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UNITED STATES DISTRICT COURT

DISTRICT OF OREGON

PORTLAND DIVISION

MATS JARLSTROM, an individual, Plaintiff, v. **CITY OF BEAVERTON**, an Oregon municipal corporation**,** Defendant.	Case No.: 3:14-cv-00783-AC **DECLARATION OF MATS JARLSTROM**

I, Mats Jarlstrom, being sworn, say:

1. I am a resident of Beaverton, reside at 13520 S.W. Hart Road in the Hyland Hills neighborhood between Murray Boulevard and Hall Boulevard and make this declaration based upon my own personal knowledge.

2. I was born, raised and educated in Sweden with an equivalent of an American degree of a Bachelors in Science in Electrical Engineering or higher, which has given me excellent mathematical and scientific skills. I did my military service in the Swedish Air Force as an airplane-camera mechanic. I also worked in Sweden as an audio engineer in the research

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and development department for Luxor Electronics, a subcontractor for both Volvo and SAAB. Additionally, I was an engineering consultant designing powered loudspeakers for Audio-Pro in Sweden before moving to the United States in 1992. Here in the United States I am a legal resident but not a registered professional engineer. However, my skills as an expert in motional feedback of powered loudspeakers, which includes the knowledge of motion of an object (distance, velocity and acceleration) such as a moving loudspeaker cone and the electro-mechanical-acoustical relationships in this type of a system, enabled me to work as an expert witness in the United States District Court in the Western District of Washington on behalf of Audio Products International (Robert Carver v. Audio Products International). Currently I am self-employed and conduct research and development with electronics and acoustics to develop new test and measurement methods. I also currently contract with the United States Navy to maintain, upgrade and calibrate digital storage oscilloscopes for the United States Naval Air Warfare Division that are used in the testing and evaluation of military ordinance.

3. My family and I have lived in Beaverton for 19 years. I am a licensed Oregon driver. Most of my driving activity occurs within the City of Beaverton. I estimate that I am on Beaverton roads 10 or more times per week.

4. Within the City of Beaverton, much of my driving involves traveling on Murray Boulevard, Allen Boulevard, Hall Boulevard, Lombard Avenue, Denny Road and Tualatin Valley Highway. I regularly drive through Beaverton signalized intersections at Lombard and Allen, Hall and Allen, Murray and Allen and Tualatin Valley Highway and Murray. My driving activity is sometimes alone and other times involves my family which consists of my wife, son and daughter, either individually, all together or a combination.

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5. Most of my activity as a pedestrian at signalized intersections occurs at the intersection of Murray Boulevard and Allen Boulevard. At that intersection location is a Safeway, which I shop at regularly, my bank which I use at least once a week, a Shari's and a McMenamin's which I eat at about once a month, and an accountant which I visit at least twice a year.

6. During the last year, I have devoted approximately one-third of my time to the study and analysis of traffic light timing at intersections in the City of Beaverton. This has involved monitoring and the taking of measurements at multiple intersections and an exhaustive analysis of the available literature regarding the engineering of traffic control devices and in particular the safety issues related to yellow signal timing in connection with traffic flow. Based upon my education and background, I believe that I am qualified to analyze the basic mathematics and physics related to a vehicle in motion and traffic flow to assess the potential for increased levels of collisions where yellow light intervals are shorter than required under the specifications in the Oregon Vehicle Code.

7. Attached as Exhibit 1 is a working Scientific Report, with its most current version dated September 9, 2014, that I authored on the subject of the Institute of Transportation Engineers (ITE) formula used in calculating traffic light change intervals.

8. My working scientific report presents simple tools to analyze and visualize the motion of a vehicle using basic mathematics and physics. The report also presents how the ITE formula's individual terms are related to a traffic intersection's geometrical dimensions together with conflicting traffic and a vehicle's critical stopping distance. It also explains the ITE formula calculations of the yellow and all-red phase times for the two different yellow light vehicle codes currently used in the United States – the *restrictive* and *permissive* yellow light laws.

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Furthermore, the report presents the details related to the ITE formula when a *yellow light violation* can occur based on the restrictive yellow law requiring that a driver "shall stop" facing the yellow light as per Or. Rev. Stat. 811.260(4).

9. Attached as Exhibit 2 to this Declaration is a study conducted and published in 2002 in the Journal of *Accident Analysis and Prevention* which I relied on in my study and analysis of traffic light timing. The study concludes that modifying traffic signal change intervals to values associate with the ITE recommended practice -- computing the length of the all-red or yellow clearance interval as a function of speed and width that *must be cleared* -- reduces the risk of crashes involving pedestrians and bicyclists and may reduce the overall risk of multiple-vehicle crashes, particularly those resulting in injuries. The study found that there was a significant 12% reduction in all reportable crashes involving injuries and a 37% reduction in crashes involving pedestrians and bicyclists for intersections that were re-timed to follow the ITE proposed practice compared to a control group of intersections.

10. Attached as Exhibit 3 to this Declaration is a Graph that compares a driver entering the example intersection attached as Exhibit A to my Complaint at 30 mph and a driver at 20 mph constant speed. The velocity versus time and distance graph show the ITE formula terms plotted along with current traffic light phase times linked to the motion of vehicles. The line marked "car critical stopping distance" (the line between the Green Safe "STOP" area and the Yellow Unsafe "STOP" area) divides the line between when it is safe for the driver to stop at the point the yellow light illuminates and when it is unsafe to stop, meaning the driver must proceed through the intersection with caution.

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11. Oregon's Vehicle Code contains a *restrictive* yellow law at Or. Rev. Stat. 811.260(4), and provides that a driver "shall stop" facing the yellow light. However, as both Exhibit A from the complaint and Exhibit 3 attached to this declaration show, the example intersection's traffic light change interval seems to be timed to a combination of the two different yellow laws (*permissive* and *restrictive*). The example's yellow light's phase time currently only includes the ITE formula's stopping term which is used for the *permissive* yellow law. However the *permissive* yellow law *mandates* that the very important ITE formula's clearance term is included in an all-red phase time to protect the intersection from any interfering cross-traffic including pedestrians since a vehicle is *permitted* to enter the intersection during the *full yellow phase.* Thus, the driver can legally enter the intersection at the very end of the yellow phase as the examples show. For the *restrictive* yellow law the important clearance time is included in the yellow light so the all-red phase becomes *optional* which is what the example intersection's minimal all-red phase time indicates. The words "the driver facing the light *shall stop* " under Or. Rev. Stat. 811.260(4) is *restricting* the driver to use the *full length* of the yellow light and is thus only allowing the driver to enter the intersection during the ITE formula's safe stopping time, and the yellow light's *added clearance time* is thus *restricted* by the wording of the law. Hence, a yellow light violation occurs if a driver did not stop when faced with the yellow light and enters the intersection during the *added yellow clearance time* as the ITE formula's clearance term calculates. Currently the example intersection shows that the very important ITE formula's clearance term is neither included in the yellow phase time nor is it included in the *optional* all-red phase, which is the reason the pedestrian is at danger when the pedestrian is given a "walk" signal *before* the vehicle has cleared and exited the intersection and crosswalk.

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12. The "critical stopping distance," which is directly related to the ITE formula's first two terms as presented in Exhibit 1, is the exact distance at which a driver has two choices based on three specified input variables at a level intersection (0% grade): (1) driver perception-reaction time, (2) vehicle approach speed, and (3) a safe and comfortable deceleration rate. The first choice is that he can comfortably and safely stop at the entry of the intersection. The second choice is that he can travel the critical distance at the constant speed to be able to reach the intersection's entry point without violating either a red (permissive yellow law) or a yellow (restrictive yellow law) light at which point the driver will have to proceed through the intersection with caution. If a driver is at any point beyond the speed dependent critical stopping distance facing the yellow light, the driver *cannot* stop safely, and must proceed through the intersection with caution. This is why it is critical that the yellow phase (restrictive yellow law) or the all-red phase (permissive yellow law) include enough time for the driver to drive through and clear the intersection *before* the light changes and any conflicting traffic is allowed access to the intersection. Exhibit 1 explains the two yellow laws and how to implement the ITE formula's clearance term and time in the yellow and all-red phase described above.

13. Exhibit 3 shows how the critical stopping distance works. The critical stopping distance at 30 mph (or 44 ft/s) is 140.8 feet (Exhibit 1 includes the formula to calculate the critical distance at other vehicle speeds). For example, if a driver traveling at 30 mph faces the yellow light one/tenth of a second before reaching the critical stopping distance or 4.4 feet farther away from the intersection, a driver is in the Safe "STOP" Area, and the driver must stop. If the driver were to continue without accelerating, the driver would reach the intersection and violate the red light (permissive yellow law). If a driver traveling at 30 mph and facing the yellow light one/tenth of a second closer to the intersection than the critical distance or 4.4 feet

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closer, then the driver is in the Unsafe "STOP" Area, which means the driver cannot stop comfortably and safely and must proceed through the intersection with caution.

14. To stop "safely" means that the driver is perceiving-reacting and decelerating at the given parameters used to calculate the yellow light and its critical distance. If the driver is required to stop faster or in less distance (as presented with the two unsafe emergency stopping distances based on maximum roadway friction in Exhibit A to my Complaint) the driver has to react faster and/or decelerate harder, thus it becomes unsafe. In addition, stopping safely does not mean that a driver should have to rely on the safety features of the vehicle such as anti-lock braking systems, electronic stability control, seatbelts or even airbags to stop. Thus, the "nonemergency" deceleration rate defined by ITE is what is deemed safe and any higher rate is deemed unsafe.

15. As demonstrated in Exhibit 3, for vehicles that are in the Unsafe "STOP" Area when the yellow light illuminates and cannot stop safely but must proceed through the intersection with caution, yellow light durations must be long enough to allow the driver to reach and clear the "intersection exit" (78 feet), which is also the intersection's far side crosswalk and the path of the conflicting pedestrian in Exhibit A, *before the light turns red*. This is also what Or. Rev. Stat. 811.260(4) is describing: "If a driver cannot stop in safety, the driver may drive cautiously through the intersection." If a driver cannot stop safely, and must drive cautiously through the intersection, he cannot "accelerate" or violate the speed limit in order to reach the exit at 78 feet and fully clear the intersection.

16. However, the slower the driver goes, the longer it takes to clear the intersection. This effect is a product of the ITE formula itself presented in Exhibit 1. The ITE formula's first two terms calculates the yellow phase for the time it takes to travel the critical distance at

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constant speed and the ITE formula's deceleration term has the vehicle speed (velocity, V) in the numerator so the time it takes to travel the critical stopping distance is thus linearly decreasing with decreasing vehicle speed. The ITE formula's clearance term, which is calculating the time it takes to travel the intersection's width to the widest interference point, includes the vehicle speed (velocity, V) in the denominator. Having the velocity (V) variable in the denominator will have an opposite effect for the time it takes to clear the intersection – decreasing vehicle speed equals *increased* time to travel through the intersection.

17. An example of this effect is demonstrated in Exhibit 3. If a driver first faces the yellow light within the critical distance and must cautiously travel through the intersection, it takes more time for a slower driver than a faster driver to clear the intersection. The "critical stopping distance" for the 20 mph speed is 72.4 feet but the slower speed will add .9 seconds to the time it takes to reach the intersection's 78 feet clearance width. If a driver is driving 15 mph instead of 30 mph, it can add an additional 1.8 seconds to clear the intersection.

18. The danger from failing to exit the intersection before the light turns red is demonstrated in Exhibit A to my Complaint and Exhibit 3 to this Declaration. At 30 mph, the light turns red roughly at the same point the vehicle *enters* the intersection. The vehicle will take another roughly 1.8 seconds to reach the exit and another .5 to fully exit the intersection with a typical vehicle length (all the while the light is currently red). The pedestrian signal turns to "walk" when the car is .5 seconds into the intersection (assuming no timing errors in the programmed *optional* restrictive yellow law all-red phase). A pedestrian has a reaction time of less than 1.0 seconds to react to the "walk" signal before entering the intersection, and will likely enter the intersection before 1.5 seconds, roughly the same time the vehicle is .3 seconds away from reaching the exit of the intersection and, therefore, the pedestrian. Even if the driver was

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being "cautious" and *expected* the pedestrian to enter the crosswalk, the driver could not react to the pedestrian's presence in less than 1.0 seconds.[1] In addition to reacting, the driver could not physically stop, as the driver would travel 44 feet in the 1.0 seconds it takes to react, and it would take a total of 94 feet for an emergency stop on dry pavement, or 130 feet for an emergency stop on wet pavement. At the time the driver saw the pedestrian, the driver would be 13.2 feet away from the pedestrian. Therefore, even a "cautious" driver simply cannot avoid hitting a pedestrian under this scenario without other tactics, such as swerving.

19. At 20 mph, the light currently turns red after the driver has been in the intersection for approximately 0.7 seconds and a distance of 21.5 feet. It will take an additional 1.9 seconds for the vehicle to reach the intersection's exit and the light will currently be red during that time. The pedestrian signal turns to "walk" after the vehicle has been in the intersection for about 1.2 seconds, and the pedestrian will be entering the crosswalk within 2.2 seconds. Here, the driver will have only .5 seconds to react (.2 seconds more than for the 30 mph driver) and the pedestrian will have traveled farther into the roadway. If the driver is being cautious and expects the pedestrian to enter the crosswalk, the driver can *react* in 1.0 seconds, but the driver cannot both react *and conduct an emergency stop* in less than 1.0 seconds. An emergency stop at 20 mph takes 51.6 feet and 2.5 seconds, considering dry pavement, and 62.7 feet and 3.3 seconds considering wet pavement. At the time the 20 mph driver saw the pedestrian, the driver would be 14.7 feet away from the pedestrian.

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[1] Driver perception and reaction time according to ITE is typically 1.0 seconds for a low complexity expected event and 2.5 seconds for an unexpected event.

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20. A driver would have to drive as slow as 12.5 miles per hour to be able to emergency stop for the pedestrian stepping into the roadway if we assume dry pavement, 1.0 seconds perception-reaction time for both the driver and pedestrian, pedestrian moving at 4 ft/s and no timing errors in the currently programmed 0.5 seconds *optional* all-red phase time. An increased unexpected reaction time of 2.5 seconds will reduce the speed to 9.1 mph for the driver who is able to emergency stop for the pedestrian. Driving 12.5 miles per hour in a 30 mph speed zone obviously creates additional safety hazards. In a high-density traffic pattern, driving under half the speed limit is likely to induce a rear-end collision -- a prominent type of accident in traffic today. Driving 12.5 miles per hour is not safe, "cautious" or prudent and is also counterproductive for the overall traffic flow, one of the main reasons in addition to safety that traffic lights are used.

21. This is also true if a driver merely "decelerates" once he or she enters the intersection. If a driver is approaching the intersection at 30 mph constant speed and he faces the yellow light just within the "critical stopping distance" and the driver then slows down to be "cautious" before *entering* the intersection, the yellow phase time calculated by the ITE formula will neither allow this driver enough time to reach and enter the intersection on a legal yellow light which means the driver is violating a red light (*permissive* yellow law) or a yellow light (*restrictive* yellow law) nor allow the driver the time needed to travel through and exit the intersection. The reason is that a driver decelerating will not be covering the same distance as a vehicle that keeps traveling at the constant 30 mph speed as the ITE formula inherently is designed. Therefore, the decelerating driver will enter the intersection too late and thus violate the traffic signal and thereby cause more danger because the vehicle is in the intersection longer after the light has transitioned and will with higher probability interfere with any cross-traffic

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given a green light or a "walk" signal.

22. By studying the ITE formula, using mathematics and the laws of physics for a vehicle in motion traveling through an intersection, we can determine what driving "cautiously" through the intersection actually means. Here, “cautiously” must mean that a driver is prohibited from unsafely accelerating and violating the speed limit through the intersection in order to beat the red light -- *i.e.*, maintaining constant speed. If "cautious" meant that the driver was supposed to slow down, the driver would actually make the situation more dangerous. That is, driving slower does not prevent the danger to the pedestrian, it actually increases the danger.

23. Not only is the pedestrian in danger in the two driver speed examples above, the driver and drivers of other vehicles are also in danger. Because short yellow light durations do not allow the two drivers in the 30 mph and the slower 20 mph vehicle to drive through and clear the intersection *before* giving the pedestrian a "walk" signal, those drivers are likely to engage in other actions to avoid colliding with the pedestrian. A driver who is not able to emergency stop might make an evasive action just before hitting the pedestrian, or even after, due to the impact or shock. This evasive action can put the driver in the wrong lane, crash into another third party vehicle, or force a third party into oncoming traffic.

24. Exhibit A attached to my Complaint and Exhibit 3 to this Declaration do not account for the variation in the types of vehicles or the length of these vehicles traveling through the intersections. (Bicyclists, children and elderly are also not shown which all require extra time to stop or traverse an intersection). Other vehicles such as long trucks, public and school buses, or vehicles with trailers typically use air brakes which require extra reaction delay time before the brakes engage. The current yellow light phase timing only allows standard vehicles using hydraulic brakes to stop safely at 30 mph. Vehicles using air brakes, even assuming that these

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vehicles are able to stop with the typical ITE "nonemergency" deceleration rate, need both longer deceleration and intersection clearing times. If the design of the yellow-light phase does not adequately take into account these types of vehicles, these vehicles will need to drive slower to avoid the dilemma zone created by the too short yellow light which will in turn reduce the overall traffic flow and the danger is even more acute.

25. Attached as Exhibit 4 to this Declaration is a drawing showing two Graphs (the top graph shows velocity versus time *and* distance, the bottom graph shows velocity versus distance). The graphs combine all the relationships set forth by the ITE formula's individual terms with input variables related to a traffic light's change interval and the motion of a 30 mph vehicle traveling through the to-scale example intersection used in Exhibit A of the Complaint. The colored areas represent the green, yellow and red traffic light phases. The yellow area shows the time required for the yellow light phase for different *design speeds* or *posted speed limits* based on the ITE formula if it would follow Or. Rev. Stat. 811.260(4). For example, as demonstrated in this Exhibit 4, the eastbound S.W. Allen Blvd approach has a posted speed limit of 30 mph. For a vehicle following the *design speed* of 30 mph, total yellow phase time needs to be 5.5 seconds *minimum* to allow the vehicle to (1) travel the critical stopping distance, (2) traverse the intersection's clearance width and (3) travel one typical vehicle length. Proper application of the ITE formula's clearance term per Or. Rev. Stat. 811.260(4) into the yellow light as shown in Exhibit 4 would allow drivers who cannot stop safely to travel through and clear the intersection *before* allowing the pedestrian to enter into the vehicle's path. Doing so will greatly reduce the danger to the pedestrian, the driver, and drivers of other vehicles in the vicinity. This is the true purpose of the ITE formula and the use of a traffic control device in an intersection – maximize traffic safety and traffic flow.

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I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge.

DATED this 10th day of September, 2014.

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Mats Jarlstrom

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CERTIFICATE OF SERVICE

I hereby certify that on the 10th day of September, 2014, I served the foregoing **DECLARATION OF MATS JARLSTROM,** on the following:

Gerald L. Warren
Law office of Gerald Warren
901 Capitol Street, NE
Salem OR 97301

Attorney for Defendant

by the following indicated method(s):

☐ by **mail** with the United States Post Office at Portland, Oregon in a sealed first-class postage prepaid envelope.

☐ by **email**.

☐ by **hand delivery**.

☐ by overnight mail.

☐ by **facsimile**.

☒ by the court"s Cm/ECF system.

/s/ Michael E. Haglund
Michael E. Haglund, OSB No. 772030

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