NORTH CAROLINA		IN THE GENERAL COURT OF JUSTICE
		SUPERIOR COURT DIVISION
WAKE COUNTY		10-CVS-19930
BRIAN CECCARELLI and LORI MILLETTE individually and as class representative,	)	
Plaintiff,	)	
v.	)	AFFIDAVIT OF JOHNNIE HENNINGS
TOWN OF CARY,	)	
Defendant.	)	

I, Johnnie Hennings, am over the age of 21 and am competent to testify to the following facts and opinions.

1. I have a bachelor's degree in Mechanical Engineering from North Carolina State University. Some of the required lectures to acquire this degree included multiple classes in mathematics, statics (the study of bodies at rest), dynamics (the study of bodies in motion), and physics (the equations and laws that govern all movement in our universe). My education also includes several semesters of design, safety and failure analysis. These classes are the backbone that majority of subsequent engineering classes are built upon.
2. Upon graduating from North Carolina State University I was employed by Accident Reconstruction Analysis, Inc. Over the past fifteen years the majority of my work has revolved around automobile accident reconstruction. The act of reconstructing automobile accidents involves many facets of physics, statics, dynamics and human perception and reaction. These factors play key roles in determining how an automobile accident has occurred and how it may have been avoided.
3. I have been qualified as an expert in accident reconstruction, vehicle dynamics and all facets of reconstructing automobile accidents in both civil and criminal matters.
4. In the course of my involvement in this matter I have reviewed various trade and industry publications related to traffic signal timing, various sources of human perception and reaction. The following is a brief list of Discovery materials that were also reviewed.
    a. Deposition of Brian Ceccarelli
    b. Deposition of Elizabeth George
    c. Deposition of Joseph Hummer
    d. Deposition of Greg Fuller
    e. Deposition of Lisa Moon
    f. Deposition of Darren Marceau
    g. Deposition of Joe Shovlin
    h. Affidavit of Greg Fuller
    i. Affidavit of Lisa Moon

j. Affidavit of Joseph Hummer
k. Affidavit of Darren Marceau

5. This matter is focused on the solution to simple problem of how the driving public perceives and reacts to a yellow traffic signal and why a very small percentage of vehicles enter an intersection on red. The ultimate reaction of the motorist upon seeing a yellow signal will include the decision and action to go or the decision and action to stop. These perceptions, decisions and reactions/inactions are normally processed during the yellow cycle of the traffic light. The result of these decisions is that the vehicle legally stops before entering the intersection, legally enters the intersection on yellow, or illegally enters the intersection on red.
6. It is important to distinguish between the undisputed purpose and timing of the yellow and "all red" light phases.
    a. The red light's purpose is to let the traveling motorist that their right of way has ended. The timing of the "all red" is simply the time required for a vehicle who legally entered the intersection at the last possible moment to travel from the stop bar to a safe position at/near the exit of the intersection so that conflicting traffic can be allowed to safely proceed under their green light.
    b. The yellow light timing is solely based on the movement of a vehicle before it reaches the stop bar and it's purpose is to indicate to the motorist that their right of way is soon ending. The timing of the yellow light provides the through (or left turning) driver time to traverse the safe stopping distance and affords the stopping driver adequate distance to safely stop.
    c. The two light timings are mutually exclusive, unlinked and are calculated in separate portions of a larger equation.
7. In the course of my role in this matter I have come to be intimately familiar with the facts at hand with respect to yellow and red stoplight timing. I have also familiarized myself with the ITE formula, its iterations and its origins as derived in 1956 in the Denos Gazi technical treatise.
    a. As outlined in a multitude texts and documents, and **Moon's affidavit**, the purpose of the yellow change interval formula is to allow the through (or left turning) driver time to traverse the stopping distance and affords the stopping driver adequate distance to safely stop.
8. An important issue to the matter at hand is human perception and reaction. In the course of my career I have reviewed dozens of scientific studies focused on human perception and reaction. These studies come from many sources: independent, professional, educational, and governmental agency financed research.
9. The Defense in this matter contends that plaintiff's experts, including myself, are not qualified to testify to signal light timing and vehicle motion due to having no expertise in programming and designing traffic signals. This matter, however, is not based on programming and designing traffic signals, instead, this matter is simply an issue of how a vehicle operator perceives and reacts to a stimulus, the physics of the operator's actions or inactions, and what factors affect the reaction of the operator to that stimulus. The inputs and equations required to provide solutions in this matter are not technically difficult and could be addressed by any capable high school physics student.

a. The defense contends that degreed physicists and a licensed professional engineer are unqualified to testify to matters of physics and vehicle motion. However, the defense argues the heart of the perception and reaction matter, in part, based on the results of a study of human factors reportedly performed by traffic engineers **(Moon)** and not by human factors experts.

10. At issue in this matter is the proper timing for yellow and red phases for turning and straight-through vehicle movements at signalized intersections. The opinions given in my deposition include that the human perception and reaction time of 1.5 seconds used in the ITE formula by the NCDOT is inadequate to allow a significantly complete percentage of the safe and attentive driving public to properly perceive, decide and react to a yellow signal.
    a. Reliable references and scientific studies point to two and one-half seconds as a minimum value to account for approximately 95% of the motoring public to perceive and react to a stimulus on the roadway.
        i. Most notably, AASHTO (The American Association of State Highway Traffic Officials), recommends using a minimum of two and one-half seconds for human perception and reaction in highway design. The following excerpt is from AASHTO's *A Policy on Geometric Design of Highways and Streets*.
            1. *"Minimum brake reaction times for drivers could thus be at least 1.64 s and 0.64 s for alerted drivers as well as 1 s for the unexpected event. Because the studies discussed above used simple prearranged signals, they represent the least complex of roadway conditions. Even under these simple conditions, it was found that some drivers took over 3.5 s to respond. Because actual conditions on the highway are generally more complex than those of the studies, and because there is wide variation in driver reaction times, it is evident that the criterion adopted for use should be greater than 1.64 s. The brake reaction time used in design should be large enough to include the reaction times needed by nearly all drivers under most highway conditions. Both recent research (4) and the studies documented in the literature (1, 2, 3) show that a 2.5-s brake reaction time for stopping sight situations encompasses the capabilities of most drivers, including those of older drivers. The recommended design criterion of 2.5 s for brake reaction time exceeds the 90th percentile of reaction time for all drivers."* (underlining added)
        ii. AASHTO clearly understands the complexity of the motorist approaching an intersection as is explained in this excerpt from AASHTO's *A Policy on Geometric Design of Highways and Streets.*
            1. ***"****A brake reaction time of 2.5s is considered adequate for conditions that are more complex than the simple conditions used in laboratory and road tests, but it is not adequate for the most complex conditions encountered in actual driving. The need for greater reaction time in the most complex conditions encountered on the roadway, such as those found at multiphase at-grade intersections and at ramp terminals on*

through roadways, can be found later in this chapter in the section on "Decision Sight Distance." (underlining added)

iii. NC Commercial Driver's Manual 2009 published by the NCDOT, recommends 2.5 seconds for perception and reaction **(Exhibit ?? page 2-14)**

iv. Outside of AASHTO and the NCDOT is a study produced by the Oregon Department of Transportation citing several scientific studies finds 2.5 seconds for urban arterial routes as an adequate perception and reaction time. **(Exhibit ?? page 8)**

11. Defense experts contend that one and one-half seconds for perception and reaction is adequate to account for appreciably all of the driving public as an "expected" perception and reaction time. Based upon the references cited above including numerous scientific studies 1.5 seconds is not adequate to account for an appreciably complete percentage of the driving public.
    a. The value of 1.5 seconds assumes the average driver is focused on the light in question at the exact instant the light turns yellow.
    b. The value of 1.5 seconds assumes the average driver is not performing other necessary, normal and safe functions such as checking mirrors, gauges, surrounding vehicles, encroaching vehicles or generally scanning their surroundings. These functions take time and require the operator to divert their focus from the traffic light to other areas. A safe motorist cannot direct all of their attention to the traffic signal and disregard the actions of potentially dozens of vehicles, pedestrians or hazards around them at a signalized intersection. If the light shifts to yellow during this redirection of focus, the inadequate yellow time will become even more inadequate resulting in a likely red-light violation by a safe and attentive driver.
    c. Though only one second of additional yellow may sound insignificant, studies show that the overwhelming majority of red light traffic violations are in the first second after red illumination and by adding one second to the yellow phase of the signal, red light violations are nearly eliminated. See, **for example, the graphs attached** to several depositions showing the rise and fall of violations when the yellow light interval is changed.
    d. The use of 1.5 seconds of perception and reaction in the formulation of yellow times results in many motorists being incapable of perceiving and reacting in the time afforded to them.
12. For straight through and turning movements, it is my opinion that yellow light times that are equal or less than the values derived from the current use of the ITE formula with 1.5 seconds of perception and reaction are inadequate to account for an appreciably complete percentage of the safe motoring traffic.
13. The NCDOT uses a different methodology to calculate the yellow times for left turning movements. Instead of using the legal approach speed to determine the actions of vehicles prior to reaching the stop bar, the current methodology uses the speed of vehicles at or beyond the stop bar as inputs into this formula. It is important to recall the purpose of the yellow light at this time.

a. The yellow change time is to allow the through (or left turning) driver time to traverse the stopping distance and legally enter the intersection and affords the stopping driver adequate distance to safely stop.

14. The NCDOT uses a traveling speed of 20 or 30 mph as the design speed when determining the proper light timing for left turning vehicles. Based upon my review of the testimony in this matter this value has been determined by measuring the speed of vehicles at the stop bar and/or entering the intersection.
    a. For left turning movements a systematic migration of unrelated statements has contributed to the inappropriate use of 20 to 30 miles per hour for the timing of the left turn yellow **(Ceccarelli exhibit of NCDOT 5.2.2)**.
15. Regardless of the reasoning, the use of 20 to 30 miles per hour is an inappropriate value to use for the timing of yellow lights at intersections where the legal approach speed is greater than the 20 to 30 miles per hour used. As outlined in my deposition, a more accurate modeling of the left turn vehicles should consider the vehicle legally approaching at the speed limit.
    a. For reference, the braking distance required for a vehicle traveling 20 mph is only 44% of the braking distance required to stop from 30 mph, 25% of the distance required to stop from 40 mph and only 16% of the distance required to stop from 50 mph.
        i. A driver stopping from 20 mph requires approximately 40 feet of brake application at the prescribed deceleration of approximately 1/3 g. A driver stopping from 30, 40 and 50 mph will require approximately 90, 160 and 250 feet of brake application under the same conditions.
        ii. A vehicle cannot stop under emergency/maximum braking effort in 40 feet of brake applicationunless that vehicle is traveling at approximately 33 mph or less at the onset of braking.
    b. The previous points do not address the inadequacies of determining the distance traveled during perception and reaction of a vehicle traveling at 20mph when compared to a vehicle traveling at 40 mph.
    c. In some instances, the approaching driver that plans to stop cannot physically do so in the distance provided and must therefore enter the intersection on a red signal.
16. Whereas the Defense contends an arbitrary "20 or 30 mph" is the proper number for determining the yellow timing for left turning vehicles, NCHRP-731 published by the Transportation Research Board within the National Academies sponsored by AASHTO and the Federal Highway Administration in 2012 clarifies the proper method to use when determining the speed used in the yellow signal timing for vehicles making a left turn. The following text is the conclusion from this technical treatise.
    a. *"…it is recommended that the approach speed limit minus 5 mph be utilized as a rule-of-thumb estimate for the 85th percentile speed for purposes of timing of the yellow change interval for left-turning vehicles."*
    b. It is clear from the previous statement that the NCHRP study agrees with my position that the use of 20 to 30 mph on the approach is an inappropriate number. The reasoning for this is clear: Vehicles legally approaching an intersection at speeds greater

than 20 to 30 mph cannot perceive, react and stop (or go) in the same distances and times afforded using the current methodology.

17. Commercial Motor Vehicles (CMV) present an even greater dilemma when using the shorter perception and reaction times. A CMV equipped with air brakes requires additional time beyond the perception and reaction time to allow the brake system to fully charge and become activated. Typical times for full actuation approach .75 seconds. Therefore, when equating the yellow time for CMV's, the designer should include this additional time, however, there is no indication this matter is addressed in the current methodology.
    a. This issue may explain why some studies have shown a <u>disproportionate</u> number of CMV's experiencing red light violations when compared to passenger vehicles.
18. The previous points outline the reasoning and give examples of the shortcomings of the methodology used to determine the yellow light timing. Any light timing that is approximate to the value as determined by the current methodology using the ITE formula for straight through vehicles and the methodology of modeling the ITE formula for left turning drivers does not provide adequate time and distance to an appreciably complete percentage of the safe motoring public. These statements are true whether the yellow timing was derived using the ITE formula or other methods.
19. It is admitted that designers, engineers, mathematicians and physicists may disagree on the methodology used to solve a problem. The scientific method is taught in technical higher education such as physics and engineering and it prescribes a methodology to solve a problem. The scientific method is also the basis for determining the admissibility of an expert's opinion **(cite rule)**.
    a. In this matter, several theories have been expressed by the various parties about how to <u>model the yellow timing</u>, however, only the Plaintiff's experts have quantified the problem of <u>why</u> people are running red lights and how to <u>solve the problem</u>.
    b. As the final step of the scientific process we use the camera data to show trends that supports my position regarding the inadequacies of the current timing. This data can be combined with other studies that also show similar trends. This matter can be summarized no more concisely than the following three statements.
        i. When the yellow time is lengthened beyond the ITE values the number of red light violations drops significantly.
        ii. When the yellow time is shortened, the number of red light violations increases significantly.
        iii. By extending yellow time, we reduce the number of red-light violations and increase the safety of the roadways.
    c. There may be many ways to model the average or ideal motorists' response to yellow signal timing, however, values that are inadequate to account for the an appreciably complete percentage the motoring public can be clearly discerned from the data.
20. By careful analysis of the information, research and studies it is my opinion that yellow timing consistent with the current use of the ITE formula, the omission of the needs of CMVs and the currently methodology for left turning vehicles causes excessive red light violations at no fault of the overwhelming majority of motorists who are cited.

This the 14th day of December, 2012.

_____
JOHNNIE HENNINGS

STATE OF _____
COUNTY OF _____

Sworn to and subscribed before
me this ___ day of December, 2012.

_____
Notary Public
My Commission Expires:_____