of the question. Can you repeat it? I didn't understand it.

Mr. Stam: Yeah.

Q Could an engineer who does not accurately know how to add, subtract, multiply, and divide do sound engineering as applied to traffic engineering?

A I feel like you're trying to trap me into something, but I will say that as an engineer you do need some basic education to be a traffic engineer.

Q And would that apply, for example, to the three laws of motion that Newton taught?

A You're talking about laws of motion. That is not my job. That is not my degree. That is not my practice.

Q Okay. Are you--I'll tell you what I think the three laws of motion are and you tell me if you've heard of these three things. If you have, fine. If you haven't, that's fine too.

A If it's from school---

Q (interposing) Yeah.

A ---I may have heard of it but it's been awhile.

Q Yeah. These are so common I bet you've heard of them. Have you heard of this law of motion? An object in uniform motion remains in uniform motion unless a force acts on it.

A Yes.

Q Otherwise known as the law of inertia.

A I couldn't tell you the name, but I've heard of it.

Q And does that apply to the physics of traffic engineering?

A Abstractly, yes.

Q How about this one? Force equals mass times acceleration. The acceleration of a body is directly proportional to the net force acting on the body and is

inversely proportional to the body's mass.
A Yes. I've heard of that equation, and that's pure physics, yes.
Q And is that something that would apply to traffic engineering because you're talking about force, mass, and acceleration?
A As a very limited, vacuumed world, yes.
Q Okay. Here's one that applies to politics too. For every action there is an opposite and equal reaction. Is that something that applies in traffic engineering?
A They all apply to some extent, but they only take into account those particular things. There are so many other things involved in traffic engineering that we as a practice don't go back to those physic equations and design based on them.
Q Well, we talked about the turning vehicles.
A Uh-huh.
Q So for example, a vehicle is headed down the road at 45 miles an hour and the driver wants to turn left. And the question is what is the opposite reaction--in other words, why are they having to slow down to make that left turn? What is the opposite force acting on the car?
A See, you're getting into specifics. I can generally tell you the earth's gravity has a play in it. Friction on the road has a play in it. The braking force of the car has

a play in it. They all have different pieces and parts that go into it.

Q The weather, the grade of the road?

A There's lots of different things that go into that, yes.

Ms. Martineau: Can we take a quick break?

Mr. Stam: Sure.

The Reporter: Off the record. 2:49 p.m.

(A brief recess was taken.)

The Reporter: On the record. 2:53 p.m.

(Plaintiffs Exhibit B was marked for identification.)

By Mr. Stam:

Q I show you what's been marked for identification as Plaintiffs Deposition Exhibit B, and ask if you have had a chance to look at that.

A I did. I looked at this. It is an equation.

Q Is it anything that you can explain or discuss to elaborate on your answer or not?

Ms. Martineau: Objection to the form of the question. She's here to answer your questions, but go ahead.

Q Is it helpful to you--are these equations, 1, 2, 3, 4, helpful to you in discussing cars in motion and traffic signals and that kind of thing?

A No, not necessarily. It's a physics equation, which

is just a piece of what I do.
Q Does it appear to be accurate?
A That appears to be accurate, yes.
(Plaintiffs Exhibit C was marked for identification.)
Q Okay. I show you what's been marked for identification as Plaintiffs Deposition Exhibit C. And Ms. Moon, this comes out of a larger---
A (interposing) I'm familiar---
Q ---document.
A ---with the design manual.
Q If you're familiar with this, that's good. Do you use this--first of all, what is the source of this exhibit?
Ms. Martineau: Do you mean what is it?
Mr. Stam: Yeah.
Q What is it?
A Where did it come from? The North Carolina Signal Design Manual, ITS Signal Design Manual.
Q Okay. And does it have any legal status as far as you know?
Ms. Martineau: Objection. She's not an attorney.
Q I'm just asking as far as you know.
A As far as I know. I design with it. I don't know what the legal--the specific legal---
Q (interposing) You use it?

A I use it.

Q All over the state of North Carolina?

A Yes.

Q And do you know what the date of this--it's got a--it appears to have a date in the bottom left corner, but was it perhaps---

A (interposing) That is---

Q ---implemented earlier than that?

A ---probably the revision date. I know that this--I was involved with the yellow and red task force that was done by the North Carolina section of ITE with practitioners from all across the state, state, private, municipal, that we evaluated and reviewed the change and the clearance intervals.

Q And did you bring your file from that task force with you?

A No. I didn't bring my file from that task force.

Q Okay. As part of the task force discussions, do you recall any discussion--how many members--I'll back up. How many members of the task force were there, approximately?

A It's been years ago. I'm not sure; probably between 30 and 60, but I'm not sure exactly.

Q Do you recall at the meetings of the task force or any subcommittee that you were on any discussion about whether the physics of the formula actually fit the engineering and

fit the---
A (interposing) Hard core physics, like what you're talking about?
Q Yes.
A No. There was not discussion about that that I am aware of.
Q Okay. If you would look at the equation there at the top left called Yellow Change Interval--this is one you do use, this equation?
A Uh-huh.
Q If you would explain that first equation, yellow interval, is that asking how long you should stay at the yellow interval?
A Uh-huh. Yellow interval equals perception reaction time plus the design speed divided by two times the acceleration rate plus 64g, which is the grade. I don't know exactly what you want me to---
Q (interposing) All right. 64.4g is the grade?
A g is the grade. 64.4 has to do with--I think it's the earth's gravitational pull or something.
Q All right. So things would change if you're going uphill as opposed to downhill. Is that what grade means?
A That's what the little g means, yes.
Q All right. All my questions are going to be assuming that we're on a level playing field because I think that's

what they are in Cary.

Ms. Martineau: They're at 0 grade? Is that what you mean?

Mr. Stam: 0 grade, yeah.

Ms. Martineau: Okay.

Q Is that what you call no grade, 0 grade, or do you call it 1?

A 0.

Q 0, that's what I thought.

A 1 is a positive effect. Minus 1 is a negative effect.

Q So when it says yellow interval, what that means is the time to set the yellow interval, like in number of seconds?

A Uh-huh.

Q Like three seconds, four, five, six?

A Based on the calculation, yes.

Q All right. t, you plug in 1.5 seconds; is that correct?

A Perception reaction time, yes.

Q What is perception reaction time?

A How long---

Q (interposing) I know you know and I know, but the judge needs to know.

A How long it takes a driver to perceive the change and react to it.

Q Okay, get your foot from the accelerator to the brake pad after deciding perhaps whether to stop.
A It's---
Q (interposing) Or from the brake pad to the accelerator---
Ms. Martineau: (interposing) Wait till he--he needs to ask you a question.
The Witness: Okay.
Q Or getting from the brake pad to the accelerator after deciding to go through the intersection.
Ms. Martineau: If you have a question you can ask that question.
Q Is that correct? Is that what the perception time is?
Ms. Martineau: She just told you what it was. She in her own words told you what she thought it was.
Mr. Stam: Okay, and I elaborated on the question.
Q Is that still what you think it is? In other words---
A (interposing) It is the amount of time that it takes for somebody to perceive a change and react.
Q And is reacting things like moving your foot from the accelerator to the brake or from the brake to the accelerator?
A Or even not reacting at all.
Q Okay. Design speed, what is the design speed in feet

per--we know it's in feet per second. But what is the design speed?

A Design speed is--in North Carolina it's been agreed upon that the design speed is the posted speed limit unless you have a speed study done where the speed is documented at the 85th percentile to be greater or less than.

Q Okay. In Cary at the intersections in question in this lawsuit, do any of them use a design speed other than the posted speed limit? In other words, has a speed study been done and therefore you use a different design speed than the speed limit?

A As far as I'm aware, none of the ones in this case that is true for and none of the ones that I've designed.

Q Okay. So in every case we're using the posted speed limit as the design speed?

A Uh-huh.

Q So looking at my board over here, the posted speed limit is 45 miles an hour at Cary Parkway and Kildaire Farm Road no matter what lane you're in. So that v would be 45 miles per hour?

A And that is what we use for the through movements. For a left turn, everybody generally accepts that you do not make a left turn at the posted speed limit. You are making that at a slower speed. They evaluated that---

(Interruption by passing train.)

Mr. Stam: Let's hold just a second.
The Reporter: Off the record. 3:01 p.m.
(A brief recess was taken.)
The Reporter: On the record. 3:01 p.m.
By Mr. Stam:
Q Okay. I'll restate the question.
A Okay.
Q So my question is Cary Parkway and Kildaire Farm Road, you agree the speed limit is 45 miles per hour?
A Right.
Q So v in this equation will be 45 miles per hour; is that correct?
A For the through movement because in practice, traffic engineers as a whole agree that left turns are going slower than the through movements. So we have adopted a standard practice of 20 miles an hour for a left-turn speed, which can be raised or lowered based on engineering judgment, usually based on the skew of the intersection or other factors that we determine. So it is based on the speed, posted speed, for the through movement.
Q I'm not sure if my question is when or where. I'll say when, but I may mean where.
A Uh-huh.
Q If a driver is turning left, when is the assumption made or where, at what point, is the assumption made that the

driver is going 20 miles an hour?
A Crossing the stop bar.
Q At the stop bar, okay. I'm going to---
A (interposing) I was not part of the subcommittee who dealt with this, but my understanding is that is the typical speed through a left turn, 20 miles an hour.
Q It says 20--the footnote says 20 to 30 miles an hour, but I understand most people use 20, so that as you actually make the turn it's even perhaps slower?
A No, 20.
Q 20. 20 through the intersection?
A There's a range that has been gathered, but 20 is---
Q (interposing) Okay. Now, we talked earlier about how much time would be needed for a straight-through vehicle as opposed to a left-turning vehicle to proceed through.
A Right.
Q I'm not going to go over that again. Suppose these two vehicles are in their--I'm glad cars are not magnetically attracted to each other, but suppose these cars decide to stop. The red car is in the left-turning lane. The blue car is in the straight-through lane.
A Uh-huh.
Q The yellow light comes on back here at about 294 feet.
A Okay.
Q And they decide to stop. Which vehicle needs more

time or distance to stop, the one in the left-turn lane or the straight-through lane?
A If they're both going 45 miles an hour---
Q (interposing) Right here (indicating).
A ---at that point---
Q (interposing) 45 miles an hour. They decide--the yellow light comes on. They both see it. After one and a half seconds, they're about right here (indicating), or at some point farther. They decide to stop. Which of those vehicles needs more time to stop, the left-turning vehicle or the straight-through vehicle?
A If they're exactly equal, cars with equal drivers at an equal distance, they're going to need equal amounts of time to stop.
Q Okay. Do you know at this particular intersection how much time the straight-through vehicles are given to stop?
Ms. Martineau: Objection to the form of the question. Are you trying to ask how much--what the yellow time is?
Mr. Stam: Yes.
Q What is the yellow change interval for straight-through motions at Cary Parkway and Kildaire Farm Road?
Ms. Martineau: During what time? Do you want her to look at the---
A (interposing) It's on the plan I'm sure.

Ms. Martineau: ---on the 1991 plan?

The Witness: No. This is Cary Parkway and Kildaire. This is a newer plan.

Ms. Martineau: Oh, okay.

By Mr. Stam:

Q We'll be getting to that plan. If you want to--let's--why don't--do you have that with you?

A Uh-huh.

Q If you would look at that one?

A Kildaire and Cary Parkway?

Q Uh-huh.

A This one has two versions.

Q Yours are so much more legible than mine.

A I have two different versions at two different dates. I think they maybe have the same--are you talking about a specific movement that you want to address?

Q Yes. Let's address the straight-through going north, as Ms. Lori Millette was, and turning left on Cary Parkway.

Ms. Martineau: We have two different plans. Why don't we all agree which plan you want her to testify off of?

Mr. Stam: Well, it may be the same answer for both of them.

A Phase 2, they're slightly different in the red time. They both have 4.5 seconds in yellow time.

Q For the left-turning vehicle?

A For the three---
Q (interposing) Oh, for three movements?
A For the three movements.
Q All right, 4 point what?
A 4.5.
Q All right. So 4.5 is allowed for the yellow change interval for this vehicle right here (indicating)?
A Uh-huh.
Q Okay. For the left-turning vehicle, it's---
A (interposing) Three seconds.
Q And is this true on both sets of plans?
A Yes, it is.
Q All right. So this vehicle (indicating) and this vehicle (indicating), if they decide to stop, one has 4.5 seconds and the other has three seconds?
Ms. Martineau: Objection to the form of the question. That's not what she testified to. You're asking her---
A (interposing) That is not correct, and that is not how the formula is---
Q (interposing) Okay. Explain it to me.
A How much time they have to stop is totally different than the yellow time as what we're calculating. So you're implying that the yellow time is an equation about how long it takes them to stop and that is not true.

Q Okay. What is it?

A It is the point that if you reach a critical point and you go through the intersection, the distance from that point, where you've decided to go through, to the stop bar is a certain distance. How long does it take you to travel that speed to get through the intersection legally? So it's not about stopping. It's about going.

Q It's about going?

A Right. And so both of those people stopping, it may take them ten seconds to stop. I don't know. But that is not what the intent of yellow is or what we're trying to do with the yellow, because they're at a point where they've decided to stop, and so the yellow time isn't really critical to them because they're stopping and they're not going to be in opposing traffic. So the stopping time at this point does not equal the yellow time that you're implying.

Q Okay. Now, I think you said that for the going time for the left-turning vehicle, you're assuming what's not in the equation, but that you're assuming that that vehicle is going 20 to 30 miles an hour. I think you said 20 miles an hour.

A 20 miles an hour is the assumed v for left turns.

Q At what point is that on this road?

A At some point between 45 and the turn. There is not a way to specifically calculate where exactly and what speed

exactly a left turn will be going.
Q Okay. I think you said it was at the stop bar.
Ms. Martineau: That's where they measured it. She said that's where the task force measured the speed of left-turning vehicles.
Mr. Stam: Okay.
Q So 20 miles an hour is the v in the equation for left-turning vehicles?
A Uh-huh.
Q And it's measured---
Ms. Martineau: (interposing) You have to say yes or no.
A Yes. Sorry.
Q I understood you. And it's measured at the stop bar, which is right before the intersection?
A That is where the task force measured it.
Q Do you measure it somewhere differently, somewhere else?
A I don't measure it. The task force agreed upon that that was appropriate for the formula. I think the basic difference between you and I is you want the math to be everything in this equation, and as a traffic engineer, I know that it's not all about the math. It's about human characteristics and human behaviors and various human factors that cannot be captured with math.

Q I understand. I'm going to ask now about the red change interval.

A Okay.

Q But if you could keep these out as well (indicating), I would appreciate it.

Mr. Stam: If you don't have any objection, at some point we'll mark these as exhibits because they're much more legible than mine.

Ms. Martineau: Yeah. What I would prefer is--if you want to mark them as an exhibit you can. We can make a good copy of them and give them to the court reporter, but these are her file materials.

Mr. Stam: Got it, got it. That would be fine.

Ms. Martineau: Okay.

By Mr. Stam:

Q If you would look at the red clearance interval on Exhibit C?

A Okay.

Q Okay. Would you explain that somewhat simpler equation?

Ms. Martineau: Objection to the form of the question. Do you want her to read what the equation is?

Mr. Stam: I would like her to explain the---

A (interposing) Which equation?

Mr. Stam: ---equation for red interval equals w

divided by v.
A Width divided by velocity. You take the width of the intersection, divide it by the velocity to get the amount of time that it takes to clear an intersection.
Q All right. Is that talking then about the time from here to here (indicating)?
A Yes.
Q From the time when they enter the intersection---
A (interposing) Uh-huh, from the stop bar to---
Q (interposing) From the stop bar---
A ---any opposing traffic.
Q ---to there (indicating)? Do you happen to know if that's when the front of the car exits or the back of the car?
A It's actually--different states do it different ways, and I would have to go back and look at ours. I think ours is from the front of the car to the front of the car, not front of the car to the back of the car.
Q Okay. So that v design speed in this example, Cary Parkway and Kildaire Farm, would that be the 45 miles an hour or would that be the 20 miles an hour?
A v is set for the left turn at 20 miles an hour for both yellow and red.
Q Okay. Do you know looking at the notes on the right-hand side whether that 20 mile per hour is an assumed speed

at the stop bar or is it an average of something else?

Ms. Martineau: Objection to the form of the question; asked and answered. You can go ahead if you understand it.

A This documentation says for most left turns, assume a speed of 20 miles an hour.

Q And that's at the stop bar?

Ms. Martineau: No. It's---

A (interposing) No. Assume that speed for the equation for both, which was determined in the task force in a subcommittee than I was on. I do not know all the details of that.

Q All right. You've answered that. Okay. Would you look at the note that begins "For left turns without a separate phase"? Do you see that down there? It's a little farther down, the fifth note.

A Yes.

Q Okay. What does without a separate phase mean?

A That means if you do not ever have a left turn arrow.

Q Okay. It says--in those circumstances, which I guess is not this case; is that correct?

A No, not at all. It's a---

Q (interposing) But there is a left turn arrow here (indicating)?

A Uh-huh.

Q Okay. But if there wasn't an arrow here, it says, "calculate yellow and red times for both the through movement and the left turn movement. Use the highest yellow and enough red to equal the highest total time."

A Uh-huh.

Q Okay. So assume for a moment that there was no yellow left turn light, not a separate---

A (interposing) A green arrow?

Q Yeah, not a separate--yeah.

A There's no arrow.

Q Okay, just red and yellow--I mean red, yellow, and green.

A Just a standard two phase.

Q A standard two phase, okay. In that case, would that mean that instead of using three seconds for the left turn, you would use the 4.5?

A Yes.

Q Okay.

A Because there is no way to separate out. So you take the calculated--the highest, which would be the safest, and they both should be able to stop under that.

Q Okay. The next note, a very lengthy note, that begins "Where existing times are higher," if you would look at--three, four, five, six--the sixth line, fifth and sixth line, it says, "consider adding a note to the plan to direct field forces to reduce the time incrementally."

A Yes.

Ms. Martineau: Go ahead and read the whole paragraph.

Q Yeah. You take the time to read it all, but I'm going to ask you about the fifth and sixth line.

(Witness peruses document.)

A Okay.

Q Ms. Moon, I believe that there will be testimony in this case that at this intersection Cary went from four seconds to three seconds overnight rather than doing it incrementally.

A And that's allowed.

Q It is allowed?

A Yeah.

Q Okay. Why would this note say to do it--reduce it incrementally?

A Because there are times when it could be more significant that the engineer in question would not be comfortable reducing it directly overnight, but it is an engineering call based on the situation that you're looking at.

Q And when would be a situation where you would not want to do it incrementally, you'd do it all of a sudden?

A The majority of the time whenever you're changing something at an intersection and people know that there's construction work going on, they have expectations that things are different, and in that situation there's no reason to do it incrementally. And most of the time if you're doing it incrementally, most people can't tell two tenths of a second difference.

Q So the time to do it suddenly would be an unusual circumstance, like construction? You need to get it done quickly?

Ms. Martineau: Objection; asked and answered.

Q But how about---

A (interposing) That's not what I said.

Q All right. When would--why would in this case---

A (interposing) I don't know what "this case" is, first of all.

Q Cary Parkway and Kildaire Farm Road going from four seconds to three seconds overnight.

Ms. Martineau: Well, she doesn't know that to be true.

Q If that turns out to be a true fact, can you think of a reason why Cary would have done it overnight rather than---

A (interposing) Because they would have had plenty of time to stop, and four to three would not have been excessive, so there was no reason. There is not a safety issue not to drop it suddenly.

(Plaintiffs Exhibit D was
marked for identification.)

Q Okay. I show you what's been marked for identification as Plaintiffs Deposition Exhibit D.
A Uh-huh, another formula.
Q Yeah. Have you had a chance to look at that?
A Yes. I've looked over it.
Q Are these equations or formulas something---
A (interposing) They seem to be---
Q ---that appear to be accurate?
A ---appropriate or accurate for what they are, yes.

(Plaintiffs Exhibit E was
marked for identification.)

Q Okay. I show you what's been marked for identification as Plaintiffs Exhibit E. I don't think you've seen that, so you may want to take a little more time to look at that one and see if that's--it appears to be an equation of how one figures out that the critical distance is 294 feet long---
Ms. Martineau: (interposing) Well, if you're---
Q ---if you're traveling---
Mr. Stam: If I could finish the question?
Ms. Martineau: Go ahead.
Q It appears to be an equation how to calculate that the critical distance is 294 feet long if the speed limit is 45

miles an hour and there's no grade. Does that look to you--
and take a minute or two or as long as you need to see if
that's the correct way to calculate the critical distance.
A I'm not---
Ms. Martineau: (interposing) Objection. Excuse me. Objection.
The Witness: Sorry.
Ms. Martineau: Leading; asking questions of things that are not in evidence. You can answer if you can.
By Mr. Stam:
Q And really, since you didn't have this ahead of time, please feel free to take a---
A (interposing) My answer would be I don't--I have not researched it, do not know the formula to compute critical distance as you've shown it here. At this point I'm not on the fly going to say that it's right or wrong.
Q Okay. Equation 1 appears to be derived from a variation of what's used on Exhibit C.
Ms. Martineau: Again objection. Counsel is testifying.
Q Is that correct?
Ms. Martineau: Objection; leading. You can answer if you can.
A I do not know how those two relate to each other specifically. They have the same values, some of the same

letters, but that doesn't mean that they mean the same thing.
Q Do you have another equation that you use to determine the critical distance at intersections for which you design traffic signals?
Ms. Martineau: Objection to the form of the question. Do you calculate critical distances?
The Witness: I do not calculate critical distances.
Q Ever?
A Not unless it's embedded in the yellow change interval and the intent of the yellow change interval, but no, I don't calculate critical distances.
(Plaintiffs Exhibit F was marked for identification.)
Q I show you what's been marked for identification as Plaintiffs Deposition Exhibit F and ask if this is a document that you have seen or used before.
A Uh-huh. I have it in my stack. This is from the task force that I was involved with.
Q It appears to be--I can't testify, but it appears to be from the *ITE Journal* for January of 2008.
A Uh-huh. This--I can specifically say this was a summary of the task force.
Q And first of all, I would like to apologize. The handwritten scribbling on page 1 is from me.

A Okay.
Q That word "yellow" and that "all red" is from me, so I apologize for adding that. But is it correct that the first term of the equation is the yellow and the second one that says "all red" is the all red?
A From the ITE formula of the most--what this says. A recent study done by the most common method in use today and termed ITE formula, yellow plus red is--yes.
Q Okay. So y is yellow change interval in seconds?
A Yes.
Q Plus red clearance in seconds?
A Right.
Q Equals--and I'm not going to read it, but the equation there.
A Right.
Q Okay. If you would turn to the next page?
(Witness complies.)
Q At the bottom of the first column and the top of the second column, if you would just read the sentence that's italicized?
A "Calculation of the yellow change and all-red clearance intervals should not vary based on the presence or absence of enforcement devices."
Q Such as cameras?
A Correct.

Q Okay. And why is that true, that when you calculate it, you should not be thinking will there be a camera or not?
A We use the same calculations to determine yellow and red, as shown here (indicating)---
Q (interposing) Exhibit C.
A ---throughout the state. We want drivers to have an expectation that in a certain condition they're going to receive a certain yellow or red time. So we follow this to have consistency for yellow and red times across the state, and that has nothing to do with whether there's a camera there or not.
Q Agreed. What is the purpose of the all-red clearance interval?
A To clear a car through the intersection prior to the side street--well, opposing traffic.
Q To avoid crashes?
A Yes.
Ms. Glover: Can we just take a break real quick?
Mr. Stam: Sure.
Ms. Glover: We've got somebody who needs to get something from this room.
Mr. Stam: Sure.
Ms. Martineau: Sure.
The Reporter: Off the record. 3:25 p.m.
(A brief recess was taken.)

The Reporter: On the record. 3:26 p.m.
By Mr. Stam:
Q At another point I'm going to come back to that question, so if you would just hold that question in your mind.
A Sure.
Q In the middle of the second column on page 21, the italicized statement at the beginning of that paragraph, would you read that for the record, that begins "Separate practices"?
A "Separate practices should not exist for different regions of the state, unique vehicle streams (such as a high percentage of heavy vehicles), or left-turning vehicles versus through vehicles."
Q Now, are you saying at Kildaire Farm Road and Cary Parkway that it is not a separate practice to give through vehicles 4.5 seconds and left-turning vehicles three seconds of a yellow change interval, yellow light change interval?
Ms. Martineau: Objection to the form of the question. This is not her words. This the task force's words, but go ahead and answer.
A The task force is all on the same page, and we all know that you calculate throughs with one and lefts with another. And we're using one consistent formula with a net parameter to calculate them.

Q Where does it say that on Exhibit C?
A I don't know that it says it, but as a practicing traffic engineer, you know that. It's part of the engineering practice. Do you have things in your profession that you do that's based on standard practice that aren't written down somewhere?
Q Yes.
A Okay. So do I.
Q Okay. So what you're telling me is that the assumption that the speed will be 20 miles an hour at the stop bar and that that---
A (interposing) The assumed speed for a left turn is 20 miles an hour for the whole equation.
Q At the stop bar.
A You keep adding the stop bar because you asked me where it came from.
Ms. Martineau: I'm just directing the witness' attention to later on in that document.
Mr. Stam: Okay.
A This is more information in this document about left-turn speeds and how it's calculated.
Q Okay. Go ahead. Direct to me that.
A The next page.
Q Page 22?
A Page 22, first column.

Q Okay. Which part of that, the first full paragraph?
A If you look at the first full paragraph, it talks about the history of the 20 and the 30 and the fact the task force basically came back to that 20 miles an hour was a reasonable speed to use for the left-turn calculations.
Q I understand that, but the question is where? At what point---
A (interposing) We don't say where. It's not a where question.
Q Or when? I think you've told me that it's at the stop bar.
A I told you that I was told that some of the calculations for the average speeds were taken at the stop bar, but that is not--you're moving that into all these other i.e. and it's not.
Q Okay.
A The task force agreed that 20 miles an hour was the appropriate speed to use for calculating a left turn. That includes the yellow and the red, and it's not based on a point in time.
(Plaintiffs Exhibit G was marked for identification.)
Q I show you what's been marked as Plaintiffs Deposition Exhibit G.
A Okay.

Q Ms. Moon, I've tried to--are you familiar with this publication?
A Yes, I am.
Q I tried to find everything in that manual that I thought was relevant, but I only found two pages, page 489 and page 512. Do you know if there's any part of that manual that you think I should know about that relates to yellow light timing other than those two pages?
Ms. Martineau: Objection to the form of the question. She's here to answer your questions. I mean it's a book. It's enormous.
Q My question was do you know of any page in there other than 489 or 512 that I should look at?
Ms. Martineau: Same objection. You can go ahead and answer.
A I have flagged page 485. It talks about the intent of the yellow and the red and the calculation of them.
Q Could I see that for just a second?
(Document handed to counsel.)
A In the middle of the page.
Q Okay. 4D.26?
A Uh-huh, which is the last half of what you have here but it's not the entire section.
(Mr. Stam peruses document.)
Q Okay. On those pages, 485 through 488, do you see

anything that is actually different to determine by engineering practices, somewhere between three and six seconds in determining the timing?

A I don't know what you're asking me.

Q Is there anything on pages 485 through 488 that says anything other than the yellow change interval has to be between three seconds and six seconds, or the duration of the steady yellow change interval shall be determined using engineering practices or engineering judgment?

Ms. Martineau: Objection to the form of the question. The contents of the pages will show what is on the pages.

A There's a whole lot more said than that. There are more sentences.

Q There are more sentences, but is there any more content than that as to how long to set the yellow light interval?

Ms. Martineau: If you want, we can make a copy of that.

Mr. Stam: Can we make a copy of those pages and make it part of this exhibit?

Ms. Martineau: Sure. Can we do it at the end of the deposition?

Mr. Stam: Yeah, sure.

Ms. Martineau: What pages are we going to copy?

Mr. Stam: 485 to 488.

Ms. Martineau: Okay.

The Witness: I don't know if you need 486.

Ms. Martineau: We'll just go ahead and copy it.

Mr. Stam: That's Exhibit G, I believe. Thank you. That will save us some time.

(Plaintiffs Exhibit H was marked for identification.)

By Mr. Stam:

Q I show you what's been marked for identification as Plaintiffs Exhibit H.

A Okay.

Q Do you know what this is? Have you seen this document before?

A I maybe have glanced at it, but it's not something that I've studied.

Q Typically are traffic lights and signal plans design-build?

A No.

Q They're not?

A No.

Q All right. I'll just set this aside, but you are familiar with it. It's a---

Ms. Martineau: (interposing) I think she said she's seen it before but she doesn't use it.

A I've seen it and I may eventually use it, but design-build projects are not something that I have a whole lot of experience with at this time.

(Plaintiffs Exhibit I was marked for identification.)

Q I show you what's been marked for identification as Plaintiffs Exhibit I, which is the same as number 6 to the George deposition. See if that's a document that you have seen or used.

(Witness peruses document.)

A I have.

Q And what is it?

A *Traffic Engineering Handbook*, 6th Edition.

Ms. Martineau: Excerpts from it.

Q Excerpts.

A Pieces, yes, excerpts from it.

Q And who publishes this?

A ITE, Institute of Transportation Engineers.

Q All right. Is that one you happened to bring along with you?

A No. This is something that I refer to occasionally, but it's not one that I am intimately familiar with.

Q I'll not ask any questions on it, then.

(Plaintiffs Exhibit J was marked for identification.)

Q I show you what's been marked for identification as Plaintiffs Exhibit J. I believe these were attached to an affidavit by Mr. Ceccarelli where he graphed over time the number of citations at some intersections based on records of the Town of Cary. Have you ever seen this exhibit?

(Witness peruses document.)

A Not that I recall. If I did, it was just to glance at it.

Q Have you had any opportunity or have you examined the statistics for the number of citations over time at some of the intersections at issue in this case?

A No, I haven't.

Q Okay. Let me just look at a couple of them and see if you have any comment there. The first one--and all these, like I said, came from Mr. Ceccarelli. So if he's graphed them wrong, then time will tell, I guess.

But at a certain point, the four second yellow change interval at Convention Center Drive and Cary Town Boulevard was lengthened from 4 seconds to 4.5 seconds straight through.

A Okay.

Ms. Martineau: Is that your representation to her, because I don't know if she knows.

Mr. Stam: Yeah. That's what I'm saying. That's what it purports to be.

Ms. Martineau: Okay.

By Mr. Stam:

Q And we know from other depositions that that's because Cary--the signal plan had been assuming a 35 mile per hour speed limit, but actually it was 45. So they realized it was 45 and went, "Whoop, we've got to change this."

Ms. Martineau: Objection.

Q They didn't say whoop, but they submitted an engineering plan to DOT and said, "Look, we've got to change this," so it changed.

Ms. Martineau: Objection. Move to strike. Go ahead.

Q It appears from this that the average monthly number of citations went down about 80 or 90 percent after that change was made of a half a second. If that's the case, you as a traffic engineer, what is your opinion about that effect?

Ms. Martineau: Objection to the form of the question. Answer if you have an opinion.

A My opinion is that I do not know enough of the situation to tell you what caused this, if that was the only change, if there were other changes. I don't know the full situation to be able to answer accurately.

Q Assuming there were no other changes, hypothetically, for a moment---

A (interposing) I--you want me to answer this on a hypothetical?

Q No. Let me ask this question here. Assuming that after correcting the problem, you're having about 20 to 40 violations a month, and that may be people dangerously running a red light.

A Okay. First of all, you're saying assuming they corrected something. I don't know enough about the situation to know what existed, if there was a problem, if something was corrected, or if something was modified or changed. I don't want to get into hypotheticals in this situation when I'm not fully aware of the situation and what happened.

Ms. Martineau: Then I guess she's saying she has no opinion. So if you have folks that have opinions---

Mr. Stam: (interposing) Yeah.

Q Is it possible that a traffic engineer other than yourself--this wasn't you---

A (interposing) Right.

Q ---can make a mistake in setting the yellow light change interval?

A I have looked at the plan of record and it looked to be done appropriate at the time for the plan of record and how it was set. So I do not want to call--and I'm ethically not allowed to call anybody else in my profession as sloppy or poor engineering.

Q All right. Which plan was that? Was that the plan before or after March of 2010?
A It was 1991.
Q It was 1991?
A Uh-huh.
Q Okay. Do you recall what the assumed design speed was?
A It was 35 miles an hour.
Q So---
A (interposing) And I cannot tell you what happened between 1991 and now, and I don't know the situation to be able to tell you ifs, ands, buts, mistakes. I don't know.
Q Okay. But if in fact the posted speed limit was 45 miles per hour, is it not true that the design speed, the v in the equation, would be higher and therefore the yellow light change interval would be longer?
Ms. Martineau: At what time are you asking that question?
A I assume--and this is an assumption--that when the signal plan was done--it was posted at 35--they would have done a field review and calculated based on the posted speed. My assumption would be at some point after that it's possible that the speed limit changed, but I don't know the situation. All I know is my plan of record that I see is 35 miles an hour.

Q So the 1991 plan of record is appropriate for that intersection?
A It appears to be appropriate for the intersection for everything I know about the situation, yes.
Q Okay. Thank you. If you would look at the second page of that exhibit?
(Witness complies.)
A Uh-huh.
Q This purports to be at Kildaire Farm Road and Cary Parkway, and it appears purports to graph what happened when there was a change from 4.0 seconds to 3.0 seconds.
(Witness peruses document.)
A Okay. This says, "4.0 second Left Turn Yellow (should be 4.5 seconds).
Q Well, the "should be 4.5 seconds" is the opinion of Brian Ceccarelli.
A Okay.
Q So let's just leave that parenthetical on the ground, okay?
A Got it.
Q But what the graph purports to show is that when the change was made from four seconds to three seconds, that the number of violations went up drastically.
A Just like at the beginning, I don't know why they changed the time. I don't know if it's the only change that

they made. I do not know enough about this situation particularly to say why there's necessarily an increase.

Q But here's my question.

A Okay.

Q Here's my question. Let's take, for example, the April '10---

A (interposing) April '10, the highest point.

Q The highest point, 450 violators.

A Uh-huh.

Q You had had between 50 and 100 before then, average.

Ms. Martineau: According to this document.

Q According to this document, if it accurately graphs the facts.

A Okay.

Q It came from Cary data. Were these additional 350 to 400 people a month acting in a dangerous way by proceeding through that intersection and getting tagged with a citation at three seconds when if they had been there at four seconds they wouldn't have been caught?

Ms. Martineau: Objection to the form of the question. Objection to the assumption, but go ahead and answer the question.

A This is purely my opinion and it doesn't regard this directly. But in trying to understand or get you to understand my point of view when it comes to yellow and red times, part of the reason we did the task force is because the longer the yellow light is, people instead of making the decision to stop or go, go, "Oh, it's long enough. I can make it." And you end up with more aggressive drivers and people not respecting the yellow. It is longer.

The point of the yellow and reducing the yellow in terms of left turns was to encourage drivers to stop when they could possibly stop. I don't think dangerous is the correct word that I would use, to say that they're being dangerous.

The point of the tickets was to try to modify that behavior to respect the light, but yellow does mean if you can stop, please stop. But I think they were used to not being have--being able to--they did not have do that at this point before we changed the formula.

Q Were you the traffic engineer on that particular change?

A I know that I have sealed plans, but I don't know about this particular change. I know my name is on one of these.

Q Do you know which one it's on, because then I think I'll ask you about that one.

A I think it's High House and Cary Parkway.

Q Okay. I don't have that one here. Let me ask this question. On the second page, because I'm going to ask it again on another one, do---

A (interposing) I don't know what else was changed at this time. I don't know if they changed from a protected left to a protected permissive left or a protected permissive left to a protected left or a flashing yellow arrow. I do not know what other changes were in account when any of these changes happened.

Q Or perhaps they added a second to the all-red clearance?

A They could have done--yes, it's one of those things. This is a snapshot of one specific thing that you're attributing to this reduction, but I can't say it's necessarily just due to this reduction. It could have other factors.

Q Well, if they reduced the yellow change interval by a second and added a second to the red clearance interval, then for safety purposes, there's the same amount of---

A (interposing) Exactly.

Q ---protected time?

A Uh-huh.

Q But the difference is that 350 to 400 extra people a month are paying a $50 citation. There's no change in safety.

A Because they're breaking the law, and the law says you're supposed to be in the intersection before the yellow.

Q Okay. Let me ask you about that. They're breaking the law?

A I'm not saying why, how, or---

Q (interposing) I understand. I understand. It's strict liability. It doesn't matter why you're breaking it. If you're breaking it, you break it. But if you had done this, or if the traffic engineer who did this, did anybody calculate that in 3.0 seconds from the time the yellow light went on that a person actually did have the distance to stop?

A You talk about distance to stop again and we're not talking about distance to stop. The formula, as we use it, is to take the critical distance and then divide it by the speed to see how much time it takes to go through the intersection when you're at those points.

Q Would you look at the fourth page of this document?

A Uh-huh.

Q And this is Walnut Street and Meeting Street. Is that one that you happen to have a plan for?

A I do have a plan for it.

Q If you could pull that out?

(Witness complies.)

Q I'm so glad you brought those.

A I know what size they have to be to read them.

Ms. Martineau: If you could, Ms. Moon, would you identify the date of the plan and the number of the plan?

The Witness: Yes. This is Signal Inventory Number 05-1558, which is how the state would identify the plan, and it's signed and sealed by Hemang Surti on 10/26/09.

By Mr. Stam:

Q Okay. And is this for Walnut Street turning left into Meeting Street?

A This is for the entire signal of Walnut Street at Meeting Street that includes that movement.

Q Okay. So if you would look at that movement of left turn?

A Uh-huh.

Q How much time is the yellow change interval there?

A 3.2 seconds.

Q Okay. And is there an all-red the other way?

A 3.--well, the all---

Q (interposing) After that, an all-red clearance after that.

A 3.3 seconds.

Q Okay. 3.2 plus 3.3 gives a total of 5.5 seconds.

A 6.5.

Q 6.5 seconds, which is actually protected?

A Uh-huh.

Q Okay. Do you have a more recent plan for that intersection?

A Not that I am aware of.

Q I see a drastic reduction in March of 2010.
A Let me review the plans that I have.
Ms. Glover: We had a lot of construction and those signals were not working at all at that point in time.
Mr. Stam: They may have been turned off there. Okay. I'll withdraw that question, and thank you for the actual answer.
By Mr. Stam:
Q That's dated in the early part of '09 did you say?
A This was the construction drawings. I believe this was part of the construction that we signed and sealed plans to go into a bid package that then eventually gets built. I don't know exactly when it was installed.
Q Okay. So is there anything on there that would tell you what changed from the previous signal plan? In other words, was there a longer time given previous to this?
A I don't know what the previous plan looked like, but I know that I did--I sealed a version of this earlier, and they had additional through lanes, one at the intersection. There's lots of changes that happened at this intersection between the--more than likely between the two plans.
Q Okay. Thank you. Just for the record, I'd like to introduce your résumé and mark it as Exhibit K.
(Plaintiffs Exhibit K was marked for identification.)

Q Is Exhibit K an accurate résumé for you? This is the one time you're allowed to brag.

A I wrote it, so yeah.

Q Okay. Have you ever seen reference to or have you ever read *The Problem of the Amber Signal Light in Traffic Flow* by Denos Gazis?

A Denos Gazis?

Q It's cited in there, but---

A I went back to it a little, but you're talking physics and pure math, which is not my forte.

Q I'll just show it to you. Is that something you've ever read or looked at?

(Witness peruses document.)

A I think based on the reference, I looked at it, glanced at it, but I don't think I've actually read it and reviewed it and all that stuff.

Q 1959. We were children then; right?

A I wasn't even a glimmer.

Q That's before you were born?

A I wasn't even a glimmer.

Q Well, congratulations.

Mr. Stam: I'm close to the end. Could I consult with my client for just a few minutes?

Ms. Martineau: Sure.

The Reporter: Off the record. 3:57 p.m.

(A brief recess was taken.)

The Reporter: On the record. 4:14 p.m.

Mr. Stam: All right. Can we agree that Exhibit L will be the witness's signal plans that she brought with her, and that they will be copied after this deposition and will bear Exhibit L?

Ms. Martineau: Yes.

Mr. Stam: All right.

By Mr. Stam:

Q I have two more questions if our minds can meet on these two questions.

A Okay.

Q I think, Ms. Moon, that your testimony is that the yellow change interval is all about the time to proceed and not about the distance to stop. If that's true, if you made the yellow change interval for the left lane to be two seconds, would that give the driver enough distance to stop?

Ms. Martineau: Objection to the form. It doesn't matter what you think. If you understand his question and agree with its premise, you can answer it.

The Witness: I don't understand his question enough to answer because he's mixing time and distance in the question to the point that I'm not getting it.

Mr. Stam: Okay. I'll try it one more time.

By Mr. Stam:

Q If you designed a yellow change interval for a left lane turning left on Cary Parkway and Kildaire Farm Road and used two seconds as the yellow change interval, would that give the driver of a car in that left lane enough distance to stop?

A I don't know. I'm not prepared to do that calculation here and now.

Q Second question: if the yellow light is a warning to the driver, what is the content of that warning? In other words, what does the yellow light tell the driver to do?

A It does not tell him to do anything. It warns that there is a change in the right of way sign.

Mr. Stam: No further questions.

Ms. Martineau: Thank you. I have no questions.

(The deposition was closed at 4:17 p.m.)

(Plaintiffs Exhibit L was marked for identification after the close of the deposition.)

STATE OF NORTH CAROLINA

COUNTY OF WAKE

C E R T I F I C A T E

I, Alexandra Hatcher, Notary Public-Reporter, do hereby certify that **Lisa Moon, P.E.** was duly sworn or affirmed by me prior to the taking of the foregoing deposition, that said deposition was taken by me and transcribed by me, and that the foregoing pages 5 through 69 constitute a true and correct transcript of the testimony of the witness to the best of my ability, and that the witness reserved the right to review her testimony.

I do further certify that I am not counsel for or in the employment of either of the parties to this action, nor am I interested in the results of this action.

In witness whereof, I have hereunto set my hand, this 26th day of October, 2012.

/s/ Alexandra Hatcher

Alexandra Hatcher, CVR
Notary No. 19931480077

S I G N A T U R E

I have read the foregoing pages 5 through 69, which contain a correct transcript of the answers made by me to the questions herein recorded. My signature is subject to corrections on the attached errata sheet, if any.

____
(Signature of Lisa Moon, P.E.)

State of ______________________
County of _____________________

I certify that the following person personally appeared before me this day and I have personal knowledge of the identity of the principal or have seen satisfactory evidence of the principal's identity in the form of a________________ or a credible witness has sworn to the identity of the principal, acknowledging to me that he or she voluntarily signed the foregoing document for the purpose stated herein and in the capacity indicated:______________________________.
(Name of Principal)

Date__________________ _______________________________
(Official signature of Notary)

(Official Seal) ___________________, Notary Public
(Notary's printed or typed name)

My commission expires_________.

****

I, Alexandra Hatcher, the officer before whom the foregoing deposition was taken on October 9, 2012, certify that the foregoing transcript was delivered to the witness either directly or through the witness' attorney or through the attorney retaining the witness on _______ and that as of this date I have not received the executed signature page.

Therefore, more than 30 days having elapsed since receipt of the transcript by the witness, the sealed original transcript was filed with attorney for Plaintiffs on ______ by means of US Priority Mail, in accordance with Rule 30(e) of the North Carolina Rules of Civil Procedure.

__________________ ________________________
Date Alexandra Hatcher, CVR
Court Reporter

North Carolina State University
CIVIL ENGINEERING CURRICULUM

Degree earned: B.S. in Civil Engineering

For students entering after July 2010 (Sum2 '10)

FRESHMAN YEAR

Fall Semester		Credits
CH 101	Chemistry – A Molecular Science	3
CH 102	General Chemistry Laboratory	1
E 101	Intro. to Engineering & Prob. Solving	1
E 115	Intro. to Computing Environments	1
ENG 101	Academic Writing and Research	4
MA 141	Calculus I	4
PE 10X	Fitness & Wellness Course*	1
		15

Spring Semester		Credits
CSC 112	Intro. to Computing-Fortran	3
EC 205	Economics (GEP Soc Sci Req*)	3
MA 241	Calculus II	4
PY 205	Physics for Engrs. & Sci. I	4
PE XXX	Phys. Ed/Healthy Living Elective*	1
		15

SOPHOMORE YEAR

Fall Semester		Credits
CE 214	Engr. Mechanics - Statics	3
GC 120	Foundations of Graphics	3
MA 242	Calculus III	4
PY 208	Physics Engr. & Sci. II	4
GEP Requirement*		3
		17

Spring Semester		Credits
CE313	Mechanics of Solids	3
CE 382	Hydraulics	3
MA 341	Applied Diff. Equations I **or**	3
MA 305	Elem. Linear Algebra	
MSE 200	Mech. Prop.of Structural Materia	3
GEP Requirement*		3
		15

JUNIOR YEAR

Fall Semester		Credits
CE Area Intro Elective I[1]		3
CE Area Intro Elective II[1]		3
CE Area Intro Elective III[1]		3
CE 390	Engineering Economics	1
ST 370	Prob. & Statistics for Engrs.	3
GEP Requirement*		3
		16

Spring Semester	Credits
CE Area Intro Elective IV[1]	3
CE Area Intro Elective V[1]	3
CE Elective I[2]	3
Basic Science Elective[3]	3
CE Lab if needed (CE324, CE381)	0
GEP Requirement[1]	3
	15

SENIOR YEAR

Fall Semester		Credits
CE Elective II[2]		3
CE Elective III[2]		3
CE Elective IV[2]		3
CE/MA/SCI Elective[4]		3
COM 110	Public Speaking **or**	3
ENG 331	Comm. for Engr. & Tech.	
MAE 301	Thermodynamics **or**	3
ECE 331	Principles of Electrical Engr.	18

Spring Semester	Credits
CE Elective V[2]	3
CE Elective VI[2]	3
CE Elective VII[2]	3
GEP Requirement*	3
GEP Requirement*	2-3
	14-15

Minimum Credit Hours Required for Graduation = 126

***GEP REQUIREMENTS** to be selected from the list approved by the College of Engineering.
[1]**CE Area Intro Elective** to be selected from the approved list (on back)
[2]**CE ELECTIVES** to be selected from the approved list (on back)
[3]**Basic Science Elective** Select one: BIO 183, MEA 101
[4]**CE/MA/SCI Elective** to be selected by student and adviser

10/14/10

CIVIL ENGINEERING CURRICULUM
COURSE LISTING WITH PRE- AND COREQUISITES IN PARENTHESES
For students entering after July 2010 (Sum2 '10)

FRESHMAN YEAR

Fall Semester

CH 101	(CoReq. CH 102)
CH 102	(CoReq. CH 101)
E 101	
E 115	
ENG 101	
MA 141	
PE 10X*	

Spring Semester

CSC 112	(CoReq. E 115 and MA 141)
EC 205	(GEP Requirement)*
MA 241	(C- or better in MA 141)
PY 205	(C- or better in MA 141)
PE XXX	Phys. Ed//Healthy Living Elective*

Matriculation Requirements:
1. C- or Better in CH 101, CH 102, E 101, MA 141, MA 241, PHY 205
2. Satisfactorily (S) in E 115

SOPHOMORE YEAR

Fall Semester

CE 214	(GPA 2.5, C- or better in PY 205, CoReq. MA 242)
GC 120	
MA 242	(C- or better in MA 241)
PY 208	(C- or better in PY 205 and MA 241)
GEP Requirement*	

Spring Semester

CE 313	(MA 242, C-or better in CE 214)
CE 382	(CE 214, CoReq. MA 341, MA 305 or ST 370)
MA 341	(MA 242) **or**
MA 305	(CoReq. MA 242)
MSE 200	(CH 101)
GEP Requirement*	

JUNIOR YEAR
(All CE courses listed below also require Junior Standing in CE, CEM, or ENE)

Fall Semester

CE Area Intro Elective I[1]
CE Area Intro Elective II[1]
CE Area Intro Elective III[1]
CE 390 (CSC 112, CoReq. MA 341 or
ST 370 (MA 241)
GEP Requirement*

Spring Semester

CE Area Intro Elective IV[1]
CE Area Intro Elective V[1]
CE Elective I[2]
Basic Science Elective
CE Lab if needed (CE 324, CE 381)
GEP Requirement*

SENIOR YEAR

Fall Semester

CE Elective II[2]
CE Elective III[2]
CE Elective IV[2]
CE/MA/SCI Elective[4]
COM 110 **or**
ENG 331 (Junior standing)
MAE 301 (MA 242, PY 208) **or**
ECE 331 (MA 241, PY 208)

Spring Semester

CE Elective V[2]
CE Elective VI[2]
CE Elective VII[2]
GEP Requirement*
GEP Requirement*

*GEP Requirements to be selected from the list approved by the College of Engineering
[1]CE Area Intro Elective to selected from the approved list
[2]CE Electives to be selected from the approved list
[3]Basic Science Elective (select one): BIO 183, MEA 101
[4]CE/MA/SCI Elective to be selected by student and advisor

CE ELECTIVES

- Pick at least one CE AREA Introductory course (**I**) in five different areas for a total of five (5) courses.
- Pick an additional seven (7) courses, at least one of which must be a Capstone Design Course (**C**).
  At least one course must be an additional design course (**D**) in an area different from that of the capstone.
- Pick at least three (3) CE laboratory experiences (**L**)

				Hrs	Sem	Pre and Co-Requisites
Coastal Engineering and Water Resources						
	L	**CE 381**	**Hydraulics Sys. Meas. Lab**	1	F/S	CoReq. CE 382
I	**D**	**CE 383**	**Hydrology & Urban Water Systems**	1	F/S	C- or better in CE 382
I		**CE 487**	**Intro. To Coastal and Ocean Engineering**	3	S	Senior standing and CE 382
	D	**CE 488**	**Water Resources Engineerieng**	3	F	CE 339 or equivalent; CoReq. CE 383
C	**D**	**CE 480**	**Water Resources Engineering Project**	3	F	CE 390, C- or better in CE 382 and CE 383
Computing and Systems						
I		**CE 337**	**Civil Engineering Computing**	3	S	CSC 112, CoReq. MA 341 or MA 305
I		***CE 339**	**Civil Engineering Systems**	3	F	CSC 112, CoReq. MA 341 or MA 305
Construction Engineering and Management						
		***CE 261**	**Construction Engineering Systems**	3	S	CEM Majors; CoReq. ST 370
I	**D**	**CE 367**	**Mech. and Elec. Systems in Buildings**	3	S	CE 382
I		**CE 463**	**Construction Estimating Plan. And Control**	3	F	CE 261 (Priority to CEM)
1	**D**	**CE 466**	**Building Construction Engineering**	3	F	CoReq. CE 327 (Priority to CEM)
Environmental						
I		**CE 373**	**Fundamentals of Environmental Engineering**	3	F/S	CoReq. CHE 205 or CE 382
		CE 479	**Air Quality**	3	S	CE 373, CE 382; CoReq. ST 370
	D	**CE 476**	**Air Pollution Control**	3	F	CE 373, CE 390, MAE 301; CoReq. ST 370
	D	**CE 477**	**Principles of Solid Waste Engineering**	3	S	CE 373, CE 390, CE 382; CoReq. CE 342
	D	**CE 484**	**Water Supply and Waste Water Systems**	3	F	CE 373, CE 382
Geotechnical						
I	**L**	**CE 342**	**Engineering Behavior of Soils & Foundations**	4	F/S	C- or better in CE 313; CoReq. CE 382
		CE 435	**Engineering Geology**	3	Alt S	MEA 101 and Junior standing
	D	**CE 443**	**Seepage, Earth Embank., and Retain. Str.**	3	Alt S	CE 390, C- or better in CE 342
C	**D**	**CE 440**	**Geotech. Engineering Project (Foundations)**	3	F	CE 390, C- or better in CE 342
Structural						
	L	**CE 324**	**Structural Behavior Meas.**	1	F/S	C- or better in CE 313
I	**D**	**CE 327**	**Reinforced Concrete Design**	3	F/S	CE 332, C- or better in CE 313
		CE 325	**Structural Analysis**	3	F/S	CSC 112, C- or better in CE 313
		CE 425	**Introduction to Matrix Structural Analysis**	3	F/S	C- or better in CE 325
I	**D**	**CE 426**	**Structural Steel Design**	3	F/S	C- or better in CE 313
C	**D**	**CE 420**	**Structural Engineering Project (Buildings)**	3	S	CE 327, CE 390, CE 426, CoReq. CE 425
C	**D**	**CE 421**	**Structural Engineering Project (Bridges)**	3	F	CE 327, CE 390, CE 426, CoReq. CE 425
Transportation						
I	**D**	**CE 305**	**Traffic Engineering**	3	F/S	CE or CEM Majors, ST 370
		CE 401	**Transportation Systems Engineering**	3	F	C- or better in CE 305
	D	**CE 402**	**Traffic Operations**	3	F	C- or better in CE 305
	D	**CE 403**	**Highway Design**	3	S	C- or better in CE 305
	D	**CE 413**	**Principles of Pavement Design**	3	F	CE 332; CoReq. CE 342
C	**D**	**CE 400**	**Transportation Engineering Project**	3	S	CE 390, C- or better in CE 305; and one of the following: CE 401, CE 402, CE 403 or CE 413
Other Civil Engineering Courses						
		CE 215	**Engineering Mechanics-Dynamics**	3	F/S	Minimum GPA =/> 2.5, Grade of C- or better in CE 214 and MA 242
I	**L**	**CE 332**	**Materials of Construction**	3	F/S	MSE 200, Jr. standing in CE or CEM
	L	**CE 301**	**Civil Engineering Measurements & Surveys**	3	F/S	CEM, CE or ENE majors (Priority to CEM)

*Credit for Both CE 261 and CE 339 is not allowed.

Notes:
1. Due to departmental constraints, not every course may be taught in every semester suggested in the table above. Students should Check with the online course schedule for courses to be taught in the upcoming semester.
2. Undergraduates with a major GPA >2.5 and appropriate prerequisites may elect 500-level courses to satisfy their CE electives.

10/21/10

Exhibit B.

The relationship between acceleration, velocity and time.

Equation 1	$\boldsymbol{acceleration = \frac{change\ of\ velocity}{change\ of\ time}}$
Equation 2	$\boldsymbol{a = \frac{\Delta v}{\Delta t}}$
Equation 3	$\boldsymbol{\Delta t = \frac{\Delta v}{a}}$
Equation 4 t = time it takes for an object to stop from initial speed decelerating at constant rate a.	$\boldsymbol{t = \frac{v}{a}}$

$$a = \frac{change\ of\ velocity}{change\ of\ time}$$

EXHIBIT C

Determination of Yellow Change and Red Clearance Intervals

Yellow Change Interval

$$\text{Yellow interval} = t + \frac{v}{2a + 64.4g}$$

t = perception reaction time, typically 1.5 seconds
v = design speed*, in ft/sec
a = deceleration rate, typically 11.2 ft/sec^2
g = grade

Round up to nearest 0.1 second.

Minimum yellow change interval is 3.0 seconds.

Hold stakeholder discussion** when calculated yellow change interval is longer than 6.0 seconds.

Red Clearance Interval

$$\text{Red interval} = \frac{w}{v}$$

w = width of intersection, in feet
v = design speed*, in ft/sec

If the initial calculation results in an all red time longer than 3.0 seconds, recalculate the red time as follows:

$$\text{Recalculated red interval} = \frac{1}{2}\left(\frac{w}{v} - 3\right) + 3$$

Round up to nearest 0.1 second.

Minimum red clearance interval is 1.0 seconds.

Hold stakeholder discussion** when recalculated red clearance interval is longer than 4.0 seconds.

Notes

* Design speed is the speed limit unless a speed study determines that the 85th percentile speed is faster or intersection geometrics compel vehicles to traverse the intersection slower.

** The purpose of a stakeholder discussion is to provide advance notification and involvement to stakeholders and provide an opportunity to consider possible countermeasures.

For most left turn lanes, assume a speed of 20 mph (32 kph) to 30 mph (48 kph). For locations with unusual conditions a higher or lower speed may be appropriate.

For separate left turn phases, calculate yellow and red intervals.

For left turns without a separate phase, calculate yellow and red times for both the through movement and the left turn movement. Use the highest yellow and enough red to equal the highest total time.

Where existing times are higher than calculated times, use the calculated values unless there is a documented history of the need for higher times. If approach is high speed and existing times are significantly higher than the calculated times, use the calculated values but consider adding a note to the plan to direct field forces to reduce the time incrementally. Include in the note how much and how often to reduce time until the final value is reached. (Ex. Existing Yellow Change Interval for phase 2 may be decreased by 0.2 seconds per week until the required value is reached.)

Where revising a location or adding a new signal along a corridor, consider comparing clearance times at adjacent intersections to new calculations to meet driver expectations.

Sources:
Traffic Engineering Handbook, Fifth Edition, Institute of Transportation Engineers, 1999.
A Policy on Geometric Design of Highways and Streets, Fourth Edition, American Association of State Highway and Transportation Officials, 2001.

Critical Distance--also known as the Distance Required to Stop.

Equation 1	$$\text{Critical Distance} = v\ t_p + \left[\frac{v^2}{2(a + Gg)}\right]$$
Equation 2	$$\text{Yellow Change Interval} = \frac{[\text{Critical Distance}]}{\text{Approach Speed}}$$
Equation 3	$$\text{Yellow Change Interval} = \text{Perception Time} + \frac{[\text{Safe Braking Distance}]}{\text{Approach Speed}}$$
Equation 4	$$Y = t_p + \frac{\left[\frac{v^2}{2(a+Gg)}\right]}{v}$$
Equation 5	$$Y = t_p + \frac{v}{2(a + Gg)}$$
Equation 5	$$Y = t_p + \frac{v}{2a + 64.4g}$$
Equation 6. Grade = 0	$$Y = t_p + \frac{v}{2a}$$
Equation 7.	$$Y - t_p = \frac{v}{2a}$$
Equation 8.	$$v = 2a(Y - t_p)$$

A Simple Computation of Critical Distance.

	Equation
Equation 1	$c = v \ \ t_p + \left[\frac{v^2}{2(a + Gg)}\right]$
Equation 2	$c = 45 * 1.47 * 1.5 \ \ + \left[\frac{(45 * 1.47)^2}{2(11.2 + G * 0)}\right]$
Equation 3	$c = 99 \ \ + 195$
Equation 4	$c = 294 \text{ ft}$
	The critical distance is 294 feet long.

Application of the ITE Change and Clearance Interval Formulas in North Carolina

DURING 2005, THE NORTH CAROLINA SECTION OF ITE CONVENED A TASK FORCE TO INVESTIGATE AND RECOMMEND A PRACTICE FOR DETERMINING YELLOW CHANGE AND RED CLEARANCE INTERVALS. THIS FEATURE BRIEFLY SUMMARIZES KEY DELIBERATIONS AND DECISIONS OF THAT TASK FORCE. THE METHODOLOGY AS IMPLEMENTED BY THE NORTH CAROLINA DEPARTMENT OF TRANSPORTATION ALSO IS PRESENTED ALONG WITH SAMPLE YELLOW AND RED TIMES RESULTING FROM ITS APPLICATION.

BY STEVEN M. CLICK, PH.D., P.E.

INTRODUCTION

In December 2004, in response to a formal request by the North Carolina Department of Transportation (NCDOT), the Traffic Engineering Council of the North Carolina Section of the Institute of Transportation Engineers (NCSITE) announced a task force to investigate and recommend a practice for determining yellow change and red clearance intervals at signalized intersections in North Carolina. The purposes of this feature are to briefly summarize key deliberations of that task force and present the resulting methodology as implemented by NCDOT.

BACKGROUND

One issue in determining appropriate yellow and red intervals is that, despite the existence of several well-recognized guidance documents, there is no national standard. The *Manual on Uniform Traffic Control Devices* (MUTCD), which typically provides prescriptions for device operation, does not stipulate the manner in which yellow or red intervals should be determined. It does, however, require the use of a yellow interval; require that the duration of the yellow and red intervals be predetermined; and suggest durations of 3 to 6 seconds for yellow and, at most, 6 seconds for red.[1]

Calculation methods are available in the *Traffic Engineering Handbook* and other sources.[2] A recent survey by ITE suggests that, by far, the most common method in use today is based on what is termed the "ITE formula," shown below:[3]

$$Y + R = t + \frac{v}{2a + 2Gg} + \frac{w + l}{v} \qquad (1)^{4}$$

where:

Y = yellow change interval (seconds [sec.])
R = red clearance interval (sec.)
t = perception-reaction time (sec.)
v = design velocity (feet/sec.)
a = deceleration rate (feet/sec.^{2})
G = acceleration due to gravity (32.2 feet/sec.^{2})
g = grade in decimal form (1 percent = 0.01)
w = clearance distance (feet)
l = vehicle length (feet)

In discussion of the yellow and red intervals, the *Traffic Engineering Handbook* goes on to suggest a typical application of the first two terms to determine the yellow and the last term to determine the red.

The ITE formula has been published, with timely revisions, since the first edition of the *Traffic Engineering Handbook* in 1941. Beginning in 1965, the formula appeared in its present form, although without the effect of grade. In this same year, ITE suggested the use of a red interval under certain conditions. The inclusion of the effect of grade on the yellow and red intervals appeared in 1982. In all, the formula has been updated eight times since 1941.[5] Still, the *Traffic Engineering Handbook* has not accrued any legal status.

Although the NCDOT documentation covers only the more recent practices for calculation of yellow and red, it gives clear evidence of its desire to provide both safe and efficient operation. One source, from February 1990, summarizes a meeting NCDOT hosted to discuss change and clearance intervals, involve traffic engineers from across the state and examine current practice. At the time of the meeting, NCDOT and most other state agencies were using the ITE formula as the foundation of their practice.[6]

More recently, NCDOT has worked to improve signal design consistency through publication of the *Traffic Management and Signal Systems Unit Design Manual.*[7] The purpose of the manual is to highlight standards of practice in signal design and operation. Although all the design manual editions have required the use of the ITE formula, specific division of the resulting total clearance into yellow and red times has not been consistent over the last 15 years and has been, at varying levels, left to the discretion of the design engineer.

The result is inconsistent yellow and red timing throughout the state.

The resulting inconsistencies, differing preferences among designers and a general consensus among NCDOT design and field personnel that these intervals are becoming too long all were factors in the decision to request a recommendation from NCSITE.

THE NCSITE TASK FORCE

In December 2004, a call went out for volunteers for the NCSITE Task Force. The NCSITE mailing list offered a representative pool of traffic engineering professionals from all over North Carolina, with a wide cross-section of relevant experience and knowledge. The resulting volunteer membership included:

- municipal engineers: 11
- consulting engineers: 10
- NCDOT engineers—central office: 7
- NCDOT engineers—field forces: 2
- non-profit organizations: 1
- research organizations: 1
- students: 1

The full NCSITE Task Force met a total of four times between January and June 2005 and divided into subcommittees to help meet the prescribed 6-month deadline. During the first task force meeting, a discussion and brainstorming session provided a list of issues to be addressed. Subcommittees held teleconferences and in-person meetings to discuss their topics and conducted data collection and reduction efforts in support of their tasks.

Issues Addressed by the Task Force

For purposes of organization, the issues tackled by the task force are presented in the sequence that they would be encountered using the methodology, beginning with text from the written recommendation and ending with summaries of key issues.

The ITE formula for the calculation of the total change plus clearance interval should be the basis for NCDOT practice. Both NCDOT's long history and the recent ITE surveys suggested the ITE formula was the logical starting point for use in the methodology.

Calculation of the yellow change and all-red clearance intervals should not vary based on the presence or absence of enforcement devices. At this time, NCDOT does not operate or intend to operate automated enforcement devices (such as red-light cameras); however, individual municipalities can petition the state legislature for the authority to install such devices. The recommended practice should result in safe and efficient intervals, independent of enforcement.

RECENTLY, NCDOT HAS WORKED TO IMPROVE SIGNAL DESIGN CONSISTENCY THROUGH PUBLICATION OF THE *TRAFFIC MANAGEMENT AND SIGNAL SYSTEMS UNIT DESIGN MANUAL.*

The NCSITE Task Force also discussed the option of including a grace period at automated enforcement locations, but it decided to leave such choices to the operating agency. NCDOT does recommend a break-in period to allow drivers to become accustomed to any changes made as a result of the new practice.

Separate practices should not exist for different regions of the state, unique vehicle streams (such as a high percentage of heavy vehicles), or left-turning vehicles versus through vehicles. Because one of the primary motivations for the task force was consistency, there was little discussion of this issue. The recommended practice should result in safe and efficient intervals, independent of region, stream, or movement.

Calculation of the yellow change interval should be performed using the first two terms of the ITE formula, with the result rounded up to the next 0.1 sec.

$$Y = t + \frac{v}{2a + 2Gg} \qquad (2)$$

The yellow and red intervals serve different functions; therefore, the calculation should be made as independently as possible. In past practices, time might be shifted from the red to yellow, but not in the new practice. Independent calculations are needed to help prevent excessive yellow time from contributing to disrespect of the yellow change interval.

The 2001 constants from the American Association of State Highway and Transportation Officials (AASHTO) for deceleration (11.2 feet/sec.^{2}) and perception/reaction time (1.5 sec.) are sound. The longer perception/reaction time responds both to the aging driver population and to the increasing number of distractions in the driving environment. At higher speeds, the higher deceleration rate does help offset the additional perception/reaction time.

The NCSITE Task Force also looked into the performance characteristics of trucks. Although no specific information could be found related to "comfortable" stops, AASHTO constants were within the expected performance capabilities of trucks.

The effect of positive grade should be factored into the yellow calculation. In past practice, NCDOT included the detrimental effects of negative grades but ignored the beneficial impacts of positive grades. None of the ITE publications suggests that positive grades should be ignored in calculations, and the Federal Highway Administration's *Signalized Intersections: Informational Guide* clearly indicates that positive grades can be used.[8]

The minimum value for yellow should be 3.0 sec. Not only does MUTCD recommend this minimum value, it also is required by the National Electrical Manufacturers Association Standards Publication.[9] Note that when the calculated yellow is less than 3.0 sec., the time difference is not shifted from red: In other words, the yellow increases without a change in the red.

Current practice in the Signals and Geometrics Section for selection of vehicle speeds, "v", was reviewed and retained in this application. For through movements, current practice uses the posted speed limit as the design speed unless a speed study has been specifically performed. When provided, the design speed will be taken as the 85th-percentile speed, up to a maximum of 10 mph above the posted limit. Because NCDOT does not signalize facilities with

Site	Left Turn Angle	Single or Dual	Collection Method*	Sample Size	Speed					
					Min	15%	Avg	StDev	85%	Max
1	125	Dual	All	39	14	15.0	**18.9**	**3.4**	21.3	30
2	110	Single	All	40	11	12.0	**15.6**	**2.7**	18.0	24
3	120	Single	All	71	12	16.0	**18.4**	**2.9**	21.0	26
4	110	Single	Sample	120	14	16.0	**18.1**	**2.1**	20.0	23
5	100	Single	Sample	120	9	11.0	**13.6**	**2.2**	16.0	20
6	100	Dual	End Car	80	14	17.0	**19.0**	**1.8**	21.0	23
7	70	Dual	End Car	160	10	13.0	**14.6**	**1.6**	16.0	20
8	115	Dual	End Car	80	13	16.0	**18.7**	**2.3**	21.0	26
9	130	Dual	End Car	156	14	17.0	**19.3**	**2.3**	22.0	25
10	85	Single	End Car	160	12	15.0	**17.2**	**2.0**	19.0	23
11	90	Dual	End Car	80	13	16.0	**17.4**	**1.8**	19.2	21
ALL	-	-	-	1106	9	14.0	17.1	2.9	20.0	30

*** Collection Methods:**
All = Speed recorded for all vehicles making the left turn
Sample = Speed recorded for an initial vehicle, a mid-queue vehicle, and an end-of-green vehicle
End Car = Speed recorded for the last vehicle using the phase each cycle

Figure 1. Left-turn speed data.

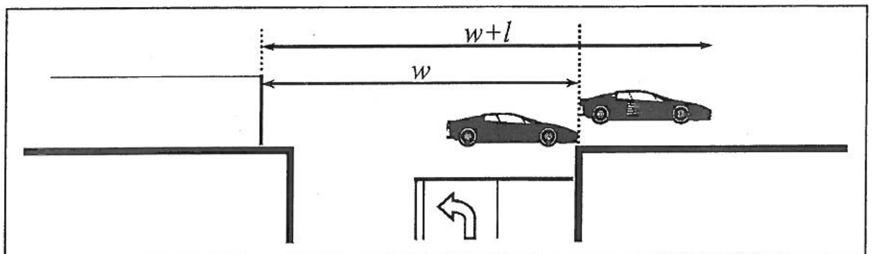

Figure 2. Effect of removing "l" from red calculations.

speed limits greater than 55 mph, the highest allowable design speed is 65 mph.

For left-turn movements, past editions of the *Traffic Management and Signal Systems Unit Design Manual* suggested a speed between 20 and 30 mph, with 20 mph the almost universal selection. Many expressed concern that 20 mph was overly conservative and led to excessive red intervals, so a field investigation was conducted. Unexpectedly, the study results, shown in Figure 1, indicated typical speeds slightly lower than 20 mph but not low enough for the task force to justify changing current practice.

Calculation of the all-red clearance interval should be based on the third term of the ITE formula, but with the following modification: The vehicle length should be removed from the all-red formula, and the result rounded up to the next 0.1 sec.

$$R = \frac{w}{v} \tag{3}$$

Unlike MUTCD, which does not require the use of a red interval, the North Carolina Supplement to the MUTCD does.[10] As noted above, NCDOT design and field personnel shared the belief that reds were becoming too long, and NC-SITE Task Force discussions showed this sentiment was shared by both municipal and consulting engineers within the state.

The culprits: increasing intersection widths and the need to provide protected phases for left turns. The causes: increasing corner curve radii standards; the separation of crosswalks with two handicapped ramps on each corner; and increasing facility size in terms of number of lanes. To be clear, neither accident nor ticketing issues had developed to draw public attention to the problem; however, the task force members wished to correct any problems before such statistics evolved.

As modified, the red interval serves to carry the front bumper of a last-instant legal intersection entry to the far edge of the conflict zone. Originally, any vehicle equal to or shorter than the assumed length would be carried past the conflict zone. The resulting difference is shown in Figure 2.

The obvious advantage to removing the assumed vehicle length is a reduction in the red interval. Past NCDOT practice used 20 feet as the assumed vehicle length. Removing this results in a 0.7-sec. reduction at 20 mph; 0.4-sec. at 35 mph; and 0.2 sec. at 55 mph.

Despite this anticipated reduction, the formula still allows the red to increase without bound. Left-turn clearance distances of 200 ft. currently exist, resulting in red intervals of 6.9 sec., much longer than acceptable to the task force.

If the initial calculation results in an all-red clearance interval greater than 3.0 sec., the all-red clearance interval should be recalculated as follows:

$$R = \frac{1}{2}\left(\frac{w}{v} - 3\right) + 3 \tag{4}$$

Discussion of reducing excessive red times consumed a large portion of the NC-SITE Task Force effort. The recommended method was determined to best balance competing concerns related to overly short and overly long red times. The result of this mitigation was that all of the first 3 sec. calculated for the red interval are used, but only half of the portion above that. So, if the initial calculation resulted in 4.0 sec. of red, the mitigation will reduce it to 3.5 sec. As with the other calculations, the result is rounded up to the next tenth.

The only other method receiving serious consideration was the reduction of red time based on expected time to conflict point. Although a preliminary field study looked positive, investigation of current literature, notably Muller et al., provided only minimal adjustments.[11] Faced with minimal benefits and questions about proper application, the task force discontinued its investigation into this option.

The clearance distance should be measured to the far side of an exclusive right-turn lane.

- *In the presence of a crosswalk with pedestrian signals, the clearance distance should be taken to the near side of the crosswalk*
- *A crosswalk without pedestrian signals should not be considered when determining clearance distance.*

These recommendations did not represent a change from past practice. This includes clearance distance measurements using the "straight line" method rather than a vehicle turning arc. A preliminary comparison of the straight line method to an outside wheel arc method resulted in an average difference of +2.2 feet, only +0.07 sec. at 20 mph. The task force agreed to continue using the straight-line method.

Past practice left consideration of crosswalks to the discretion of the design engineer. The task force felt it was important to always consider crosswalks with pedestrian signals when determining clearance distance. The decision to not consider crosswalks without signals was based on two factors: unsignalized crosswalks typically have insignificant pedestrian volume; and unsignalized crossings provide no guidance, so pedestrians cannot be expected to cross during any particular interval, reducing the probability of providing protection.

The *Traffic Management and Signal Systems Unit Design Manual* gives specific guidance for calculating clearance distances, shown in Figure 3.

The minimum value for all-red clearance intervals should be 1.0 sec. Prior practice suggested at least 1.0 sec., so this was not a significant change.

The proposed implementation of a yellow change interval longer than 6.0 sec. or a red clearance interval longer than 4.0 sec. is cause for a "stakeholder discussion" to provide advance notification and involvement to stakeholders and provide an opportunity to consider possible countermeasures.

Field personnel should be involved in developing and applying the practice. Stakeholder discussions help ensure these personnel are not surprised by new installation of long intervals.

Although countermeasures for reducing the yellow are difficult, typically involving the reduction in grade over the stopping distance or making geometric and enforcement changes to reduce travel speed, identification of excessive yellow at an intersection can provide an opportunity for present or future mitigation.

The opportunity for reducing the red is more likely, with lower cost solutions such as reduced median widths, positive offset left turns and channelized right-turn lanes.

For a "shared clearance" phase (when a phase serves multiple movements needing different yellow change and all-red clearance intervals), the following procedure should be applied:

- *Calculate each movement's change plus clearance intervals as if it had a dedicated phase.*
- *Use the largest yellow value; then subtract this yellow value from the largest total change plus clearance to determine red.*

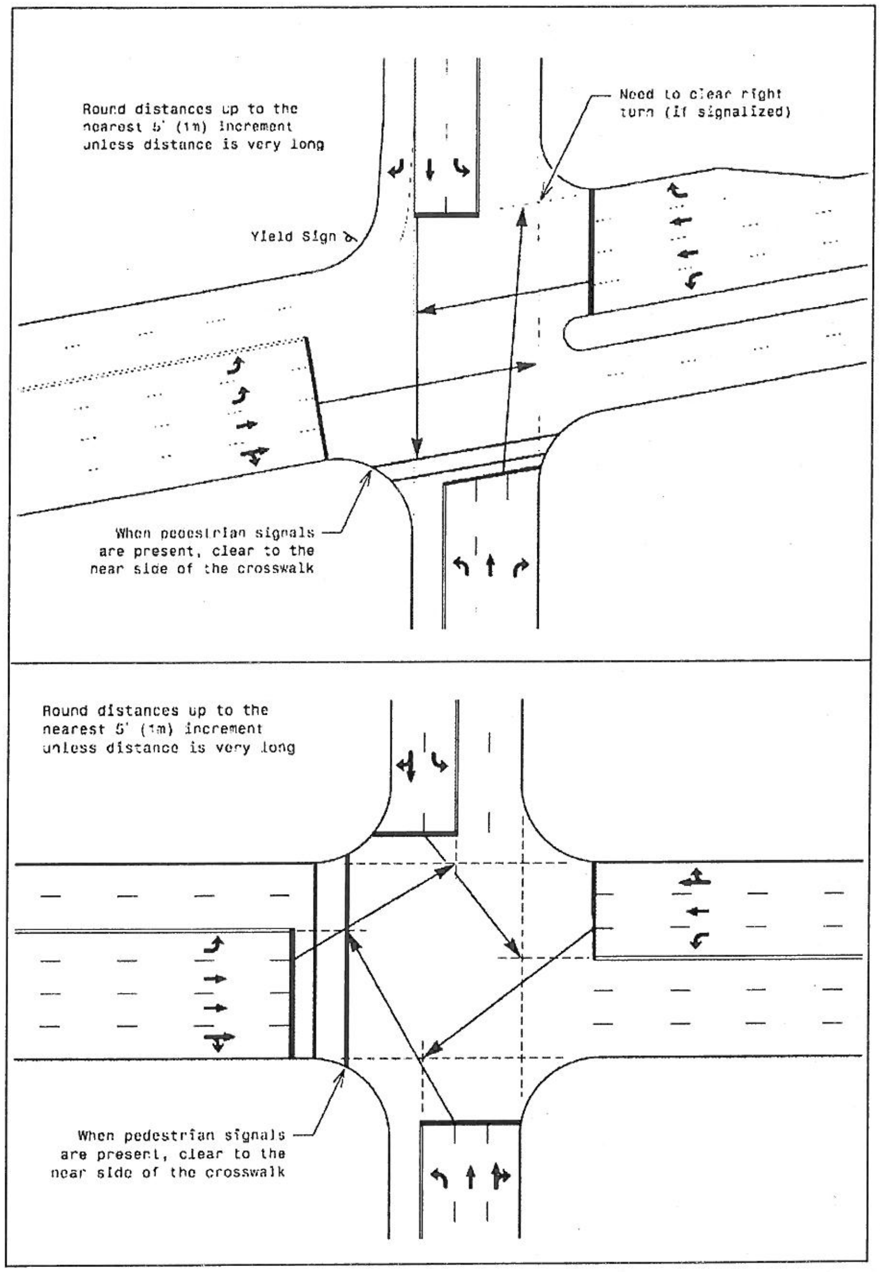

Figure 3. Measuring clearance distances.

Although this is not a change from past NCDOT practice, this confirms that mitigation of excessive red clearance intervals will take place for each movement before the shared change plus clearance is determined.

The Task Force considered but rejected both the use of the longest yellow change with the longest red clearance interval and the use of the yellow change and red clearance interval associated with the longest total clearance. The former option was rejected because it was incompatible with the goal of reducing interval length; the latter was rejected to ensure that every movement received sufficient yellow change time.

CONCLUSION

After receipt of the NCSITE Task Force recommendations, Greg A. Fuller, P.E., of the Intelligent Transportation Systems and Signals Unit of NCDOT, officially adopted the revised methodology, and the *Traffic Management and Signal Systems Unit Design Manual* was revised accordingly. The resulting methodology is presented in full in Figure 4, and a sample set of yellow and red intervals is presented in Figure 5.

Determination of Yellow Change and Red Clearance Intervals

Yellow Change Interval

Yellow interval = $t + \frac{v}{2a + 64.4g}$

t = perception reaction time, typically 1.5 seconds
v = design speed*, in ft/s
a = deceleration rate, typically 11.2 ft/s_2
g = grade

Round up to nearest 0.1 second.

Minimum yellow change interval is 3.0 seconds.

Hold stakeholder discussion** when calculated yellow change interval is longer than 6.0 seconds.

Red Clearance Interval

Red interval = $\frac{w}{v}$ w = width of intersection, in feet; v = design speed*, in ft/s

If the initial calculation results in an all red time longer than 3.0 seconds, recalculate the red time as follows:

Recalculated red interval = $\frac{1}{2}(\frac{w}{v} - 3) + 3$

Round up to nearest 0.1 second.

Minimum red clearance interval is 1.0 seconds.

Hold stakeholder discussion** when recalculated red clearance interval is longer than 4.0 seconds.

Notes

* Design speed is the speed limit unless a speed study determines that the 85th percentile speed is faster or intersection geometrics compel vehicles to traverse the intersection slower.

** The purpose of a stakeholder discussion is to provide advance notification and involvement to stakeholders and provide an opportunity to consider possible countermeasures.

For most left turn lanes, assume a speed of 20 mph (32 kph) to 30 mph (48 kph). For locations with unusual conditions a higher or lower speed may be appropriate.

For separate left turn phases, calculate yellow and red intervals.

For left turns without a separate phase, calculate yellow and red times for both the through movement and the left turn movement. Use the highest yellow and enough red to equal the highest total time.

Where existing times are higher than calculated times, use the calculated values unless there is a documented history of the need for higher times. If approach is high speed and existing times are significantly higher than the calculated times, use the calculated values but consider adding a note to the plan to direct field forces to reduce the time incrementally. Include in the note how much and how often to reduce time until the final value is reached. (Ex. Existing Yellow Change Interval for phase 2 may be decreased by 0.2 seconds per week until the required value is reached.)

Where revising a location or adding a new signal along a corridor, consider comparing clearance times at adjacent intersections to new calculations to meet driver expectations.

Sources:
Traffic Engineering Handbook, Fifth Edition, Institute of Transportation Engineers, 1999.
A Policy on Geometric Design of Highways and Streets, Fourth Edition, American Association of State Highway and Transportation Officials, 2001.

Change and Clearance Intervals
SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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Figure 4. The revised methodology, as adopted.

Speed		Grade				
mph	fps	-6%	-3%	0%	3%	6%
20	29.3	3.1	3.0	2.9*	2.8*	2.7*
25	36.7	3.5	3.3	3.2	3.1	2.9*
30	44.0	3.9	3.7	3.5	3.4	3.2
35	51.3	4.3	4.1	3.8	3.7	3.5
45	66.0	5.1	4.8	4.5	4.3	4.1
55	80.7	5.9	5.5	5.2	4.9	4.6
65	95.3	6.7+	6.2+	5.8	5.5	5.2

* Less than 3.0 second minimum, increase yellow time to 3.0
\+ Greater than 6.0 sec threshold, requires stakeholder meeting prior to approval

Speed		Clearance Distance (feet)						
mph	fps	50	75	100	125	150	175	200
20	29.3	1.8	2.6	3.3	3.7	4.1+	4.5+	5.0+
25	36.7	1.4	2.1	2.8	3.3	3.6	3.9	4.3+
30	44.0	1.2	1.8	2.3	2.9	3.3	3.5	3.8
35	51.3	1.0	1.5	2.0	2.5	3.0	3.3	3.5
45	66.0	0.8*	1.2	1.6	1.9	2.3	2.7	3.1
55	80.7	0.7*	1.0	1.3	1.6	1.9	2.2	2.5
65	95.3	0.6*	0.8*	1.1	1.4	1.6	1.9	2.1

Shaded cells indicate mitigated red intervals
* Less than 1.0 second minimum, increase all red time to 1.0
\+ Greater than 4.0 sec threshold, requires stakeholder meeting prior to approval

Figure 5. Sample yellow and red intervals.

With the adoption of this practice, NCDOT has established a consistent method for calculating yellow and red intervals that will provide safe and efficient operation. Because of the prohibitive cost associated with an immediate statewide change, the new practice will be used for new signals and phased into existing signals as they require other revisions, with a review of closely spaced signals to help promote the desired consistency. ■

References

1. *Manual on Uniform Traffic Control Devices for Streets and Highways.* Washington, DC: Federal Highway Administration (FHWA), November, 2004.

2. *Traffic Engineering Handbook, Fifth Edition.* Pline, J.L. (ed.). Washington, DC: Institute of Transportation Engineers (ITE), 1999.

3. Tarnoff, Philip J. and J. Ordonez. *Signal Timing Practice and Procedures: State of the Practice.* Washington, DC: ITE, 2004.

4. *Traffic Engineering Handbook,* note 2 above.

5. Eccles, K.A. and H.W. McGee. *A History of the Yellow and All-Red Intervals for Traffic Signals.* Washington, DC: ITE, 2001.

6. North Carolina Statewide Stakeholder Meeting on Clearance Intervals. Unpublished Meeting Minutes, 1990.

7. *Traffic Management and Signal Systems Unit Design Manual.* North Carolina Department of Transportation (NCDOT), 2004. Note: The former Traffic Management and Signal Systems Unit since has been renamed the ITS and Signals Unit, and the manual has been renamed the accordingly.

8. *Signalized Intersections: Informational Guide* (FHWA-HRT-04-091). Washington, DC: FHWA, 2004. Accessible via www.tfhrc.gov/safety/pubs/04091.

9. *NEMA Standards Publication TS 2-1998: Traffic Controller Assemblies with NTCIP Requirements.* National Electrical Manufacturers Association, 1998.

10. *2004 North Carolina Supplement to the Manual on Uniform Traffic Control Devices.* NCDOT, 2004.

11. Muller, T.H.J., T. Dijker and P.G. Furth. "Red Clearance Intervals: Theory and Practice." *Transportation Research Record,* No. 1867 (2004): 132–143.

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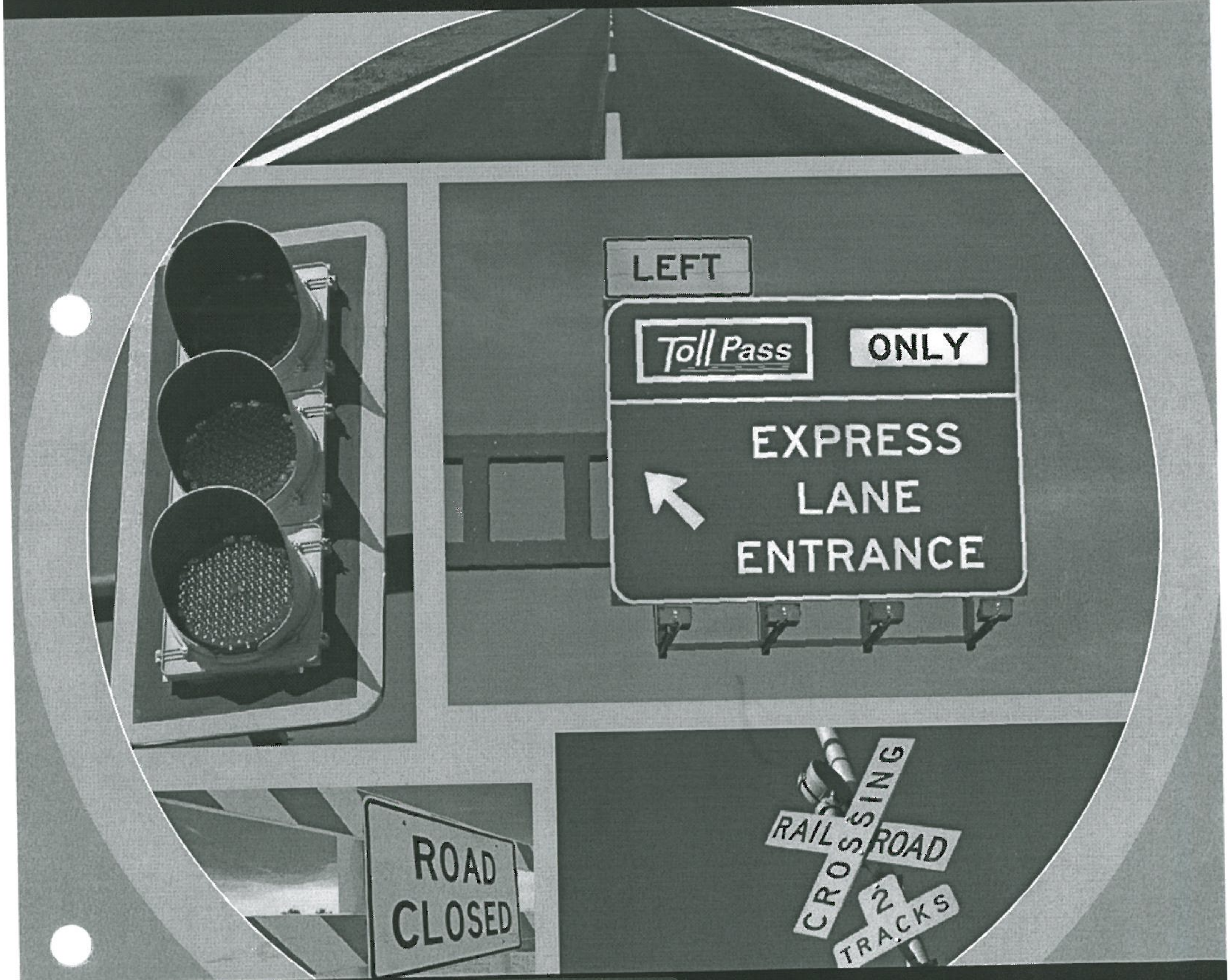

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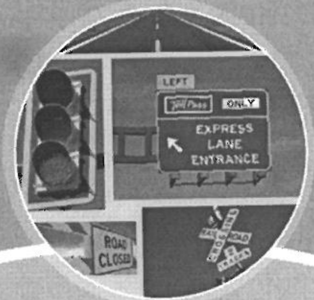

Manual on Uniform Traffic Control Devices

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The Manual on Uniform Traffic Control Devices (MUTCD) is approved by the Federal Highway Administrator as the National Standard in accordance with Title 23 U.S. Code, Sections 109(d), 114(a), 217, 315, and 402(a), 23 CFR 655, and 49 CFR 1.48(b)(8), 1.48(b)(33), and 1.48(c)(2).

Addresses for Publications Referenced in the MUTCD

American Automobile Association (AAA)
1000 AAA Drive
Heathrow, FL 32746
www.aaa.com
800-222-4357

American Association of State Highway and Transportation Officials (AASHTO)
444 North Capitol Street, NW, Suite 249
Washington, DC 20001
www.transportation.org
202-624-5800

American National Standards Institute (ANSI)
1819 L Street, NW, 6th Floor
Washington, DC 20036
www.ansi.org
202-293-8020

American Railway Engineering and Maintenance-of-Way Association (AREMA)
10003 Derekwood Lane, Suite 210
Lanham, MD 20706
www.arema.org
301-459-3200

Federal Highway Administration Report Center
Facsimile number: 814-239-2156
report.center@fhwa.dot.gov

Illuminating Engineering Society (IES)
120 Wall Street, Floor 17
New York, NY 10005
www.iesna.org
212-248-5000

Institute of Makers of Explosives
1120 19th Street, NW, Suite 310
Washington, DC 20036-3605
www.ime.org
202-429-9280

Institute of Transportation Engineers (ITE)
1099 14th Street, NW, Suite 300 West
Washington, DC 20005-3438
www.ite.org
202-289-0222

International Organization for Standardization
1, ch. de la Voie-Creuse
Case Postale 56
CH-1211
Geneva 20, Switzerland
www.iso.ch
011-41-22-749-0111

International Safety Equipment Association (ISEA)
1901 North Moore Street, Suite 808
Arlington, VA 22209
www.safetyequipment.org
703-525-1695

National Committee on Uniform Traffic Laws and Ordinances (NCUTLO)
107 South West Street, Suite 110
Alexandria, VA 22314
www.ncutlo.org
800-807-5290

National Electrical Manufacturers Association (NEMA)
1300 North 17th Street, Suite 1752
Rosslyn, VA 22209
www.nema.org
703-841-3200

Occupational Safety and Health Administration (OSHA)
U.S. Department of Labor
200 Constitution Avenue, NW
Washington, DC 20210
www.osha.gov
800-321-6742

Transportation Research Board (TRB)
The National Academies
500 Fifth Street, NW
Washington, DC 20001
www.nas.edu/trb
202-334-3072

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1331 F Street, NW, Suite 1000
Washington, DC 20004-1111
www.access-board.gov
202-272-0080

Acknowledgments

The Federal Highway Administration gratefully acknowledges the valuable assistance that it received from the National Committee on Uniform Traffic Control Devices and its more than 250 voluntary members in the development of this Manual.

13 The duration of a yellow change interval or a red clearance interval may be different in different signal timing plans for the same controller unit.

Guidance:

14 *A yellow change interval should have a minimum duration of 3 seconds and a maximum duration of 6 seconds. The longer intervals should be reserved for use on approaches with higher speeds.*

15 *Except when clearing a one-lane, two-way facility (see Section 4H.02) or when clearing an exceptionally wide intersection, a red clearance interval should have a duration not exceeding 6 seconds.*

Standard:

16 **Except for warning beacons mounted on advance warning signs on the approach to a signalized location (see Section 2C.36), signal displays that are intended to provide a "pre-yellow warning" interval, such as flashing green signal indications, vehicular countdown displays, or other similar displays, shall not be used at a signalized location.**

Support:

17 The use of signal displays (other than warning beacons mounted on advance warning signs) that convey a "pre-yellow warning" have been found by research to increase the frequency of crashes.

Section 4D.27 Preemption and Priority Control of Traffic Control Signals

Option:

01 Traffic control signals may be designed and operated to respond to certain classes of approaching vehicles by altering the normal signal timing and phasing plan(s) during the approach and passage of those vehicles. The alternative plan(s) may be as simple as extending a currently displayed green interval or as complex as replacing the entire set of signal phases and timing.

Support:

02 Preemption control (see definition in Section 1A.13) is typically given to trains, boats, emergency vehicles, and light rail transit.

03 Examples of preemption control include the following:

A. The prompt displaying of green signal indications at signalized locations ahead of fire vehicles, law enforcement vehicles, ambulances, and other official emergency vehicles;
B. A special sequence of signal phases and timing to expedite and/or provide additional clearance time for vehicles to clear the tracks prior to the arrival of rail traffic; and
C. A special sequence of signal phases to display a steady red indication to prohibit turning movements toward the tracks during the approach or passage of rail traffic.

04 Priority control (see definition in Section 1A.13) is typically given to certain non-emergency vehicles such as light-rail transit vehicles operating in a mixed-use alignment and buses.

05 Examples of priority control include the following:

A. The displaying of early or extended green signal indications at an intersection to assist public transit vehicles in remaining on schedule, and
B. Special phasing to assist public transit vehicles in entering the travel stream ahead of the platoon of traffic.

06 Some types or classes of vehicles supersede others when a traffic control signal responds to more than one type or class. In general, a vehicle that is more difficult to control supersedes a vehicle that is easier to control.

Option:

07 Preemption or priority control of traffic control signals may also be a means of assigning priority right-of-way to specified classes of vehicles at certain non-intersection locations such as on approaches to one-lane bridges and tunnels, movable bridges, highway maintenance and construction activities, metered freeway entrance ramps, and transit operations.

Standard:

08 **During the transition into preemption control:**

A. The yellow change interval, and any red clearance interval that follows, shall not be shortened or omitted.
B. The shortening or omission of any pedestrian walk interval and/or pedestrian change interval shall be permitted.
C. The return to the previous green signal indication shall be permitted following a steady yellow signal indication in the same signal face, omitting the red clearance interval, if any.

03 **Except as provided in Paragraph 4, the pedestrian signal heads shall continue to display a steady UPRAISED HAND (symbolizing DONT WALK) signal indication when the pedestrian hybrid beacon faces are either dark or displaying flashing or steady CIRCULAR yellow signal indications. The pedestrian signal heads shall display a WALKING PERSON (symbolizing WALK) signal indication when the pedestrian hybrid beacon faces are displaying steady CIRCULAR RED signal indications. The pedestrian signal heads shall display a flashing UPRAISED HAND (symbolizing DONT WALK) signal indication when the pedestrian hybrid beacon faces are displaying alternating flashing CIRCULAR RED signal indications. Upon termination of the pedestrian clearance interval, the pedestrian signal heads shall revert to a steady UPRAISED HAND (symbolizing DONT WALK) signal indication.**

Option:

04 Where the pedestrian hybrid beacon is installed adjacent to a roundabout to facilitate crossings by pedestrians with visual disabilities and an engineering study determines that pedestrians without visual disabilities can be allowed to cross the roadway without actuating the pedestrian hybrid beacon, the pedestrian signal heads may be dark (not illuminated) when the pedestrian hybrid beacon faces are dark.

Guidance:

05 *The duration of the flashing yellow interval should be determined by engineering judgment.*

Standard:

06 **The duration of the steady yellow change interval shall be determined using engineering practices.**

Guidance:

07 *The steady yellow interval should have a minimum duration of 3 seconds and a maximum duration of 6 seconds (see Section 4D.26). The longer intervals should be reserved for use on approaches with higher speeds.*

on the approach, the signal faces for the approach shall be as described in Items B.1 and B.2, except that flashing YELLOW ARROW signal indications shall be used in place of the GREEN ARROW signal indications for the turning movement(s) that conflicts with the signalized vehicular or pedestrian movement.

Support:

05 Figure 4D-20 illustrates application of these Standards on approaches that have only a shared left-turn/right-turn lane, and on approaches that have one or more exclusive turn lanes in addition to the shared left-turn/right-turn lane.

Option:

06 If the lane-use regulations on an approach are variable such that at certain times all of the lanes on the approach are designated as exclusive turn lanes and no lane is designated as a shared left-turn/right-turn lane:

A. During the times that no lane is designated as a shared left-turn/right-turn lane, the left-turn and right-turn movements may start and terminate independently, and the left-turn and right-turn movements may be operated in one or more of the modes of operation as described in Sections 4D.17 through 4D.24; and
B. If a protected-permissive mode is used, the shared left-turn/right-turn signal face provided in Paragraph 4 may be modified to include a dual-arrow signal section capable of displaying both a GREEN ARROW signal indication and a flashing YELLOW ARROW signal indication for a turn movement(s) in order to not exceed the maximum of five sections per signal face provided in Section 4D.08.

Section 4D.26 Yellow Change and Red Clearance Intervals

Standard:

01 **A steady yellow signal indication shall be displayed following every CIRCULAR GREEN or GREEN ARROW signal indication and following every flashing YELLOW ARROW or flashing RED ARROW signal indication displayed as a part of a steady mode operation. This requirement shall not apply when a CIRCULAR GREEN, a flashing YELLOW ARROW, or a flashing RED ARROW signal indication is followed immediately by a GREEN ARROW signal indication.**

02 **The exclusive function of the yellow change interval shall be to warn traffic of an impending change in the right-of-way assignment.**

03 **The duration of the yellow change interval shall be determined using engineering practices.**

Support:

04 Section 4D.05 contains provisions regarding the display of steady CIRCULAR YELLOW signal indications to approaches from which drivers are allowed to make permissive left turns.

Guidance:

05 *When indicated by the application of engineering practices, the yellow change interval should be followed by a red clearance interval to provide additional time before conflicting traffic movements, including pedestrians, are released.*

Standard:

06 **When used, the duration of the red clearance interval shall be determined using engineering practices.**

Support:

07 Engineering practices for determining the duration of yellow change and red clearance intervals can be found in ITE's "Traffic Control Devices Handbook" and in ITE's "Manual of Traffic Signal Design" (see Section 1A.11).

Standard:

08 **The durations of yellow change intervals and red clearance intervals shall be consistent with the determined values within the technical capabilities of the controller unit.**

09 **The duration of a yellow change interval shall not vary on a cycle-by-cycle basis within the same signal timing plan.**

10 **Except as provided in Paragraph 12, the duration of a red clearance interval shall not be decreased or omitted on a cycle-by-cycle basis within the same signal timing plan.**

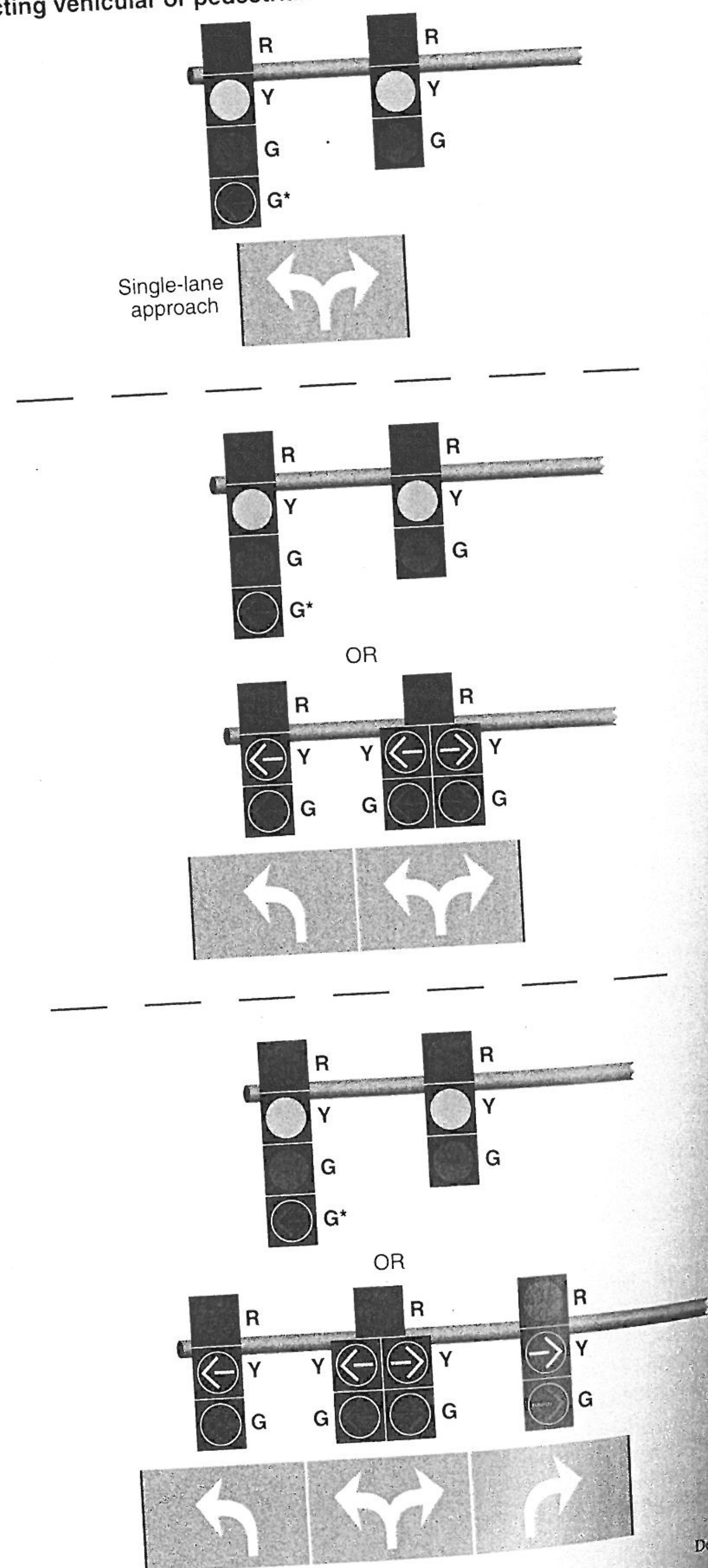
Option:

11 The duration of a red clearance interval may be extended from its predetermined value for a given cycle based upon the detection of a vehicle that is predicted to violate the red signal indication.

12 When an actuated signal sequence includes a signal phase for permissive/protected (lagging) left-turn movements in both directions, the red clearance interval may be shown during those cycles when the lagging left-turn signal phase is skipped and may be omitted during those cycles when the lagging left-turn signal phase is shown.

Figure 4D-20. Signal Indications for Approaches with a Shared Left-Turn/Right-Turn Lane and No Through Movement (Sheet 1 of 3)

A - No conflicting vehicular or pedestrian movements



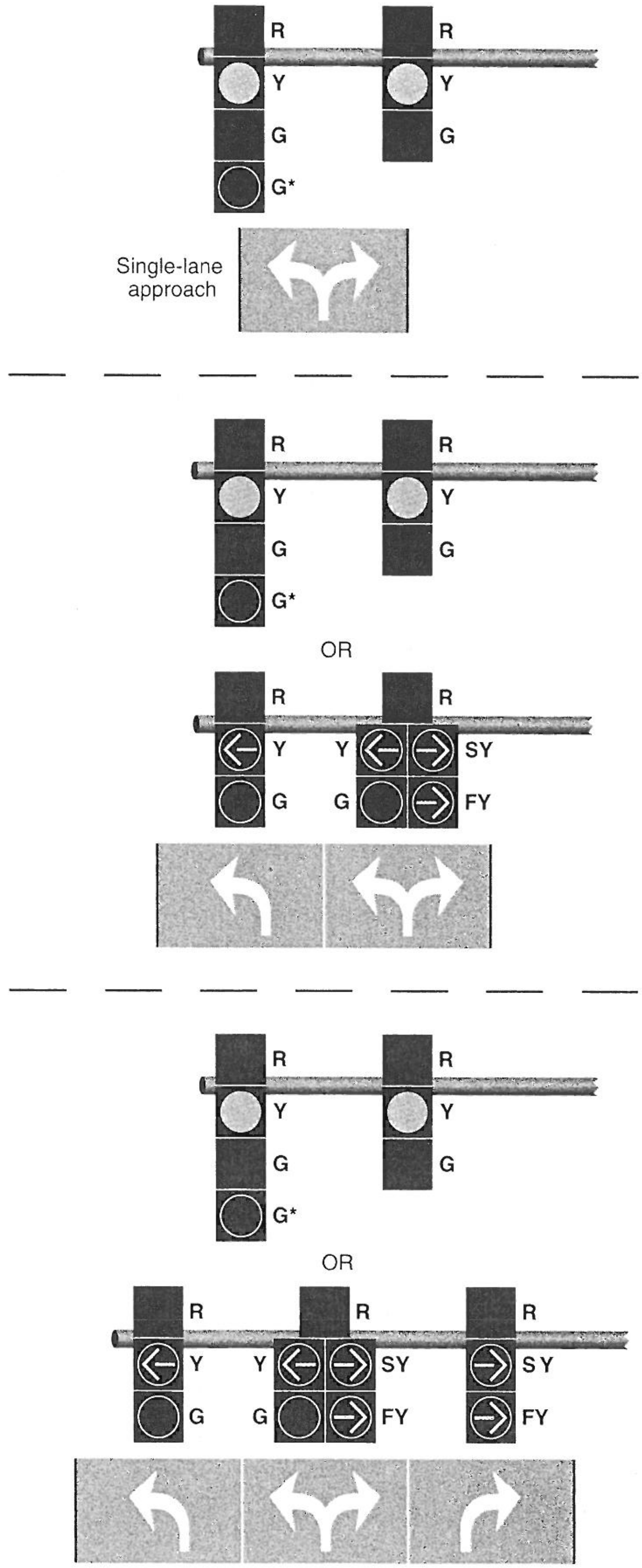
* Left-turn GREEN ARROW section shall be included if there is an opposing one-way approach and the signal phasing eliminates conflicts.

Notes:

1. Horizontally-aligned signal faces may also be used.
2. Shared signal faces may also be 5 sections in a vertical straight line instead of a cluster.

Figure 4D-20. Signal Indications for Approaches with a Shared Left-Turn/Right-Turn Lane and No Through Movement (Sheet 2 of 3)

B - Pedestrian or vehicular conflict with one turn movement



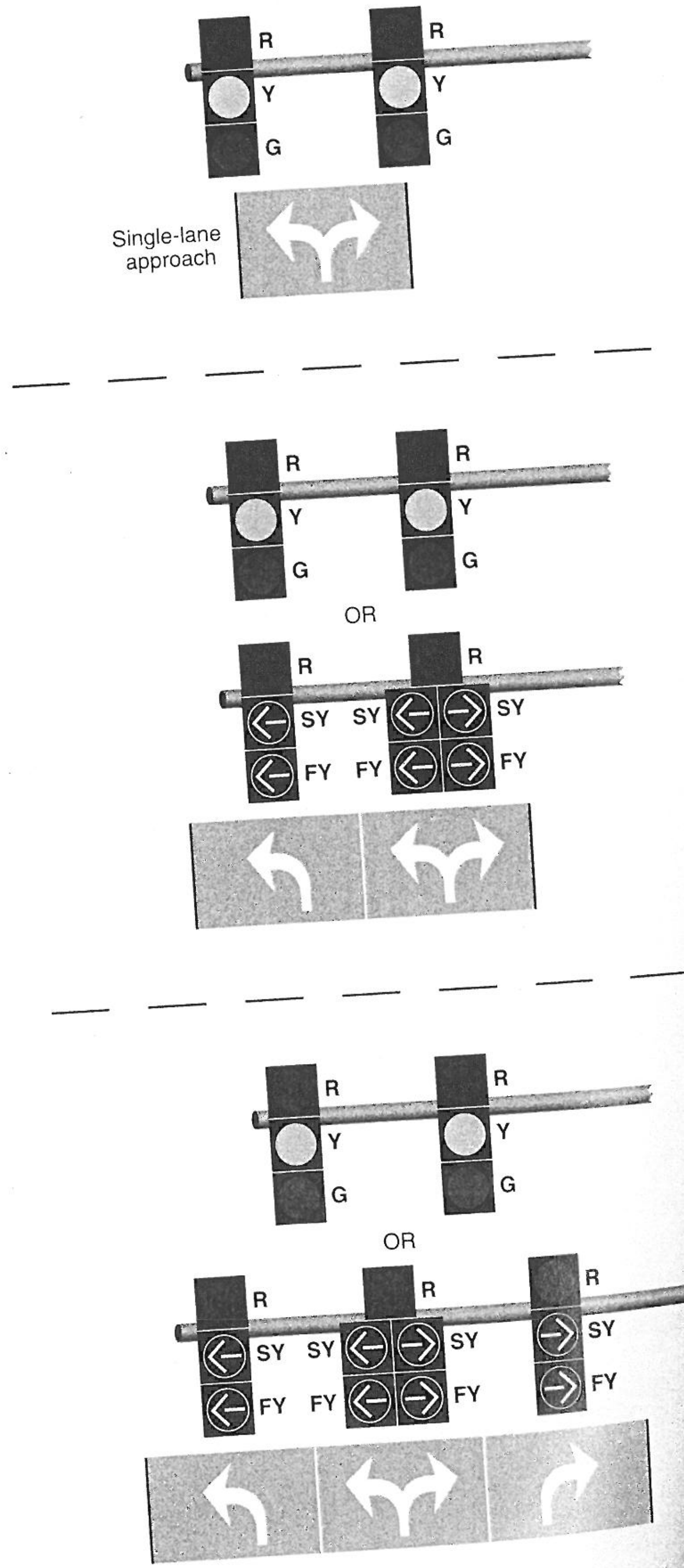
* Left-turn GREEN ARROW section shall be included if there is an opposing one-way approach and the signal phasing eliminates conflicts.

Notes:

1. A conflict with the right-turn movement is illustrated.
2. Horizontally-aligned signal faces may also be used.
3. Shared signal faces may also be 5 sections in a vertical straight line instead of a cluster.

Figure 4D-20. Signal Indications for Approaches with a Shared Left-Turn/Right-Turn Lane and No Through Movement (Sheet 3 of 3)

C - Pedestrian or vehicular conflicts with both turn movements



Notes:

1. Horizontally-aligned signal faces may also be used.
2. Shared signal faces may also be 5 sections in a vertical straight line instead of a cluster.

Guidelines for the Preparation of Traffic Signal & Intelligent Transportation System Plans on Design-Build Projects
May 2009

INTRODUCTION

Use the following Guidelines in conjunction with the Traffic Signal & Intelligent Transportation Systems Scope of work provided in the Request for Proposal and Design-Build Submittal Guidelines to develop the Traffic Signal & Intelligent Transportation System Plans.

GENERAL PROCEDURES AND REQUIREMENTS

The Traffic Signal & Intelligent Transportation System Plans shall include all existing and proposed traffic signals, electrical and programming details, utility make-ready plans, communications cable and conduit routing plans and project special provisions.

Ensure the development of the Traffic Signal & Intelligent Transportation System plans are in compliance with the most current:

- Manual on Uniform Traffic Control Devices for Streets and Highways
- North Carolina Supplement to the Manual on Uniform Traffic Control Devices for Streets and Highways
- NCDOT Traffic Signal Specifications and all addenda
- NCDOT Intelligent Transportation and Signal Systems Unit Design Manual
- National Electrical Safety Code
- National Electric Code
- NCDOT Roadway Standard Drawings
- NCDOT Standard Specifications for Roads and Structures

NCDOT's 2006 *Roadway Standard Drawings* – Section 1700 contains traffic signal and communications cable standard details. These will need to be incorporated into the plans for most work activities.

The Traffic Signal & Intelligent Transportation System's website, shown below contains the latest microstation cell libraries and the Unit Design Manual.

http://www.doh.dot.state.nc.us/preconstruct/traffic/ITSS

PLAN LAYOUT

General Overview

Submit Traffic Signal & Intelligent Transportation System Plan Sheets to comply with the following:

- Titlesheets showing an overview of all traffic signals along the corridor
- Temporary and permanent traffic signal designs (including electrical details)

- Metal pole loading diagrams / details
- Communications Cable & Conduit Routing Plans (including splice details)
- Communications Cable Construction Notes sheet
- Full-size sheets should be 22" x 34"
- Half-size sheets should be 11" x 17"
- Number all sheets

Title Sheet

The Title sheet shall include the following:

- Overview of project
- Index of plan sheets
- Vicinity map
- Legend

Title Sheet shall also contain the following for NCDOT contacts:

- NCDOT Traffic Signal & ITS Contact Information
- Phone Number (919) 773-2800   Fax number (919) 771-2745
- G. G. (Buddy) Murr, Jr., PE – Signals & Geometrics Engineer
- Gregory A. Fuller, PE – ITS & Signal Systems Engineer
- Milton I. Dean, PE - Signals Management Engineer

Traffic Signal Plans

Traffic Signal Plans shall be prepared for permanent and temporary installations on the standard size border and shall include, but not be limited to, the following information with all supporting documentation:

- Traffic signal analysis of the intersections to determine the necessary criteria (cycle lengths, clearance intervals, maximum intervals, etc.) for the required phasing
- Phasing diagrams for each active movement through the intersection. Phasing diagrams shall show actual operation. "Typicals" shall not be accepted.
- Table of operations
- Standard signal face clearances
- Timing charts
- Graphic scales
- North arrows
- Legends
- Street grades
- Speed limits
- Plan notes
- Loop / detection installation charts for all detection devices
- Locations, sizes, arrangements, and identification of signal heads
- Location of proposed poles and messenger cable arrangements
- Location of proposed underground conduit and pull boxes
- Location of proposed lead-in routing

- Location of existing utility poles as shown on the roadway construction plans. (Only if in conflict with design.)
- Location of right of way
- Title block information
- Coordination of the traffic signal plans with the final pavement marking plan to show the final detection locations and the associated detection charts
- Metal pole designs (with or without mastarms) to include, but not be limited to the following information with all supporting documentation:
    - Reference to the "Typical" loading case *(when applicable)*
    - Loading diagrams (including dimensions on a plan view and dimensions of all signal heads, signs, and luminaires utilized and attachment heights) *(when applicable)*
    - Documentation in the form of cross-sections, typicals, etc.

The supporting documentation for each signal design shall include:

- Signed clearance chart with distances (show dimensions)
- Controller timings for all existing signalized locations
- Most recent traffic counts with breakdown (vehicular and pedestrian)
- Roadway plan sheet for intersection
- Profile at intersection
- Capacity analysis
- Summary of Quantity Sheet
- Division requests for specialized items (preemption, pedestrian signals, metal poles, system work, etc.)
- Notes on all correspondence with Department personnel

Acceptance by the Department must be given on the phasing and detection methods used.

Coordinate the traffic signal plans with the construction staging to determine whether interim traffic signal treatment will be necessary to maintain actuated signalized operation during construction phasing. Interim traffic signal treatment may be defined as the following:

- Moving traffic signal poles out of the construction zone.
- Temporary traffic signals (to be removed at the completion of the construction) which require new traffic signal plans.
- Revised phasing at existing traffic signal locations which requires revised traffic signal plans.
- Temporary traffic signals installed during a construction phase which will be revised during another construction phase and / or for final traffic patterns.

All Traffic Signal Plans shall be sealed by the Engineer. The Engineer must be duly registered to practice engineering in North Carolina.

Electrical and Programming Plans

Electrical and programming detail plans shall be prepared for all traffic signal plans with supporting documentation to include but not be limited to the following information:

- Field connection hook-up charts showing the connection in the controller cabinet for each signal head.
- Conflict monitor / Malfunction management unit programming card details showing the required jumpers and switch settings.
- NEMA overlap card details showing all required jumpers.
- Equipment information sections showing the controller brand and model number, cabinet type and mounting style (pole-mounted or base-mounted), number of loadbay positions, loadswitchs used, phases used, and overlaps used.
- Typical connection charts for detectors defining the detector pin functions and the connection on the loop termination panel or detector rack set-up.
- Backup protection relay wiring details showing required jumpers and connections for phase omits and the wiring circuitry needed to serve the omit phases.
- Special detector wiring details showing any special wiring needed for detection operation. Details will be required for detection other than inductive detection loops (microwave, ultrasonic, machine vision, etc.).
- Communication interface details showing the telemetry panel and all connections.
- Preemption panel wiring details showing the preemption panel and all connections.
- Detail notes addressing installation and programming procedures in sufficient detail for construction. Notes shall address start-up programming, start-up phases, power-up flash times, unused phases, conflict-flash, etc.
- Special cabinet wiring details showing any special wiring needed to the controller cabinet.
- All non-standard controller programming shall be shown such as preemption programming, time-of-day programming, special ring configurations, etc. All controller display screens and menus needed to program these features shall be shown.

Final electric and programming detail plans shall be sealed by the Engineer. The Engineer must be duly registered to practice engineering in North Carolina.

Utility Make-Ready Plans

In conjunction with the development of the Communications Cable and Conduit Routing Plans and Traffic Signal Plans a set of **Utility Make-Ready Plans** shall also be developed. The Utility Make-Ready Plans must be developed in accordance with the *National Electrical Safety Code* and all applicable Utility Codes.

- Develop and submit to the Department a set of Utility Make-Ready Plans for the routing of the proposed communications cable, either aerial, underground, or a combination of both. Plans shall be coordinated with utility representatives' from the appropriate Utility Agencies and should address any modifications or adjustments deemed necessary to provide a pole attachment and / or show the underground installation location for the communications cable. The plans shall also address any aerial or underground utility adjustments necessary to facilitate the safe installation of the signal poles around each intersection. The Design-Build Team shall be responsible for coordinating and obtaining any utility make-ready adjustments.

Plans should show, as a minimum:

- final roadway
- joint - use utility pole locations

- signal poles
- intersection controller cabinets
- signal inventory numbers
- right of way
- driveways / streets
- legend
- intended NCDOT cable attachment points
- a description of each pole showing the type of utility make-ready work required

Utility Make-Ready Plans do not require an Engineer's seal.

Communications Cable and Conduit Routing Plans

The Communications Cable & Conduit Routing Plans will include the following information with all supporting documentation and information:

- Title Sheet
- Construction notes and legend, typical details, and any plan specific details.
- Construction plans. The construction plans should show as a minimum:
  - final roadway
  - right of way
  - driveways / streets
  - joint-use utility pole locations
  - signal poles
  - intersection controller cabinets with signal inventory numbers
  - communications cable attachment locations
  - general construction notes
  - Splice Plans (This information will address how the communications cable will be terminated at each location)

All Communications Cable & Conduit Routing Plans shall be sealed by the Engineer. The Engineer must be duly registered to practice engineering in North Carolina.

Project Special Provisions

Project Special Provisions shall include the following information with all supporting documentation and information:

- The project special provisions will cover all items of work, material, equipment, and methods of construction for the installation of a complete traffic signal installation that are not otherwise covered in the *Standard Specifications for Roads and Structures,* Dated July 2006 and all addendum.
- Each section of the project special provisions shall contain subsections titled: Description, Materials, and Construction Method. The Design-Build Team is encouraged to utilize the Intelligent Transportation and Signal Systems Unit's generic *Project Special Provisions* in developing the project special provisions.

- Project Special Provisions shall be sealed by the Engineer. The Engineer must be duly registered to practice engineering in North Carolina.

Catalog Cut Sheets

Product Catalog Cut Sheets shall include the following information with all supporting documentation and information:

- Manufacturer's make and model number for each piece of equipment.
- Quantity of items to be used.
- Catalog Cuts do not require an Engineer's seal.

ite

TRAFFIC ENGINEERING HANDBOOK

6TH EDITION

Institute of Transportation Engineers

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The Institute of Transportation Engineers (ITE) is an international educational and scientific association of transportation and traffic engineers and other professionals who are responsible for meeting mobility and safety needs. ITE facilitates the application of technology and scientific principles to research, planning, functional design, implementation, operation, policy development and management for any mode of transportation by promoting professional development of members, supporting and encouraging education, stimulating research, developing public awareness, exchanging professional information and maintaining a central point of reference and action.

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a head start or the pedestrians can be held until the initial queue of vehicles has been served. However, such controller phasing may have a detrimental effect on vehicle flow and, if part of a system, on system capacity.

The goals of traffic safety and traffic capacity must be balanced when determining controller phasing for an intersection. The following section describes the various components of controller phasing. More in-depth discussion can be found in the *Manual of Traffic Signal Design* and *Signalized Intersections: Informational Guide.*[14,15]

Green Interval. Ideally, the length of the green display on each approach to an intersection will be sufficient—but not excessive—to serve all the vehicles and pedestrians queued during the red interval. Several PC-based computer programs are available to assist in determining the green interval timing.

For semi- or fully-actuated controllers, a minimum and maximum amount of green time must be determined and allocated for each phase and programmed into the controller. These values are derived from the analysis results of the timing software or other method of analysis used by the designer.

For pre-timed signal controllers, the length of the green display is based on engineering judgment. Traffic and pedestrian counts for a specific period of time are often used in determining the signal timing.

Yellow Change Interval. The purpose of the yellow change interval, which is required to be the first interval following every circular green or green arrow indication, is to warn approaching traffic of the termination of the related green interval or that a red signal indication will follow (see "Vehicle Detector Placement").

MUTCD states that yellow change intervals should have duration of 3 to 6 sec.[16] To determine the appropriate yellow time for the approach, this should be calculated using the Kinematic Model—Formula 1 found in ITE's *Determining Vehicle Signal Change and Clearance Intervals:*[17]

$$Y = t + [v/(2a+2Gg)]$$

where:
Y = yellow clearance interval (sec)
t = reaction time (typically 1 sec.)
v = design speed (ft./sec.)
a = deceleration rate (typically 10 ft./sec.^{2})
g = acceleration due to gravity (32.2 ft./sec.^{2})
G = grade of approach (percent/100, downhill is negative grade)

The equation shown above includes a reaction time, a deceleration element and an intersection clearing time. In view of the operational history of the yellow change interval and the assumptions used in the formula, applying the formula requires the exercise of engineering judgment.

Because a long yellow change interval may encourage drivers to use it as a part of the green interval, maximum care should be used when exceeding 5 sec. If the interval is too short, rear-end crashes may result. When the calculation for yellow change interval time indicates a time longer than 5 sec., a red clearance interval typically provides the additional time.

Some jurisdictions time the yellow change interval to enable a vehicle to clear the intersection before the onset of a conflicting green display. Other jurisdictions allow a conflicting green display to be shown before the intersection is cleared. Still others allow a conflicting green display to be shown after the vehicles have cleared the center line of the conflicting approach. Engineering judgment should be exercised in selecting the operation of the yellow change interval to ensure safe passage of vehicles in the intersection.

As can be seen from the formula above, slower speeds result in higher values of yellow clearance time. When calculating the needed time, consideration should be given to the values for the 15th-percentile speed, particularly at wider intersections.

The calculations for steep downgrades will yield values that some drivers may consider excessive. Simply reducing the interval times may create dangerous operating conditions. The engineer should consider lowering the approach speeds by reducing the speed limit or by the use of a warning beacon or other measures.

Red Clearance Interval. The red clearance interval is an optional interval that follows a yellow change interval and precedes the next conflicting green interval. The red clearance interval is used to provide additional time following the yellow change interval before conflicting traffic is released.

MUTCD states that the red clearance interval should not exceed 6 sec.[18] The appropriate red time for the approach should be calculated using the following formula found in ITE's *Determining Vehicle Signal Change and Clearance Intervals*:[19]

$$R = (w+L)/v$$

where
R = all red interval (sec.)
w = width of stop line to far side no-conflict point (ft.)
v = design speed (ft./sec.)
L = length of vehicle (typically 20 ft.)

For exclusive turn movements, the value of w should be measured along the vehicle turn path from the stop line to the no-conflict point.

The decision to use a red clearance interval is determined by intersection geometrics, crash experience, pedestrian activity, approach speeds, local practices and engineering judgment.

6. Left Turns

Three operational modes are available when provisions for left turns are made in the phasing of a traffic control signal:

1. **Permissive (permitted) mode only**—in which drivers may turn left after yielding to conflicting traffic or pedestrians during the circular green indication, along with the parallel through movements. A separate left-turn lane is often provided but not required. No regulatory sign is required, but an informational sign may be used.

2. **Protected (exclusive) mode only**—during which left turns are permitted only when a left green arrow is displayed. There is no conflicting vehicular or pedestrian traffic. Typically, a separate left-turn lane is provided. If the left-turn movement occurs when the adjacent through movement is shown a circular red indication, a separate left-turn lane must be provided.

   A separate left-turn signal face must be used where the signal sequence does not provide for the simultaneous movement of the parallel through traffic. The change interval display may consist of either a yellow left arrow or a circular yellow. The yellow indication must match the green indication; that is, if the separate left-turn face provides a circular green, a circular yellow is provided. If the separate left-turn signal face provides a green left arrow, the yellow indication must be a left arrow. MUTCD requires that all green arrow indications must be followed by yellow arrow indications. The red interval may use a red arrow only if a yellow arrow indication is used. Otherwise, a circular red is required.

   When a separate signal face is used, it should be positioned in line with the turning movement approach. A left-turn signal sign (R10-10) is required unless the signal face consists of arrows only or unless it is properly hooded, shielded, or louvered to ensure that conflicting circular yellow or red indications are not readily visible to motorists in the through lanes.

3. **Protected/permissive (exclusive/permitted) mode**—a combination of both the protected and the permissive modes whereby left turns may be made during the green display as defined under the respective modes. Green and yellow arrow indications are required for this type of operation.

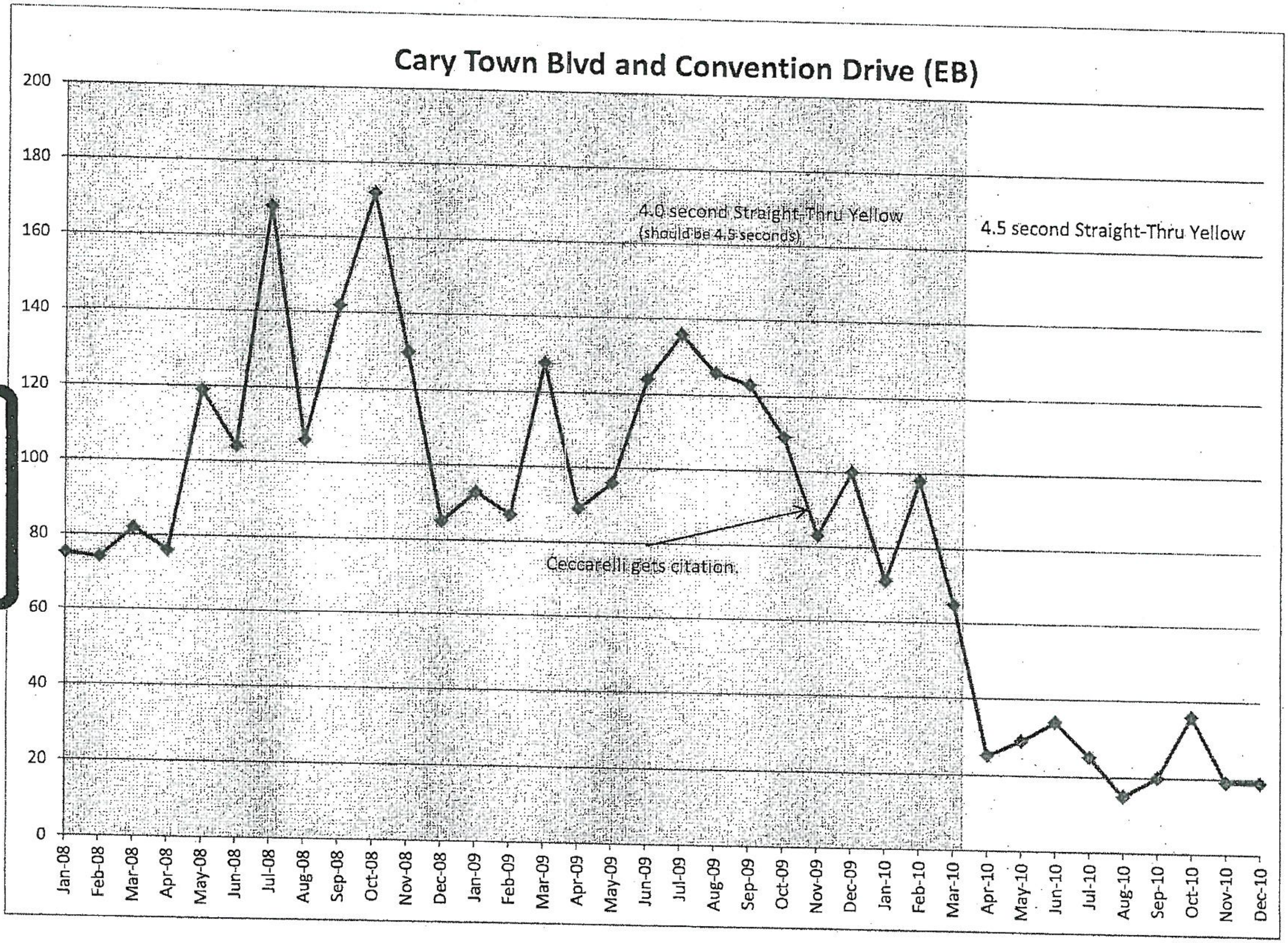
   The controller phasing for protected/permissive mode is the most complicated of the three modes in that it combines the other two modes. Four distinct controller-phasing schemes are commonly employed:

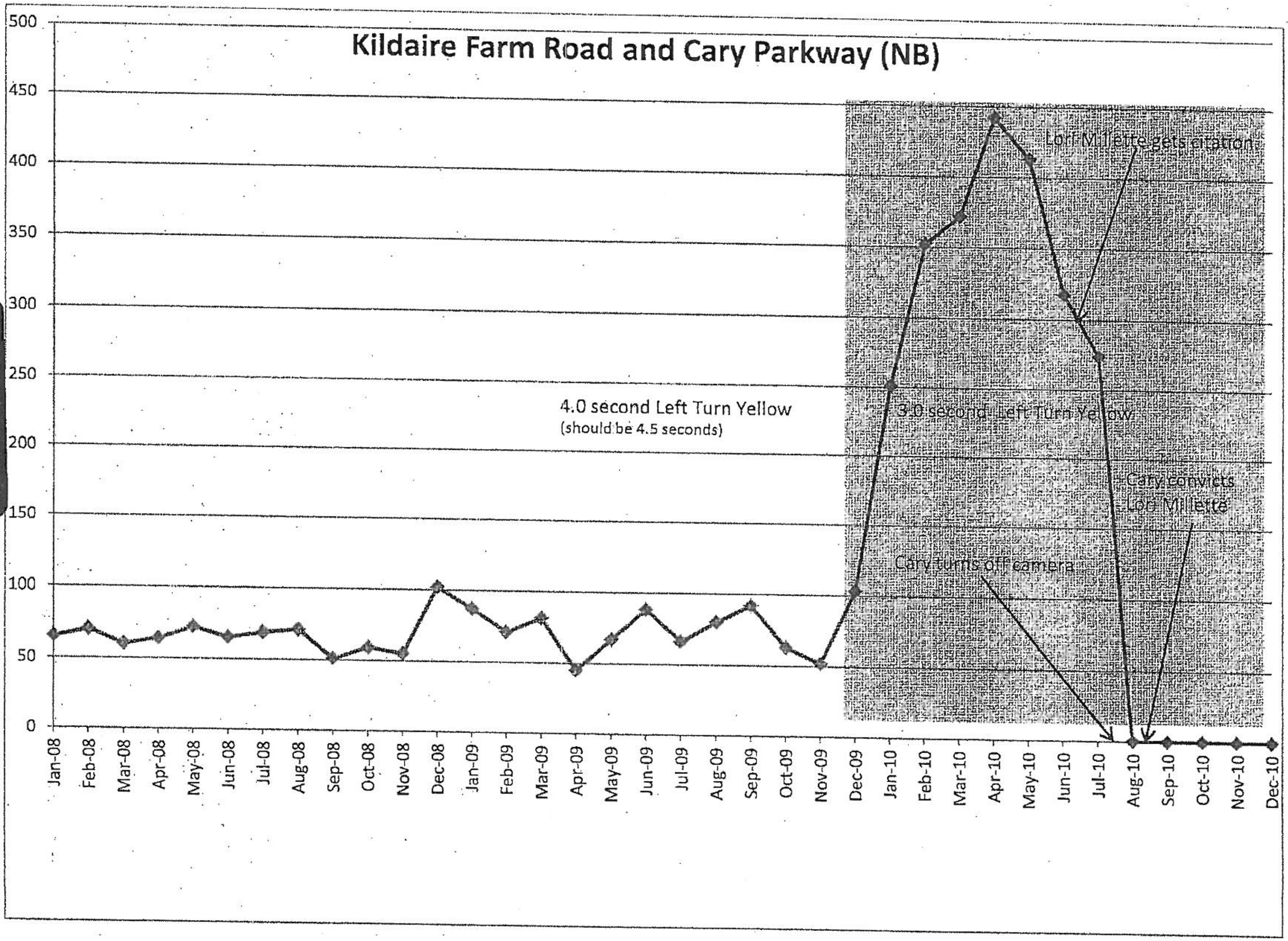
   - lead-left turn with parallel, non-conflicting through traffic;
   - simultaneous lead-left turns with no parallel through traffic;
   - lag-left turn with parallel, non-conflicting through traffic; and
   - simultaneous lag-left turns with no parallel through traffic.

EXHIBIT C

PLAINTIFF'S DEPOSITION EXHIBIT J Moon 10/9/12

PLAINTIFF'S DEPOSITION EXHIBIT 3 George




Kildaire Farm Road and Cary Parkway (NB)
500
450
400
350
300
250
200
150
100
50
0
4.0 second Left Turn Yellow
(should be 4.5 seconds)
3.0 second Left Turn Yellow
Lori Millette gets citation
Cary convicts
Lori Millette
Cary turns off camera
Jan-08
Feb-08
Mar-08
Apr-08
May-08
Jun-08
Jul-08
Aug-08
Sep-08
Oct-08
Nov-08
Dec-08
Jan-09
Feb-09
Mar-09
Apr-09
May-09
Jun-09
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
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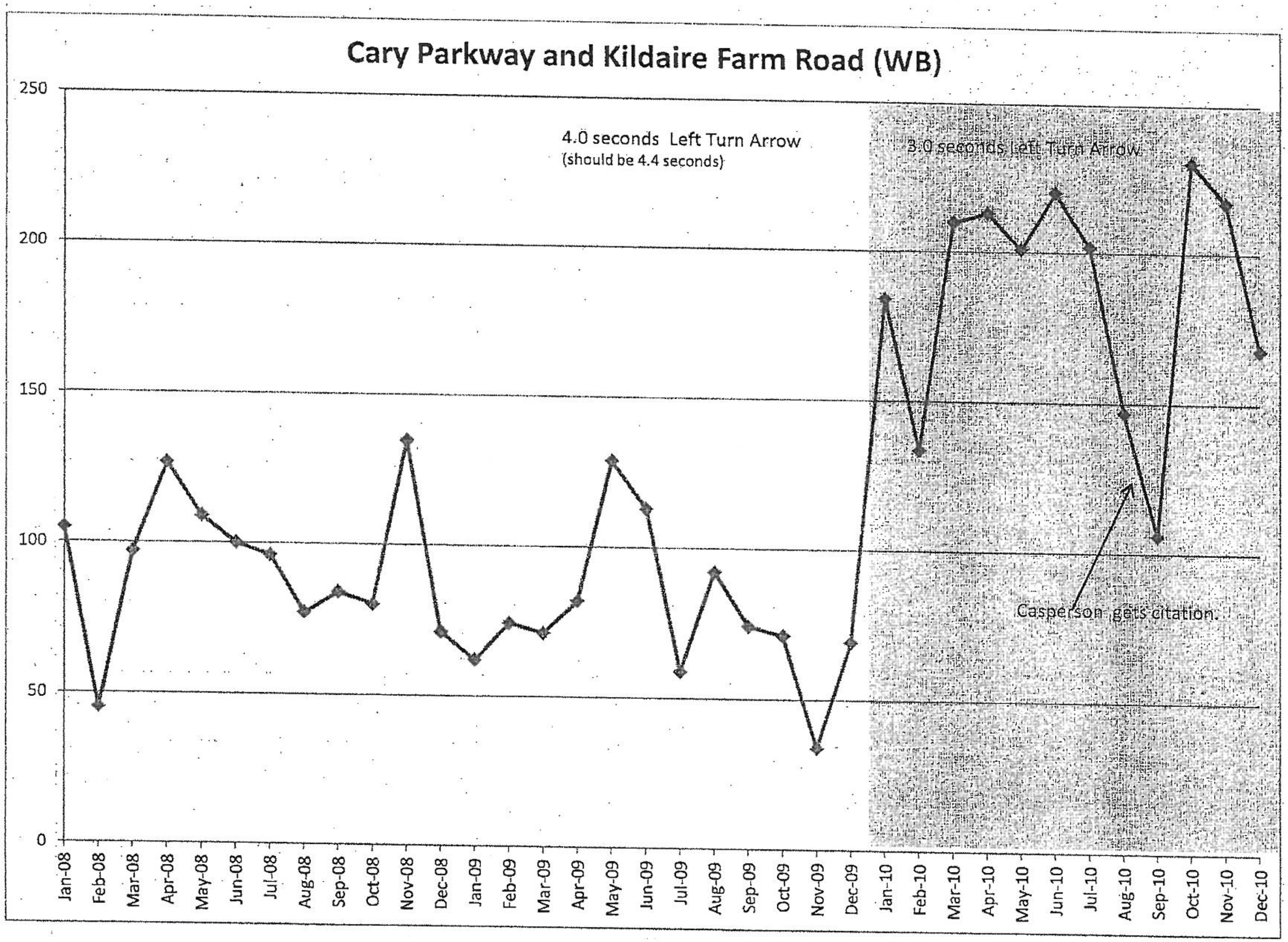
Cary Parkway and Kildaire Farm Road (WB)
4.0 seconds Left Turn Arrow
(should be 4.4 seconds)
3.0 seconds Left Turn Arrow
Casperson gets citation.
0
50
100
150
200
250
Jan-08
Feb-08
Mar-08
Apr-08
May-08
Jun-08
Jul-08
Aug-08
Sep-08
Oct-08
Nov-08
Dec-08
Jan-09
Feb-09
Mar-09
Apr-09
May-09
Jun-09
Jul-09
Aug-09
Sep-09
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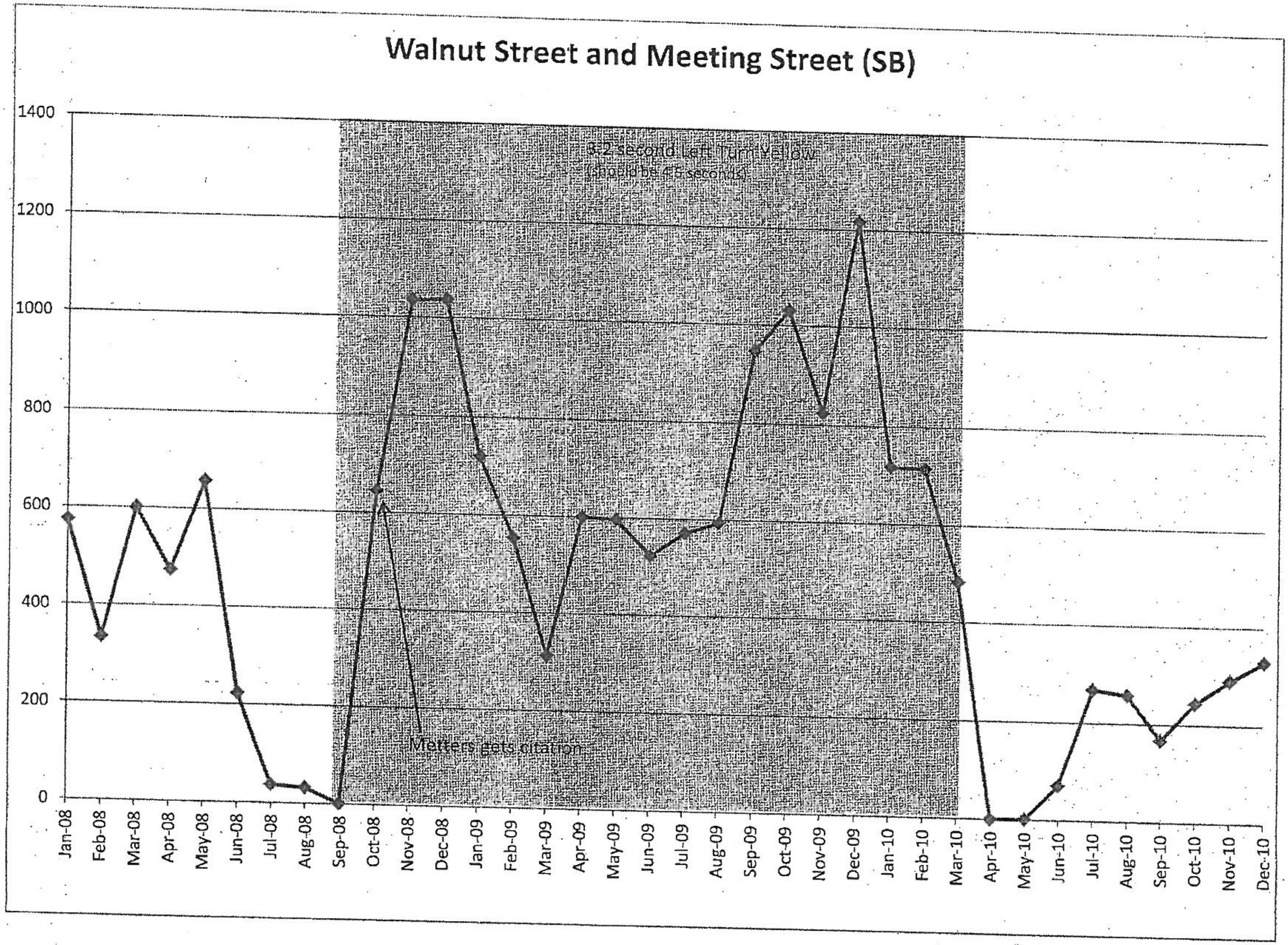
Walnut Street and Meeting Street (SB)
3.2 second Left Turn Yellow
(should be 4.5 seconds)
Metters gets citation
1400
1200
1000
800
600
400
200
0
Jan-08
Feb-08
Mar-08
Apr-08
May-08
Jun-08
Jul-08
Aug-08
Sep-08
Oct-08
Nov-08
Dec-08
Jan-09
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Jan-10
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Aug-10
Sep-10
Oct-10
Nov-10
Dec-10

Lisa M. Moon, PE

Project Engineer
Atkins

Education
B.S., Civil Engineering, North Carolina State University

Registrations/Licenses
Professional Engineer
North Carolina 022516, 1997
South Carolina 27340, 2009
Virginia 46356, 2009

Employment
1998-current
Atkins
Senior Project Engineer

1991-1998
North Carolina Department of Transportation
Signal & Geometrics Section

Lisa Moon has 21 years of traffic engineering experience in traffic engineering, with a focus on traffic-signal analysis and design. She has designed over 750 traffic signals, either isolated or in arterial closed-loop traffic-signal systems, for private, municipal, and state clients and has recently personally inventoried over 700 traffic signals throughout North Carolina. Ms. Moon was also as a member of a joint North Carolina Section Institute of Transportation Engineers (NCSITE)/NCDOT Task Force that developed new, uniform procedures for computing yellow and all-red interval timing for traffic signals.

While at Atkins, Ms. Moon's project experience includes:

Limited Traffic Engineering Services Agreements, 1998-2012, North Carolina Department of Transportation (NCDOT). Led or contributed to numerous on-call traffic signal projects to provide traffic engineering services to the NCDOT's Traffic Engineering and Safety Systems Branch. Design included the review of and/or the new calculations for change intervals of the signals. Relevant projects are listed below:

- B-2225 Greenville - Greene St/Pitt St Closed-Loop System
- U-2414B Conover - Tate Blvd. Ext. Traffic Signals & FOC Cable Routing
- U-2916 Kinston Closed-Loop Signal System Design
- U-3116 Wilmington - Signal Plans
- I-0306DB I-85 in Durham County - Traffic Signals & FOC Cable Routing
- U-2520 Fayetteville - Cliffdale Road Traffic Signals & FOC Cable Routing
- R-2906C Durham - NC 55 Traffic Signals & FOC Cable Routing
- R-1030D Wilson - US 301 Bypass Traffic Signals & FOC Cable Routing
- Wallace Closed-Loop Signal System
- Dunn Closed-Loop Signal System
- Laurinburg Closed-Loop Signal System
- Fairmont Closed-Loop Signal System
- Clinton Closed-Loop Signal System
- R-0967CB Signal Plans
- Smithfield Closed-Loop Signal System
- R-2533B Concord US 601 Signal Upgrades
- R-2417BB Sanford - NC 42 Traffic Signals & FOC Cable Routing
- U-4448 Concord/Kannapolis Closed-Loop Signal System
- R-0617C Lincionton - Traffic Signal and Cable Routing Plans
- R-2201 King – Traffic Signal and Cable Routing Plans
- U-3810 Jacksoville – Traffic Signal Plans

Winston-Salem Traffic Signal System Upgrade and Expansion, North Carolina Department of Transportation (NCDOT), Winston-Salem, NC. This project involves the plans, specifications, and estimates (PS&E) for the rehabilitation and expansion of the City of Winston-Salem's existing computerized traffic signal system. Work includes replacement of the existing copper-wire communications system with a new Ethernet communications system comprised of predominately of new fiber-optic communications cable with potential for wireless communications, particularly in the downtown area. **Employee Role:** Task manager responsible for data collection (signal cabinets and cable routing), signal designs, and cable routing plans.

Rocky Mount Signal System, North Carolina Department of Transportation (NCDOT), Rocky Mount, NC. This project involved the preparation of plans, specifications, and estimates (PS&E) for the rehabilitation and expansion of the existing Rocky Mount computerized traffic signal system. The system was initially comprised of 150 signalized intersections, 15 closed-circuit television (CCTV) cameras and approximately 46 miles of new fiber-optic communications cable. Employee Role: Task manager responsible for signal inventories, signal design, utility make-ready (UMR) data collection, and cable routing plan preparation.

City of Newport News On-Call – Newport News Signal Designs, Newport News, Virginia (City of Newport News). Served as project engineer for signal designs. Signal designs included metal poles with mastarms, video detection, emergency preemption, and pedestrian features. Projects include:

- **Jefferson Avenue Streetscape and Utility Underground Project.** Included five signal upgrades with one temporary each. Design integration with ongoing Newport News signal system project.
- **Warwick Boulevard Signal Replacement.** Included four signal upgrade plans As a pilot project, designed red light confirmation features to assist the local police force with red light enforcement for three of the four locations.
- **Mercer Avenue at Warwick Boulevard.**
- **Old Oyster Point at Canon Back Entrance.** Design for a new signal with the incorporation of the new signal into the ongoing Newport News signal system project including splice diagrams and ¾-mile fiber-optic cable route.
- **Oyster Point Transportation Public Opportunity Fund.** Prepared signal upgrade plans for three intersections with roadway improvements.

Wilmington Signal System Rehabilitation and Expansion, North Carolina Department of Transportation (NCDOT), Wilmington, NC. This project involved the plans, specifications, and estimates (PS&E) for the rehabilitation and expansion of the City of Wilmington's computerized traffic signal system. The project included display upgrades and controller replacement for the approximately 215 intersections that will comprise the expanded system. Work included traffic signal inventories, field inventories of utility poles along candidate communications cable routes, preparation of preliminary UMR plans, communications cable routing plans, and fiber-optic splice diagrams. **Employee Role:** Task Manager for data collection (signal cabinets and cable routing) and cable routing plans.

Raleigh Traffic Signal System Design, City of Raleigh, Raleigh, NC. This project where Atkins assisted with the preparation of PS&E for the rehabilitation and expansion of Raleigh's traffic signal system. Atkins was

Lisa M. Moon, PE
Project Engineer
Atkins

the technical lead on communications system architecture, CCTV surveillance system, traffic control center (TCC) enhancements, specifications and design standards, and was responsible for 35 percent of the overall project work. **Employee Role:** Project engineer and signal design/data collection task manager.

Cary Opticom, Town of Cary, Cary, NC. Project manager for this project that involved designing emergency vehicle (EV) preemption for 37 signalized intersections. Services included verification of the existing conditions, the preparation of traffic signal plans, and preparation of electrical and programming details. **Employee Role:** Project manager responsible for the development of signal plans.

Knightdale Opticom, Town of Knightdale, NC. The signal upgrade plans for US 64 Business (Knightdale Boulevard) at Smithfield Road to be updated with Opticom emergency preemption equipment. Project included signal design, wiring diagram update, and special provisions, as well as assisting client with obtaining bids from signal contractors and assisting with the preparation of the contract bid documents. **Employee Role:** Project manager responsible for leading the design work for this signal upgrade.

Chapel Hill Traffic Signal Designs, Town of Chapel Hill, Chapel Hill, NC. Served as project manager for the preparation of traffic signal plans for upgrading four existing traffic signals in downtown Chapel Hill and for one propose new signal at the intersection of Millhouse Road and Eubanks Road. The signal upgrades include new signal head upgrades to LEDs, the addition of countdown pedestrian signals, and bicycle detection. The new signal included railroad preemption and preparation of a railroad encroachment agreement application.

Safety Studies South Carolina Department of Transportation (SCDOT) – Task manager for operational analysis efforts for twelve study areas, including 26 signalized and unsignalized intersections, in South Carolina. The existing networks were analyzed to gain insight into any existing capacity issues in 2005. The estimated 2025 design year traffic volumes were applied to conceptual designs of proposed safety improvements to review the traffic operations. The analysis led to recommendations for intersection geometrics, specifically turn bay lengths.

US 117 Bypass - No Oversight Project, North Carolina Department of Transportation (NCDOT), Wilson, NC. For US 117 Bypass on new location between the US 264 Bypass and a point south of US 301 south of Wilson, served as task manager for preparation of signing plans, including existing and proposed regulatory and route marker designs, and design of freeway guide signs for one existing and two new interchanges.

Cary Parkway at Lochmere Drive, North Carolina Department of Transportation (NCDOT), Cary, NC. Project manager for the preparation of plans for the installation of a new traffic signal with non-standard metal poles with mastarms and equipment compatible with future city signal system.

Lisa M. Moon, PE

Project Engineer
Atkins

Computerized Traffic Signal System Feasibility Study, Town of Cary, Cary, NC. Project engineer for a computerized traffic signal system feasibility study for approximately 100 traffic signals in and around Cary, North Carolina.

Cary Emergency Vehicle Pre-emption System Design, Temple, Inc. Cary, NC. Serving as project engineer to design and implement an emergency vehicle pre-emption system for 11 signalized intersections.

Kinston Closed-Loop Signal System Design (U-2916), North Carolina Department of Transportation (NCDOT), Kinston, NC. Served as project manager assisting with the preparation of plans, specifications, and estimates (PS&E) for a closed-loop city signal system, which included closed-circuit television (CCTV) surveillance capabilities. Plan preparation included utility make-ready plans, fiber-optic cable layout plans, and special detail sheets. Gained experience with the new Model 2070 "Lite" controllers.

Hillsbourgh Street and Boundary Lane/Entrance to DSS Building – Prepared signal design with materials list for a new signal location.

Garner Computerized Traffic Signal System Feasibility Study, North Carolina Department of Transportation (NCDOT), Garner, NC. Project engineer for a computerized traffic signal system feasibility study for approximately 100 traffic signals in and around Garner, North Carolina.

Concord Mills Boulevard Traffic Signals. Assisted with the preparation of plans, special provisions, and estimates for two signals that will be incorporated into a fiber-optic system in the future by NCDOT. Plans included a layout of the underground conduit necessary for the connection of the signals into an adjacent arterial closed-loop system.

Emergency Vehicle Pre-emption System, Lexington, NC. Assisted project manager in adding 3M Opticom emergency vehicle pre-emption to 16 existing traffic signals.

Tate Boulevard Extension Signal Design (U-2414B), North Carolina Department of Transportation (NCDOT), Hickory, NC. Assisted with the preparation of plans, special provisions, and estimates for an arterial closed-loop system to be included in the existing city of Hickory signal system utilizing 170 type controllers and cabinets.

Y2K Compliance Signal Inventory Project, North Carolina Department of Transportation (NCDOT). Assisted in the management of field personnel, as well as planning and organizing the gathering of field data. Compiled field data for over 1,200 signals into a comprehensive master database for the use of NCDOT. Coordinated with personnel from NCDOT and municipalities in the divisions of our responsibility.

Roadway and Signal Design for Lowes Foods, Lowes Foods, Asheboro, NC. Prepared the plans, special provisions, and estimate for signalizing a new location and interconnecting it into an existing arterial closed-loop signal system. Signal design included trip generation for proposed development, as well as an HCM analysis. The plans for interconnection included ¼ mile of twisted-pair communications cable with appropriate signal equipment for integration.

Fayetteville Signal System Design, City of Fayetteville, Fayetteville, NC. Prepared signal design with materials list for a new signal location in the city of Fayetteville, North Carolina.

Professional Development

Synchro in Traffic, Understanding the Project Management Process, Managing Multiple Priorities, NMAHuman Factors in Traffic Operations, NCDOTAASHTO Roadside Design Guide, FHATraffic Signals, NCDOTPavement Markings, NCDOTTraffic Signal Operations and Design, NCDOTTraffic Engineering, NCDOTCADD Training Program, NCDOTHighway Capacity Manual Workshop, ITREConcepts of Leadership Workshop, NCDOT