

November 29, 2021

**BY EMAIL**

Christopher Burton, Director  
Planning, Building and Code Enforcement  
San Jose, California  
chris.burton@sanjoseca.gov

**Re: Rebuttal to Supplemental for LED Billboards**

Dear Christopher Burton,

The Soft Lights Foundation hereby responds to the numerous incorrect and invalid statements made in the city's response to our analysis of the Zeiger Engineering report and proposed LED Billboard project. Fundamentally, the response shows a lack of understanding of the physics of radiation emitted by a flat surface. In this document, we will explain in detail how LED radiation is not spatially isotropic, and is therefore toxic, hazardous, and discriminatory.

**Response A.1:** Quote: "Spatially anisotropic radiation as it pertains to light means the light is highly focused and is directed in a single direction, similar to a laser. Conversely, isotropic radiation radiates at the same intensity in all directions. LED light emissions from the proposed signs would be fractionally more narrow than completely isotropic."

Spatially anisotropic radiation means that the light has different energies at different points in space. This does not necessarily mean that the light is highly focused, although it could be. It just means that the light energy is not uniform. In the case of LEDs it is true that the visual radiation emitted by the flat chip source is highly directional. This is widely known throughout the LED engineering community and is not disputed. Therefore, the statement that LED emissions from an LED billboard are fractionally more narrow than isotropic radiation not supported by any science, mathematics, or research.

Each LED is created on flat surface, with numerous holes to allow photons to exit. As shown in Figure 1, the photons escape in a cone shape. This occurs because of the physical properties of the chip. Some photons emit perpendicular, others emit at an angle, all randomly.

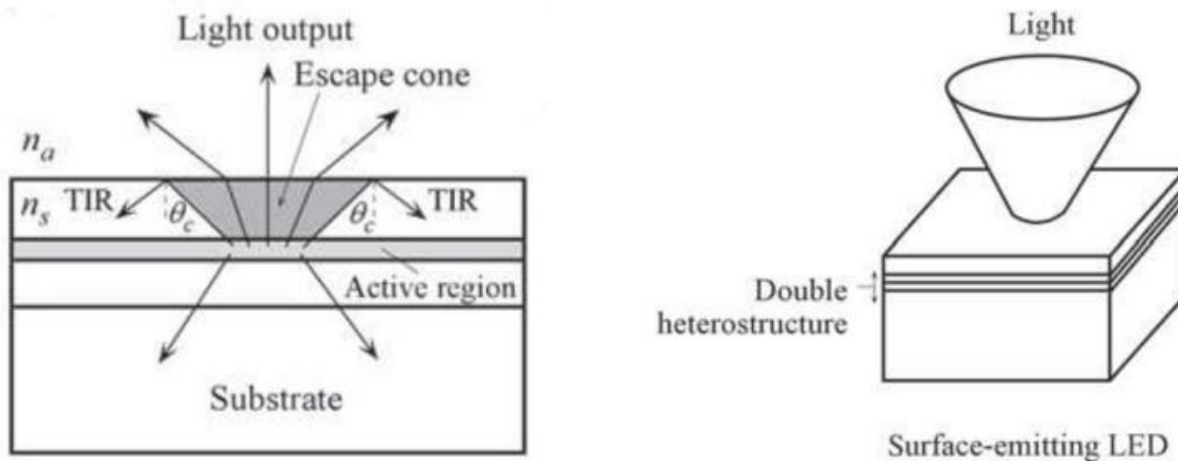


Figure 1 - Photon Escape Angle<sup>1</sup>

As shown on the left side of Figure 2, there is not just one cone. There are many, many cones, and these cones overlap. The most overlap occurs in the middle of the chip area. The least overlap occurs on the edges of the chip.

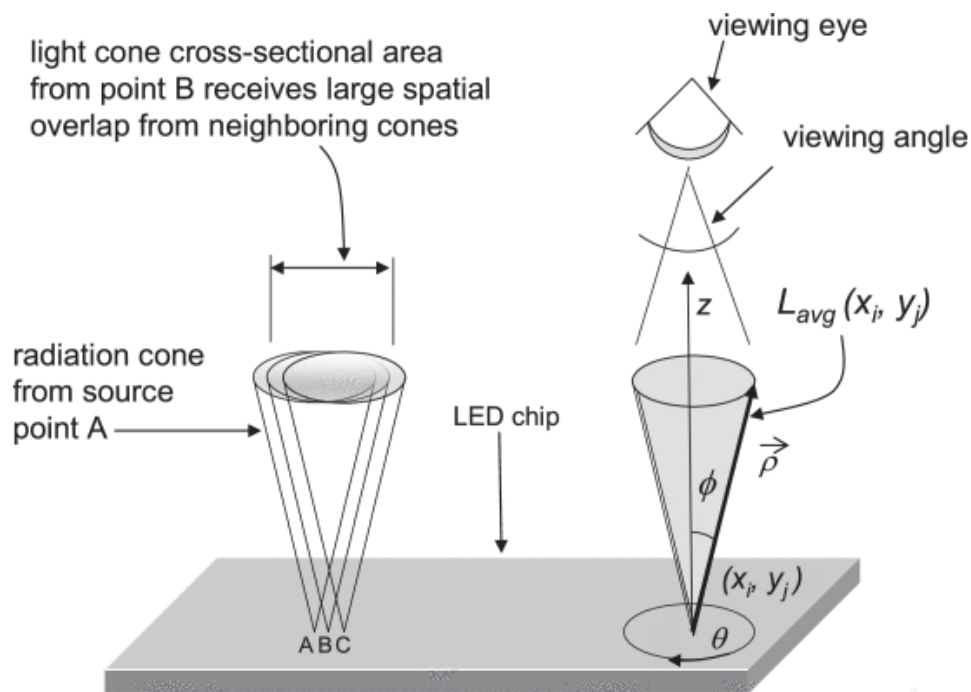


Figure 2 - Overlapping Cones<sup>2</sup>

<sup>1</sup> <http://www.zjuisee.zju.edu.cn/weisha/Lectures/Files/Light%20Emitting%20Diodes.pdf>

<sup>2</sup> <https://ieeexplore.ieee.org/document/8879542>

Figure 3 shows the resulting shape of the overlapping cones known as a Lambertian ball. The false colors show the density of the spatially anisotropic radiation. This diagram matches the idea that LED radiation is highly focused, like a laser. In fact, nearly all lasers today are initiated from radiation emitted by an LED, then further focused to make the radiation coherent. As is clear from this diagram, LED radiation is spatially anisotropic.

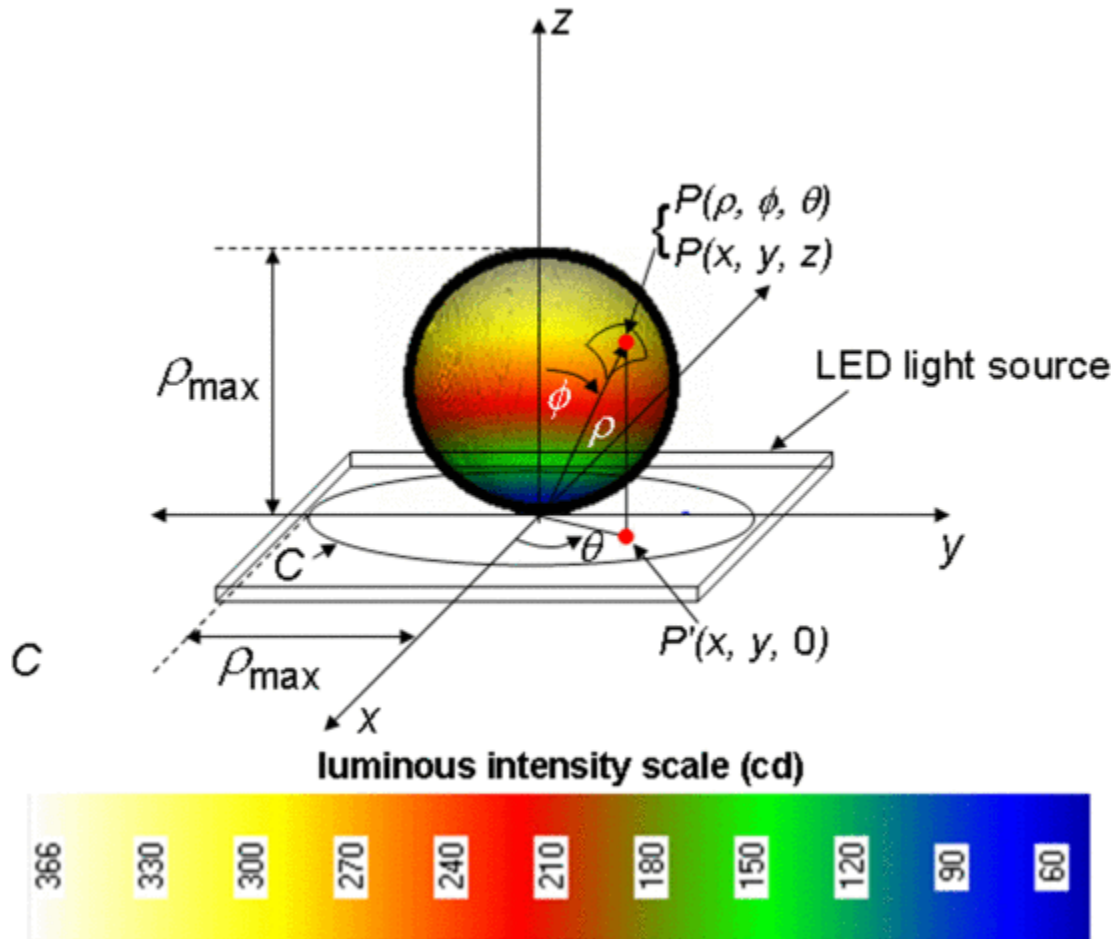


Figure 3 - Lambertian Ball<sup>3</sup>

Given this proof that LED radiation is highly focused and spatially anisotropic, it is not possible to then claim that an entire LED billboard somehow magically becomes spatially isotropic. There is no LED radiation directed in the reverse direction of the billboard, and the light cones from each individual LED, continue to overlap each other even more. LED radiation is spatially anisotropic, period.

The LED billboard industry measures the light output from LED billboards using luminance, measured in candela per meter squared, typically called nits. The maximum of 9,000 nits for the proposed LED billboard means the maximum density of the LED radiation. Even at the proposed typical

<sup>3</sup> <https://ieeexplore.ieee.org/document/8879542>

luminance of 5,000 nits, the density of the radiation is very tight, very dense and will cause pain, eye damage, loss of vision, epileptic seizures, migraines, and thoughts of suicide. Human beings, especially those with excellent sensitivity, are overwhelmed both by the excessive peak luminance, and the fact that the radiation is non-uniform across the eye.

Notice in Figure 4 how the light rays emanate uniformly in all 4pi steradians. This is spatially isotropic radiation. Simple mathematical formulas can be used to calculate luminous intensity and illuminance. The Zeiger Engineering report invalidly attempts to use these same simple formulas for spatially anisotropic LED radiation, which is not possible. The only way to calculate the luminous intensity for LEDs is using integral calculus and showing a graph of all points in space because each point in space carries a different energy. This is one reason why the LED billboard industry does not measure luminous intensity from LED billboards and instead measures luminance (density).

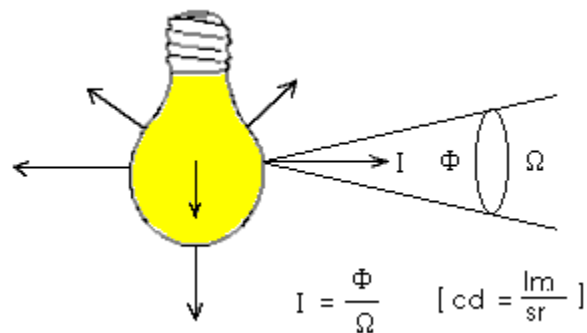


Figure 4 - Spatially Isotropic Radiation

**Response A.2:** This response attempts to pretend that the photo of a typical LED billboard shown in Figure 5 cannot apply to the LED billboard proposed by the city. Why? The LED billboards for San Jose are proposed to be even larger, creating even more glare. The Zeiger Engineering report admits that there will be special shields just to funnel this radiation even more directly into the eyes of drivers on the freeway. What reasoning is the city using to justify that one LED billboard is not like another?



*Figure 5 - Typical LED Billboard*

Even the Zeiger Engineering report includes a photo of the excessively intense LED billboard light contrasted with the dark night, as shown in Figure 6. This contrast causes the pupil to constrict, thus reducing vision and the 5,000-nit luminance overwhelms the eye and nervous system. For safe driving, there should be very little contrast between the ambient dark night and any artificial light. This will allow the pupil to open and allow the highly efficient rod cells to function.



*Figure 6 - LED Billboard at Night*

**Response A.3:** Quote: “In practice, the proposed signs would never operate under these conditions [9,000 nit all white]”. This is a false statement. We routinely see news reports of LED billboards being accidentally set to all white through operator error. Figure 7, Figure 8, and Figure 9 are all examples of

the LED billboards having an error. The statement that this will never happen is false. It is highly probable that such an error will occur, and when it does, the glare may dazzle or distract a driver or pilot, which may result in death.



*Figure 7 - Billboard Technical Issue*

Quote: The firm behind the billboard said there had been a technical issue which had now been fixed.<sup>4</sup>



*Figure 8 - Billboard Glitch*

Quote: The construction company responsible for the project said Thursday afternoon that there was a glitch in programming the shut off timer for the lights.<sup>5</sup>

<sup>4</sup> <https://www.bbc.com/news/uk-england-leeds-57825510>

<sup>5</sup> <https://vancouver.sun.com/news/local-news/its-utter-hell-west-end-residents-decry-new-safeways-green-glow>

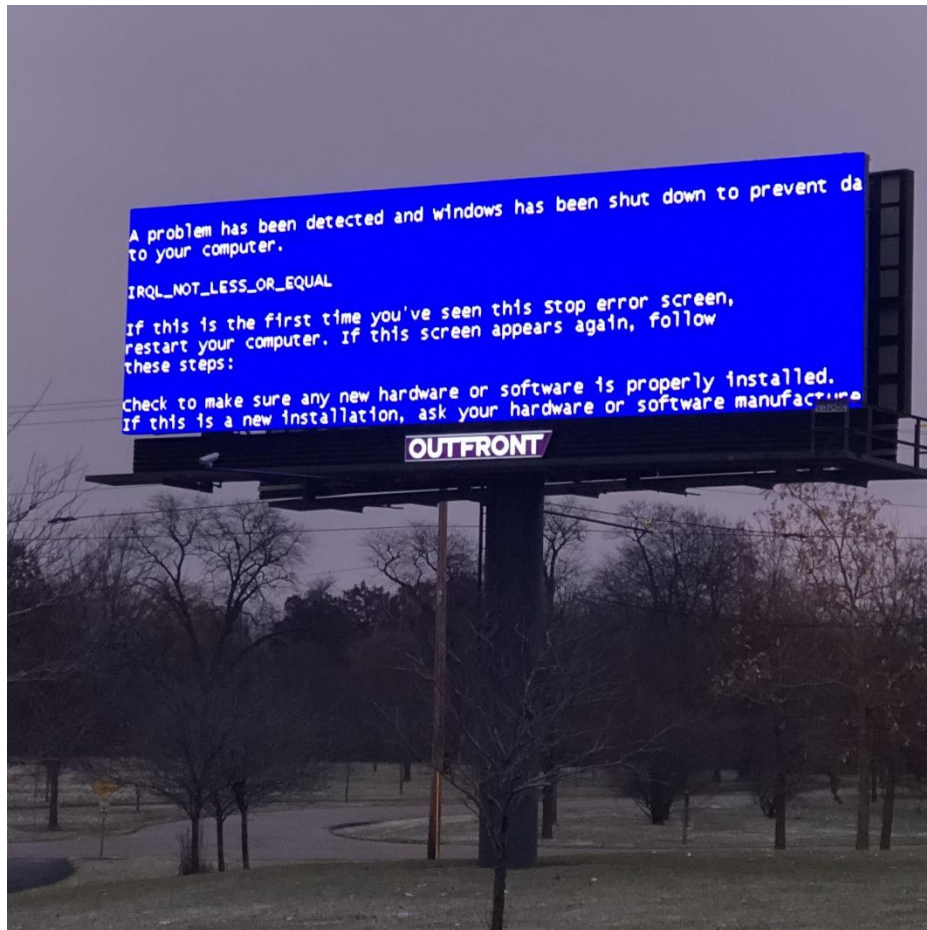


Figure 9 - Billboard Crash

**Response A.4:** The city does not assert that the diagram, which was created by Mark Baker, who holds a degree in Electrical Engineering and is the founder of the Soft Lights Foundation, is invalid. The response only states that the reader didn't know who drew the diagram. The diagram is, in fact, correct and valid. The response also falsely claims that LED radiation is isotropic, which it is not.

**Response A.5:** The city somehow attempts to claim that the study on LED radiation doesn't prove anything. The city should be aware that it is unethical to endanger the life of a human to perform a study. Therefore, most researchers use other animals that have similar characteristics to humans. The city seems to be suggesting that the city should first install the LED billboards, then study to see what happens to people's eyes, and then decide as to whether the eye damage that occurred warrants removal of the LED billboards. We object to that type of dangerous and irresponsible logic. Since the city desires additional research, we shall provide it here.

**1) Light pollution: the possible consequences of excessive illumination on retina<sup>6</sup>**

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<sup>6</sup> <https://www.nature.com/articles/eye2015221>

Quote: *“Constant exposure to different wavelengths and intensities of light promoted by light pollution may produce retinal degeneration as a consequence of photoreceptor or retinal pigment epithelium cells death.”* – The city wishes us to believe that somehow an LED electronic sign does not contribute to retinal degeneration. Cellular death in the eye is cumulative, so vehicle headlights, streetlights and floodlights are already contributing to retinal damage. Adding unnecessary high-luminance light further increases retinal damage.

Quote: *“In morphological studies, Ham et al demonstrated that the action spectrum for retinal damage near-ultraviolet spectrum (405, 380, 350, and 320 nm wavelengths) produced irreparable damage to rod and cone photoreceptor cells...”* – Notice the words “irreparable damage”. This means that the damage to the eye cannot be undone. The cells will not regenerate like skin cells. The artificial light, especially 5,000 nit LED radiation that far exceeds human comfort levels, will damage the eye, even with brief exposures.

Quote: *“for example, Shear et al showed that in albino rats the retinal stimulation in continuous low white light ( $\approx 750$  lux) causes a progressive deterioration of photoreceptor cells.”* – Notice this time the words “progressive deterioration”. The eye cells will slowly die when exposed to artificial light. For the safety of the public, artificial light must be severely limited, which certainly means prohibiting LED electronic billboards that provide no public benefit.

## 2) Light-Induced Retinal Ganglion Cell Damage and the Relevant Mechanisms<sup>7</sup>

Quote: *“excessive light has been reported to have a negative effect on the survival of various types of retinal cells. Among them photoreceptors and retinal pigment epithelial (RPE) cells degeneration after light exposure is widely observed...”* – Unnecessary artificial light must be avoided to protect public health.

Quote: *“So RGCs can certainly be injured by excessive light, ...”* RGCs are retinal ganglion cells which control human circadian rhythms. The use of LED electronic billboards has a significant negative impact on RGC's, which can delay sleep by several hours, which in turn can lead to diseases such as breast cancer and mood disorders.

There are 26 research articles listed referenced in this article. The city health specialists must evaluate all research articles and apply the information to the proposal to installed LED billboards.

The city made little or no effort to evaluate the health effects of LED visible radiation on the eyes. As shown above, the injury to eye cells from artificial light is substantial, cumulative, and permanent.

**Response A.6:** Quote: *“The comment does not provide substantial evidence that the project would result in a significant impact with regard to Airport operations or drivers on U.S. 101.”* - The comment stated that the proposal for the LED billboard is to direct the radiation away from the eyes of any pilots and into the eyes of drivers on the freeway. Why? Do pilots have special eyes that cannot tolerate LED radiation? Are driver's eyes expendable? If the LED billboard has no significant impact on drivers, then why is the LED billboard being installed? Clear Channel must certainly disagree the city that their proposed billboards have no impact on the buying habits of the people who view their billboards, and if

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<sup>7</sup> <https://link.springer.com/article/10.1007/s10571-020-00819-0>



the visible radiation is so safe, then why is the city putting so much effort into keeping this visible radiation out of the eyes of pilots?

The billboard industry believes that advertising is very powerful. According to the article *The Psychological Impact of Billboard Advertising*<sup>8</sup>, "...it's clear that customers are susceptible to messaging delivered through this channel whether they're aware of it or not." Another quote from the article is "While there are psychological connotations associated with every type of advertising, few mediums are as impactful on the human mind as billboards" - The statement by the city that LED advertising billboards have no significant impact is in direct contrast to the claims by the billboard industry and the city's claim that LED billboards have no significant impact on drivers must be eliminated as false.

**Response A.7:** The response ignores the fact that 93% of San Jose residents do not want their eyes damaged and do not want their minds captured by LED billboards and do not want to die on the freeway because of an LED billboard. When or where has the city ever seen such a near-universal hatred of something?

**Response A.8:** The response states that the all-white scenario would be extremely rare, and yet we already showed above that this scenario occurs frequently. When the all-white situation does occur and people die, will city officials still claim that the deaths were worth it?

**Response A.9:** Quote: "The comment does not provide substantial evidence that the project would result in a significant impact with regard to Airport operations." – Our comment is that Zeiger Engineers used incorrect math. Mr. Zeiger wrote, "'Due to the upper shielding on the LED modules providing an 18 degree cutoff, planes within 1-mile of the billboards would need to be below 1,700 feet altitude to first observe the display, and at that distance the illumination would be less than 0.0012 footcandle (0.012lux).'" – Mr. Zeiger's calculations are wrong and we strenuously object to the city allowing these calculations to go unquestioned. As used by the nearly the entire LED industry, the measurement for LEDs is candela per square meter, or nits. The radiation, as already noted by the city, is tightly focused and non-uniform. Therefore, the proper measurement is density, not illuminance as Mr. Zeiger erringly attempts to show. The full 5,000 nits will be directed either into the eyes of a driver or a pilot, neither of which is safe. The light will not be 0.012 lux of illumination. The LED radiation does not spread out.

To illustrate the fact that Mr. Zeiger's calculations are wrong, we offer this screenshot of Dr. M. Nisa Khan's derivation of the formula for the distribution of light from an LED.<sup>9</sup>

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<sup>8</sup> <https://75media.co.uk/blog/psychological-billboard-advertising/>

<sup>9</sup> <https://ieeexplore.ieee.org/document/8879542>

We can now write the generalized function of luminous intensity for  $dA$  as

$$I = (V)(dA)(L) \quad (2)$$

▶ View Source

where  $V$  is the integral of  $d\Omega$ . It is best to carry out the integral of  $d\Omega$  in spherical coordinates as one would use such to calculate the volume of a sphere. For the generalized cone represented by  $d\Omega$  in Fig. 2, we note that the length of  $\rho$  is arbitrary as is  $\phi$  because we wish to generalize  $d\Omega$  as a function of  $\phi$ , but that  $\theta$  must make a full revolution going from 0 to  $2\pi$  to form the conical volume. This is a classical problem in advanced calculus that use analytic geometry and utilizing such, we can write the integral of  $d\Omega$  as an indefinite volume integral for the  $\rho$  and  $\phi$  variables, and a definite integral for the  $\theta$  variable in  $(\rho, \phi, \theta)$  spherical coordinates [13],

$$V = \int_0^{2\pi} \int \int \rho^2 \sin(\phi) d\rho d\phi d\theta. \quad (3)$$

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Solving the integral in Eq. (3) leads to

$$V = \frac{2\pi|\rho|^3}{3} \cos(\phi). \quad (4)$$

Figure 10 - Portion of Derivation of LED Light Distribution

Dr. Khan has been providing guidance to the Soft Lights Foundation. She is the author of the peer-reviewed paper cited above, and the book Understanding LED Illumination, 2014, CRC Press. Dr. Khan's profile states:

M. Nisa Khan received her bachelor's degree in physics and mathematics from Macalester College in St. Paul, Minnesota, and her master's and Ph.D. degrees in electrical engineering from the University of Minnesota, Minneapolis, USA. During her studies, she worked at Honeywell Solid State Research Center in Bloomington, Minnesota. After completing her doctorate, she was at AT&T Bell Laboratories' (now Alcatel Lucent) Photonics Research Laboratory at Crawford Hill doing pioneering work on 40-Gb/s optoelectronic and integrated photonic devices, and in 2006 started an independent research and engineering company on LED lighting which performs feasibility studies for LED lighting used in entertainment and signage industries and offers platform design and development solutions for general lighting applications.

Mr. Zeiger's invalid calculations cannot be used by the city to support the authorization of an LED billboard. If the city wishes, the Soft Lights Foundation can arrange a meeting with Dr. Khan (pending her approval) to meet with Mr. Zeiger and city officials to explain the proper mathematics for calculating light distribution from LEDs.

**Response A.10:** The response from the city is that the reaction of a single individual to an LED billboard is irrelevant. It seems likely that if we had presented 10, or 100, or 1,000 similar experiences, the city still would ignore their suffering. We find this reaction to be unacceptable. 93% of residents do not want this harm, individuals from other cities are sharing their painful stories, and yet the city

chooses to close their minds to the injuries. We find this response by the city to be a highly risky strategy in regards to liability issues.

Below are additional quotes members of the Soft Lights Foundation and similar groups. Names are removed to protect privacy.

*“...in the brief moment before my brain reacts, the worst LEDs look like a spray of strobing needles”*

*“When exposed to LED light sources I experience nausea, vertigo, anomia and sometimes migraine-like, pounding headaches combined with a feeling of reality loss...certain street lights or LED panels induce very fierce symptoms after only a short exposure.”.*

*“ Yes they (LEDS) do and they cause migraines! They are horrible! “*

*“ Yes, they (LEDs) do (cause problems) for my kid. (they are seizure triggers.)“*

*“Within seconds of being exposed to LED lights, even if I cannot see the actual light source, I begin to feel the effects. My symptoms are typical auric sensations before a seizure and migraine. I feel dizzy, cranky, shaky, I get heartburn, I am drawn to the source of the light. After a few minutes, I'll usually sit down (assuming I'm alone, which doesn't happen much) and either vomit or cry, or both.*

The city cannot ignore these reactions to LEDs out of hand. The city must perform due diligence and investigate how LED radiation impacts the nervous system. Several members of our group cannot use a computer because the LED screen will cause a severe reaction. The city has no justification or authority to impose a giant LED screen on the public, knowing that a portion of that public will be injured by the LED radiation device.

**Response A.11:** The city’s response that LED radiation is not spatially anisotropic is false. The claim that LED billboard radiation is nearly isotropic contradicts the research from the LED billboard industry.

**Response A.12:** Again, the city falsely claims that LED radiation is essentially isotropic. As we explained above, the LED billboard industry measures LED radiation in terms of luminance, which is density. The full 5,000 candela per square meter does not substantially change over distance, even at one mile, so the impact on the eye is severe.

**Response A.13:** The city references no standards for LED billboards. The city claims that other cities have ordinances for signs, which are “the norm”. This is a false claim. The norm is certainly trending away from LED billboards due to their toxicity and hatred by the public. For example, the states of Alaska, Vermont, Hawaii, and Maine have banned either all billboards or electronic billboards specifically. The cities of Reno, Nevada, Charleston, South Carolina, and 700+ other communities have similar bans. To claim that LED billboards are the norm is false.

**Response A.14:** The city offers no response to our claim that 300 nits is the maximum level of comfort. In addition, these 300 nits are for uniform radiation. For radiation from LEDs that is highly focused and in a Lambertian-ball shape, the maximum level of comfort is less than 300 nits. The 5,000 average nits from the LED billboard will be at 10-20 times greater than comfort level.

**Response A.15:** Quote: “This technique properly measures the illumination for LED signs.” We have stated this multiple times above but measuring illumination from a spatially anisotropic LED billboard with a handheld meter produces invalid results. The hardware and software in the meter are designed for spatially isotropic radiation only and cannot be used to measure the illuminance from an LED radiation device. In addition, the main issue with LEDs is the luminance/radiance and the Lambertian shape that interferes with the nervous system. Attempting to measure the illuminance of an LED digital billboard is an exercise in futility and produces unusable results.

**Response A.16:** Quote: “*Note that while the comment asserts that ‘LED billboards also violate the ADA because they put persons with autism at high risk of injury or death,’ no evidence is provided to support that conclusion for this specific project.*” – These comments by the city warrant extra attention.

The Americans with Disabilities Act is a federal law, originally signed in 1990, and then further clarified in 2008 with the Americans with Disabilities Act Amendment Act. Congress passed this second law to make it exceedingly clear that persons with disabilities were to be given full consideration during the design or implementation of any project. People with disabilities are not to be an afterthought and it is not the public’s job to prove that they will a given project will not harm them. It is the legal requirement of the city to show why a person with a disability won’t be harmed by the proposed project.

The city must understand that we are notifying the city **prior** to the installation of the LED billboards. The city has shown no effort to comply with the ADA by holding meetings with those with disabilities who might be affected by LED radiation devices such as those with epilepsy, autism, migraines, bipolar disorder, PTSD, photophobia, or any of the dozens of other conditions that might make a person sick or become injured from LED radiation. The city will not be able to claim an undue burden or fundamental change to the nature of services when the city fails to consult with the disability community prior to the project. Any ADA lawsuit that occurs after installation of the LED billboards based on discrimination will likely be successful simply because the city made no effort to ensure the protection of those with disabilities. The city’s ADA Coordinator must be a main component of this project.

The City of San Jose was required by federal law to have created an ADA self-evaluation plan.<sup>10</sup> We were unable to locate the plan on the city’s website, showing a lack of good faith by the city to meet the needs of the disability community.

As a person with autism and in a protected class under the ADA, I wish to alert the city to my own personal experiences with LED billboards. It is not safe for me to be around them. I have been subjected to their radiation in Sacramento, California. Because of my autism, the LED radiation captures my attention. I am unable to pull my thoughts away because the LED visible radiation overloads my nervous system with information, forcing out other information such as awareness of other vehicles on the road. I am fully aware that my attention is captured, so I attempt to look away, but my thoughts remain with the billboard. My life is in danger each time I am subjected to the energies of an LED billboard. The city of San Jose has no right to discriminate against me in such a way. Without an LED

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<sup>10</sup> <https://adata.org/faq/what-self-evaluation>

billboard distracting me, I am a very capable driver with excellent attention and awareness of my surroundings. An LED billboard is an illegal barrier to my safe access to the public roadways in San Jose.

For purposes of the ADA, major life activities include seeing, thinking, concentrating, and communicating. An LED billboard impairs every single one of these major life functions for me. There is no pill that I can take, and no safe alternative to avoiding the LED billboard on a freeway. The size is massive and its impact on my life in the vicinity of the LED billboard is huge. Since these LED billboards are proposed to be near the San Jose airport, it means that I would be unable to safely approach the airport.

For a person with epilepsy, the situation is even more dire. Members of our group report immediate epileptic seizures in the presence of LED radiation for even a fraction of a second. One of our members has suffered hundreds of seizures since the large-scale release of LED radiation devices which has resulted in broken bones and lost teeth. Other members with epilepsy report feeling an aura or queasiness around LED radiation devices. As mentioned earlier, some of our members cannot even use an LED computer screen. While many people with epilepsy are not allowed to drive, that does not give the city of San Jose the right to inflict a seizure on them as a passenger in a vehicle or as a pedestrian.

The Enforcement Act of 1871 is available to force governments to stop subjecting citizens to injurious LED radiation. By installing LED billboards that direct LED radiation directly into the eyes, skin and skulls of persons, the city will be depriving them of their rights to live a life without being subject to such toxic, hazardous, and discriminatory radiation.

#### Enforcement Act of 1871 **Sec. 1**

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That any person who, under color of any law, statute, ordinance, regulation, custom or usage of any State, shall subject, or cause to be subjected, any person within the jurisdiction of the United States to the deprivation of any rights, privileges, or immunities secured by the Constitution of the United States, shall, any such law, statute, ordinance, regulation, custom, or usage of the State to the contrary notwithstanding, be liable to the party injured in any action at law, suit in equity, or other proper proceeding for redress; such proceeding to be prosecuted in the several district or circuit courts of the United States, with and subject to the same rights of appeal, review upon error, and other remedies provided in like cases in such courts, under the provisions of the act of the ninth of April, eighteen hundred and sixty-six, entitled "An act to protect all persons in the United States in their civil rights, and to furnish the means of their vindication"; and the other remedial laws of the United States which are in their nature applicable in such cases.<sup>11</sup>*

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<sup>11</sup> <http://www.antibiaslaw.com/list/enforcement-act-of-1871#n2953>

San Jose is a supporter of the Vision Zero program and adopted this program in 2020.<sup>12</sup> The idea of using distracting LED billboards is directly in opposition to the goals of Vision Zero such as safety and reduction in crashes and death. A quote in the article *Are Digital Billboards Dangerously Distracting* states, “...they analyzed how long participants spent looking on and off the road before, during, and after the approach, and found that participants overall spent significantly less time visually oriented on the road while approaching the billboard.” It is inexplicable that the city would simultaneously adopt the Vision Zero program and then allow dangerous, distracting, discriminatory digital billboards at the same time.

The Soft Lights Foundation recently initiated our first lawsuit related to LED radiation. The Foundation is also engaged in several other legal actions across the USA and United Kingdom, and although we are still in the early stages of developing our legal strategy, it should be clear to the city of San Jose that the city has multiple liability exposures if the city proceeds with the installation of LED billboards, including failure to ensure the protection of those with disabilities, the reliance on the invalid Zeiger engineering report, and the failure to act within the goals of the Vision Zero program. The city would be liable for any roadway injuries that occur near the digital billboards as well.

The City of San Jose must abandon the idea of authorizing dangerous and discriminatory digital billboards and protect the public’s right to health, safety and liberty.

Sincerely,



Mark Baker  
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[mbaker@softlights.org](mailto:mbaker@softlights.org)

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<sup>12</sup> <https://www.sanjoseca.gov/home/showpublisheddocument?id=51859>