STATE OF NORTH CAROLINA   IN THE GENERAL COURT OF JUSTICE
COUNTY OF WAKE   SUPERIOR COURT DIVISION
10-CVS-019930

BRIAN CECCARELLI and LORI MILLETTE, individually and as class representatives,
Plaintiffs,
vs.
TOWN OF CARY,
Defendant.
____

The Deposition of JOSEPH E. HUMMER, Ph.D., P.E.,
Taken at 5050 Anthony Wayne Drive,
2170 Engineering Building, Second Floor,
Detroit, Michigan,
Commencing at 9:28 a.m.,
Wednesday, October 17, 2012,
Before Helen F. Benhart, CSR-2614.

Job No. AMB201292

APPEARANCES:

PAUL STAM - Via telephone
Stam & Danchi, P.L.L.C.
510 West Williams Street
Apex, North Carolina 27502
919.362.8873
Appearing on behalf of the Plaintiffs.

ELIZABETH A. MARTINEAU
Martineau King
200 South College Street
Suite 1550
Charlotte, North Carolina 28202
704.247.8524
Appearing on behalf of the Defendant.

TABLE OF CONTENTS

EXHIBITS

Detroit, Michigan
Wednesday, October 17, 2012
9:28 a.m.

JOSEPH E. HUMMER, Ph.D., P.E.,

was thereupon called as a witness herein, and after having first been duly sworn to testify to the truth, the whole truth and nothing but the truth, was examined and testified as follows:

EXAMINATION

BY MR. STAM:

Q. My name is Paul Stam, attorney for Brian Ceccarelli and Lori Millette. For your information, Mr. Ceccarelli is here with me and can hear. Just for my information, is anyone present other than the court reporter, Ms. Martineau, and yourself?
A. No.
Q. What is your name and business address?
A. Name is Joseph Hummer. Business address is Department of Civil and Environmental Engineering at Wayne State University, Detroit, Michigan 48202.
Q. Do you have your resume or curriculum vitae with you?
A. Yes.
Q. I would like to have that marked as Plaintiff's Deposition Exhibit 1 and just ask you if that is an

accurate and current resume.
A. Yes. The one I just printed out here we're marking as Exhibit 1 is recently updated with my address change, so it must be just slightly different from one that you see from a few weeks ago, but in substance it is the same.
Q. Thank you very much. You have been a professor of engineering, is that correct?
A. Yes.
Q. And you have a doctorate in engineering?
A. Doctorate in civil engineering, yes, Purdue University.
Q. In the course of your obtaining this doctorate and undergraduate education as well, have you studied physics?
A. Yes. I believe I had a two physics courses back during my bachelor's degree days at Michigan State.
Q. Really? I went to Michigan State as well.
A. Excellent. Go Spartans.
Q. Go Spartans. Other than two undergraduate courses in physics, have you had other courses in physics in your education -- formal educational training?
A. I don't think so. I don't remember it.
Q. What is the dictionary definition of engineering?
MS. MARTINEAU: Objection to the form of

the question. We don't have a dictionary here.
MR. STAM: Let's see if he can answer it. If he can't, I'll ask a different one.
MS. MARTINEAU: I think he can say what he thinks the definition is, but I don't think it's --
MR. STAM: That's my question is.
BY MR. STAM:
Q. Dr. Hummer, you're a professor of engineering. You have a doctorate in it. What do you think the dictionary definition of the term engineering is?
MS. MARTINEAU: Same objection as to dictionary. Go ahead and answer.
THE WITNESS: My definition of engineering is the application of scientific principles to solve difficult technical problems.
BY MR. STAM:
Q. Do those scientific principles include the disciplines of math and physics?
A. Yes, and many others as well.
Q. What does -- in traffic engineering, what is the -- in the operation of the roads, what does the yellow light mean?
A. Yellow light is a warning that the red light is about to begin.
Q. Is that its only purpose?

MS. MARTINEAU: You asked him what the definition was.
MR. STAM: No. I asked him what does the yellow light mean.
MS. MARTINEAU: Right, and now you're asking him the purpose, so objection to the form of the question. Go ahead and answer if you can.
BY MR. STAM:
Q. Does it mean anything -- I'll rephrase the question. Does it mean anything other than what you just said, which I believe was something to the effect that yellow warns the drivers that a red light is coming?
A. No. That is the purpose.
Q. What is the purpose of having a minimum length for a yellow light?
A. Well, there's several purposes that come to mind. One purpose is, one very important thing to us in timing the yellow light is uniformity, that drivers approaching an intersection, approaching a signal know what to expect. That is we put a high priority on that and feel like that saves many lives and many collisions, and a minimum yellow time ensures that we're just not flashing the yellow at drivers, that they will know to expect and they do expect at least a certain amount of time.

In addition to that, there is -- needs to be time for drivers to use the information that we've given them to make a decision and either get their vehicle stopped before they cross the stop bar or to decide to proceed through the intersection in a minimum time to get those drivers who are making a decision to go through to indeed get through the intersection.

Q. What information does the driver need to have in order to make that decision?

A. Well, the driver needs a lot of information. Drivers are always bringing in, integrating information from their surroundings. What do they need to have at a very minimum, they need to know what speed they're going, they need to make a judgment of how far it is from where they are to the stop bar, they need to know what the surrounding traffic conditions look like, they need to know what kind of movement, maneuver they're making when they get to the intersection and then there's probably -- if we sat here and listed it, there's a hundred other things that they should use or could use in helping make that decision. It's a -- as drivers we're taking in information from all kinds of different sources constantly.

Q. The term ITE I believe is Institute of Transportation

Engineers. Are you familiar with that?
A. Yes. I'm a member of that organization.
Q. If the driver decides to proceed toward and into the intersection, according to ITE, what speed must the driver go?
A. I don't think ITE prescribes that speed. I'm searching through my mind right now to recall what -- and I don't remember that there's an ITE publication that prescribes a certain speed.
Q. Are you familiar with the 1994 publication by ITE entitled Determining Vehicle signal Change and Clearance Intervals chaired by Beverly Thompson in the report of the Institute of Transportation Engineers dated August 1994?
MS. MARTINEAU: Is that a document you provided to me, Skip?
MR. STAM: At the Shovlin deposition, it was part of Exhibit 4, and it's referenced in the attachments to the Ceccarelli affidavits, but I don't think we've discussed it at previous depositions.
MS. MARTINEAU: Okay. Well, I just object because if he -- it's not -- this is not a memory test.
MR. STAM: Let's do this. Let me continue and then maybe if you could give me your fax number we

could send that to you and then I could ask further questions.

THE WITNESS: Sure. The fax is area code 313-577-3881.

MR. STAM: Do I have to put it to anybody's attention or does that come right to you?

THE WITNESS: Put to it my attention for sure. That's the department fax.

MR. STAM: Let me go ahead and start that fax, but I'll pass on it and we'll come back to it until you've had a chance to look at it. The easiest thing to do is I'll just fax Exhibit 4.

MS. MARTINEAU: Skip, Dr. Hummer just left to let his staff know to look for a fax so he'll be right back.

MR. STAM: Okay.

MARKED BY THE REPORTER:

DEPOSITION EXHIBIT 1

9:37 a.m.

(Off the record at 9:37 a.m.)

(Back on the record at 9:41 a.m.)

MS. MARTINEAU: We're on record. Can you identify what the document is, Skip, for the record.

MR. STAM: Yes. I'm referring to a document which is Exhibit 4 to the Shovlin deposition, and it's entitled Determining Vehicle signal Change and Clearance Intervals dated August 1994 by the Institute of Transportation Engineers, and my first question is is Dr. Hummer familiar with this document.

THE WITNESS: I had seen it referred to in the documents for this case. I looked for it. Our library didn't have it, so this is the first time I've seen it, but I had been aware of it.

BY MR. STAM:

Q. Okay. I'm going to ask you about Page 3, which at the top says Yellow Change Interval Timing and Application Procedures, and just ask if you had time to look at Page 3.

A. Yes.

Q. And in particular formula one on the second column.

A. Yes.

Q. Okay. And in the second particular -- in the first column, the third bullet point.

A. Yes. Sure.

Q. Okay. Let me ask my question then. What is ITE's physics definition of a yellow change interval according to this publication?

MS. MARTINEAU: Objection to the form of the question.

THE WITNESS: Yeah. I'm not sure that ITE refers to physics in this definition. ITE's an organization of engineers providing information for engineering, so I don't know that they're providing a physics definition. The third bullet is not a definition of the yellow time. It's a -- well --

BY MR. STAM:

Q. For this question I'm referring to formula one.

MS. MARTINEAU: He can tell you what the formula he sees on that page is. Is that what you're asking?

MR. STAM: Yes.

THE WITNESS: Okay. Well, formula one is solving for Y, which is the length of the yellow change interval in seconds. Y is equal to two terms. First term is T, which is the driver perception-reaction time, generally assumed to be 1.0 seconds, and then the second term is the vehicle speed, velocity of approaching vehicle in feet per second divided by an acceleration term which is two times the average deceleration in feet per second squared assumed from 10 to 15, so it says here added to a grade correction, which is some multiplier to the standard acceleration for gravity.

BY MR. STAM:

Q. And what is V? Is it the initial speed of the

vehicle, is it the stopped speed of the vehicle or somewhere in between?
A. In the application of this formula, V is the speed of the vehicle at the point at which they're making a decision whether to stop or whether to go. Initial speed, I don't know what that term refers to, and it's certainly not the stopped speed. That would be zero. So the formula wouldn't make any sense in that case, but the application is -- V is the speed at the time the vehicle in question -- the driver in question is making their decision.
Q. Okay. And that is a critical distance away from the intersection, is that correct?
MS. MARTINEAU: Objection to the form of the question.
THE WITNESS: At the -- what the formula is doing is -- let me back up and say this formula is derived from the standard stopping distance formula that engineers have used for probably over a hundred years to design hundreds of billions of dollars worth of roads and signals and signs and all kinds of things, find that stopping distance for a vehicle approaching the signal as we expect and then provide enough time for a vehicle at the -- at that stopping distance away from the stop bar to proceed through the

intersection past the stop bar during the yellow before the red starts.

BY MR. STAM:

Q. Okay. At what speed -- I think you've answered this, but to be clear, at what he speed --

A. Well, this --

Q. -- that it proceeds through? In other words, talking now about a vehicle that is not stopping but a vehicle that is going through. At what speed does that vehicle go through according to this formula?

MS. MARTINEAU: Objection to the form of the question. Vehicles can travel at a variety of speeds and go through the intersection on a yellow light so I'm -- objection to the form of the question.

MR. STAM: I do want to proceed with the question, so would the court reporter read the question back so the witness could remember what it was without the testimony of my friend Ms. Martineau.

(The requested portion of the record was read by the reporter at 9:47 a.m.)

MS. MARTINEAU: Objection to the form of the question.

THE WITNESS: And my answer is that on Page 3 here in the text below the formula, it's not clear what the speed of that vehicle should be. This says vehicle's velocity of approaching vehicle so that's not clear. On the left side of the page down toward the bottom, it does define it, and to quote here, it says approach speed is defined as the higher of the 85th percentile speed or the posted speed limit, so that's I think what this committee was intending for us to do.

BY MR. STAM:

Q. And right above the formula, three lines up, does it also clarify what speed we're talking about by the words at its initial speed? If you would read the introductory sentence before the formula to yourself and then see if you can further answer the question.

A. Sure. Yeah. And you're correct in that above the formula it does say provides yellow time for a vehicle to travel at its initial speed over the distance it would take to stop at a comfortable average deceleration. Again, I'm not clear from this what that term initial speed means, initial speed of what, initial speed where is not clear here.

The typical application of this formula in North Carolina is to use the speed limit, and we cannot, we will not without bankrupting the state design for 100 percent of vehicles going any speed from zero to infinity. That's just not something that engineers can do. We're in the business of designing roads, signals that are practical to drive and use for most drivers within the budget that we have. There's certainly vehicles out there that exceed the speed limit. We wish they wouldn't, but sometimes they choose to do that. The speed limits are often set at the 85th percentile speed anyway, so ITE's verbiage here about using the higher of the 85th percentile or the posted speed. Often that's the same thing anyway.

Furthermore, drivers adjust to the conditions that they are under whether those are bad conditions such as wet and rainy conditions where it's going to take longer to stop or good conditions where drivers are driving a brand-new vehicle on a brand-new piece of pavement on a nice clear day. Drivers, I said before, they sort of integrate all the information they have available and will adjust their speed, will adjust their deceleration rates as well will adjust their perception-reaction times.

So our choice of the speed limit as the speed that drivers can go through the intersection here promotes that uniformity I talked about before and accommodates most drivers and most conditions and allows drivers who choose to, for instance, exceed the speed limit, allows them to adjust and still be able to make a good decision.

Q. Thank you. Using that page with the formula and what you mention on the bottom part of column -- the left-hand column that you referred to, I understood what you said. It's the speed limit or if a speed survey is done the 85th percentile. Can an engineer in determining the yellow change interval use a V which is less than the speed limit?

A. I suppose so. The law, you know the law better than I, but my understanding of the law is that engineers have to follow the book called the Manual of Uniform Traffic Control Devices MUTCD, which I'll call it that from now on --

Q. I'll come to that later.

A. MUTCD specifies that -- I don't have the words right in front of me, but that's for -- specifies that engineers use judgment and apply engineering practice and that's -- sure, there will be times when using a speed below the speed limit is perfectly appropriate. It's -- the MUTCD is meant to promote that uniformity that I've talked about several times but also has to allow for local judgment, local conditions, the experiences of the responsible engineers to come into play, and one great example of a place where we would use lower than the speed limit is when timing for the

end of a protected left turn phase.
Q. So if an engineer uses a V which is less than the -- excuse me. Strike that. Start again.
So if an engineer uses a vehicle in the formula less than the speed limit, does the driver have the distance to stop?
A. Well, a driver who is traveling at the speed limit and encounters that situation where the yellow signal is timed with a V that is less, that driver could stop by using a shorter perception-reaction time, reacting quicker or by decelerating quicker than we had plugged into the formula, and all of this presumes that this driver is exactly at that stopping distance before, and that's, of course, really the case. That's, you know, an exact distance, a certain number of feet away from the stop bar, and almost every signal cycle we'll find drivers who are closer or further away but not exactly at that place when the yellow signal comes on, so, you know, again, it's -- you know, we never are able to accommodate the 100 percent of drivers that are out there, but the vast majority would be able to make a good decision to either go through or get stopped.
Q. Not talking about 100 percent of drivers but just the average or the ideal driver according to North

Carolina DOT usages, isn't the perception-reaction time 1.5 seconds?
A. That's not the average. That 1.5 seconds is quite slow. It's well at the far side of the distribution. The average, and we can pull up some literature here to get more precise with that, but the average perception-reaction time for a driver coming up to the start of a yellow signal is something on the order of .7 seconds. It's far less than one.
Q. All right. But you design according to 1.5 so that a significant minority of drivers won't be involved in crashes, is that not correct?
MS.MARTINEAU: Objection to the form of the question.
THE WITNESS: But that's -- of course. Everything we engineers do out on the road, highway, signal design, sign design, everything is to try to avoid crashes.
BY MR. STAM:
Q. So -- and you're aware that NCDOT bases its decisions on 11.2 seconds per second for deceleration?
MS. MARTINEAU: Objection to the form of the question. Are you talking about NCDOT's yellow time formula?
BY MR. STAM:

Q. Go ahead and answer the question, Dr. Hummer.

MS. MARTINEAU: Same objection. Go ahead.

THE WITNESS: My understanding is again we could pull up a document here to see that, but the current NCDOT practice is to use 11.2 feet per second squared deceleration rate in the yellow time formula.

BY MR. STAM:

Q. Okay. If the speed limit is 45 miles an hour, according to ITE and the laws of motion as you understand it, can a driver decelerate, say, quickly from 45 miles an hour down to 10 miles an hour and still proceed through or does he have to proceed at 45 miles an hour for the other initial speed to get through the intersection?

MS. MARTINEAU: Objection to the form of the question as to -- well, just objection to the form of the question. Answer if you can.

THE WITNESS: Yeah. That's a hypothetical. There's so many things I'd need to know about the specifics there before answering that. There's too many other things going on. I can't answer that.

BY MR. STAM:

Q. All right. Let's hypothesize zero grade, clear day, 90-degree intersection, ordinary care, ordinary driver, no obstructions. If the speed limit is 45 miles per hour according to the ITE formula, for a driver who wants to proceed through the intersection, is the driver to proceed through at 45 miles an hour or something equivalent to it or can the driver, say, decelerate to 10 miles an hour and still proceed through the intersection?

MS. MARTINEAU: Same objection. Do you want to give him in your hypothetical where the driver is when he first makes a decision to proceed through the intersection? Because I think that's -- we don't know that.

BY MR. STAM:

Q. Dr. Hummer, if you would see if you could answer the question.

A. I really can't. Is the driver 500 feet away or 50 feet away, and --

Q. All right. Let's suppose the driver is 294 feet, which according to the calculations of the plaintiff is -- and using the laws of physics is the critical distance, so let's, in addition to the other assumptions that I stated in the previous question, state that the driver's at a -- 294 feet away from the entry to the intersection. Does the driver then have to proceed at the speed limit or the initial speed to get through or could the driver decelerate to, say, 10 miles an hour and still make it through?

MS. MARTINEAU: Objection to the form of the question. Is this a straight through? Is he going straight?

MR. STAM: Yes. Well, actually the answer to that question doesn't matter. I mean, that factor doesn't matter, so let's leave that to the side.

BY MR. STAM:

Q. Can you answer that question, Dr. Hummer?

MS. MARTINEAU: Well, same objection.

THE WITNESS: If I'm understanding correctly, the answer is that that driver at 294 feet away with the amount of yellow that the ITE formula recommends as applied in North Carolina, that driver would have to proceed -- keep proceeding at 45 miles an hour or higher to be able to cross the stop bar before the yellow ends.

BY MR. STAM:

Q. On that piece of paper, could we mark that as Exhibit 2 to your deposition, please.

A. I was going to add to my answer, though, if I could.

Q. Oh, please, please.

A. That a driver at 45 miles per hour at the 294 foot distance, when the yellow occurs, that driver starts to decelerate from 45 to 10, as you mentioned, we would hope, we would expect that that driver would just come to a stop if they -- and we don't know why they're decelerating there, but if they're -- you know, something in the road, something -- you know, some extraordinary condition there that they come to a stop and that the 294 feet, if I am understanding this correctly, would have given them enough time to come to a stop if they need to and that they could always, like we said earlier, adjust, react quicker, decelerate at a greater rate than the formula allows for as well, so -- okay. That's my answer.

Q. All right. Some drivers think that a yellow light means proceed with caution and that caution means slow down, and my question is this: If a driver going at the speed limit within the critical distance, let's say at or closer than 294 feet going 45 miles an hour, the posted speed limit, all the other assumptions I gave previously, clear day, no other interruptions, 90-degree angle, no grade, if that driver decides to be cautious and, therefore, slow down to some speed below 45 miles per hour, whether it's 10 miles an hour or 20 or 30, will that driver have enough distance to clear the intersection if the driver slows down?

MS. MARTINEAU: I just want to object not to the question but to the -- to your statements before your question. Go ahead and answer.

THE WITNESS: Yeah. First response is that, of course, we hope all drivers are cautious at all times going through all intersections, and drivers that slow down as you described certainly are not the only cautious ones out there and don't have a sort of corner on that market.

Second response is that if drivers have that perception that that's what the yellow means, then we need to do better in our driver education because that's certainly not what we intended, and my observation in almost 30 years in this business is that's not how most drivers behave out on the roads. They may profess that in some survey, but what they actually do out on the roads in response to yellow signals is quite different.

The other response I have is that, as I said before, yes, the ITE yellow time formula is designed get a driver across the stop bar during the yellow who was at the stopping distance when the yellow first came on, and drivers at that constant speed of the speed limit and anybody who drives -- was at that speed limit and then slows down and still tries to make it through the yellow will not do so. That's easy to show, fortunately, I think a pretty

rare condition.
Q. And in my previous question I misused one word so I'm going to correct it. I don't think it will make a difference to your answer, but please tell me if it did. I think what I said in the question is would they have enough distance to clear the intersection when what I should have said and meant to say was would they have enough distance to enter the intersection. If I change that term in my question, does it change your answer?
A. No. Thank you for that. I guess I was hearing you to say enter the intersection anyway. Cross the stop bar is the key thing for the purpose of the yellow calculation, so no problem there.
Q. All right. When you drive personally, Dr. Hummer, do you ever have to tap your brakes for cars emerging or egressing from business entrances in front of you or to accommodate the movement of cars in front of you?
A. Of course.
Q. As the driver such as you must be cautious and slow down for these type of obstacles, in the case of entering an intersection, will these kinds of real life actions violate ITE's mandate for the use of its yellow change interval formula?
A. Well, no. Like I said before, we can't design for the

100 percent case. There's no formula that will do that and be practical on the roads would provide for that uniformity that we talked about and have the other facts which I'd like to get into of the bad effects of longer yellow times, to keep yellow times practical and somewhat uniform.

Q. I'm going to ask about that also. We'll give you a chance, but --

MS. MARTINEAU: Let him finish his question if you would. Finish his answer.

BY MR. STAM:

Q. You can finish, but I'm not sure you have to go off on that subject to answer this question because I will ask you about that.

A. Right. So in the case you mentioned, my professional opinion is that's rare. Most drivers are not going to do that, and, again, we're talking about the slimmest of probabilities already with the driver going exactly the speed limit at exactly 294 feet away and then who chooses to decelerate at exactly 11.2 feet per second squared.

Most drivers adjust to the conditions around them, and, you know, seeing somebody coming out from a driveway, seeing somebody about to merge into their lane will already be off the accelerator and may already be on the brake well before that person gets into their lane, and so in that situation, they're going to adjust and make the best decision they can make for themselves at that time, and in all likelihood they're going to have enough yellow to make a good decision, so, you know, it works for the huge vast majority of drivers in most times in most circumstances.

Q. Are you implying or stating that the DOT's specifications do not work for its own ideal driver as set out in the specifications?

A. No. A driver that has exactly 1.5 seconds perception-reaction time and 11.2 seconds feet per second squared deceleration rate driving exactly at the speed limit at exactly that distance away from the stop bar will be able to make a good decision and, for that matter, at any other distance away from the intersection will be able to make a good decision, so, no. The formula works the way it was supposed to.

Q. Okay. Dr. Hummer, this is a multiple-choice question with four possible -- I'd like to suggest four possible answers or you can come up with a fifth or sixth, so let me ask the entire question.

Using the DOT's assumptions for the ideal driver, that is the one who perceives and reacts in

1.5 seconds and decelerates at 11.2 feet per second squared, what is the length of the yellow change interval, four possibilities or a fifth, whatever, is it 50 percent of the time it takes a driver to stop, 100 percent of the time it takes a driver to stop, 150 percent of the time it takes a driver to stop or something else?

MS. MARTINEAU: Objection to the form of the question as to ideal -- DOT's assumptions for ideal driver.

THE WITNESS: And the question doesn't make any sense to me. The yellow time formula provides time for a driver at that stopping distance away from the intersection to go through the intersection so --

MS. MARTINEAU: Or the stop --

THE WITNESS: Or to pass -- yeah, pass the stop bar. So I don't understand the way the question was phrased. The yellow time formula is not trying to do what you describe if I heard it right.

BY MR. STAM:

Q. All right. I'll take that answer to my question.

Do you know who Denos Gazis is?

A. He's the author of the classic paper in 1959. I don't know that I ever met him or heard him speak.

Q. Well, my question is are you -- obviously you're

familiar with his 1959 paper, The Problem of the Amber Signal Light in Traffic Flow?
A. Yes.
Q. What is a dilemma zone?
A. A dilemma zone is a space on the roadway on an approach to an intersection where a driver in that space has no chance to get stopped before crossing the stop bar at the onset of a yellow and has no chance to proceed past the stop bar before the yellow ends and that is to stop or proceed according to their capabilities.
Q. If you still have it handy, I think it's Exhibit 2, the Shovlin deposition, it's the ITE 1994 paper, Page 3. You still have that handy?
A. Oh, yeah. Yeah, sure.
Q. If you could look in the first column and the third bullet point, but it's actually a square, I don't know if you call that a bullet point, is that what is being described in that third bullet point? And I'll just read it for the record. When approaching an intersection, a driver's faced with one of several situations when the yellow change interval appears, and then the third alternate is the driver can neither stop comfortably nor proceed into and clear the intersection before the appearance of a conflicting

green indication. Is that what is referred to as a dilemma zone?

A. That's maybe just slightly different from what I described, but generally speaking, that's a dilemma zone. My definition of it did not include the clear the intersection part before the appearance of a conflicting green, but in North Carolina we use an all-red indication after the yellow to take care of clearing the intersection, so with that slight difference, generally that's a dilemma zone, sure.

Q. What is an indecision zone?

A. That's not a standard term in traffic engineering as far as I know.

Q. I may come back to that.

According to the ITE formula, what would cause a dilemma zone?

A. If we apply the ITE formula to time the yellow signal, a driver who was exceeding the speed limit could potentially be in a dilemma zone. A driver who was not able to decelerate at at least the assumed rate, 11.2 feet per second squared, in North Carolina could be in a dilemma zone. A driver who didn't react within the 1.5 seconds could be in a dilemma zone, but --

Q. Are those -- I'm thinking of the word. Ors and ands.

In other words, are those four different possibilities, each of which could cause it, or are you saying all four of those would have to occur to create a dilemma zone?

A. No. That's each of those -- any of those individually could create a dilemma zone. Of course, a combination of those could create a dilemma zone as well.

Q. For example, a driver of a vehicle who is not exceeding the speed limit at any point could find him or herself in a dilemma zone through no fault of his or her own?

MS. MARTINEAU: Objection to the form of the question. You can answer.

THE WITNESS: Yeah. No, I would not characterize it that way at all. The 1.5 second perception-reaction time is quite generous, as I mentioned before, really over twice the average, generally speaking, and it's really quite slow. That's got to be a driver that's not paying attention, attention diverted for some reason, so a driver who's not able to decelerate at 11.2 feet per second squared, we have to question whether that vehicle should be on the road.

Most drivers and vehicles are able to decelerate at something like 20 feet per second squared on dry pavement and at least 13, 14, 15 or so feet per second squared or on wet pavement without any harmful effects, and in an emergency situation, drivers can decelerate at something like 30 feet per second squared. So 11.2 is really pretty poor performance by that driver and vehicle, and, of course, exceeding the speed limit is illegal so I don't -- I don't agree with your characterization there.

BY MR. STAM:

Q. Well, let me ask it this way. If a driver suppose approaching an intersection at 45 miles per hour, no grade, clear day, no wet pavement, if this driver never exceeds the posted speed limit, does have a perception-reaction time of 1.5 seconds, is able to decelerate at 11.2 feet per second, with that driver, is there a dilemma zone according to the ITE formula?

A. No. No. The ITE formula makes sure that that driver has a good decision to make. Drivers can always make bad decisions, and many do, unfortunately. Again, you know, it's -- we can't find a way to prevent that, unfortunately, with our current technology and current budgets, but that driver at least has a decision to make to either stop or proceed, and most of the time drivers like that will make the correct decision and the results at most of the intersections are good. It works.

Q. Now, I just want to be clear because you answered two different ways I think, but I don't want to put words in your mouth. At the end you said most of the time and so let's be clear. Let me be clear. If I'm not clear on this, let me know.

Intersection's coming up, 45 miles an hour. This driver does perceive and react in 1.5 seconds per second. This driver is able and does decelerate at 11.2 feet per second per second. Can this driver that I hypothesize in this question be caught in a dilemma zone which Gazis describes and which is also described as a third bullet point on the first column of Page 3 of Exhibit 2, the ITE paper, if that driver --

MS. MARTINEAU: And you're saying that they're at the stopping distance when they first see the yellow light?

MR. STAM: Just inside it, right.

THE WITNESS: Just inside. There is no dilemma zone for that driver. That driver has a decision to make, and if they're just inside the stopping distance, then they will have enough yellow to proceed through the intersection. They should choose to proceed.

BY MR. STAM:
Q.   All right. Suppose that that driver is going to turn left at that intersection. All the other assumptions are the same as in my last question. Can that driver be caught in a dilemma zone? The driver never exceeds the speed limit, perceives and reacts in 1.5 seconds or less, decelerates at 11.2 seconds per second or faster -- or, excuse me. The faster's not the right word. Decelerates at 11.2 seconds per second. Can that driver be caught in a dilemma zone described by Gazis and also -- and/or in the third bullet point of the first column Plaintiff's Exhibit 2?
A.   Well, North Carolina practice is not to design yellow times for -- at the end of a protected left turn phase for a driver going the speed limit. The practice is typically to use a speed of 20 miles an hour and sometimes to use a higher speed depending on the conditions. We could talk about those conditions.
There's many that a good traffic engineer should look at before making that decision, but typically 20 miles an hour, so the supposition that, you know, we would have a driver approaching it at 45, well, drivers don't approach the end of a protected left turn at 45 miles an hour. That's -- you know, we have a long history, much practice and experience and

data that say 20 or so is appropriate for that condition and so our timing of the yellow signal at the end of a protected left turn phase is typically based on that 20 miles an hour speed.
Q. Measured where?
A. Let me finish. A driver going 45 would have a dilemma zone. That's not something we're, by our standard engineering practice, are designing for. A driver driving 20 will not have a dilemma zone and will use the yellow long enough to eliminate that.
Q. Let me repeat my question. Where is the 20 miles per hour measured?
MS. MARTINEAU: That's a different -- you haven't asked that question yet, but object to the form of the question. Go ahead and answer.
THE WITNESS: The 20 miles an hour would be at the stopping distance. That's going to be typically 100, maybe 200 feet upstream of the stop bar.
BY MR. STAM:
Q. Does the driver know that?
A. Sure. Most drivers have gained the experience, have been through protected left turn phases and made many left turns as they drive through the years, gain experience. This is part of learning to drive. We

count on that.

As I said before, the driver's integrating information from all kind of sources including looking at the lengths of yellows, and, in fact, you know, I said several times before we count on that with the business of trying to be uniform and give drivers what they expect. Well, drivers have an expectation because they've been through many somewhat similar intersections before and are -- have this sort of embedded after, you know, just a short bit of experience, so, yeah, I think that generally drivers are aware of this and we, traffic engineers, work hard to create that awareness.

Q. All right. Are you familiar with the intersection where Lori Millette was cited?

MS. MARTINEAU: Do you know which one that is?

MR. STAM: Kildaire Farm turning left -- going north turning left on Cary Parkway.

MS. MARTINEAU: Is it okay, Paul, if I get that traffic signal plan out so he can take a look at it?

MR. STAM: Sure, but it actually would be any left turning intersection with a zero grade, 90-degree angle.

THE WITNESS: And I used to live just down the street from that anyway, down Cary Parkway, about a mile from there. I lived they're for ten years so I'm --

BY MR. STAM:

Q. What years were those?

A. -- very aware of that. I lived there 1992 to 2001 I think in the Kildaire Farm subdivision, so I'm very familiar with --

Q. You're familiar with that intersection?

A. Yes.

Q. We'll probably get into this in more detail later, but suppose Lori Millette has been driving that for years and it's been a four-second yellow change interval and then they decide to make it a three-second interval. You're relying on the yellow change interval. If you're relying on drivers to know what speed they can go differently than the posted speed limit, you see how this might affect drivers?

A. A change -- any kind of change out on the road -- a change in the yellow time is a difficult thing. We don't like to do that. We have to do that sometimes. There's, you know, good reasons I'm sure to make that change and other changes. We -- engineers, we weigh the cost of the change, and there will be some, and surprise drivers and such against the benefit from the change, which I'm sure there were many.

I would add, too, in addition to relying on the driver's prior experience about how long the yellow is -- well, I think I did say before, too, that there's many other clues that drivers are using and integrating as they make their decisions. One of the big ones is, and applies to that intersection, is the turns are tight. The left turn at that place, at many of our intersections, allows a turning speed of something like 15 to 20 miles an hour.

That's very clear in our professional literature, in the design manual that we all use to design the roads, that's the policy on geometric design of highways by an organization called AASHTO, A-A-S-H-T-O, that the speed for a left turn, designed speed, which is on the high side, is going to be something on the order of 15 to 20 miles per hour and could be less if the turn is even tighter, so, you know -- and drivers know this and experience -- drivers with experience at that intersection know that, too.

Q. Is that the speed approaching the intersection or the approach -- the speed within the intersection?

A. That is the speed within the intersection, but there's --

Q. Not the approach speed?

A. Well, the drivers are in the process -- they're going to need to go 15 to 20 miles an hour on the high side within the turn. Often during the left turn phase they're following other drivers who are going 15 to 20 at the most within the turn, and so it doesn't -- and we're only talking about, as I said before, 100, maybe 200 feet in front of the stop bar anyway, so, no, we're not designing for somebody to go 45 miles per hour 100 to 200 feet before the stop bar and then hit the brakes really hard to get to 15 to 20 miles an hour to make the turn just past the stop bar. That's -- most drivers will make a much smoother deceleration, will kind of cruise in through that left turn.

Let's not forget as well that all the drivers at that place, at all left turn lanes had to shift over from the through lane to the left turn lane before they're making their turn anyway and had to slow down to do that, and sometimes, depending on the intersection and the shape of the taper, that's a relatively -- that movement has to be made relatively slowly, too, so it's just not plausible for drivers to be going 40 through the sort of stopping distance that we're talking about here, 40, 45, whatever, and then slowing down to 15 or 20 during the turn. That just -- that's not what we design for.

Q. To be clear, my understanding is there's really two speed limits. One is the posted speed limit, for example, 45 miles an hour, but every driver has -- is forbidden to drive without due care and caution though as to cause accidents, but my question is really different than that. I think you're assuming that all these left turning vehicles are in a cue lined up right there.

If a driver has a clear, unimpeded path of the intersection, the signal is green, shows a green arrow are left turning drivers allowed to go the speed limit approaching the intersection so long as they exercise due care and caution within the intersection?

A. You know, I guess legally, sure, the speed limit is 45, and as long as they stay below 45, I don't think the police department will be able to give them a ticket. That's just not plausible. Again, does it ever happen? Can somebody in a race car take that turn at 45 that we've designed for 20 or less? Probably. Should we set the yellow time for that, that -- again, I really wanted to get into at some point here the negative effects of extending yellow

times, but, you know, without extending the yellow, should we be designing for that diver who is sort of ripping into that turn at quite high speed? I don't think so.
Q. I understand you want to talk about that. Let me ask you at this point what are the negative effects of -- that you see of having yellow change intervals that are, quote, too long, end quote?
A. Right. Yeah. Thanks. There are actually two major ones that I could think of, and one is the lack of uniformity, and the MUTCD could not be clearer on this point. It's the reason the whole manual exists. It's a -- the central pillar in the whole highway system is as much uniformity as possible worldwide, nationwide, statewide as much as we can manage because our driver population is so diverse and people are -- we're driving -- trying to accommodate people who have never seen this place for the first time, the uniformity's there, and if we start to allow some places to have yellow times that are more than twice other places, we'll lose that and drivers will not know what to expect, and crashes occur because of that, that lack of uniformity. It's just a central thing to the way -- the standard engineering practice.
The second point is with a long yellow,

that we lose capacity at the intersection. The reference that we use to calculate that is called the highway capacity manual. It's a standard reference across the U.S. and in many other countries.

The equation for capacity at a signalized intersection has only three terms. One of those terms is called effective green time, and that's the part of the signal phase that drivers actually use. Effective green time is the actual green time plus the actual yellow time plus the all-red time. In other words, the full phase minus the loss time. Loss time is time that's wasted. Nobody's going through the intersection. Well, the longer the yellow, the higher the loss time.

The highway capacity manual instructs us that loss time at the end of a phase equals the yellow plus the all-red minus two seconds. The longer the yellow --

Q. Is it two seconds how long it takes the green people to get going?

A. No. That's at the beginning of the phase. That's another bit of loss time called beginning loss time.

Q. Please continue. I'm sorry.

A. There's two bits of loss time. There's some at the beginning, there's some at the end. Longer yellow means longer ending loss time at the end of the phase, and that's on every phase. So, for instance, at Cary Parkway and Kildaire Farm Road, that signal has basically four phases. If we extend the yellow let's say two seconds each of those phases, that's eight more seconds of wasted time for everybody at the intersection, loss capacity, and then that compounds, of course, over all of the cycles throughout an hour or peak hour and what have you.

That loss of capacity is -- not only wastes gas and adds to the carbon emissions and all that bad stuff, but it has a safety effect as well. The cues grow longer at the intersection which leads to more rear-end collisions at the back of the cue. Drivers react to the long cues by starting to cut through neighborhoods, and believe me, in my time as a resident of Kildaire Farm, we worried a lot about drivers cutting through our neighborhoods already at that intersection, and we sure didn't want to lose capacity out there and have even more cut-through traffic. There's all kinds of ways that that loss of capacity turns out, you know, not only to lose efficiency, waste money, waste gas, et cetera, but also has a safety effect as well in lots of different ways, so we engineers struggle hard with this. It's not an easy solution to try to keep that bounded and to try to keep the yellow reasonable and avoid those very nasty negative effects.

Q. Let's talk about that. Before I do that, is there a third reason besides lack of uniformity and capacity?

A. Those are the two that occur to me here. I can look back at my notes perhaps, but those are the two that occur to me.

Q. Let me ask about the effective green at that particular intersection of Cary Parkway and Kildaire Farm that you're familiar with. In a given hour, I would guess the cars approaching from each side get, therefore, somewhat less than 30 minutes of effective green. I don't know how much less than 30 seconds it would be, but subtracting all the whatever you called it, the down time, the two seconds --

A. Right, loss time.

Q. Loss time. So it would be something less than 30 minutes out of every hour. Could you give a ballpark thought? I mean, would it be like 29 minutes of every hour or --

A. Roughly speaking, at an intersection like that with typical times, about 10 percent of the time is already lost in that loss time. The remaining 90 percent of the time is split up with maybe -- let me -- I don't

like to do math on the fly here, but perhaps --
Q. It's an estimate. I'm not looking for --
A. Sure. Thirty percent of the time for the east and west through, 30 percent of the time for the north and south through, 15 percent of the time for the north and south left turn, 15 percent of the time for the east and west left turn. I think that adds up to 100 percent.
Q. Okay. So let's take the driver going east and west that would be affected by my next question. They would have effective green light to go through that intersection of about how much per hour? Something less than 30 minutes but --
A. Oh, yeah. Thirty percent of 60 minutes, that's again math on the fly here, but I think that's something like 18 minutes.
Q. Okay. So they have 18 minutes of effective green time. Now, Lori Millette's light after a time period of being four seconds allowed for the yellow change interval went to three seconds, and another exhibit you'll see later shows the dramatic results of that. If it were four seconds instead of three seconds, how much would that reduce from the effective time in any given hour for east-west traffic? They had 18 minutes before. If we added back a second for Lori Millette's

left turn, in an hour, how many -- well, we could calculate it. In an hour, how many left turn yellow change intervals in Lori Millette's direction are there in an hour?

MS. MARTINEAU: Object to the form of the question. What about the all-red?

MR. STAM: Well, that doesn't change this question.

THE WITNESS: Yeah. Let me --

BY MR. STAM:

Q. Because you could always -- if you had added a second back for yellow, you could always reduce a second for the all-red and it would amount to the same -- as far as safety is concerned, it would amount to the same thing.

MS. MARTINEAU: Objection to the form of the question.

BY MR. STAM:

Q. My question is if you had four seconds instead of three seconds for cars traveling as Lori Millette's was traveling, how many -- how much time would that detract from the effective green for east-west traffic?

A. Well, that's -- if we were only worried about that phase, the left turn for the north and south street, one second taken away -- well, let's put it this way. One extra second of -- added to the north and south left turn takes away that time from everybody else. A typical signal cycle at a place like this is maybe 120 seconds. I don't know what it is exactly at this place, but just roughly, so, you know, that's -- one divided by 120 is in the neighborhood of one percent loss of capacity, but, you know, almost always when we're making changes like this, we're also making that same change to the east-west left turn and another one percent there, but --

Q. I know, but I'm asking for the east-west driver who has 18 minutes of effective green light every hour. How much effective green time would the east-west driver have per hour if we added one second to Lori Millette's yellow change interval?

A. Well, my back-of-the-envelope estimate there would be a one percent loss in capacity for that one second change.

Q. Let me do the math here. I can take -- 18 minutes times 60 would give me 11 -- and you tell me if I'm right on this -- 1,140 seconds.

MS. MARTINEAU: We don't have a calculator here, Skip.

BY MR. STAM:

Q. All right. One percent of 1,140 would be 11 and a half seconds, so if -- and you just tell me if this sounds right. Instead of 18 minutes of effective time, the east-west traffic would have 17 minutes and 49 seconds.

MS. MARTINEAU: We're not going to do math. I mean --

BY MR. STAM:

Q. Does that sound right, Dr. Hummer?

A. Well, for this very rare hypothetical that you're proposing here, sure, that's about right.

Q. I mean, east-west traffic would lose eleven seconds -- 11 and a half seconds per hour. Does that sound about right?

A. For that rare hypothetical you're proposing there, sure.

Q. It wasn't a hypothetical because they did raise it -- lower it from four seconds to three seconds at a point in time, did they not?

A. They -- my understanding is that they did, but that -- almost always in concert with that they would be changing the phasing -- changing the timing of other phases as well.

Q. Which would mean that the north-south traffic would also go from 18 minutes per hour effective green time to 17 minutes and 48 and a half seconds of effective green time?

A. Well, right. Everybody around the intersection loses that one percent capacity, not just the east-west through movement, and the -- you know, almost always we'd be changing the yellow time for the east-west left turn as well, that phase, and take away another second there.

One thing I want to add here at this point is that the effective capacity loss is not linear. That is to say if we lose one percent of capacity, the effect on delay could actually be much more than one percent, 5 percent, 10 percent, who knows. The curve is not linear. The effects of even a small change in capacity at the wrong time in the wrong place can be quite large in effect to the driver driving through there.

Q. For sound engineering in this field, does traffic capacity or safety issues have priority?

A. Safety is the number one goal of all transportation agencies.

Q. Do you believe that sound physics creates dilemma zones as described by Denos Gazis?

MS. MARTINEAU: Do you want to point out what you're talking about so he can look at --

BY MR. STAM:
Q. Do you believe that sound engineering practices create dilemma zones as described by Denos Gazis in his 1959 paper?
MS. MARTINEAU: Do you want him to look at that paper? We don't have it in front of us.
MR. STAM: He's already told us what it -- I'll ask it a different way.
BY MR. STAM:
Q. Do you believe sound engineering practices create dilemma zones as described in Plaintiff's Exhibit Number 2, Page 3, left column, bullet point number three?
A. No. No. Sound engineering practices eliminate dilemma zones as described there. If we apply sound engineering practices, apply the yellow time equation as I've discussed, that all drivers will have the opportunity to make a good decision to get stopped or proceed through.
Q. If the judge decides that current engineering practices in North Carolina in fact do create dilemma zones as described in Plaintiff's Exhibit Number 2, Page 3, first column, third bullet point, would you agree that those engineering practices are not sound engineering practices?

MS. MARTINEAU: Objection to the form of the question.

THE WITNESS: Well, I -- who am I to argue with the judge? We engineers obey the law. If the judge's decision becomes law, we'll adjust to that and obey the law and do what's legally required.

BY MR. STAM:

Q. According to engineering standards of care, are engineers in traffic signal design responsible to accommodate the requirements of physics and for a range of reasonable driver behavior?

MS. MARTINEAU: Objection to the form of the question. Go ahead and answer.

THE WITNESS: Well, we certainly can't violate the laws of physics. That doesn't work on earth gravity anyway, and we have to do -- we want to -- we integrate in what we know about human factors and vehicle performance and a whole range of other aspects as well in putting together these kinds of decisions and applying these practices.

BY MR. STAM:

Q. In the literature on this subject, are you familiar with the term critical distance?

A. I've seen it, not a term I would use -- not a term I have used often, but I have seen the term, sure.

Q. Is it related to safe stopping distance?
MS. MARTINEAU: Objection to the form of the question.
THE WITNESS: Yeah, and it -- I think so. Again, the term safe stopping distance, I've seen it out there. I'm not in total agreement with that, either, but I've seen it. I think it is related generally, sure.
BY MR. STAM:
Q. All right. Does the ITE formula for yellow time for the yellow change interval also embed the formula to compute the critical distance?
A. I'll phrase it this way. I think I said this earlier. The ITE yellow time formula as shown here on Page 3 of Exhibit 2 starts from the stopping distance formula that we all use for a wide variety of applications and then use that stopping distance in the way described before, so, sure, this formula starts from the stopping distance formula.
Q. In that same formula does changing V in the equation change the length of the critical distance?
A. In the stopping distance formula, sure, yes.
Q. That same formula and the laws of physics, at what specific location on the road would the traffic engineer measure the V?

MS. MARTINEAU: Objection to the form of the question.

BY MR. STAM:

Q. Where would the -- where must the traffic engineer measure the V? And we sort of touched on that an hour ago. I want to make sure we're still on the same page.

A. Right. That's -- the speed is most important at the -- at that stopping distance at that place that we are trying to calculate. It's a bit of a circular process here, is going to do the initial speed study we have to sort of guess where that's going to be, collect our data, then do the calculation of what the actual stopping distance turns out to be. It's difficult to get that exactly right as with any iteration of the process in the first time, but generally speaking we're trying to get the speed at or as near as we can to that stopping distance.

MR. STAM: If you'll give me just a moment, I may be able to edit my remaining questions, although they're quite a few. Can you give me a minute here?

MS. MARTINEAU: Do you want to go off the record for a few minutes?

MR. STAM: Let's take five minutes.

MS. MARTINEAU: Okay.

(Off the record at 10:52 a.m.)
(Back on the record at 10:59 a.m.)
MARKED BY THE REPORTER:
DEPOSITION EXHIBIT 2
10:59 a.m.
MR. STAM: Back on the record.
BY MR. STAM:
Q. Dr. Hummer, suppose the speed limit's 45 miles per hour but a traffic engineer plugs a value for V of 35 miles an hour into the ITE yellow change interval formula. Will the resulting yellow change interval allow all drivers traveling greater than 35 miles per hour stop safely using DOT assumptions about perception-reaction time and decelerations?
MS. MARTINEAU: Objection to the form of the question. Go ahead and answer.
THE WITNESS: No. And let's be clear. That formula didn't allow all drivers to do that beforehand. The formula allowed all drivers to make a decision beforehand, and the formula as you described with that change in speed would create a dilemma zone for those particular drivers with those particular assumptions, but I really must add, as I said before, that drivers adjust, and in my opinion, most drivers going a slightly faster speed than we put into the

formula finding themselves in or near that dilemma zone would decelerate faster, would proceed faster, would find a way still to make a good decision and not have to proceed through the -- past the stop bar on red.

BY MR. STAM:

Q. Okay. Here I'm referring to Walnut Street and Meeting Place, and I wonder if you're familiar with that intersection, the turn into Crossroads Shopping Center.

A. I am familiar with that one, yes.

MR. STAM: And if you want to bring up, Ms. Martineau, the signal plan for that, that's fine.

MS. MARTINEAU: Sure. Hold on.

THE WITNESS: We're looking at it.

BY MR. STAM:

Q. If this road had a 45 miles per hour speed limit, a driver is going to turn left at Meeting Place to turn into the shopping center and is far from the intersection, say two to 300 feet long -- two to 300 feet away, the left turn lane is long, over 300 feet, there's no cue waiting to turn left, the arrow is green, can that left turn lane accommodate a 45 miles per hour driver up until the point the driver needs to slow down to proceed safely?

A. That driver's probably going to have to slow down to make the move over into the left turn lane. If I recall correctly, that left turn lane is a finite distance, and the driver would have to make a maneuver through the taper there to get into the left turn lane, so some slowing there. The turn is a relatively sharp one. The speed in the turn in this place is probably on average no more than 20 miles an hour, probably average less than that.

Q. Does your signal plan show how long the left turn lane is?

A. I don't think so. This particular drawing there's a break mark here so we have -- actually I think it's -- we could determine from the scale drawing here the length of the full dual left turn lanes. The length of the taper because of the -- where they had a break doesn't look like it could be determined here. We could get -- I think we could scale off and get the length of the full left turn lanes anyway.

Q. Well, if there's no cue -- how -- at what point on that signal plan does the driver have to reduce speed to 20 miles per hour?

MS. MARTINEAU: Objection to the form of the question.

THE WITNESS: The driver's going to have to get speed reduced, and, you know, my estimate would be something less than 20 miles an hour on average in the turn and so I don't know precisely, but some distance before entering the turn the driver's going to need to get slowed down on average past 20, so I don't know what the distance is there, but it will be some distance before the stop bar.

BY MR. STAM:

Q. We'll come to another exhibit called determination of yellow change and red clearance intervals which is part of the signal design section, transportation, mobility and safety division, DOT, and it says in a note, I'm sure you've seen this, for most left turns assume a speed of 20 miles an hour -- 30 miles per hour, and I'm just trying to ask you as a designated witness -- expert witness for the town, where is that speed to be measured?

MS. MARTINEAU: Objection to the form of the question, as if it's to be measured.

THE WITNESS: Yeah. And it's difficult to say and it would be difficult for the town engineers to do that as well. It's some distance prior to the stop bar. We -- to do a speed study, we would probably want to go out there and watch it for a while, watch the traffic for a while and try to see

where that location is. It's not -- I don't think there's an easy formula application to do this. I should add, too, in this particular place, in this particular case of approach to a protected left turn, that this is a very difficult speed study to perform. There's not -- our current equipment, our current technology is really unsuited to the job of even performing a speed study at this place. Most of the tubes, loops, electromagnetic counting equipment and such that we have doesn't accurately measure speeds below 15 miles an hour so --
BY MR. STAM:
Q. And is that why the --
A. Let me finish, please. This is a, you know, very difficult study to perform, and that is why in most places we're relying on the judgment of the engineer, the engineer's consultant who's very familiar with the area and has made field visits and watched, and their judgment of the speed is probably the best information we have.
Q. Looking at that signal plan for Walnut Street and Meeting Place, we've gotten out of scale and it looks like -- on the map itself it looks like in excess of 20 feet. Would you take the scale and see if you can estimate the minimum length of that left turn lane?

A. Sure. Hang on a second. If I scale it correctly, the full width, dual left turn lane, this is southbound Walnut heading toward Meeting Street, looks to be about 215 feet, and then again it doesn't include the taper which is pretty impossible to measure with this drawing because of the break point.
Q. Okay. There are two left turn lanes there, is that correct?
A. Yes. It's a dual left turn lane.
Q. So you have one left turn lane that goes back even farther, then it doubles at 215 feet, is that about right?
A. What I can confirm from this drawing is that the full dual left turn lane configuration is about 215 feet long. I don't know what happens upstream of that.
Q. A different question. A road has a 45 miles per hour speed limit, zero grade, perpendicular cross traffic. A driver wants to turn -- intends to turn left but is still far from the intersection, say two or 300 feet. The left turn lane is short, say 100 feet, but there's no cue waiting to turn left. The arrow is green. Can this driver who is still in a common lane travel at 45 miles of hour switch to the left turn lane when the left turn lane starts?
MS. MARTINEAU: Objection to the form of

the question.

THE WITNESS: Yeah. I'm sorry. I need that question repeated. I didn't understand it.

BY MR. STAM:

Q. The road has a 45 miles per hour speed limit sign for the approaching driver, zero grade, perpendicular intersection. The driver intends to turn left but is still far from the intersection, and by that I mean at least two to 300 feet, but the left turn lane is short, say just 100 feet before the intersection but there's no cue waiting to turn left. The arrow is green. Can this driver who is still in the common lane travel at 45 miles an hour then switch to the left turn lane when the left turn lane starts?

A. I doubt it. A left turn lane only 100 feet long, that implies a short little taper, and that driver's probably going to have to slow down a good bit just to get themselves into the left turn lane before starting to turn, so that doesn't sound like that they could be traveling 45 at the place you're talking about. You know, again, there's so many factors that work here in real intersections. We can't sit here and second guess what people see out in the field and actually observe, but my guess in that instance you're mentioning, there is no -- they're going to have to slow down a good bit to get into that left turn lane before making their maneuver.

Q. Assume the left lane is a center road lane. You know what I mean? Like you have five lanes and the one in the middle -- there's no taper. There's no taper, just a center lane.

A. Well, in that case, the pavement markings direct when the driver should enter that lane. There's a -- the pavement markings turn from a yellow -- with a solid yellow with a yellow dashed line beside it, then there's either a gap or the pavement markings turn to a white dash line and then the pavement marking turns to a white solid line.

The driver's supposed to maneuver into the left turn lane at either the gap or the white -- I should say that's a white skip line. Either during the gap or the right skip line, so, you know, again, drivers can do all kinds of things. We can't accommodate the 100 percent driver. No, we can't do that. A driver who's performing as intended, as designed, as legal enters that left turn lane either in the skip or the gap, and so that's similar to the situation where there's a curbed median, actually.

The reason we do that is that two-way left turn lane almost always exists to accommodate left

turns going in the opposite direction into some kind of driveway or side street or something and so it's not like there's an infinitely long left turning deceleration space or cuing space. It doesn't work that way. The two-way left turn lane almost always is accommodating some other use.
Q.   Assuming that the driver is not violating some other law, is it legal for a driver to travel 45 miles an hour if the posted speed limit is 45 miles an hour no matter which lane the driver is in?
A.   I don't know. I'd want to consult the lawyer on that. I'm not sure.
Q.   Do you know any approach to any intersection in North Carolina where the North Carolina DOT posts a different speed limit for a left turning driver as opposed to the through driver?
A.   I can't think of one. There are a lot of intersection geometries out there. There's a lot of places where left turn drivers are physically separated from the through drivers, and I wouldn't dismiss the possibility of that, but I don't know of one, no.
Q.   I don't think you've answered this, but maybe an hour ago you did. A 45 mile per hour zero grade road using DOT's assumptions about perception-reaction time, deceleration rate, about how far back from the

intersection is the critical distance or the safe stopping distance?
A. With a 45 --
Q. 45 miles per hour.
A. -- speed limit? I believe that -- with DOT's assumptions, I believe that number was 294 feet. In fact, if you hang on for just a minute, I've got that calculation in my file. Hang on just a moment. I don't have to guess. I've got that. Yeah. Right, 294 feet.
Q. That same route are drivers allowed to go the speed limit 294 feet back from the intersection?
MS. MARTINEAU: What road are we talking about?
MR. STAM: Well, actually it doesn't matter.
BY MR. STAM:
Q. Are they allowed to go to the speed limit 294 feet away from an intersection?
A. Of course.
Q. Okay. A hypothetical for your opinion. Two drivers are traveling side by side approaching an intersection at the speed limit of 45 miles per hour, zero grade, perpendicular intersection. One intends to turn left, the other intends to travel straight through. At the

exact same moment, they're side by side, they pass -- they're 294 feet from the intersection. Or let's say they're 293 feet from the intersection. Both proceed toward and enter the intersection. The light turns yellow. Both drivers still have their foot on the accelerator. Eventually the left turning driver will slow down to about 23 miles an hour before entering the intersection. The straight through driver will proceed through at a constant rate of 45. Which driver takes the longer amount of time to reach the intersection entry point, the left turning driver or the straight through driver?

A. The left turning driver.

Q. Did you know that DOT current engineering practice is to give the turning driver less time, not more time?

MS. MARTINEAU: For what?

THE WITNESS: Yeah.

MR. STAM: To traverse the critical distance or the safe stopping distance.

THE WITNESS: Well, and that's -- DOT's current practice, as we said, is to -- for an end of a protected left turn phase is to assume a speed of 20 to 30 miles an hour, usually 20, for the reasons we talked about, the turning driver's going to have to slow down to likely below 20 or 15 or so during the turn, and the hypothetical that you're posing there is unlikely, that that left turning driver has probably already started to slow down, should be already off the accelerator preparing to get -- make their turn and has hopefully looked up and seen that the green arrow has been on for a while and that noticing that would hopefully reduce their perception-reaction time a good bit and so that --

BY MR. STAM:

Q. After the --

MS. MARTINEAU: Let him finish. Let him finish.

THE WITNESS: The situation that you're describing there is -- it seems to me to be a vanishingly remove possibility.

BY MR. STAM:

Q. Of course, this is after the perception-reaction time question, and I think this is the point. If the left turning driver is decelerating at a rate sufficient to make a safe left turn and the through driver is either accelerating or maintaining the speed at the speed limit, is it not true that the left turning driver will need more time to enter the intersection than the through driver?

A. Of course that's correct, but that's -- the left turning driver decelerating means that they should stop. That the correct decision for them would be that they're decelerating anyway, go ahead and get stopped, and I'm sure relative to their stopping distance at that slower speed, that they can decide to get stopped and go ahead and get stopped. So even with the very slow 1.5 second perception-reaction time, that since they're decelerating anyway, they can get themselves stopped.

Q. At this point I would like to authenticate or introduce some exhibits, and I think Ms. Martineau has them there.

MS. MARTINEAU: I should. I'm not sure if I have them in the order you gave them to me the other day. So go ahead and identify them and I'll grab them.

MR. STAM: Can we go off the record for a minute?

MS. MARTINEAU: Sure.

(Off the record at 11:21 a.m.)

(Back on the record at 11:27 a.m.)

MARKED BY THE REPORTER:
DEPOSITION EXHIBITS 3-12
11:27 a.m.

BY MR. STAM:

Q. I show you what's marked, Dr. Hummer, as Plaintiff's Deposition Exhibit 3 and ask if you're familiar with that.
A. Yes, I am.
Q. Did you help prepare it?
A. No.
Q. And with some change in detail, does it express the same basic formula as the ITE formula one determining yellow change interval length using the kinematic model that was in Exhibit 2?
A. Yes, it's basically the same.
Q. But it has -- if you would, look at Page 1, middle column.
A. Okay.
Q. Does it also add the red interval formula?
A. Yes, yes. That's what it does.
Q. On both sides of the equation?
A. Yes.
Q. Yellow interval and an all-red interval. And do you note that the term V is used in both terms of the equation, once for the yellow term -- yellow change interval and once for the red clearance?
A. That's correct.
Q. When the same -- is the meaning of the variables in the first term of that equation -- is the meaning of

that variable V in the first part of that equation the same as its meaning in the second part of the equation? In other words, where it's V over 2a plus 2Gg, it has a certain meaning, whereas W plus L over V has a certain meaning?

MS. MARTINEAU: Do you mean does the value need to be the same?

MR. STAM: That's my question to the witness, is what is the meaning of V in that equation, is it the same meaning where it is used in two different places?

MS. MARTINEAU: Objection to the form of the question. You can answer.

THE WITNESS: Yeah. It's the same V, and the assumption here is that the speed stays constant throughout the interest area of this formula.

BY MR. STAM:

Q. Okay. Would you go to Page 22.

A. Okay.

Q. Third column, you see an equation there?

A. That's equation four?

Q. Is that equation four? Yes, equation four. Are you familiar with that equation?

A. Not as much as the previous one. I read this paper, but I'd have to confess, I was paying more attention

to the information on the yellow than on the red, so familiar with it but didn't concentrate on it.
Q. Looking at the introduction to it, it said how to calculate an all-red clearance interval. Would that be an important equation for traffic safety?
A. Sure. Yeah. All-red is important to traffic safety, sure.
Q. I would like to go to what's been marked for identification as Plaintiff's Exhibit 4.
A. Okay.
Q. Are you familiar with this document? What is it?
A. I actually wrote a chapter in this one so I'm very familiar with it. It's the Traffic Engineering Handbook, sixth edition, from ITE.
MS. MARTINEAU: It's excerpts of it.
THE WITNESS: Excerpts.
BY MR. STAM:
Q. Excerpts, yes. And I can't tell -- what chapter did you write?
A. I wrote the chapter on how to conduct traffic engineering studies. I don't remember which chapter number that was, but it's not part of these excerpts.
Q. It's not part of these excerpts?
A. Right.
Q. But you're -- are you familiar with the entire

handbook?
A. Well, yeah. I can't say I've read the whole thing, but --
Q. Are you familiar with these two pages that are excerpted here?
A. Yes.
Q. I'm sorry. I don't have a page number. I don't know why I don't, but --
A. You included here Page 412 and 413.
Q. Okay. Thank you. Looking at Page 412 toward the bottom -- well, the middle is -- well, it's toward the bottom. The second full paragraph from the bottom that says as can be seen, would you read that for the record. It's just two sentences.
A. It's says as it 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.
Q. Is the first sentence of that paragraph correct?
A. I don't believe so. I think that the first sentence is -- there's an error in there, and I think that what they're talking about is the all-red time.
Q. Instead of the yellow change clearance?

A. Instead of the yellow. That's my interpretation, yep.
Q. Do you know if this has ever been corrected?
A. I don't know.
Q. Would you look at what's been marked for identification as Exhibit 5.
A. Sure.
Q. And I'll represent to you this is prepared by my client, Mr. Ceccarelli. Is it -- do you have any comment on it?
MS. MARTINEAU: Well, ask him a question.
MR. STAM: That is a question?
MS. MARTINEAU: Well, objection to the form of the question. That's not a question.
THE WITNESS: I have no comment on it.
BY MR. STAM:
Q. Do you agree with it? I could take them one by one if you prefer.
A. Yeah. I'm -- I guess I'm okay with equation one and two and four as they are. How to go from equation two to equation three, I -- basically my comment was that I would have liked to seen more explanation here of how to get from -- I guess it was from equation three to equation four, to remove the changes and get to constants. I felt like it -- you know, for me to fully understand what he's trying to say here, I'd

want more explanation.
Q. Okay. Are there any terms there you don't understand? And I could suggest -- maybe we could -- I mean, you know what the -- A is acceleration.
A. Correct.
Q. B is -- I'll proceed. We'll save that for later. Show you what's been marked as Deposition Exhibit 6.
A. Okay.
Q. Have you seen this before today or --
A. Yes. Ms. Martineau showed it to me yesterday.
Q. Are these equations correct as far as you know in your opinion?
A. They look to be, yes.
Q. I show you what's been marked as Plaintiff's Exhibit 7.
A. Okay.
Q. And I note at the very bottom the critical distance is 294 feet long, which is the exact answer you gave previously. Does this equation -- do these equations appear correct to you?
A. Again, my discomfort is with the term critical distance. I refer to this as the stopping distance, but that aside, the equation and plugging in these numbers, it appears to be correct.
Q. So the stopping distance -- so you would say the

stopping distance is 294 feet long?
A. I would have called this stopping distance, yes. That's my usual term.
Q. Where the speed limit is 45 miles per hour?
A. That would be my usual usage, yes.
Q. I show you what's marked for identification Exhibit 8, 11 pages, excerpts from the Manual on Uniform Traffic Control Devices.
A. Okay.
Q. The very last page attached, probably should be the very first page because it says Page 1, I'd ask if you would go to that page.
A. Yes.
Q. If you would look at the middle of the page under guidance, to be effective, a traffic control device should meet five basic requirements, do you see that?
A. I do.
Q. Can you tell me how a yellow change interval conveys a clear simple meaning?
A. Sure. That as I think it was your -- one of your first questions. The yellow change interval says that the green has ended and the red is about to begin. That's in my mind a clear and simple meaning.
Q. And can you tell us E, looking at E, how the yellow change interval, the light -- actually I mean the

light, not the interval, how it gives adequate time for proper response?

A. Sure. That's -- as we talked about before, if we use standard engineering practice and apply the ITE equation with the typical values in place for perception-reaction and deceleration, then a driver operating at those parameters will be able to make a good decision and either get stopped before passing the stop bar or proceed past the stop bar before the yellow ends while using their constant speed, so the adequate time for proper response to me is if the -- if we apply the formula, drivers have a chance to make a good decision.

Q. All right. This is a multiple-choice question.

MS. MARTINEAU: I object to your multiple-choice question, but go ahead.

MR. STAM: We'll place the laughter by Ms. Martineau in the record.

MS. MARTINEAU: Sure.

MR. STAM: And counter laughter by Mr. Stam.

BY MR. STAM:

Q. This is a-multiple choice question. Does the yellow light give adequate time for proper response to the average driver, all drivers, 85 percent of all drivers or some other way that you would answer?

MS. MARTINEAU: Object to the form of the question. Go ahead and answer.

THE WITNESS: I'll pick D, and my answer would be that it gives adequate time for proper response to almost all drivers, and as I said several times before, there's just no way we can accommodate with current technology every single driver on every single road in every single position doing every single thing, but almost all drivers would have adequate time for proper response if we follow our standard engineering practice.

BY MR. STAM:

Q. Dr. Hummer, could you quantify almost all? Again it's a multiple-choice question. Which would be closer to? Would it be 99.9 percent of all drivers, 99 percent, 98 percent, 90 percent or some other figure?

MS. MARTINEAU: Object to the form of the question. Go ahead and answer.

THE WITNESS: Some other figure, something higher than 99.9 percent. I'm basing that on the fact that most drivers don't end up violating red signals, and as I said, even where we have provided adequate time for proper response, some drivers will do things that lead them to violate anyway, but most drivers don't violate, and that's our best evidence to say that we're providing adequate time for proper response, so something far greater than 99.9 percent.

BY MR. STAM:

Q. All right. Does the ITE yellow change interval formula consider the air brake lag time for trucks and school buses?

A. Well, the formula allows a chance for engineers to plug in a deceleration rate. The NCDOT and other agencies, NITE, make suggestions as to what a typical deceleration rate should be. If you follow that typical deceleration rate, then there's a greater chance for a truck or a bus to not be able to decelerate at that typical rate, but in a place where we know that there's a lot of trucks and buses, expect a lot of trucks and buses, expect a lot of trucks and buses, expect a lot of trucks and buses to be operating at the speed limit coming through the intersection at a time, that they could be around the stopping distance here, then an engineer has a chance to plug in his or her own value into the equation.

You know, keeping in mind that we're trying to also achieve uniformity. There still is a chance, and all of our main documents allow engineers a chance to customize for individual intersections, and a large

number of trucks and buses would be one of those
things that, you know, could lead us to customize.
Q. Do you know what the lag time is for air brakes to
engage after the action by the driver on the brake?
A. I don't have that here, no.
Q. Do you know whether it's approximately three-quarters
of a second?
A. I'd have to look that up. I don't know offhand.
Q. Let's take the intersection where Lori Millette turned
left, and you're familiar with this intersection,
Kildaire going north, left on Cary Parkway. If a
driver used 1.5 seconds to perceive and the driver
happened to be a school bus driver or a truck driver,
does that driver get extra time to get through or
isn't it the same yellow change interval no matter who
the driver is?
A. Of course it's the same yellow change interval
regardless of who the driver is, but traffic engineers
are also conscious of a couple other things regarding
trucks and buses, and one of those is that they are
driven by professionals with many years of experience
and additional driver certification. Another thing
we're conscious of is that those professional drivers
are hopefully driving somewhat slower than the speed
limit and especially that they've looked up and seen

that the light has been green for a while, applying that experience and, you know, starting to slow down before they even get close to being at their stopping distance, you know.

For instance, truck drivers are routinely asked to survey the road 10 or 12 seconds ahead of where they are, and auto drivers I'm sure don't do that, which leads to the third point, is that truck and bus drivers sit up higher. They've got a better view of the road. There's much less chance that their view will be blocked by a vehicle ahead or if there's a curve in the road their view would be blocked by a sign or a hedge or something, so all of those things together go to my point that I made some time ago, that all drivers use all the information that they have available to them and make these adjustments.

The formula is a good one and it covers, as I said, almost all drivers almost all times, and then the times that it doesn't, such as a truck or a bus being in sort of the wrong place, that we expect some of these other things to kick in and a truck or a bus driver to make a good decision for themselves as well.

Q. If you go to the next preceding page which appears to be Page 512, and I'm looking at the very end of that page, the standard and guidance, the duration of the flashing yellow interval and the duration of the steady yellow change interval and then below that the guidance of about three to six seconds. Other than a minimum of three seconds and a maximum of six seconds, does this manual have any objective criteria other than engineering judgment or engineering practices?

A. Well, my response is that I think their word here is determined and used in engineering practice. That is pretty objective as well. That's --

Q. Is there -- in your engineering judgment --

MS. MARTINEAU: Let him finish if you would.

MR. STAM: I'm sorry. It's a little hard for me to know when he's finished if --

MS. MARTINEAU: Oh, I know.

MR. STAM: -- he stops talking. I'm not intending to interrupt, I'm really not. I don't like interruptions.

THE WITNESS: And I'm trying to compose my thoughts as quickly as I can, too. Sorry about that. But where was I going with that, actually? What I was wanting to say was that the engineering practice in this case is very clear.

Almost all traffic engineers would identify that ITE formula and its application with perception-reaction times and deceleration rates, somewhat like we're talking about here, as the standard practice. There is -- in our profession, there's very few times when we actually have such widespread agreements on what we should do and what we should use.

There's certainly agencies out there that use, for instance, a constant yellow time, but even those agencies would recognize that the ITE formula is something they should look at and consider before they choose their constant yellow, so in our profession of 50 different state DOTs and hundreds of different local transportation agencies, it's hard to get this kind of lock step like we have in the case of the yellow time formula so that in this case, you know, the practice I would argue is pretty objective and clear.

BY MR. STAM:

Q. Do you -- is there a difference between engineering judgment and engineering practice as used on this page toward the bottom?

A. Sure, there's a difference. I'm going to apply my words to it and somewhere in the MUTCD here there may be better definitions and I would certainly defer to those, but my understanding of engineering judgment is a chance for the local engineer to apply all of the knowledge they have about a particular site or particular group of drivers and then make their designs and decisions, engineering practice being more of a particular methodology, a particular formula, a particular algorithm on the way to doing something, so my interpretation, the judgment would be a little bit more localized.

Q. Okay. I understand. If the judge should decide that the engineering practices for yellow change intervals, whether it's a steady or a flashing yellow, is contrary to the laws of physics, and I preface that by saying if the judge should so decide, would you agree that it would not be a sound engineering practice or sound engineering judgment to oppose the laws of physics?

MR. MARTINEAU: Objection to the form of the question.

THE WITNESS: Well, I just -- I don't think we can oppose the laws of physics. You know, as long as we're on earth and dealing with humans and machines and, you know, we're not Star Trekkers, some alternate universe, we can't oppose the laws of physics, so if a judge makes a ruling, we will abide by the law and adjust to that.

Let me add here, though, that such a ruling -- no, no. Let me stop there. No. We don't oppose the laws of physics. They apply to us just as well as everybody else on earth.

BY MR. STAM:

Q. If you would look at Exhibit 9, five pages.

A. Sure.

Q. This purports to be the same chart over time as a document of the signals in geometric section. Are you familiar with any or all of these iterations of the determination of yellow change and red clearance intervals?

A. Well, I reviewed this yesterday. I probably have seen these documents before. Which ones I don't remember. I don't remember quite what the contexts were. I've been doing this kind of work for many years, 20 years, 22 years as an engineering professor in North Carolina so I probably saw these before but really reviewed them again for the first time yesterday.

Q. Would you be able to speak to the reasons for the changes over time?

A. Just generally. These are NCDOT documents, and an NCDOT person would certainly be more qualified than I to talk about that. I think generally speaking there has been movement in our profession toward using the -- what's now the standard practice, the ITE formula, more and more.

I think years ago, probably when traffic signals first developed and when yellow first appeared, that the practice was a constant yellow time, and the movement I think through the years, especially let's say up until the mid 2000s decade, was to go more and more toward the application of the ITE formula of course first developed by Gazis in 1959.

I think the Task Force, 2004, and it resulted eventually in the document that we use as Exhibit 3, that came from maybe a bit of a let's kind of hold the line here, that if we apply the ITE formula, especially on roads with quite high speeds, above 55 mile an hour speeds, we'd get to these excessive yellow times, and I talked about that before, the negative effects that those have.

So maybe in the last, oh, let's say five, six, seven years there's been sort of a stabilizing of the practice, but the -- what I would say generally is the practice was going from more use of the constant yellow to more use of the ITE formula with a chance to customize for individual intersections.

Q. Would you take a look at Plaintiff's Exhibit 10.

A. Sure. Yes.
Q. And if you would, take a look at the first page. Well, no. I'm sorry. If you would look -- go back to the fourth page where it begins a document entitled Calculation of Yellow Change and All-Red Clearance Intervals: The North Carolina Experience, do you see that?
A. Yes.
Q. It appears to me that this document is sort of a working draft or a preliminary version of Exhibit 3.
A. I think so. My interpretation would be, and I was not involved in drafting either of these documents so I do not know for sure, but my interpretation is that this Exhibit 10 document is sort of the longer report form that was intended for North Carolina audiences, and then Exhibit 3 was a publication in the ITE journal, which is the journal of the organization, ITE, and goes to a national and international audience and was intended really to tell the rest of the world what the North Carolina task force had done and had come up with, but certainly the shorter version published in the ITE journal seems to be closely based on this longer what I'm calling a report.
Q. And my understanding from Greg Fuller who testified Monday is that Steven Click, who is the corresponding

author, was actually employed by DOT at time of -- at the time he prepared the report or was somehow involved with the task force. Do you know Mr. Click or Dr. Click?
A. I do, yeah. He attended NC State during my time there. I was on his dissertation committee. I know him well. I think that Mr. Fuller is right about that, that Steven was at NCDOT during the days that the task force met and was involved with that task force, yes.
Q. If you turn to Page 7 of his -- of that document, I just would like you to comment on the final paragraph, which is not in Exhibit 3, but the paragraph that begins initially the speed subcommittee. Do you see that paragraph?
A. I do, yes.
Q. Would you read that to yourself and then tell me whether you agree with it, disagree with it or any other comment on it.
MS. MARTINEAU: Objection to the form of the question.
THE WITNESS: Okay. I've read it. Could you restate your question, please.
BY MR. STAM:
Q. Do you agree with it, disagree or have other comments?

MS. MARTINEAU: Same objection.

THE WITNESS: Well, I'm glad that a subcommittee was looking at different options. That's what committees should do. That's what the whole task force was supposed to do, I thought was to look at all the available options for yellow and all-red timing and make recommendations on what the best practice was, so I'm glad they were looking at different options.

I guess this is the second sentence here talking about the difficulty of quantifying all the variables, and that's I think I've been trying to say that several ways throughout my deposition here, is that there's so many factors that go into the determination of the speed that we're, you know, best to leave the formula as it is, make a recommendation of sort of a default value, 20 miles an hour, leave some discretion for local engineers to change that to 25 or 30 if they think that that's more appropriate but not try to what I would call over engineer and come up with some formula that's -- that we really don't understand, that we really don't have enough data to back it up.

Which reminds me, of course, you know, another difficulty here is that we don't do anything out there in the way of changing practices or signs or signals without empirical evidence, without running a test and seeing how it goes in the field, and I think that's sort of implied in the last paragraph here, too, is, you know, it's difficult to quantify all these variables.

I said before it's difficult to collect the speed, difficult to quantify all those variables because the experiment would be really difficult the research would be really difficult, and we don't put anything in the field without testing it first, without the empirical evidence, so I think they're kind of hinting at that in this response as well, so I --

BY MR. STAM:

Q. Looking at the second to the last line there, they're going to come up with a single speed, quote, determined when the vehicle was negotiating the left turn. Do you see that?

A. I do.

Q. So for the situation of the North Carolina DOT ideal driver turning left, have you ever done the math or could the math be done that shows the difference in location between where a driver must slow down in order to stop and the location where a driver must

slow down to a comfortable intersection entry speed?
MS. MARTINEAU: Objection to the form of the question.
THE WITNESS: You know, I've done some stopping distance calculations if -- that's what I think you were asking.
BY MR. STAM:
Q. Well, that wasn't what I was asking, but I do appreciate the answer. The V in the equation, if they do it when the vehicle V is negotiating the left turn as in the second to last line of that page, will obviously be different than the V in the initial speed as in Exhibit 2, the 1994 ITE paper. Is that correct?
MS. MARTINEAU: Objection to the form of the question.
THE WITNESS: Well, no, not obviously. There's lots of cases, I'm sure majority of the cases where drivers kind of cruise through the left turn bay and into their left turn at a constant speed, and especially when they're cued, but even drivers who know that they've got time enough to make their turn and want to make a comfortable deceleration and just kind of cruise through the bay in their turn, so, no, I don't think that's obvious.
I think the -- I think the committee's

expressing here that they -- that we really don't know, that it's a very complex procedure. It's different at all kinds of intersections. It's difficult to collect the data. It would be difficult to put an equation together that would apply in a lot of places, and when we don't know, let's pick a value, and, again, 20 miles an hour is on the high side for the turn. Most drivers, you know, our data are very clear about this, the data in the paper here are clear, that, you know, most drivers are turning -- making a left turn at a speed lower than 20.

BY MR. STAM:

Q. But for the driver who doesn't see the yellow light right at the stop bar but sees it at some point back from the stop bar at some point, where is the critical distance for the safe stopping distance for that driver who may be going 30 miles an hour at some distance back?

A. Well, again, I'm not using the critical point. That's not my terminology. The stopping distance depends on speed, so, you know, where -- a driver approaching an intersection at the speed limit, let's say 45 miles an hour, makes a left turn at a speed on an average of 15 miles an hour, so they've got to get slowed down somewhere on the approach to the intersection between

45 and 15. It's complex. We don't know what that profile looks like. We don't know where they do.

I've given you several reasons to think that most drivers do most of their deceleration before they get into the left turn bay and that the choice of 20 miles an hour as our standard practice is appropriate for most of those drivers most of those times, and, you know, I've also agreed that there's -- there will be other drivers that will not do what most do, and that's always the case for us. We can't design for the 100 percent.

Q. Look at Exhibit 11.

A. Sure. Okay.

Q. It's four pages, and I'm looking at Page 2, the second page, which is labeled Kildaire Farm Road and Cary Parkway.

A. Okay.

Q. I'll represent to you where this comes from, that Mr. Ceccarelli got the Excel spreadsheet directly from the town of Cary, that he pushed a couple of buttons on his computer which generated this graph. I wouldn't know how to do it myself, but that's what it appears to be, is a graph of over time the number of citations per month at a particular intersection, northbound turning left on Kildaire Farm Road. Do you

see that graph there?
A. I see the graph, yeah.
Q. And later on we'll look at the signal plans which tell when the plans were approved, but those plans don't show when they go into effect. As a professor of engineering, if you had seen this graph, what would your immediate -- what would your impulsive immediate nonscientific reaction be to looking at that graph?
A. That something changed in November, December of 2009. Yeah. Something changed on the road, in the signs, in the signal. Something changed.
Q. Before that time there were about two -- well, let's say about an average of 75 violators per month which would mean about two to three a day.
MS. MARTINEAU: Are you purporting that that's what this graph shows?
MR. STAM: Well, the witness can --
MS. MARTINEAU: Because he I mean, he's --
BY MR. STAM:
Q. Looks to me about 75 a month. Does that look like it to you, Dr. Hummer?
A. Yeah. I just have no idea where these numbers came from. You're representing something to me. I have no way to check or verify or --
Q. If I'm right, that the numbers came direct from the

town of Cary, your answer is totally dependent on if that is true or false?
A. Well, and --
Q. If it's false, then your -- we'll strike your answer, but --
MS. MARTINEAU: Well, no. He doesn't have any foundation for the graph, so all I'm asking you to do is just say, you know, I purport this is what this graph is showing and then ask --
MR. STAM: That's what I've done.
BY MR. STAM:
Q. And, Dr. Hummer, the town of Cary that's retained you as an expert witness in this case, have they not provided you the data for the citations for the intersections in question?
MS. MARTINEAU: What data? You mean the number of tickets at the intersections?
MR. STAM: Number of citations per intersection per month over time.
THE WITNESS: Yeah. I haven't seen those data.
Q. Okay. You may find this interesting. Mr. Ceccarelli, after he got a citation, went to the Cary office, saw the Excel spreadsheet on the walls and said, a-ha, engineering error, and my question to you is as a

professor of engineering, when you teach students to look for anomalies or things to discover engineering errors, is spikes in graphs something you would look at?

MS. MARTINEAU: Objection to the form, move to strike the part of the question that wasn't a question. You may answer.

THE WITNESS: I would never jump to the conclusion that there's any kind of error here. You know, first reaction to the graph is that something changed. We're looking at one dimension here. We're not seeing what happened around the rest of the intersection. We're not seeing what happened to collisions. We're not seeing what happened to cues, to congestion, to speeds, to -- you know, there's many dimensions to the performance of an intersection, and before jumping to any kind of conclusion that there was any kind of error here, you'd want to see much more of the complete picture to see what goes on here.

BY MR. STAM:

Q. Assuming solely for the purpose of a hypothesis that the only thing changed was the time of the yellow change interval went from four seconds to three seconds around December of 2009, and then around July to August of 2010 the town of Cary just cut the camera off, just turned it off. If that -- in those two assumptions are correct, that there was no change in the physical characteristics of the intersection or the abilities of the drivers and only a change in the time, would that change your opinion?

A. Well, if that was true, but that's almost never true, and I would go into this doubting that that would be true. It's not usual practice for agencies to go in and change a yellow time in isolation. Almost always that's done with some other package of improvements. What I happen to know about this intersection is that flashing yellow arrow was installed at some point in that time frame. I don't know if it was exactly November and December of '09, but sometime in the late part of that decade.

Were other changes made, that's -- seems to me highly unlikely that that's the only thing that changed as a person who's made a big part of my career on research. I have to say that that's a vanishingly small possibility. We go around looking for times when agencies only change one thing so that we can measure them, and we have a hard time finding those. This would be a rare and special case indeed if that were the case. It might be. I don't know, but I doubt it. Almost always it's -- a change in yellow is

made as part of the package.
Q. I mean, you would not, for example, think that maybe in December of 2009 all the drivers around Cary suddenly got a death wish to start running red lights, that driver behavior suddenly changed?
A. I agree with you with that, and I've written about that before and I've said that many times in class, that our driver population and practices tends to be one of the most stable things that we deal with, and -- but I've also said that's by design. That's because we try to promote uniformity and get those messages out there.
We have succeeded to a large extent and that's what you see, and I agree with you that one of the last things we would suppose is that the driver population or its behavior changed drastically. I agree with that, but let's, you know, bring that back and say that's by design, that's what we intend, that just doesn't happen.
Q. I'd like to look at the first page of that exhibit which is Cary Town Boulevard and Convention Drive.
A. Okay.
Q. Which again I'll represent to you is a graph of data from the town of Cary and that at a certain point around March of 2010, the town of Cary increased the

yellow change interval from four seconds to 4.5 seconds, which seems like a very small change, just a half a second, but does it appear to you that the number of violations go down significantly when they corrected their -- and I assume it was a correction or they wouldn't have done it, when they corrected their yellow change interval by only a half a second?

MS. MARTINEAU: Objection to the form of the question. He can look at the graph and the graph shows what the graph shows. You purported it to be what it is.

THE WITNESS: A lot of this, if it is what you say it is, then, again, I -- my reaction is that something changed, and, again, my instinct is based on my many years of experience here in the profession and as a researcher, is that almost always that change was not in isolation, that there were other things happening at this time, and, you know, that's what makes a good research project or a paper that's capable of being published in the peer review literature in engineering is that we are able to eliminate all those other causes and get down to, you know, just one thing or one thing we're sure of that changed, and, you know, these data not coming from a peer review paper, I'm kind of doubtful that that's the case. What I go into it thinking about here is I look at these data.

BY MR. STAM:

Q. Assuming only for purposes of discussion what our -- Plaintiff's contention is, is that the previous traffic signal plan assumed the speed limit of 35 miles per hour when the actual speed limit was 45 miles an hour and Mr. -- actually the town prepared a plan to change it before Mr. Ceccarelli got his citation, but then it wasn't actually approved by DOT and put on the ground until after he got his citation. So just for purpose of discussion, the only change was the town of Cary recognized that the signal plan was incorrect by having the wrong value for V in the equation, using 35 miles an hour instead of 45, when in fact there was no change of the actual speed limit but they just discovered a mistake.

So if the judge should find that that was the only thing that changed at the point when it went way down in March of 2010, and, indeed, the judge has limited our class to those before that time it was corrected, would that graph not show you that the number of violations goes up or down much more than linearly? I think you mentioned this when we were talking about the green time, that a one-second change

could be much more than a -- geometric instead of linear. Do you understand what I'm saying, Dr. Hummer?
A. That part, yes.
Q. Okay. So, for example -- for these first two pages, it seems like for Kildaire Farm Road and Cary Parkway that a mere one-second change out of four raises the number of violators six, seven, eight times, and in Mr. Ceccarelli's case, the first page, a mere half a second reduction or increase in this yellow change interval drastically decreases the number of violators.
MS. MARTINEAU: Do you have a question?
BY MR. STAM:
Q. The question is do you agree that that's a geometric result rather than a linear result?
MS. MARTINEAU: Objection to the form of the question, misrepresented facts. Go ahead. I'm just putting my objection.
BY MR. STAM:
Q. Mr. Ceccarelli says I may not have used the right words.
MS. MARTINEAU: Objection to the form of the question, misrepresenting --
BY MR. STAM:

Q. Dr. Hummer --

MS. MARTINEAU: Wait. Let me put my objection in. Objection to the form of the question, misrepresenting facts not in evidence. Go ahead.

MR. STAM: The question was objectionable, I agree with you, but I would like to know Dr. Hummer's answer to my objectionable question.

MS. MARTINEAU: If there was a question. I didn't really see a question in there, Skip, but go ahead.

THE WITNESS: What I see in this graph is a change in the case of the -- Page 1, Cary Town Boulevard and Convention Drive, it looks like the change happened around February or March of 2010. The shape of the change does not appear to be linear. What particular shape it is, who's to say.

One thing I would want to point out is that we don't know what happened after December of 2010 or what would have happened if the cameras would have stayed on, and drivers adjust, and it's quite possible, and it happens in all kinds of cases that we see in traffic engineering, that the agency changes something on the road, the drivers react to it not well for the first few weeks, months, and then a gradual return to the -- what you might say typical levels.

BY MR. STAM:

Q. In that duration --

A. Sorry. I'm grabbing some water. I've got something else. We've got a term for that. That's called the feedback mechanism. That's a term I think that's out of psychology or human factors, one of the other sciences that we use, and it is the process of drivers adjusting to what changes out there and then returning back to their level, so, unfortunately, in this case we don't get to see whether drivers would have, you know, reverted back to that level that we were seeing before, maybe they would have, maybe they wouldn't, but we don't get to see that.

Q. Are you talking about Page 1 or Page 2?

A. Page 1.

Q. That one never got turned off, but are you referring to the phenomena that's noted on the document, determination of yellow change and red clearance intervals? It's in a couple of the exhibits you've already talked about. It's that one -- for example, Exhibit 9, which is five pages of the most current version. It's also in Exhibit 3, that inset formula. In the second to last note it says that consider adding a note to the plan to direct field forces to

reduce the time incrementally.
MS. MARTINEAU: Where are you looking at?
BY MR. STAM:
Q. Do you know which exhibit I'm looking at?
A. Exhibit 9 which is the NCDOT five-page --
Q. I would be looking at the last page of that.
A. Okay.
MS. MARTINEAU: What's the date of that one you're looking at?
MR. STAM: July of '09.
MS. MARTINEAU: Okay.
BY MR. STAM:
Q. And in the second column under notes, do you see the second to last note?
A. Yes.
Q. If you could just scan that for a sec.
A. Right. Yeah. Exactly. That's -- the idea is when we make a change to anything, yellow time, red time, green time, signing, geometry, almost any kind of change on the highway, drivers almost universally act badly toward it. They don't like change.
That's the theme here. We try to keep things uniform. When we change, we try to monitor that, and if it's a large change and it's reaction is very bad, we try to make -- you know, kind of break

that up and -- I like their word here, is to reduce the time incrementally. That is a little bit at a time to try to ease the transition there. That's standard good practice.

Q. Using that principle, would you go back to Exhibit 11, the second page which is the graph of citations at Kildaire Farm Road and Cary Parkway.

A. Sure.

Q. Lori Millette.

A. Sure.

Q. Going from four seconds to three seconds and knowing that 1.5 of that is perception change, you're really going from 2.5 seconds to stop or to proceed through to 1.5 seconds to stop or proceed through, is that correct?

MS. MARTINEAU: Objection to the form of the question.

THE WITNESS: I don't know what that -- where that 2.5 and 1.5 came from.

BY MR. STAM:

Q. It would be four seconds minus 1.5 is perception-reaction time equals 2.5 stop or proceed time.

MS. MARTINEAU: Objection to the form of the question.

BY MR. STAM:
Q. And then for three seconds, minus 1.5 would leave you 1.5 seconds to actually stop or to continue proceeding safely into the intersection.
MS. MARTINEAU: Same objection.
THE WITNESS: Yeah. That's a -- not the way the formula's intended to be applied, but okay.
BY MR. STAM:
Q. I may have misstated it, but you understand the point I'm trying to make? That to go from four seconds to three seconds is not a 25 percent decrease in your time to brake or time to enter the intersection if you're not braking. Instead, it's almost a 40 percent reduction from 2.5 to 1.5.
MS. MARTINEAU: Objection to the form of the question. Just because that's the value of deceleration, he's already testified that's not what most people -- you know, 11.2 is not most people's -- excuse me. 1.5 is not most people's -- it doesn't take most people 1.5 seconds to make a decision whether they're going to stop or go.
BY MR. STAM:
Q. Are you able to answer the question, Dr. Hummer?
A. I'm still not particularly understanding the question. Let me try to answer it this way. Three seconds is

plenty, standard engineering practice. They meet the practice. They did what they should have done there. Previously they had four seconds, don't know why, not -- maybe the four seconds was there from some previous practice, not sure why that was there, but the change to three seconds, three was still meeting the standard practice. It was adequate. It would have worked, provided enough time for the vast majority of drivers to make a good decision.

Q. Well, Dr. Hummer, looking at your Exhibit 9 again, five pages, up until March of '02, wouldn't the yellow change interval in seconds be at least 4.7 seconds?

MS. MARTINEAU: For through or for left turns?

MR. STAM: For -- well, I don't think this one has a separate -- wait. I'm sorry. Sorry. I withdraw that. Go back to -- well, for either one.

MS. MARTINEAU: Objection to the form of the question. I think you need to restate it.

MR. STAM: I mean, look. It has -- for anything -- if you look at the first sheet, for any speed less than 40 miles an hour, yellow interval change in seconds, 4.0.

MS. MARTINEAU: What sheet are you looking at?

MR. STAM: That's true on sheets one, two, three, so even if you're saying it's 20 miles an hour, until you got to '05, the minimum was four seconds.

THE WITNESS: Again, these are NCDOT sheets and the question is better directed toward an NCDOT person, but let me take a stab at it. The first sheet in Exhibit 9 from October of 1999 does not seem to say -- well, I take that back. On the right side, even though the first sheet, the last paragraph says for most left turn lanes assume the speed of 20 miles an hour for high-speed locations with turning angles greater than 90 degrees, higher speed may be used, so it's unclear from this first sheet what NCDOT personnel are supposed to do with it, but the note directing people to use 20 miles an hour implies that they should be plugging that into the ITE formula and using what comes out of that formula at that time.

The second page of this exhibit has that same note to assume a speed of 20 miles an hour, and the second page is from May of 2001. The third page from March of 2002 has a note at the bottom of the left column. It says for separate left-turn phases use 4.0 seconds, and it appears to be the first time that that appeared, but actually it appeared on the second sheet as well, but on this third page from

March of '02, they also have the note about 20 miles per hour.

So those first three sheets I'm going to conclude are unclear and giving sort of contradictory advice, but the 20 mile per hour note on there shows that -- or implies use the formula with 20 miles an hour.

BY MR. STAM:

Q. Let me go back to Exhibit 11 and sheet two, and hopefully this will be my last question if I'm able to express it so you can answer it. You see which one I'm talking about, Kildaire Park Road and Cary Parkway?

A. I've got it.

Q. From that graph, would you hypothesize, I won't say conclude because you might want to do further investigation, would you hypothesize that the town of Cary followed the advice or the notes on that determination of yellow change interval to make the change from four seconds to three seconds gradually in increments of two-tenths of a second per week?

MS. MARTINEAU: Objection to the form of the question. He has a lack of foundation. Answer if you know.

THE WITNESS: Yeah. I don't know what else was going on out there at that time. I would need to know a lot of other things about that intersection. Where I sit right here, the people that know the most about that intersection and how it's operating are the town traffic engineers, and I'm going to defer to them to make the best judgment they can about how to make that change. There's certainly, you know, a custom in our profession, and that note that you pointed out, there's reasons to think about making changes incrementally certainly, but I'm in no position to second guess that from here. They know better. They know their intersection. They know their drivers. They know what they're trying to accomplish, so that's got to be left up to the locals.

BY MR. STAM:

Q. One follow-up question on that and then I'll go to my next exhibit. Citations for red light of violations in Cary punish drivers with a $50 penalty. Do you think that drivers should be punished for engineering changes?

MS. MARTINEAU: Objection to the form of the question. They get violations for running red lights.

THE WITNESS: Yeah. That's -- that is my answer. They get violations for running red signals.

They get violations for disobeying the law.
BY MR. STAM:
Q. On that sheet were the drivers who entered that intersection after the change any more culpable than the drivers who entered that intersection before the change?
A. Both sets of drivers violated the law.
Q. Go to Exhibit 12.
A. Okay.
Q. Are you familiar with that document?
A. No. This is another one I just saw yesterday.
Q. We may be finished. If you'd just give us about two minutes, I think I'm about finished unless I consult and have one more question.
MS. MARTINEAU: Do you want to go --
MR. STAM: I'm sorry. We are finished. We are finished.
MS. MARTINEAU: All right. I'd like to take a break. I do have a couple of questions. Do you want to take five minutes?
MR. STAM: Sure. Just un-mute when you're ready to go.
MS. MARTINEAU: Okay.
(Recess taken at 12:33 p.m.)
(Back on the record at 12:54 p.m.)

EXAMINATION

BY MS. MARTINEAU:

Q. Dr. Hummer, as you know, my name is Elizabeth Martineau. You've been designated by me on behalf of the town of Cary to serve as an expert witness in this case. I know we -- Mr. Stam attached a copy of your current CV to this deposition, but would you please talk about your education and experience with traffic signal design.

A. Sure. Yes. Education, bachelor's and master's degrees in civil engineering from Michigan State University with a course in project work in traffic signals, Ph.D. from Purdue in civil engineering with a course in project work and traffic signals, and my dissertation was on leading versus lagging left turn indication at traffic signals, so dissertation on really almost this topic, and then two and a half years as an assistant professor of civil engineering at UNC Charlotte teaching and doing research in several areas of transportation operations and safety and design, many of them related to traffic signals, and then 20 years as a professor at NC state, again with research and teaching in many areas of operations and safety and design related to traffic signals.

Q. Okay. Are you a licensed engineer?

A. Yes.
Q. Where are you licensed?
A. Professional engineer in North Carolina.
Q. Do you know in North Carolina whether traffic signal plans can be signed and sealed by someone other than a professional North Carolina licensed engineer in North Carolina?
A. No. They have to be sealed by a North Carolina PE.
Q. I wanted to ask you -- you talked -- let's first look at, if you would, the excerpts of the Manual of Uniform Traffic Control Devices that have been identified by Mr. Stam as Exhibit 8, and if you would -- are you familiar with the Manual of Uniform Traffic Control Devices, the 2009 version?
A. Yes.
Q. All right. Do you use the Manual of Uniform Traffic Control Devices in your role as a professor teaching traffic signal engineering to students?
A. Often, yeah, teaching and research.
Q. Okay. And there are -- if you look at Page 485, there are -- there's headings called guidance and standard and option. Do you see that?
A. Yes.
Q. What is the difference between what MUTCD means by standard versus guidance versus option?

A. Standard is the sort of highest level, the things that we must do. Basically the law requires us to do those things. Guidance is the next level down from that. Guidance is a should whereas standard is a shall. A should is a very strong bit of information. If -- as an engineer, if we're not following the guidance, we better have a darn good reason. We better have done a study and have some data and have some justification ready report for the file. If we violate something that's a guidance and a collision happens because of that violation, we're very vulnerable to a lawsuit and being held liable for that, so guidance is quite strong. Support is the -- or option, or the next lower level, option is to allow us to do something, and it's a good idea to have documentation if we don't follow an option but probably not going to result in a successful lawsuit, not going to be liable, and, of course, support is just other information that we should be aware of, so it's a hierarchy of strength.
Q. Okay. And for what is the Manual of Uniform Traffic Control Devices, what is the standard for determining the yellow duration or the yellow change interval according to the MUTCD 2009 edition?
A. Well, the key sentence there on page 485 is the duration of the yellow change interval shall be

determined using engineering practice.
Q. And is there also then a guidance for determining the duration of yellow change intervals on the 2009 MUTCD?
A. Back a few pages, flipping through here, Page 489, toward the top of Page 489 provides the guidance that yellow change intervals should have a minimum duration of three seconds and a maximum duration of six seconds.
Q. Okay. If you would turn your attention to the last page of Exhibit 8 that says 2009 edition, Part 1, general.
A. Yes.
Q. Okay. You were asked questions regarding under Section 1A.02, principles of traffic control devices, guidance. What is your understanding of how the yellow duration or the yellow change interval should meet Guidance D, command respect from road users?
A. Yeah. That's a really important one for us that we should not skip over. The command respect really gets to the business of lengthening the yellow and the almost universal concern among traffic engineers that if we provide too long a yellow, that drivers will start to treat the yellow as if it was green and then we'll be in a tough spot of trying to convey when we really mean it, when the drivers really should pay

attention to a yellow.

Lengthening the yellow has an excellent chance of eroding that respect that we currently now have for the yellow time, and so D there under guidance is a very important one that we all as engineers have in mind and try to maintain that respect.

Q. And are you familiar with your -- well, in your past role of teaching -- when did you stop -- when did you change from NC State to Wayne State University?

A. I moved here the start of fall semester, which was the middle of August of 2012.

Q. So when was the last time you were teaching North Carolina students traffic signal engineering?

A. I taught them during the summer of 2012.

Q. Okay. And are you familiar with the general standard practice of traffic signal engineering in North Carolina?

A. Yes.

Q. And how are you familiar with that?

A. As a teacher and as a researcher. I've never put my PE stamp on a set of signal plans, but I have taught this material for upwards of 23 years and not only to our students at NC State but also in short courses in, for instance, the PE review class where people go to

review for the exam to become a PE. For many years I taught the material on signal timing, and yellow time and all-red time is a standard question on the PE exam. So I would teach, you know, not only our graduate and undergraduate students but professional engineers or PE wannabes on how to do these things, research-wise as well as a number of projects having to do with signals, signal timing, signal operation, red light running cameras and other aspects of signals.
Q. You also indicated you were a member of the -- of ITE. What does ITE stand for again?
A. It's the Institute of Transportation Engineers.
Q. What is that?
A. It's an organization of about 15,000 members worldwide that try to promote the profession, conduct research, publish documents that we all need, establish standards and recommended practices. It's really our professional organization.
Q. Are you familiar with the recommended practice ITE has promulgated for the calculation to determine yellow change intervals?
A. Sure. Yeah. We looked at that before most prominently in the traffic engineering handbook. That's an ITE publication.

Q. Okay. Is there -- from your experience as a North Carolina professional licensed engineer as well as your role as an educator of engineers and your role as a member of ITE, is there much or any disagreement regarding what the formula should be for determining the length of yellow times?

A. There's no disagreement that I know of. There are -- there have been a series of research projects through the years to look at the values that we enter into the equation, the deceleration rates, the perception-reaction times. That research continues. It's good to have that. We keep trying to come up with the best recommendations for those values, but as far as the formula goes, I know of no disagreement out there.

This is -- and I think I said this before. In my world, in the traffic engineering profession, this is about as close to universal agreement as anything that we do. It's along the lines of that, you know, stop signs should be red kind of thing. It's -- you know, almost all of us agree on it.

Q. Can you take a look at the document that shows the North Carolina DOT -- the one that shows the calculations, NCDOT calculations. Let's see. It's exhibit -- let me --

A. This one?
Q. Yes. Take a look at Plaintiff's Exhibit 9. And you testified that this is an NCDOT internal document as far as you know, is that right?
A. Yes.
Q. And are you also familiar with NCDOT's recommended practice of using 1.5 seconds for perception-reaction time?
A. Yes.
Q. And is 1.5 seconds a more forgiving or lenient time than the recommended ITE of 1.0 seconds?
A. Yeah. Recommended ITE and other agencies. Many use one, so the 1.5 seconds perception-reaction time is more lenient.
Q. Are you familiar with the perception-reaction time that professional engineers -- excuse me, professional traffic signal engineers use currently in North Carolina currently?
A. I think it's the 1.5 seconds.
Q. Does that meet engineering practices as far as -- well, does that meet engineering practices, using 1.5 seconds as a perception-reaction time?
A. Yes. Yes, it does.
Q. Is there anything controversy in the engineering community of traffic signal engineers of using a 1.5

perception-reaction time?
A. If anything, there's maybe a feeling out there that it's overly generous. I don't have any data on this, but I would guess that, you know, most agencies actually use the 1.0, so, again, it's on the lenient side.
Q. Sure. But for North Carolina, it's your understanding that 1.5 is a general accepted practice that traffic signal engineers use when determining perception-reaction time?
A. Yes.
Q. Okay. Now, are you -- we talked a little bit about the North Carolina section of ITE Task Force, and you were not a member of that task force, correct?
A. I was not.
Q. Were you aware that they -- that such a task force was looking at the practices of North Carolina traffic signal engineers in determining yellow and red times?
A. Yes, I was aware of the task force, yes.
Q. Do you know whether or not when the task force came out with its report and later when Steven Click wrote his ITE publication, what did the publication recommend regarding the length -- excuse me, regarding how to determine the length of yellow change intervals for dedicated left turns?

A. To use the standards ITE equation and to use a speed of 20 miles an hour in most circumstances but to recommend that engineers could use a speed higher than that up to 30 miles an hour if they felt that that was more appropriate.
Q. Okay. And Mr. Stam showed you on Exhibit 9 some earlier editions of the change in clearance interval published -- or change in clearance interval with a document from the signals and geometric section of North Carolina DOT, and some versions, for example, the 5-01 version, indicates use a four-second yellow change interval for protected left turns. Do you see that?
A. I do.
Q. And then after the task force came out with its recommendation that you just discussed, do you know when that recommendation came out?
A. It was somewhere around the 2004, five time frame.
Q. If you take a look at the change in clearance interval 7-05 version from NCDOT signals and geometric session on the notes, does the 7-05 document continue to say that the minimum left turn yellow duration for dedicated left turns should be at least four seconds?
A. No. I think that -- I don't see that in this -- on this page, no.

Q. And would that be consistent then with the recommendation from the North Carolina section of ITE?
A. Right. Right. That's -- and what I said before, what I thought was generally the trend in the profession to go away from the sort of, you know, more constant value to applying the formula with the typical speed of 20, so, yep, that's consistent with the task force.
Q. Okay. And is it -- are you familiar with prior to 2005 what the traffic signal engineering practice in North Carolina was for using as a speed value when determining -- when plugging in the equation and determining the length of yellow turn intervals for protected left turns?
A. I think most everybody used 20 miles an hour even back then as well, and the prior pages had that note in there that we've looked at before, but my recollection is that that was the typical value prior to 2005.
Q. Okay. And is the -- is the 7-05 document that has the yellow change interval equation and also indicates for left turns without a separate phase -- excuse me. Where it says for most left turns assume a speed of 20 miles to 30 miles an hour, is that -- does that meet engineering practices in North Carolina for July of 2005 for traffic signal engineers?
A. Yes.

Q. Is that a standard practice for North Carolina?
A. Yes.
Q. Are you aware of other jurisdictions that use an assumed speed lower than the speed limit for calculating the length of yellow times for dedicated left turns?
A. I think there's some that use 15 miles per hour, actually.
Q. Now, do traffic signal engineers typically design for trucks and buses with air brakes?
A. Well -- in an approach to a yellow signal?
Q. Yes.
A. No. They usually don't.
Q. Is that common practice in North Carolina among traffic signal engineers?
A. Right. Right. It's common practice not to design -- I mean, like I said before, they're on our mind, we're thinking about them. They're an important part of the vehicle population, but they don't appear directly in the equation. We have other ways that we believe that they adjust successfully and manage not to go through red signals.
Q. Is the braking distance for tractor-trailers or buses calculated in your experience in the equation for determining yellow change intervals that engineers who

are members of ITE use?
A. No.
Q. And is that practice good or is that practice the standard of -- is that practice a standard practice among North Carolina traffic signal engineers?
A. Yes.
Q. Now, earlier Mr. Stam asked you a question about if an engineer calculates a yellow time that creates a dilemma zone as Mr. Stam defined that, would that be a good engineering practice, and I have a couple of follow-up questions for you.
What again is your definition or what is the definition that we saw in the materials today for dilemma zone?
A. It is a place on the road within which a driver does not have a good option for reacting to the start of a yellow signal, cannot proceed through the intersection at a constant speed without running the red light and cannot get stopped before the stop bar at the perception-reaction time and the deceleration rate that we use.
Q. Okay. And for some drivers, even using good engineering practices, some drivers just based on their characteristics of driving could be caught in the a dilemma zone, is that correct?

A. Some drivers based on their characteristics, sure, yeah, they could be in a dilemma zone.
Q. If such a driver was in a dilemma zone, that does not mean that the traffic signal design engineer had a bad design?
A. No. No. Very well, very likely could be the result of bad driving.
Q. As far as the -- if we take a look at the most current yellow change interval calculation that is the last page of Exhibit 9, change in clearance intervals, signal design section of the Transportation Mobility and Safety Division, NCDOT, that formula is what?
A. That formula in the upper left of that page is the -- what we've been calling the ITE standard formula first term perception-reaction time and second term speed and deceleration rate and a grade correction.
Q. And what is that -- can you explain -- and you did a little bit, but can you explain what that formula is designed to do?
A. Sure. Sure. That formula is designed to eliminate the dilemma zone for drivers driving at the speeds and making -- and the other characteristics that are plugged into the formula so, in other words, a driver driving at the speed in the formula with the perception-reaction time in the formula with the

deceleration rate in the formula will be able to make a decision to either stop before crossing the stop bar or to be able to proceed through the intersection at that constant speed without entering on a red signal. The formula's designed to allow every driver operating within the parameters here to be able to make a correct decision.

Q. Okay. And does -- is there any math error in that formula?

A. Error?

Q. Yes.

A. On that -- no.

Q. So, for example, if a traffic signal engineer was determining a yellow change interval using the formula in North Carolina on a roadway with a speed limit of 30 miles an hour, would that formula allow a driver -- or is that formula designed to allow a driver who at the stopping distance of the constant deceleration rate used by North Carolina engineers of 11.2 seconds and using perception-reaction time of 1.5 seconds, is the yellow change interval formula designed to allow that driver at 30 miles an hour either enough time to continue traveling at 30 and enter the intersection before the light turns red or enough distance to stop before entering the intersection?

A. Yes.
Q. Okay. So for North Carolina traffic signal engineers designing -- or determining or designing yellow times for left turns, is the purpose of using 20 miles an hour to allow a driver who is traveling at 20 miles an hour at the stopping distance either the appropriate time if he continues to travel 20 to enter the intersection or the proper distance if he decelerates at the assumed deceleration speed of 11.2 seconds or more to stop?
A. Exactly.
Q. Okay. And so for -- now, it's possible that a -- correct, that a driver who is turning left might be going at a speed less than 20 miles an hour, let's say 17 miles an hour?
A. Most of them do, sure.
Q. Okay. That driver then would certainly have the distance to stop before entering the intersection at the designed stopping speed of the yellow change interval if they use 20 miles an hour, correct?
A. That is correct. If they were at the calculated stopping distance when the light turned yellow, they would have enough distance to get stopped before the stop bar.
Q. And for those drivers who drove faster than 20 miles

an hour, let's say 23 miles an hour, at the designed stopping distance using 20, when that driver hits the designed stopping distance and the light turns yellow, that driver could proceed through the intersection before the light turned red, correct?
A. Yes. Yes. Maintaining that speed, they would have enough time to get through before the light turned red.
Q. And if a driver who had some special car that was able to maneuver a 90-degree left-hand turn going 45 miles an hour, if such a vehicle and driver existed and that driver was at the calculated stopping distance, based on the yellow change interval formula used by North Carolina traffic signal engineers, that driver, while not having enough time -- excuse me, not having enough distance to stop, could clearly continue through the intersection before the lights turned red?
A. Yes.
Q. So is it your opinion based on a reasonable degree of engineering certainty that the yellow change interval used by North Carolina traffic signal engineers, the formula shown on seven point -- excuse me, the formula shown on the last page of Exhibit 9 does what traffic signal engineers intend it to do?
A. Yes.

Q. And does that yellow change interval formula meet the standards of practice for engineering -- traffic signal engineering in North Carolina?
A. Yes.
Q. Now, you were asked a question earlier about -- I think it's the last exhibit, Exhibit 12. Is 12 the exhibit, do you know, Dr. Hummer, that talks about that -- or maybe -- do you recall the exhibit, Dr. Hummer, that talks about having increment changes or implementing increment changes? That might be Exhibit 9. But, in any event, do you recall testifying about whether or not it was proper to make an incremental change when changing the length of either the yellow change interval or the red change interval?
A. I remember that, yep.
Q. And is it your opinion that it would be a -- that it would be a good -- strike that.
Do you have an opinion of whether or not changing a yellow time interval one second either up or down would require an incremental change in order to meet good engineering practice?
A. Certainly doesn't require it, no, no. And I do see here it's on -- is this on --
Q. Sure. It's on exhibit --

A. Fifth page of Exhibit 9.
Q. Okay. Yeah. So what -- go ahead, if you would read again what it says on the fifth page of Exhibit 9.
A. Consider adding a note to the plan to direct field forces to reduce the time incrementally. Let me read the whole sentence. If approach is high speed and existing times are significantly higher than the calculated times, use the calculated values to consider adding a note to the plan to direct field forces to reduce the time incrementally.
Q. Significantly higher, is there an agreed-upon engineering practice of what significantly higher means in order to require incremental determination or is that just engineering judgment?
A. That's going to be judgment. That's going to be based on lots of local factors.
Q. If the evidence in this case was that the change in the yellow times for any of the intersections in question in this lawsuit was not done incrementally, would that -- and it was as much as one second, would that violate good engineering practice in your opinion?
A. No. No. That -- I said before that needs to be a judgment of the local engineers who know far better and know the details of that intersection.

MR. STAM: I want to mark as Exhibit 13 an NCDOT traffic signal plan with an engineering sign and seal date of 10/26/09 for Walnut and Meeting Street.

MARKED BY THE REPORTER:
DEPOSITION EXHIBIT 13
1:26 p.m.

BY MS. MARTINEAU:

Q. It's Exhibit 13, and I will --

MS. MARTINEAU: I know, Skip, you don't have a copy of this, but I will tell you that I -- there's some of my writing on there. It says -- I wrote on there Walnut and Meeting, 10/2990, S Walnut, L Meeting, August 1, 2010, and I did that based upon the order just so I could identify the correct sheet.

MR. STAM: Okay.

BY MS. MARTINEAU:

Q. Dr. Hummer, do you see what I've marked as Exhibit 13?

A. Yes.

Q. Do you recognize Exhibit 13?

A. Sure. Yes. It is the signal plan for Walnut and Meeting Street at the date you indicated.

Q. Okay. And have you -- have you looked at the yellow time for going south on Walnut making a left on Meeting Street?

A. Yes.

Q. Okay. Could you -- do you have -- could you take a pen and just draw or, you know, follow -- so you could identify what direction we're talking about.
A. Sure. I'm doing it now.
Q. Okay. And what phase is that?
A. That is -- hang on a minute. Let me make sure of this. That is Phase 5.
Q. Okay. So do you see where in the upper left-hand corner it says phasing diagram?
A. Yes.
Q. Can you circle -- or there is a circle. Is that the -- there's already a circle on there. Is that the correct phase that we're talking about?
A. Yes, that's it.
Q. Okay. And then from that can you determine what the timing chart has for Phase 5 for yellow time?
A. Yes. The timing chart for Phase 5 yellow time says 3.2 seconds.
Q. Okay. Is three point -- okay. Can you look -- do you know whether or not these plans were signed by a professional North Carolina licensed engineer?
A. Yes, they appear to be signed by an NC PE.
Q. Do you know -- do you have an opinion -- well, you're familiar, right, with the requirements of the Manual of Uniform Traffic Control Devices, correct?

A. Yes.
Q. And does the yellow time for Phase 5 south on Walnut going left on Meeting of a value of -- where is the value?
A. 3.2.
Q. 3.2. Is that value in accordance with the Manual of Uniform Traffic Control Devices?
A. Yes. It conforms with engineering practice, which is to say it uses the ITE formula with appropriate values and, therefore, meets MUTCD. It's also between three seconds and six seconds.
MS. MARTINEAU: I'm going to be marking Exhibit 14. This is the clearance time calculation, Skip, for Walnut and Meeting for this plan.
MR. STAM: I don't think I have that but --
MS. MARTINEAU: It was part of Lisa Moon's exhibits.
MR. STAM: For one of them, but, yeah. I mean, I'll just get a copy.
MS. MARTINEAU: Okay. Sorry about that.
MR. STAM: No problem.
MARKED BY THE REPORTER:
DEPOSITION EXHIBIT 14
1:29 p.m.
BY MS. MARTINEAU:

Q. Do you recognize Exhibit 14?
A. Yes, I've seen that before.
Q. What is Exhibit 14?
A. It is the clearance time calculation for Walnut and Meeting as of the time that we're talking about here.
Q. Are you familiar with the form?
A. Yeah. Yeah, seen it before.
Q. Okay. And is this form consistent with how North Carolina engineers, you know, use computer calculation forms to compute yellow and red times?
A. Yeah, yeah, it is that.
Q. Okay. And if you would circle on this the movement we're concerned about, which again is south on Walnut making a left onto Meeting Street.
A. Okay.
Q. Does that form indicate what the North Carolina engineer used as far as the speed for the left turn movement?
A. Yes. It shows a speed of 25 miles an hour.
Q. And is that speed using an assumed speed of 20 -- or using a value speed of 25 miles an hour for a left turn, does that meet the standard of care for North Carolina traffic signal engineers?
A. Yes.
Q. And moving down, what is the grade?

A. They use zero percent.
Q. Okay. And, again, do they -- is it -- does it show on Exhibit 14 what perception-reaction time they used?
A. Yes, it does. That's 1.5 seconds.
Q. Will you circle that. And is using 1.5 seconds the standard of the industry in North Carolina for traffic signal engineers?
A. Yes.
Q. Okay. How about deceleration rate? Does it use deceleration rate?
A. Yes.
Q. What's the deceleration rate used?
A. 11.2 feet per second squared.
Q. Is that the correct deceleration -- excuse me. Does that 11.2 -- is that the standard deceleration rate used by traffic signal engineers in North Carolina when determining yellow and red times?
A. Yes.
Q. And is -- what does the sheet show that was the result of that formula?
A. It's shows the result to be yellow time of 3.2.
Q. Is that 3.2 seconds what is shown on Exhibit 13 for the left turn yellow time in question?
A. Yes.
Q. Okay. So is it -- do you have an opinion whether or

not the engineer who determined the left turn yellow time Phase 4 going south on Walnut, left onto Meeting on Exhibit 13 met general engineering practices when determining that time?

A. Yes, they did meet those practices.

Q. Okay.

MS. MARTINEAU: I'd like to next mark as exhibit -- did I take your exhibits? I sure did. Here they are. Okay. I stole the court reporter's exhibits. Sorry about that. I'm going to mark here as exhibit -- I'm marking as Exhibit 15 a signal plan. It's a two-page document, and I don't know why it's a two-page document, and it's dated -- the engineering date is 6/7/06.

MARKED BY THE REPORTER:
DEPOSITION EXHIBIT 15
1:34 p.m.

BY MS. MARTINEAU:

Q. Dr. Hummer, are you familiar with this document?

A. Yes, I am.

Q. And, again, this document has some handwritten notes on it. I'll purport these are my handwritten notes just so I could identify what signal plan I wanted to ask you about and what direction I wanted to ask you about. What is Exhibit 15?

A. It is the signal plan for Maynard and Kildaire as of June th of 2006.
Q. Have you reviewed this signal plan in particular with the yellow time for westbound Maynard taking a left on Kildaire Farm?
A. Yes.
Q. Can you take your pen and draw on Exhibit 15 what that movement is.
A. There we go.
Q. And what phase is that movement?
A. That is Phase 7.
Q. Okay. Can you go ahead and circle on Exhibit 15 -- or what exhibit is this? Yeah, 15. Go ahead and on the timing chart if you could find the yellow time in question, what is the duration of the yellow time shown on 15?
A. That's 3.0 seconds.
Q. Is 3.0 seconds yellow time for Phase 7 on Exhibit 15 in accordance with the Manual of Uniform Traffic Control Devices?
A. Yes.
Q. Is that your opinion -- professional opinion as a North Carolina licensed traffic signal engineer?
A. Yes.
Q. I'm going to show you what I am marking as Exhibit 16.

MARKED BY THE REPORTER:
DEPOSITION EXHIBIT 16
1:35 p.m.
BY MS. MARTINEAU:
Q. Are you familiar, Dr. Hummer, with Exhibit 16?
A. Yes.
Q. And what's Exhibit 16?
A. That's the clearance time calculation sheet for Kildaire Farm at Maynard Road again for the date that corresponds to the signal plan that we just looked at.
MR. STAM: Excuse me. Can you hold one second? I may have the wrong one in front of me, if you'll just give me a second.
MS. MARTINEAU: Sure.
MR. STAM: Wasn't the last one -- let's see. Fifteen. Are we at 15 now or 16?
MS. MARTINEAU: This is 16.
MR. STAM: And it's Kildaire Farm at what?
MS. MARTINEAU: It's Maynard and Kildaire.
MR. STAM: Southwest Maynard? I had that as 15.
THE WITNESS: The signal -- I'm sorry.
MS. MARTINEAU: The signal plan is 15. We're now looking at the clearance sheet.
MR. STAM: Okay. I don't have that

document, but I'll get a copy later.

BY MS. MARTINEAU:

Q. Take a look at Exhibit 16, which is the clearance time calculations for the intersection in question, and can you circle the yellow time that you just plotted on Exhibit 15?

A. Sure. That's for the westbound left. The calculation here is 3.0 seconds.

Q. Can you tell -- so on Exhibit 16, the engineer calculating the yellow time, what did they -- what did they use as the speed? Did they use the assumed -- what assumed speed did they use?

A. They used 20 miles an hour.

Q. Is using 20 miles an hour standard practice for North Carolina engineers for calculating left -- dedicated left turn yellow times?

A. Yes.

Q. And what did they have for grade?

A. Zero percent.

Q. And what did they have for perception-reaction time and deceleration rate?

A. It was 1.5 seconds and 11.2 feet per second squared respectively.

Q. We've already talked about that, and that was standard practice for North Carolina traffic signal engineers,

correct?
A. Yes.
Q. And what does -- what was the calculation result?
A. They calculated a time of 3.0 seconds for yellow.
Q. Was the calculation of the yellow time as shown on Exhibit 15 done using good engineering practices?
A. Yes.
MS. MARTINEAU: I'm going to mark as 17 the traffic signal plan for Kildaire and Cary dated June 23rd, 2010.
MR. STAM: Hold on a second. Did you say Kildaire and Cary Parkway?
MS. MARTINEAU: Kildaire Farm at Cary Parkway.
MR. STAM: Because I don't have that one in front of me. Okay. I got it. So this is 17?
MS. MARTINEAU: Right.
MR. STAM: All right. Got it.
MARKED BY THE REPORTER:
DEPOSITION EXHIBIT 17
1:39 p.m.
BY MS. MARTINEAU:
Q. Dr. Hummer, are you familiar with 17?
A. Yes.
Q. What is 17?

A. It is the signal plan for Kildaire Farm at Cary Parkway dated June 23rd, 2010.
Q. Okay. And can you make a line on the movement west on Cary taking a left onto Kildaire?
A. Sure. And that's that movement there.
Q. What phase is that?
A. That is Phase 7.
Q. Can you circle that --
A. Sure.
Q. -- for us so we can identify it later.
And what is the yellow time shown for that phase on Exhibit 17?
A. That's 3.0 seconds.
Q. And is 3.0 seconds in accordance with the Manual of Uniform Traffic Control Devices?
A. Yes, it is.
Q. And is that -- is your testimony there based on your experience, education, and background as a traffic signal engineer?
A. Yes.
MS. MARTINEAU: I'm going to now mark as Exhibit 18 the clearance time calculation that corresponds with that intersection.
MARKED BY THE REPORTER:
DEPOSITION EXHIBIT 18

1:48 p.m.

BY MS. MARTINEAU:

Q. Do you recognize Exhibit 18?

A. Yes.

Q. And what is Exhibit 18?

A. It is the clearance time calculation sheet for Kildaire Farm at Cary Parkway from the date corresponding to the signal plan.

Q. Okay. I'll represent that I have -- there's some yellow marking on this document, but can you go ahead and circle the phase or the movement that we're talking about here?

A. Sure. That's westbound Cary Parkway, left turn.

Q. Okay. And what assumed speed was used in determining the yellow time?

A. That was 20 miles an hour.

Q. And does using 20 miles an hour for assumed speed for determining yellow time, is that acceptable North Carolina traffic signal engineering practice?

A. Yes.

Q. What did they use for perception-reaction time and deceleration time?

A. That was 1.5 seconds and 11.2 seconds feet per seconds squared respective.

Q. We already talked about that, and what was -- using

that clearance time calculation, what is the calculated yellow time?
A. It's 3.0 seconds.
Q. And that's what showed on the plan?
A. It is.
Q. And so do you have an opinion of whether or not the calculations were done for Exhibit 17 west on Cary, left on Kildaire using good engineering practices?
A. They were, yes.
Q. Okay. I'm going to mark as an exhibit to your deposition -- actually we need to look at another movement in this one. Can you look at north on Kildaire, left on Cary?
A. Sure.
Q. Can you draw that one and maybe put an arrow and a B so we know that's the second one.
A. (Witness complied).
Q. And what phase is that?
A. That is Phase 5.
Q. Okay. So can you circle Phase 5 and put a line and a B next to that so we know?
A. Sure.
Q. Okay. And what is the yellow time calculated for that phase, Phase 5, that we've marked as B?
A. The chart shows yellow time of 3.0 seconds.

Q. And if you would then take a look at Exhibit 18 and circle with a B the movement that you just documented or just drew.
A. That's Kildaire Farm northbound, left turn.
Q. And what is the speed used in the calculation by the engineer?
A. It's 20 miles an hour.
Q. And is using 20 miles an hour for a left -- for determining a dedicated left -- the yellow time for a dedicated left turn good traffic signal engineering practices in North Carolina?
A. Yes.
Q. And they had -- they used 1.5 and 11.2 for perception-reaction time and deceleration rate respectively, correct?
A. Yes.
Q. We've already talked about that, and that is standard practice in North Carolina, correct?
A. Yes.
Q. And I don't know if we talked about the grade, but they used a zero percent grade for the B movement?
A. Yes.
Q. The first one they used a one percent grade?
A. Yes.
Q. Is it standard in North Carolina to use grade when

determining yellow times?
A. Yes. There is a grade correction in the yellow time formula. That's correct.
Q. What was the calculation for the B movement that you drew for this intersection?
A. 3.0 seconds of yellow.
Q. Do you have an opinion based on your education, training, and background as a North Carolina traffic signal engineer whether the engineer who calculated the time used good engineering practices in making the calculation?
A. They did, yes.
MS. MARTINEAU: I'm going to now mark as Exhibit 19 -- there's two plans in Exhibit 19 so I'm going to mark -- we'll do the earlier one first so that is -- that's Lisa Moon's plan I'm going to mark as Exhibit 19. Actually I'll mark both of them as Exhibit 19, two plans. I'm going to mark the Lisa Moon signed and sealed plan dated 10/5/06 followed by the Robert Ziemba, Z-I-E-M-B-A, plan dated 2/17/2011.
MR. STAM: Can you do it 19A and 19B?
MS. MARTINEAU: Sure. I'm going to write that right on here, 19A, 19B.
MARKED BY THE REPORTER:
DEPOSITION EXHIBIT 19

1:45 p.m.

BY MS. MARTINEAU:

Q. Okay. Dr. Hummer, if you would take a look at what I've marked as 19A. Do you recognize 19A?

A. Yeah. That's the signal plan for Cary Parkway at High House Road dated from 2006.

Q. And can you -- you've seen this before, correct?

A. Yes.

Q. Can you draw for me the movement going north on Cary taking a left on High House?

A. Yes. It's already highlighted.

Q. Yeah, it's already highlighted in yellow, but go ahead and do it again.

A. (Witness complied).

Q. Thanks. What phase is that?

A. That is Phase 3.

Q. If you would go ahead and circle Phase 3.

A. Okay.

Q. What's the yellow time calculated for Phase 3?

A. 3.0 seconds.

Q. And is 3.0 seconds in accordance with the Manual of Uniform Traffic Control Devices?

A. Yes.

Q. If you would take a look at the next plan which is 19B, and that is the Robert Ziemba plan. Do you know

Robert Ziemba?
A. He's a good friend of mine, yep.
Q. Do you know him to be a North Carolina licensed professional engineer?
A. One of the best, yep.
Q. Do you see his plan dated 2/17/2011?
A. Yes.
Q. What is it?
A. That is the signal plan for High House at Cary Parkway from 2011.
Q. Okay. If you would then draw the movement north on Cary, left on High House for me.
A. Sure.
Q. What phase is that?
A. That is Phase 3.
Q. Could you circle Phase 3 on Exhibit 19B?
A. Sure.
Q. What is the calculated yellow time for Phase 3 on 19B?
A. It's 3.0 seconds.
Q. Was that done in accordance with the Manual of Uniform Traffic Control Devices?
A. Right.
Q. Then if we could take a look at the corresponding clearance time sheet. I'm going to mark that as Exhibit 20.

MARKED BY THE REPORTER:
DEPOSITION EXHIBIT 20
1:48 p.m.
BY MS. MARTINEAU:
Q. Exhibit 20 is a two-page document. Do you recognize Exhibit 20?
A. Yes. That's a clearance time calculation sheet for Cary Parkway and High House Road from the time corresponding to the 2006 signal plan.
Q. And what's the next page? Which one is that?
A. The next page on Exhibit 20 is the clearance time calculation, Cary Parkway and High House Road from 2010 which corresponds to Exhibit 19B, Rob Ziemba signal timing plan.
Q. Can you circle for me the movement that you just drew on Exhibit 19A and B?
A. Sure. That's the northbound left turn.
Q. Okay. And based on -- and in the 2005 -- strike that. The 2000 -- in Lisa Moon -- let me ask it -- the one with Lisa Moon's name on it, what is the speed she used in plugging in the left turn yellow time calculation?
A. Twenty miles an hour.
Q. Again, you already testified that that is -- it's your opinion that that is standard practice in North

Carolina?
A. Yes.
Q. All right. And what is -- what did she use for perception-reaction time and deceleration?
A. 1.5 seconds perception-reaction time, 11.2 feet per second deceleration rate.
Q. That's standard practice in North Carolina?
A. Yes.
Q. What was the value that she got for the yellow time?
A. Was 3.0 seconds.
Q. And do you have an opinion whether or not Lisa Moon used good engineering practices when calculating the yellow time for Exhibit 19A?
A. She did, yes.
Q. If you would take a look at the second page where it has Ziemba's I think initials there, do you see that?
A. Yes.
Q. All right. And if you could circle the movement that you documented on 19B.
A. Sure.
Q. That was north on Cary, left on High House?
A. Yep.
Q. What speed did he use for an assumed speed for calculating the yellow time?
A. It was 20 miles an hour.

Q. And again do you have -- is that using 20 miles an hour an accepted practice --
A. Yes.
Q. -- at that time for North Carolina traffic signal engineers?
A. Yes.
Q. What was the value again he used for perception-reaction time and deceleration rate?
A. He used eleven -- 1.5 seconds perception-reaction time, 11.2 feet per second squared deceleration rate.
Q. What is the calculated yellow time that he came up with?
A. He calculated 3.0 seconds as well.
Q. Do you have an opinion whether or not Mr. Ziemba used good engineering practices when determining the length of the yellow time for the movement shown on 19B?
A. He did, yes.

MS. MARTINEAU: Okay. Finally I want to mark as an exhibit 21. Twenty-one is the 1991 signal plan. It's a two-page document.

MARKED BY THE REPORTER:
DEPOSITION EXHIBIT 21
1:52 p.m.

BY MS. MARTINEAU:
Q. Dr. Hummer are you familiar with Exhibit 21?

A. Yes.
Q. Okay. What is Exhibit 21?
A. It's the signal plan for Western Boulevard at -- which is the same thing as Cary Town Boulevard, at Convention Drive.
Q. What's the date of this signal plan?
A. That is signed May 31st, 1991.
Q. Okay. Are you familiar with what traffic signal engineers in North Carolina need to do in order to determine what the speed limit is when they're going to be designing a signal plan?
A. Yes.
Q. What's the typical -- what's your understanding of the typical practice back in 1991?
A. To determine a speed limit?
Q. Yes.
A. Is to take a speed -- do a speed study, which is to collect some data on the speeds at somewhere on the stretch of road that we're interested in, analyze those data, determine the 85th percentile, and typically the speed limit is set somewhere around the 5th percentile. Of course, we have to round from the actual numbers to the next nearest five or -- in North Carolina next almost nearest ten with their speed limit practices.

Q. Do you know what's required in order to change a speed limit in terms of do you know how -- do you know what's required in order to change a speed limit in terms of state law, ordinance and/or posting?
A. Yes. To change -- to post or change a speed limit requires a state law and a local ordinance to be passed and then the engineering activities order a sign, get the sign out there and get it posted.
Q. Do you know what the legal speed limit was on Cary Town Boulevard, then known as Western Boulevard Extension back in 1991?
A. It was 35 miles an hour.
Q. What was the -- what are the through yellow times for traveling on Western Boulevard?
A. The through movements at Western Boulevard would be Phases 2 and 6, so the second page of Exhibit 21 with the timing chart for Phase 2 and 6 shows those yellow intervals to be 4.0 seconds.
Q. Okay. And are those times in accordance with the Manual of Uniform Traffic Control Devices?
A. Yes, they are.
Q. What are the yellow times for the through movements on Convention Drive to Principal Lane as shown on Exhibit 21?
A. The through movements on Convention Drive would be

Phase 3 and Phase 4. Phase 3 is the northbound. The yellow time there is 5.0 seconds, and Phase 4 is the southbound movement, and the yellow time there is 4.5 seconds.

Q. Okay. Are those yellow times in accordance with the Manual of Uniform Traffic Control Devices?

A. Yes, they are.

Q. What is Phase 5 and Phase 1?

A. Phase 5 and Phase 1 are the left turn movements from Cary Town onto Convention Drive.

Q. Okay. And what is the yellow time for -- calculated for Phase 5?

A. That is 4.0 seconds.

Q. And Phase 1?

A. Is 4.5 seconds.

Q. Are those times in accordance with the Manual of Uniform Traffic Control Devices?

A. Yes.

Q. If you would take a look at what I'm marking as Exhibit 22.

MARKED BY THE REPORTER:
DEPOSITION EXHIBIT 22
1:56 p.m.

BY MR. STAM:

Q. What is Exhibit 22?

A. It is the clearance time sheets, the calculations for Western Boulevard at Convention Drive dated May 20th, 1991.
Q. Okay. And what are the -- okay. Do those show the various phases?
A. They do, yes.
Q. Can you circle phase -- let's see. There's Phases 1 through 6. I guess we're missing some -- are we missing some phases?
A. I think they're all there.
Q. And can you -- for the straight-through phases going on what was then called Western Boulevard Extension, by looking at the clearance time sheet, do you have an opinion of whether or not the traffic signal engineer used good engineering practices when determining the length of the yellow times for the phases we just discussed?
A. Yes, I do. That would be Phase 2 and Phase 6, the through movements eastbound and westbound. This clearance sheet from 1991 is not as clear as the other ones, the later ones we looked at, but there's still enough information to make a judgment here.
They do show that the grade is zero percent in their calculations, and that's helpful. What they don't show, the perception-reaction time or the

deceleration rate that went into the calculation, but we can back calculate and get back to what we think they used for those values, so what this sheet does show is the minimum yellow time of 3.6 seconds for Phase 2 and Phase 6. Minimum yellow is really the same thing as the result of the ITE formula calculation. If we use that formula with a perception-reaction time of one second and a deceleration rate of 10 feet per second squared, which my understanding is those were more accepted values back in 1991, then we do calculate a result of 3.6 seconds. One second perception-reaction time, 10 seconds deceleration time are fine to use.

They're well within the bounds of standard practice. In this case, the sheet tells us that the engineers recommended yellow time for both Phase 2 and Phase 6 as 4.0 seconds, and that is well within the standard, so my conclusion here is they met the standard for acceptable engineering practice.

Q. What about the other phases that we looked at, three, four, and five?

A. Yes. That they did as well, sort of doing it that same -- that same thought process. It's different at this intersection from the other ones that we looked at in the sense that this was before the task force

and before. Before we were using the -- really the same procedure that we came to use later in the 2000s, but still those values are within the standard engineering practice for their time.
Q. Okay. And would that also be true with -- did we look at Phase 1? I know this intersection, it didn't indicate on the order what phase we needed to look at. What's Phase 1?
A. Phase 1 is the left turn -- westbound left turn that would be turning from Cary Town Boulevard onto Convention Drive going south.
Q. Okay. And is -- when you look at Exhibit 22, can you tell by Exhibit 22 or do you have an opinion looking at 22 whether or not the engineer used good engineering practices in determining the yellow time for that phase?
A. Yes, they did.
Q. Okay. And then finally if you would take a look at what's already been marked as -- by Plaintiff as the last exhibit, exhibit --
A. Their last exhibit was Exhibit 12.
Q. Yeah, Exhibit 12. In reviewing Exhibit 12, does Exhibit 12 -- it's entitled North Carolina Department of Transportation, Division of Highways, Traffic Engineering and Safety Systems Branch, standard

practice for compliance with traffic signal and electrical dash programming detail plans. Do you see that?
A.   Yes, I do.
Q.   At the bottom of that first page, does it outline what NCDOT's practice is regarding when a signal plan should be updated?
A.   Yes, it does.
Q.   What is the NCDOT -- according to this document, what is NCDOT's standard practice for updating signal plans?
A.   In that paragraph -- and if I may just read it so I don't misstate --
Q.   Sure.
A.   Starting with the second sentence, therefore, prior to beginning traffic signal or roadway construction, the division traffic engineer should check the seal date of the traffic signal and electrical programming detail plans. If the plans are more than two years old or if traffic patterns have changed, the division traffic engineer should request the ITS and signals unit review the plans for compliance with current practices.
Q.   And, Dr. Hummer, do you have any idea why Mr. Ceccarelli was in the roadway at the time the

light in his direction of travel turned yellow?
A. I have no idea.
Q. Okay. And so you don't know whether or not Mr. Ceccarelli could have stopped at the deceleration rate of 11.2 feet per second using a reaction time of 1.5 seconds prior to entering the intersection or not at the time he first turned -- at the time he first observed the light turn yellow?
A. I don't know that.
Q. All right. Thank you, sir. Those are the questions I have for you.
MR. STAM: Just a very few.

RE-EXAMINATION

BY MR. STAM:
Q. Looking at that last exhibit, Dr. Hummer, you're assuming a 35 mile per hour speed limit?
A. I'm sorry. The last --
Q. Exhibit 21 and 22.
A. I'm sorry. I still have Exhibit 12 here. Hang on a second. Okay.
Q. Were all the answers to the questions you gave to Ms. Martineau assuming a speed limit of 35 miles an hour on Western Boulevard headed east through that intersection?
A. Yes.

Q. When did you live in Cary?
A. From 1992 to 2007.
Q. And where did you live from 2007 till you moved to Michigan?
A. In downtown Raleigh.
Q. Have you traveled that section of road many times?
A. Sure.
Q. I'll call it Cary Town Boulevard?
A. Sure.
Q. Do you know what the speed limit was in 2009 on that section?
A. I don't remember that, no.
Q. Okay. You're familiar with the -- strike that.
Are you familiar with AASHTO?
A. Yes.
Q. What is AASHTO?
A. That's the American Association of State Highway and Transportation Officials. It's basically the group of the 50 state DOTs.
Q. Are you familiar with their 2004 volume of policy of geometric design of highways and streets?
A. Yes. I tried to refer to it earlier in my deposition, yes.
Q. Let me quote a sentence from Page 110.
MS. MARTINEAU: Hold on a second. He's

going to grab it.
THE WITNESS: Okay. I've got it.
BY MR. STAM:
Q. I think it's Page 110 through Page 111. You see the sentence a brake reaction time of 2.5 seconds?
A. Oh, yeah. It's kind of in the middle of Page 111. There's a sentence that starts a brake reaction time of 2.5 seconds.
Q. Would you read that sentence?
A. Sure. A brake reaction time of 2.5 seconds is considered adequate for conditions that are more complex than the simple conditions used in laboratory and road tests but is not adequate for most complex conditions encountered in actual driving.
Q. That refers to brake reaction time. Is that the same -- they're using it -- brake reaction time, is that the same -- what you were referring to previously in your deposition as perception-reaction time?
A. It's the same term, but it's in a different context. What they're talking about here on page -- in that sentence in particular is reacting to an unexpected stimulus, which is usually somebody coming over a hill, around a curve and encountering a stopped vehicle ahead, maybe an animal in the road, maybe a pedestrian walking across the road.

That's different from the yellow time case that we're talking about for most of today where the stimulus is expected, that is the driver has undoubtedly looked up and noticed that there's a signal ahead and probably noticed that the green has been on for a while. So the term is named the same, but the context is different, this sentence, from what we've been talking about.

Q.   Early on in your deposition you talked about yellow change -- yellow lights must command respect.

A.   Yes.

Q.   Okay. What is the origin of that assumption?

A.   Oh, I don't know. That goes back through the MUTCD for as many editions as I can remember. I think I studied the 1978 edition in my school days and I think it was in there then, and it probably goes back many editions before then. It's the drivers need to take our traffic control devices seriously if the road system is going to function.

Q.   Is there a problem if drivers run a yellow light?

A.   In what sense run a yellow light? I don't understand.

Q.   Is there a safety problem if a driver enters the intersection when the light is yellow?

A.   There should not be. We -- I don't like to think in terms of that there's safety problem or not safety

problem. It's a continuum. There's situations that are more safe and less safe. It's probably more safe to pass the stop bar on green than yellow, but entering the intersection, which is to say passing the step bar on yellow, is not drastically unsafe. Let's put it that way.
Q. Go to your Exhibit 13.
A. Are we done with AASHTO?
Q. Yes.
A. Okay. Exhibit 13. Got it.
Q. Looking at Phase 5, which is I understand the left turn into Meeting Place, is the yellow change interval 3.2 and red clearance 3.3?
A. That is correct, yes.
Q. So adding up -- they come consequentially, so adding them together is 6.5 seconds when conflicting traffic would be protected I guess. Is that right? 6.5 seconds combined between the yellow change and the red -- all-red clearance.
A. Well, yeah, sure, and that's -- and the same thing as to green. It's -- the green arrow for that movement as well is conflicting traffic which is westbound through, north and southbound through, north and southbound left. Those movements all have to stay stopped during that time. That's correct.

Q. Purely for safety considerations, would it be any different if the yellow change interval was, say, 4.2 and the red clearance was 2.3 adding up to 6.5 seconds?
A. It probably would make a difference in long run average of number of collisions and probably for the worse since these are the standard practice sort of as we've been talking about uniformity and all that and such, so probably makes a difference and probably makes things worse.
Q. Well, suppose that it was not just at this intersection but for every intersection in Cary in North Carolina if they added a second to the yellow change and decreased a second for the all-red interval.
A. Well, the all-red interval is extremely important in its own regard, and we haven't talked about it here today, and my understanding was that it wasn't a big part of this case, but we just can't go around taking seconds away from all-red intervals and expect there not to be an effect from that, either, so, you know, we could delve into the why 3.3 seconds of all-red at the end of that phase, but my suspicion is there's very good reasons for that and harm to be done if we are taking away time from that part of the phase.

MR. STAM: I think I'm finished if you'll just give me 30 seconds to look over my notes.

MS. MARTINEAU: Sure.

MR. STAM: I'm sorry. I do have one more question, and I have a big lawn mower outside my window.

MS. MARTINEAU: We can hear you fine.

BY MR. STAM:

Q. Thinking about Lori Millette's intersection at northbound on Kildaire turning left on Cary Parkway, what is the designed speed associated with a 3.0 second yellow change interval?

MS. MARTINEAU: I'm going to object to the form of the question, but go ahead. Which one is it again?

MR. STAM: Let me give you two things to look at. One is Lori Millette's intersection.

MS. MARTINEAU: Which is what?

MR. STAM: The second one is Exhibit 6.

MS. MARTINEAU: What's Lori Millette's intersection?

MR. STAM: Which is north on Kildaire, left on Cary Parkway, and if you would take out Exhibit 6.

THE WITNESS: Okay.

BY MR. STAM:

Q. What is the designed speed associated with the 3.0 second yellow change interval?

MS. MARTINEAU: Objection to the form of the question, but go ahead and answer.

THE WITNESS: Yeah. I think that --

BY MR. STAM:

Q. Directing your attention particularly to Equation 8.

A. The designed speed is the speed we use to put together things like turn radius and curb radius and vertical alignments and such so it's sometimes used in this context defining yellow. In the case of standard practice in North Carolina, they tend to use the speed limit rather than the designed speed.

Q. Let me use a different term that we've already used today. What is the approach speed associated with a 3.0 second yellow change interval?

MS. MARTINEAU: For the left-hand turn of Ms. Millette's intersection?

MR. STAM: Yes.

THE WITNESS: I believe that is 20 miles an hour.

BY MR. STAM:

Q. Is Equation 8 the way you could work the equation backwards according to the ITE interval formula?

A. It appears to be solving it backwards, yes.

Q. And you don't have a calculator there, but I'm going to represent to you if you work that backwards, it would be 22.9 miles an hour, so the question that I have, if that's correct, if Lori Millette was going 23 miles an hour approaching that intersection, did she have enough stopping distance or enough time to proceed through the intersection reasonably and safely?

MS. MARTINEAU: Objection to the form of the question because we don't -- you didn't tell us where she was when she saw the yellow light. How far away was she from the stop line or where was she in relation to her stopping distance?

MR. STAM: Well, that's the question by opposing counsel is where was she and I would say that's the problem with the entire approach of the city on this, but wherever Dr. Hummer would want to posit that she was. We know she was going 23 miles per hour when the camera clicked her. That's what we know. That's right at the stop bar I guess.

THE WITNESS: Yeah.

BY MR. STAM:

Q. Is it possible that she got caught in the dilemma zone?

A. It's possible that she was driving too fast in the wrong place and made the wrong decision. Typically a driver's driving faster than we assume and in many places on that approach can get through the signal holding their speed, not having to speed up but just holding their speed and get past the stop bar before the light turns red.

Q. Since we don't know whether she was decelerating to 23 or accelerating to 23, could she proceed at 23 miles an hour safely and legally through the intersection?

A. I have no idea. That totally depends on where she was when the yellow came up.

Q. I have no further questions.

MS. MARTINEAU: Okay. Thank you.

MR. STAM: Thank you very much.

MS. MARTINEAU: I'll make sure you get a copy of the exhibits.

MR. STAM: Thank you. And tell the court reporter he or she is very patient, and, Dr. Hummer, I learned a lot.

COURT REPORTER: Would you like to order the transcript?

MR. STAM: Yes. I want it e-mailed and I'm not sure I know the different terminologies, but --

MS. MARTINEAU: Do you like the E-Trans?
Do you have E-Trans or PDF?

COURT REPORTER: Yes.

MR. STAM: Yeah, and a compressed transcript, four to a page.

MS. MARTINEAU: I'd just like the E-Trans with exhibits.

(Deposition concluded at 2:19 p.m.

Signature of the witness was requested.

BRIAN CECCARELLI and LORI
MILLETTE, individually and
as class representatives,
Plaintiffs,
vs. Case No. 10-CVS-019930

TOWN OF CARY,
Defendant.
________________________________/

VERIFICATION OF DEPONENT

I, having read the foregoing examination under oath consisting of my testimony at the aforementioned time and place, subject to the changes in the attached errata sheet, do hereby attest to the correctness and truthfulness of the transcript.

____
Joseph E. Hummer, Ph.D., P.E.
Dated:

ERRATA SHEET

PAGE LINE READS PAGE LINE SHOULD READ

CERTIFICATE OF NOTARY

STATE OF MICHIGAN)
) SS
COUNTY OF WAYNE)

I, HELEN F. BENHART, certify that this deposition was taken before me on the date hereinbefore set forth; that the foregoing questions and answers were recorded by me stenographically and reduced to computer transcription; that this is a true, full and correct transcript of my stenographic notes so taken; and that I am not related to, nor of counsel to, either party nor interested in the event of this cause.

HELEN F. BENHART, CSR-2614
Notary Public,
Wayne County, Michigan.

My Commission expires: 7/7/14

d

t

BRIAN CECCARELLI and LORI
MILLETTE, individually and
as class representatives,
Plaintiffs,
vs. Case No. 10-CVS-019930

TOWN OF CARY,
Defendant.
________________________________/

VERIFICATION OF DEPONENT

I, having read the foregoing examination under oath consisting of my testimony at the aforementioned time and place, subject to the changes in the attached errata sheet, do hereby attest to the correctness and truthfulness of the transcript.

____
Joseph E. Hummer, Ph.D., P.E.
Dated:

ERRATA SHEET

PAGE LINE READS PAGE LINE SHOULD READ