

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MOBILEYE GLOBAL, INC.,
Petitioner

v.

FACET TECHNOLOGY CORP.,
Patent Owner

IPR2024-01110
U.S. Patent No. 9,335,255 B2

PATENT OWNER'S RESPONSE
(37 CFR § 42.120)

Table of Contents

Table of Authorities.....	iii
Patent Owner’s Exhibit List.....	iv
I. INTRODUCTION	1
II. BACKGROUND OF THE ’255 PATENT	3
III. OVERVIEW OF THE CITED PRIOR ART	4
A. Gallagher (Ex. 1005)	4
B. Lumia (Ex. 1014)	7
IV. LEVEL OF ORDINARY SKILL IN THE ART	13
V. CLAIM CONSTRUCTION	14
A. “a characterization profile of the at least one light intensity sensor” (’255 Patent, cl. 15)	14
1. The Established Ordinary Meaning of “Sensor Characterization” Supports Patent Owner’s Construction	15
2. The Specification Supports Patent Owner’s Construction	17
3. Petitioner’s Proposed Construction is Incorrect	19
4. The Institution Decision’s Preliminary Construction is Incorrect.....	20
VI. THE CHALLENGED CLAIMS OF THE ’255 PATENT ARE NOT ANTICIPATED AND ARE NOT RENDERED OBVIOUS	23
A. Ground 2: Claim 15 of the ’255 Patent is Not Rendered Obvious by Gallagher and Lumia	23
1. A POSITA Would Not be Motivated to Combine the Teachings of Gallagher and Lumia in the Manner Claimed	23
(a) Petitioner articulates no reason for combining the references so as to “determin[e] a luminance value,” as opposed to retroreflectance values	24
(b) There is no motivation to combine Gallagher and Lumia because Gallagher already calculates retroreflectivity and does not benefit from combination with Lumia’s disclosures	34

(c) There is no motivation to combine Gallagher and Lumia—and such combination would not be predictable—because Lumia’s teachings are fundamentally incompatible with Gallagher’s apparatus 36

(d) Petitioner’s motivation to combine theory lacks the specificity required by law 40

2. Claim 15 41

(a) Neither reference discloses or suggests “The *automated method* of claim 12, further comprising *determining a luminance value*” 41

(b) Neither reference discloses or suggests “utilizing ... a *characterization profile* of the at least one light intensity sensor” 43

VII. CONCLUSION.....44

Certificate of Service 37 C.F.R. § 42.6(e).....45

Certificate of Compliance Pursuant to 37 C.F.R. § 42.24 47

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Henny Penny Corp. v. Frymaster LLC,
938 F. 3d 1324 (Fed. Cir. 2019) 31, 41

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Regulations

37 C.F.R. § 42.23(b) 31, 41

Patent Owner's Exhibit List

Exhibit No.	Description
2001	Exclusive Patent License Agreement between Facet Technology Corp. and Mandli Communications, Inc. (and patent assignment coversheet), recorded at Reel No. 062371, Frame 0313
2002	Statutory Disclaimer of certain claims filed in file wrapper of U.S. Patent No. 9,335,255
2003	U.S. Provisional Patent Appl. No. 60/296,596
2004	Docket Control Order filed in <i>Facet Tech. Corp. v. Mobileye Glob., Inc.</i> , No. 2:24-cv-00058 (E.D. Tex.)
2005	Excerpts from U.S. District Court — Judicial Caseload Profile (2024 Ed.), <i>available at</i> https://www.uscourts.gov/file/78884/download
2006	Complaint Filed in <i>Facet Tech. Corp. v. Mobileye Glob., Inc.</i> , No. 2:24-cv-00058 (E.D. Tex.)
2007	Cover Pleading to Plaintiff's Disclosure Of Asserted Claims And Infringement Contentions, as served on August 26, 2024 in <i>Facet Tech. Corp. v. Mobileye Glob., Inc.</i> , No. 2:24-cv-00058 (E.D. Tex.)
2008	Cover Pleading to Defendant's Invalidity Contentions, as served on November 4, 2024 in <i>Facet Tech. Corp. v. Mobileye Glob., Inc.</i> , No. 2:24-cv-00058 (E.D. Tex.)
2009	National Institute of Standards and Technology, "Redefinition of 'Candela,'" <i>available at</i> https://www.nist.gov/si-redefinition/candela
2010	International Commission on Illumination, Standard. No. CIE S 017:2020 ILV: International Lighting Vocabulary, 2nd edition., entry no. 17-21-050, <i>available at</i> https://cie.co.at/eilvterm/17-21-050
2011	Excerpts from Stefanov, Konstantin D. CMOS Image Sensors. Bristol, UK: IOP Publishing, 2022.

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2012	Ang, Bernard, Keysight Technologies, “How to Achieve Accurate Sensor Characterization Using a Digital Multimeter” (Feb. 21, 2019), <i>available at</i> https://www.keysight.com/blogs/en/tech/bench/2019/01/24/how-to-achieve-accurate-sensor-characterization-using-a-digital-multimeter
2013	Steely, Sidney L., H. S. Lowery III, and R. H. Fugerer. "Laser-based direct-write scene generation methods for closed-loop focal-plane-array diagnostics." Technologies for Synthetic Environments: Hardware-in-the-Loop Testing. Vol. 2741. SPIE, 1996.
2014	Collins Dictionary Entry for “profile,” <i>available at</i> https://www.collinsdictionary.com/us/dictionary/english/profile
2015	Plaintiff Facet Technology Corp.’s Opposed Motion For Leave To Join Additional Parties, filed as Dkt. No. 32 in <i>Facet Technology Corp. v. Mobileye Global, Inc.</i> , Case No. 2:24-cv-00058-RWS-RSP (E.D. Tex.).
2016	Defendant Mobileye Global, Inc.’s Opposition To Facet’s Motion For Leave To Join Additional Parties, filed as Dkt. No. 35 in <i>Facet Technology Corp. v. Mobileye Global, Inc.</i> , Case No. 2:24-cv-00058-RWS-RSP (E.D. Tex.).
2017	Complaint For Declaratory Judgment Of Noninfringement And Demand For Jury Trial, filed as Dkt. No. 1 in <i>Mobileye Vision Technologies Ltd. et al v. Facet Technology Corp.</i> , Case No. 0:24-cv-04149-NEB-DLM (D. Minn.)
2018	Complaint for Patent Infringement, filed as Dkt. No. 1 in <i>Facet Technology Corp. v. General Motors LLC</i> , Case No. 2:24-cv-00035-RWS-RSP (E.D. Tex.)
2019	Docket Control Order, filed as Dkt. No. 22 in <i>Facet Technology Corp. v. General Motors LLC</i> , Case No. 2:24-cv-00035-RWS-RSP (E.D. Tex.)

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2020	Mobileye, “Fact Sheet: Mobileye Advanced Driver-Assistance Systems (ADAS)” (July 19, 2020) (available at https://www.mobileye.com/blog/fact-sheet-mobileye-advanced-driver-assistance-systems-adass/)
2021	SEC, “Mobileye to Offer User-Generated Mapping for Autonomous Driving” (January 6, 2016) (available at https://www.sec.gov/Archives/edgar/data/1607310/000157104916010521/t1600008_ex99-1.htm)
2022	Joseph White, “GM Has 'Heightened Partnership' with Mobileye for Autonomous Cars” (October 1, 2015) (available at https://www.reuters.com/article/us-gm-investors-mobileye-idUSKCN0RV4ZC20151001/)
2023	Declaration Of Nikolaos Papanikolopoulos, Ph.D. In Support Of Patent Owner’s Response
2024	Curriculum Vitae of Nikolaos Papanikolopoulos, Ph.D.
2025	Transcript of Deposition of Dr. Thorpe, taken in IPR2024-01110 on May 30, 2025
2026	Transcript of Deposition of Dr. Thorpe, taken in IPR2024-01111 on May 29, 2025
2027	Definition of “photodiode,” A Dictionary of Physics, Oxford University Press. (6 ed.) <i>available at</i> , https://www.oxfordreference.com/display/10.1093/oi/authority.20110803100324432?p=emailAIVd1F/alp5o2&d=/10.1093/oi/authority.20110803100324432&print
2028	National Institute of Standards and Technology, OSAC Lexicon, Definition of “Lux,” <i>available at</i> https://www.nist.gov/glossary-term/26871

Exhibit No.	Description
2029	Fiorentin, P. & Iacomussi, Paola & Rossi, Giuseppe. (2005). Characterization and Calibration of a CCD Detector for Light Engineering. Instrumentation and Measurement, IEEE Transactions on. 54. 171 - 177. 10.1109/TIM.2004.834055., <i>available at</i> https://www.researchgate.net/publication/3090945_Characterization_and_Calibration_of_a_CCD_Detector_for_Light_Engineering

Pursuant to 37 C.F.R. § 42.120, Patent Owner Facet Technology Corp. (“Patent Owner” or “Facet”) hereby submits its Patent Owner’s Response.

I. INTRODUCTION

Claim 15 is the sole remaining challenged claim of U.S. Patent No. 9,335,255 (“the ’255 Patent”), and recites “[t]he automated method of claim 12, further comprising determining a luminance value utilizing the plurality of light intensity values and a characterization profile of the at least one light intensity sensor.” Petitioner challenges claim 15 over the combination of Gallagher and Lumia, relying on Gallagher for claim 12 and Lumia for the limitations added in claim 15.

However, Lumia does not disclose an “automated method” to “determine a luminance value.” In particular, Lumia’s calibration creates a scale factor that directly converts light intensity values into retroreflectivity values, without any actual “determin[ation] of a luminance value” as claimed. Petitioner’s motivation to combine theory—compliance with *retroreflectivity* standards—motivates *against* combining the references to determine luminance values. Both references already disclose *directly* converting light intensity to retroreflectivity measurements without determining luminance values. Thus, the intermediate calculation of luminance values in order to calculate retroreflectivity values would require extra calculations with no identified benefits.

Moreover, Lumia does not use a sensor's characterization profile. Both literature in the field and the teachings of the '255 Patent show that sensor characterization is not the same as any mere calibration procedure. Rather, a sensor's characterization profile requires taking into account various conditions. However, Lumia creates its scale factor via a calibration procedure that uses one specific sign of one color at a constant and unchanging distance. This is not sufficient to satisfy the "characterization profile" limitation as properly construed.

Furthermore, Petitioner fails to articulate a plausible obviousness theory for *how* Lumia's teachings could be combined with Gallagher's apparatus. In particular, Federal Circuit case law requires a clear, evidence-supported account of the contemplated workings of the proposed combination. The Petition fails to meet this standard—it wholly fails to describe *how* Petitioner proposes to make Lumia's camera-based histogram approach work with the down-facing five to ten photodiodes array of Gallagher's system. Indeed, as Dr. Papanikolopoulos explains in detail, such a combination would be infeasible.

In particular, Lumia's image-based system requires that an operator manually aim and "lock on" the camera so that it is centered on the sign to be measured. This is necessary so that Lumia's computer can capture and isolate the image of the sign and create the histogram that Lumia uses to calculate retroreflectivity values. Lumia needs a very clear image of one sign, and the many thousands of pixels provided by

a camera, in order to make its histogram based approach work. By contrast, Gallagher continuously records light intensity information from a sensor array of only five to ten photodiodes, which sweep a wide strip of road in front of the vehicle. Because Lumia's approach needs many data points of a single road marker to create a histogram with distinct peaks, Gallagher's apparatus is simply incompatible.

For all of these reasons, Board should hold that claim 15 of the '255 Patent is patentable.

II. BACKGROUND OF THE '255 PATENT

The '255 Patent relates to recognizing road markers, such as road signs or pavement markings, using a video camera. Ex. 1001 ('255 Patent), Abstract. Road markers are generally designed to be retroreflective, which allows them to visible to drivers when lit by a vehicle's headlights at night. *Id.*, 1:61-2:4. That is, when light hits their retroreflective surfaces, they reflect nearly all the light back towards the source light or slightly off-angle from the source light. *Id.*; *see also* Ex. 2003 ('596 Prov. App.), 66-67; Ex. 2023, ¶60.

But road markers stop working well if damaged or degraded in performance, such as due to a breakdown in pigments or reflective material. Ex. 1001, 2:5-12. Thus, it is important for highway maintenance departments to check the reflective performance of installed road markers has not degraded and that they can continue to be seen by drivers. *Id.*, 2:12-18. But the systematic evaluation of road markers by

maintenance departments had been difficult, often requiring holding a handheld retro reflectometer directly in front of a sign. *Id.*; Ex. 2023, ¶61.

The '255 Patent addresses this problem by automatically identifying and creating an accurate inventory of road and traffic signs along a given street or highway. Ex. 2023, ¶62. In particular, it describes using an automated system to detect and determine the reflectiveness of surfaces along a roadway. It does so by capturing images along the roadway, using a light sensor to illuminate the roadway and measure light intensity, and using a computer processing system connected to the image capture system and light sensor that can detect objects of interest within the field of view of the light source. Ex. 1001, 3:60-4:10. The system can also determine an object's location, whether it has a reflective surface, the retroreflectivity of the surface, and whether the reflective surface is a road marker. *See id.*, 4:12-17, 8:53-9:13, 12:1-36, cl. 12.

III. OVERVIEW OF THE CITED PRIOR ART

A. Gallagher (Ex. 1005)

The Gallagher reference is dedicated to the problem of assessing the integrity of reflective pavement markers. Ex. 1005 (Gallagher), Abstract, [0034]; Ex. 2023, ¶63. In particular, it uses a vehicle with an array of photodiode sensors—typically five or ten photodiodes in total—which divide the field of view and are pointed down at the road, as well as lights that illuminate the area of the road that the sensors point

at. *Id.*, Figs. 1-2, [0035]-[0039]. Photodiodes are light sensors that measure the intensity of light using a semiconductor, where current increases proportional to the amount of light received by the sensor. Ex. 2027; Ex. 2023, ¶63.

In Gallagher, the operator must “initiate[] the measurement process,” which causes the light array and sensors to be turned on. *Id.*, [0046]; Ex. 2023, ¶64. Once a measurement session has begun, Gallagher’s photodiodes output signals to analog-to-digital converters (ADCs), which convert them to corresponding to numeric values, which are then provided to Gallagher’s computer according to a pre-specified sampling rate. Ex. 1005, [0047], [0056], Fig. 3. The computer is programmed with an algorithm to analyze the data collected from the photodiodes to determine whether pavement markers meet predetermined retroreflectance levels, and notes the physical location (using GPS or gearbox sensors) of pavement markers. *Id.*, [0049]-[0053].

In particular, Gallagher’s algorithm uses a series labeled “step a” through “step l.” Ex. 2023, ¶65. In step (a), the computer collects the sensor data from the analog-to-digital converters (ADC) which are connected to each light sensor. Ex. 1005, [0056]. In step (b), the sensor values are smoothed by averaging values in a set of sample readings. *Id.*, [0057]. In step (c), the smoothed ADC values for each sensor are multiplied by a “predetermined calibration factor” for that sensor to obtain reflectivity values. *Id.*, [0058]-[0059]; *see also id.*, [0017]. In step (d), the

previously collected sensor data is used to provide visual indicators to the vehicle operator as to the direction of current highest reflectance reading to allow the rider to center the vehicle (and its sensors) on the path of the pavement markers. *Id.*, [0060]-[0061]. That is, the indicator simply provides the raw output of *which sensor* is *currently* “reading the highest reflectance reading” at any one time. *Id.* Notably, the indicator means in step (d) of the currently highest-reading sensor is not used in any later steps of assessing the reflectivity of the pavement markers, but rather is strictly used during the data collection process to ensure the integrity of the data collected. Ex. 2023, ¶65.

In step (e), location information is collected from the vehicle gearbox to continually record the distance from where the test started, which can be used in later steps to tag the road markers. Ex. 1005, [0063]-[0064]; Ex. 2023, ¶66. In step f, the algorithm determines background reflectance levels to establish a non-marker reflectance level, i.e. it identifies how dark the dark parts of the sensor readings are so as to establish a cutoff where anything below the cutoff reflects no marker being present. Ex. 1005, [0065]. Finally, in step g, the computer reviews the previously smoothed and calibrated reflectance levels from steps a-c and identifies which responses are “peak responses,” (i.e. those above the non-marker reflectance levels). *Id.*, [0066]. The presence of a peak response is taken to conclude the presence of a pavement marker. *Id.* That is, Gallagher’s system sets a threshold and then assumes

any value above that threshold indicates that a retroreflector must be present. Ex. 2023, ¶66.

After identifying the location of road markers using peak responses, Gallagher performs a few final steps to record the data in a useful format. Ex. 2023, ¶67. In step (h), it converts the detected peak number into a format that corresponds to specific standard for retroreflectivity, either as a percent of a standard level or an absolute CIL (coefficient of luminous intensity) value in millicandela per lux. Ex. 1005, [0067]. In step (i), that value is compared to the predetermined acceptable reflectance level, and tagged as acceptable or not acceptable. *Id.*, [0068]. In step (j), the location and reflectance levels of the tagged markers are saved on a storage medium. *Id.*, [0069]. In step (k), road markers which are entirely absent (rather than just being merely degraded) are inferred from breaks in the pattern of valid road marker spacing. *Id.*, [0070]. The final results are provided in a user understandable graphical or numerical format. *Id.*, [0071].

B. Lumia (Ex. 1014)

Lumia is directed to a system for evaluating the nighttime visibility of traffic signs via a system in a car moving at highway speeds. Ex. 1014, 15-17; Ex. 2023, ¶68. In particular, it uses a vehicle with a CCD (charge-coupled device) video camera, a xenon camera flash (e.g., like would be associated with still photography), a laser range finder, and a computer. *Id.* While driving along the road, a human

operator manually aims the video camera at a target sign, and when a range finder determines that the camera is within a predetermined distance to the sign, a gray-scale image is automatically taken from the video camera using a frame grabber. Ex. 1014, 15, 17-20. Images are manually annotated by the operator with the sign type, and stored on a hard drive for analysis “at the end of the run.” *Id.*, 18, 20.

The image from the frame is then passed to a computer which crops the image to just include the sign, as shown in Fig. 3(a). Ex. 1014, 16-17, 24; Ex. 2023, ¶69. Next, the software creates a histogram of the gray scale image, where the histogram’s bins correspond to the each of the 256 different 8-bit grayscale values possible in the image (i.e. 0 to 255) and each pixel in the image corresponds to one data-point in the histogram. Ex. 1014, 16-17, 24. Lumia teaches that the histogram is expected to have three peaks. *Id.*, 17. One peak corresponds to the sign surround (i.e. the part of the image that are not part of the sign itself). *Id.* One peak corresponds to the sign’s legend—the typically brighter part of the sign, which is the relatively smaller portion of the sign’s area, (e.g. the white “STOP” text on a stop sign). *Id.* And finally, one peak corresponds to the sign’s background—the largest area of the sign, typically less bright than the legend (e.g. the red part of the stop sign). *Id.*

Lumia’s software automatically excludes the sign surround by ignoring the first four bins in the histogram (i.e. the darkest areas of the image). Ex. 1014, 17; Ex. 2023, ¶70. Then the software identifies the largest remaining peak in the

histogram as corresponding to the sign's background, and the next largest peak of brighter values as corresponding to the sign's legend. Ex. 1014, 17.. Finally, the portions around each peak are averaged to create an average 8-bit value for the sign background and an average 8-bit value for the sign's legend. *Id.* Notably, throughout the entire process of creating and analyzing the histogram, the 8-bit gray level values remain *intensity* values, i.e. corresponding to how much light intensity was received on a single element of the camera's sensor. *See, id.*, 15 ("histograms of the retroreflected intensity distribution are exploited to yield average legend and background values).

The last steps in Lumia convert the 8-bit gray level intensity values for the sign background and legend into coefficients of retroreflection values. Ex. 1014, 24; Ex. 2023, ¶71. In particular, Lumia describes that a calibration procedure is performed prior to the analysis portion of the system's operation. *Id.* That calibration is performed on a single "image of a calibrated white sheeting material." *Id.* Moreover, because Lumia's system is centered around ensuring images are taken at a specific distance (i.e., triggering the image capture when the laser range finder is at the pre-specified distance), a POSITA would understand that calibration is performed at only at the single, specified distance where actual signs will be

measured—in this instance, 200 feet. *Id.*, 24, 20.¹ The result of the calibration is a “scale factor,” which is multiplied by the 8-bit gray level intensity values for the sign background and legend to provide coefficient of retroreflection (i.e. R’) values for the sign background and legend. *Id.*, 24. Because the scale factor is simply multiplied by the 8-bit grey level intensity values to create the R’ values, a POSITA would understand that, during the calibration process, the scale factor is created by dividing the known retroreflectivity value of the calibrated white sign by the 8-bit grey levels measured from that the sign by the same video camera using the same flash, etc. Lumia discloses that, in static testing (i.e., not actually driving), its system obtained comparable results to existing hand-held retroreflectometer devices. *Id.*, 24-26.

Lumia discloses that its system operates using a number of principles that result in some degree of imperfect estimation and provide limitations on use. As noted, it requires an operator’s manual targeting of signs. Ex. 1014, 20; Ex. 2023, ¶72. And, to avoid the problem of ambient illumination throwing off readings, it

¹ Although Lumia describes a 200 foot highway mode and a 100 foot local mode, a POSITA would understand that switching between highway mode and local mode would require the operator to manually change the laser range finder settings and run separate calibration procedures to create separate scale factors for each. Ex. 2023, ¶71, n.1.

suggests limiting measurement times to when the sun is above 20 degrees elevation.

Id., 22. Because the performance characteristics of different retroreflective materials respond to changes in observation angle differently, Lumia must use a tightly controlled distance window for capturing the image to attempt to ensure a 0.2 degree observation angle. *Id.*, 21. And Lumia simply ignores the effects of differing entrance angle as having limited effect by having that distance window sufficiently far away from the vehicle (“appreciable distances”) to minimize the effect of changes in entrance angle. *Id.* Moreover, as discussed, Lumia relies on automatic cropping or thresholding software, which it explains can provide incorrect thresholding, resulting in erroneous results. *Id.*, 24.

Early in the Lumia reference, prior to the actual discussion of how Lumia’s system operates, Lumia describes certain “Background” principles, including principles of retroreflection, types of retroreflective materials, and equations relating the coefficient of retroreflection into different properties. Ex. 1014, 16. In particular, Lumia includes equation (2), that relates the coefficient of retroreflection (R') to the quotient of luminance (L) of the reflected light and the normal illumination incident on the retroreflector (E_n). *Id.* However, Lumia does not describe a system that actually uses equation (2) or tries to calculate retroreflection in that way. Indeed, as discussed, Lumia’s scale factor directly converts 8-bit grey level light intensity values into coefficient of retroreflection values, and thus Lumia

never describes an automated system trying to measure, calculate, or determine luminance of the reflected light or the normal illumination incident on the retroreflector. Ex. 1014, 24; Ex. 2023, ¶73.

As part of Lumia's background section, Lumia identifies background principles for how one can conceptualize calculating retroreflectance using a camera. Ex. 1014, 16; Ex. 2023, ¶74. In particular, Lumia notes that:

The use of a video camera effectively divides the FOV defined by the system magnification into smaller FOV's, thereby creating individual luminance meters at each sensing element site. In effect, the use of a video camera is a practical way for obtaining a large number of measurement samples from the sign so that representative legend and background retroreflectances may be calculated."

Ex. 1014, 16. However, a POSITA would not understand this as disclosing or suggesting determining a luminance value. Rather, it is simply describing a background principle of how one can conceptualize the relationship between a camera and the principles of equation (2). As noted by the word "effectively," a camera is not actually a luminance meter. Ex. 2023, ¶74.

Indeed, luminous intensity is a measurement of how bright something appears (i.e., the intensity of light in a specific direction) and is measured in candelas. Ex. 2023, ¶75; Ex. 2009, 4 ("While 'radiant intensity' is the intensity of light without adjustments for human vision, luminous intensity is a 'photometric' unit that compensates for human visual sensitivity."), 6 ("Using solid angles as part of the

candela definition specifies light that shines in a particular direction”). It is distinguished from luminous flux, which is the total amount of light emitted by a source, irrespective of direction, and is measured in lumens (defined as one candela-steradian). *Id.*, 6 (“lumens, which tells you how much light it puts out in total—telling you its brightness in all directions”). Luminance is a measurement of the amount of light travelling per unit area in a given direction (e.g., how much light a surface emits), provided in units like candelas per square meter or candelas per square foot). Ex. 2010, 1-2. Illuminance is a measurement of how much light is received by a surface, regardless of the sources or direction of that light, and is provided in lux (defined as one lumen per square meter). Ex. 2028. Thus, a camera’s measurement of received light intensity does not determine a luminance value. Ex. 2023, ¶75.

IV. LEVEL OF ORDINARY SKILL IN THE ART

Petitioner and its expert Dr. Thorpe have proposed that a POSITA would have had “at least a bachelor’s degree in mechanical engineering, electrical engineering, computer science, physics, or related discipline, and four years of experience in research, design, or development in computer vision systems.” Pet., 7; Ex. 1003 ¶33. However, this is an excessive level of ordinary skill in the art, and Patent Owner asserts instead that a POSITA would more likely have two years of experience rather than four years, as confirmed by Dr. Papanikolopoulos. Ex. 2023, ¶57. However,

none of the arguments presented herein would change if Petitioner's identification of the level of skill in the art were adopted instead. *Id.*

V. CLAIM CONSTRUCTION

A. “a characterization profile of the at least one light intensity sensor” ('255 Patent, cl. 15)

Petitioner maps this limitation to Lumia's “calibration.” Ex. 1003 ¶115; Pet., 45. Lumia describes its calibration process as “accomplished by acquiring an image of a calibrated white sheeting material and computing a scale factor to convert the 8-bit digital gray levels of the calibration target image to R' values.” Ex. 1014, 24. Because Lumia only calibrates using a single white sign at a single distance, Petitioner's application of the prior art to claim 15 requires determining the scope of this limitation, and in particular, whether a “characterization profile” can simply be the calculation of a scale factor based on a single sample in a single set of conditions. Ex. 2023, ¶76.

As explained in detail below, the appropriate construction of “a characterization profile of the at least one light intensity sensor” is “**a compilation, presented in a usable format, of the description of the properties and performance characteristics of a sensor across various conditions.**” Ex. 2023, ¶86.

1. The Established Ordinary Meaning of “Sensor Characterization” Supports Patent Owner’s Construction

As Dr. Papanikolopoulos explains, a POSITA reading claim 15 would immediately envisage the concept of “sensor characterization.” Ex. 2023, ¶77. This is a well-understood concept in the field of sensors and computer vision. *Id.* The connection between claim 15 and sensor characterization is also demonstrated by the specification, which discloses “Using an intensity algorithm 490, a light intensity sensor characterization 275 and a look-up-table 475, the computer processor 450 determines a background luminance value 500 and a foreground luminance value 510” (Ex. 1001, 8:37-41) and that “Luminance (expressed in candelas per square meter, or cd/m^2) will vary according to the intensity sensor characterization profile 275 of the light intensity sensor(s) 280 and the color of the material from which light is reflected” (*id.*, 10:65-11:3). Ex. 2023, ¶77. Similarly, Fig. 7 of the ’255 Patent depicts “intensity sensor characterization 275” being used with “Background Intensity” values and “Foreground Intensity” values to, respectively, calculate “Background R_A [retroreflectivity]” and “Foreground R_A [retroreflectivity].” Ex. 1001, Fig. 7. Like the characterization profile of claim 15, these passages and figure describe and depict the light intensity sensor characterization 275 as being used to determine luminance values from light intensity values. Ex. 2023, ¶77. Thus, the specification further confirms to a POSITA that the “characterization profile” of

claim 15 is intended to reflect the well-understood concept of sensor characterization.

As of the priority date of the '255 Patent, that “sensor characterization” is the process of describing the properties and performance characteristics of a sensor across *various* conditions. Ex. 2023 ¶78; Ex. 2011, 10-11 (§5.1) (sensor characterization “aims to experimentally measure the parameters of the sensor under different operating conditions”); Ex. 2012, 2-3 (“Sensor characterization is necessary to ensure a guaranteed level of readout accuracy over various operating conditions ... Manufacturers need to characterize the sensors they produce to analyze their dynamic range, linearity bandwidth, response time, noise and stability ... [to] allow[] users to know how to use sensors in their applications effectively.”); Ex. 2013, 1- 2 (describing developing “electro-optical sensor characterization and evaluation” as involving “[t]esting and evaluation (T&E) and modeling and simulation (M&S) of electro-optical sensor systems to assess their operational characteristics [and] their performance limits” and noting that “a sensor will generally have a particular set of important design and test parameters that characterize its operation, function, and performance”). And the word “profile” indicates that the sensor characterization has been compiled into a set of characteristics presented in a format usable by the system of the '255 Patent. Ex. 2023, ¶78; Ex. 2014, 3 (defining “profile” as, among other things, “5. a. a graph,

diagram, piece of writing, etc. presenting or summarizing data relevant to a particular person or thing”).

Indeed, it is well-recognized in the field that calibration and characterization, while related, are distinct. Ex. 2023, ¶79. For example, it is possible to *calibrate* a CCD camera’s pixels to obtain a luminance value. Ex. 2029, 1 (“A camera calibration procedure gives for each pixel of the CCD array the value that links the A/D converter output with the luminance of the pixel-framed surface (luminance calibration coefficient).”). However, characterization goes beyond mere calibration to take into account various conditions:

The knowledge of the **calibration values is not enough** to obtain accurate measures **because several parameters could influence the pixel reading** in real measurement conditions (linearity, spectral sensitivity, dark frame, presence of saturated pixels, ghost images, etc.). ...

The calibration could be applied for **different camera conditions**, and the influence of each parameter on the device performance could be easily obtained ... This is a very time-consuming procedure: It is possible to reduce the **characterization** time by considering bigger groups of pixels, but, obviously, this brings lower accuracy.

Ex. 2029, 172; Ex. 2023, ¶79.

2. The Specification Supports Patent Owner’s Construction

Patent Owner’s construction is also consistent with the specification, which describes that “[t]he light intensity sensor characterization 275 is *empirical* information about the light intensity sensor 280 that is used to create the LUT 475.”

Ex. 1001 ('255 Patent), 11:56-59; Ex. 2023, ¶80. Moreover, in a preferred embodiment, “look-up-table (LUT) 475” “is a digital table stored in memory that uses the indexes of intensity (a single gray level value from the intensity measurement 300) and sheeting color to determine the luminance.” Ex. 1001, 11:53-56.

Because LUT 475 is designed to handle signs of *various* colors, a POSITA would understand that, in the preferred embodiment, light intensity sensor characterization 275 would have to describe the properties of the sensors under various conditions (e.g. measuring signs of various colors). Ex. 2023, ¶80. This is further confirmed by the '255 Patent specification's statement that “light intensity sensor 280 characterization is essential for high precision computations since N photons of a given particular color (or wavelength) of light will represent a different gray value (intensity level) in the sensor than N photons of another color (or wavelength) of light.” Ex. 1001, 11:48-53.

Additionally, the above construction is also consistent with the '255 Patent's specification's use of the term “characterization” and “profile” for things other than the light intensity sensor. Ex. 2023 ¶81. For example, the specification describes “characterization profile of the light source” as including “[l]ight source angle characterization” “whereby empirical data from the light is modeled to establish the light intensity for *numerous* discrete vectors from the center of the light” and “light

source color characterization” describing intensity at different wavelengths “throughout the visible spectrum.” Ex. 1001, 12:9-51 (emphasis added), Fig. 8. That is, the *single* light intensity sensor characterization profile models the performance of the light sensor under *various* conditions.

3. Petitioner’s Proposed Construction is Incorrect

In its pre-institution preliminary reply brief, Petitioner did not provide an express construction, but argued that a “characterization profile” includes “a histogram” “of collected data from sensors.” Paper 8, 2. Petitioner’s argument is plainly incorrect. In particular, not all data collected from sensors is a “sensor characterization.” Ex. 2023, ¶82. Rather, as noted in the documents cited above, sensors collect data all the time—but a POSITA would not understand all sensor data to be a sensor characterization. *Id.* Rather, data collected by sensors can be *used* for sensor characterization if they are collected in a particular way (i.e. under the various conditions adequate to describe the performance and properties of the sensor as required for the purpose at hand). *Id.* Thus, data collected by sensors can be used to create a sensor characterization *profile* if such data is organized to be usable for achieving that purpose (i.e., to ensure sensor output is appropriately processed in various conditions). *Id.* But, that does not mean that every histogram created from sensor data is a sensor characterization. *Id.*

4. The Institution Decision’s Preliminary Construction is Incorrect

In its institution decision, the Board adopted a preliminary construction of “characterization profile” as “a conversion factor to convert measured light intensity into luminance.” Paper 16, 21 (citing Ex. 1001, 11:41-53, 11:53-56). However, the Board’s preliminary construction is not consistent with the understanding of a POSITA for several reasons. First, the preliminary construction conflates the specification’s “look-up-table 475” with the specification’s “light intensity sensor characterization 275.” Ex. 2023, ¶83. Since the specification describes them as two different things, a POSITA would understand the terms to have different meanings. *Id.*

In particular, the specification describes “look up table 475” as converting “indexes of intensity (a single gray level value from the intensity measurement 300) and sheeting color” into “luminance.” Ex. 1001 (‘255 Patent), 11:53-56. By contrast, as noted, “light intensity sensor characterization 275 is empirical information about the light intensity sensor 280 that is used to create the LUT 475.” *Id.*, 11:56-59. Thus, the Board’s preliminary construction is consistent with how the ‘255 Patent’s specification describes “look-up-table 475,” rather than “light intensity sensor characterization 275.” Ex. 2023, ¶83.

Moreover, in its decision on Patent Owner’s request for rehearing, the Board concluded that “requir[ing] a single characterization profile to include values for multiple conditions ... is at odds with the disclosure of the ’255 patent.” Paper 20, 6. To the contrary, a single profile including values for multiple conditions is fully consistent with the ’255 Patent’s specification, and in particular, Fig. 7. Ex. 2023, ¶84. Most notably, in the preferred embodiment illustrated, Figure 7 of the ’255 Patent depicts the same sensor characterization “275” as being input into the same “Intensity LUT [look-up table]” (475) for both background RA and foreground RA, whereas a different sheeting color is identified for both foreground (506) and background (505). Ex. 1001, Fig. 7. This demonstrates that the single sensor characterization profile can handle various different colors. Ex. 2023, ¶84.

Indeed, the specification’s description of the preferred embodiment only ever describes *one* sensor characterization profile 275, which is used to create look-up-table 475, despite the fact that look-up table 475 can handle various colors (*id.*, 11:53-56), and despite the fact that “characterization” of “light intensity sensor 280” is described as “essential” to address the sensor’s differential intensity responsiveness to *different* wavelengths of light. Ex. 1001, 11:41-43, 11:48-53. These disclosures demonstrate that a single characterization profile addresses various conditions. Ex. 2023, ¶84.

The '255 Patent's specification does state that “[b]y knowing the background or foreground color of the object of interest 460 along with the light intensity sensor's 280 ability to sense, or the light intensity sensor's 280 profile for a particular color, the intensity value 300 for a particular color can be converted into a luminance value.” Ex. 1001, 11:43-48. However, a POSITA would understand “light intensity sensor's 280 profile for a particular color” as referring to, in the preferred embodiment, the portion of the characterization profile for a particular color—rather than stating that each color had its own separate profile. Ex. 2023, ¶85. Indeed, the visible spectrum includes a huge number of different colors, i.e. different wavelengths of light between about 400nm and 700nm. *See, e.g.*, '255 Patent, Fig. 8. Thus, it would be impractical to create separate characterization profiles to handle all the various colors that may be received by the light intensity sensors of the '255 Patent. Ex. 2023, ¶85.

* * *

For all the foregoing reasons, the Board should construe “a characterization profile of the at least one light intensity sensor” as “**a compilation, presented in a usable format, of the description of the properties and performance characteristics of a sensor across various conditions.**” Ex. 2023, ¶86.

VI. THE CHALLENGED CLAIMS OF THE '255 PATENT ARE NOT ANTICIPATED AND ARE NOT RENDERED OBVIOUS

A. Ground 2: Claim 15 of the '255 Patent is Not Rendered Obvious by Gallagher and Lumia

Petitioner contends, and Dr. Thorpe opines, that claim 15 of the '255 Patent is rendered obvious by the combination of the Gallagher and Lumia references. As set forth below, the '255 Patent is not rendered obvious by the combination of the Gallagher and Lumia references.

1. A POSITA Would Not be Motivated to Combine the Teachings of Gallagher and Lumia in the Manner Claimed

Petitioner argues that it would be “obvious to implement Lumia’s determining a luminance value utilizing the plurality of light intensity values and a characterization profile of the at least one light intensity sensor to allow Gallagher’s apparatus² to calculate the retroreflectivity of road markers” because “several road

² Based on this statement, Patent Owner understands Petitioner and Dr. Thorpe to be proposing, as to claim 15, to use Lumia’s camera-based techniques with Gallagher’s photodiodes (which are part of Gallagher’s apparatus), and are not proposing to actually modify Gallagher to use a camera. This was also confirmed by the Board’s decision on rehearing, which stated that “Petitioner proposes to use Gallagher’s array of sensors to measure luminance in the manner taught by Lumia.” Paper 20, 7. This understanding was also confirmed by Dr. Thorpe’s deposition. Ex. 2025, 56:7-9 (“in the combination proposed in [paragraph] 116, this is still using the Gallagher apparatus with the sensors pointing down.”)

authorities specified minimum retroreflectivity values for road markings along a roadway” and that Lumia would help allow the apparatus “to identify and tag any markers “that do not meet the predetermined minimum acceptable reflectance level” for countries that require a minimum retroreflectivity level for road markers.” Ex. 1003 ¶116 (cited by Pet., 46). This theory suffers from at least three fundamental flaws: (1) Petitioner articulates no reason for combining the references so as to “determin[e] a luminance value” as opposed to a retroreflectivity value; (2) Gallagher already calculates retroreflectivity values in a way which does not benefit from combination with Lumia; and (3) Lumia’s teachings are fundamentally inapplicable to Gallagher because of the fundamental differences in their systems. Ex. 2023, ¶88.

(a) Petitioner articulates no reason for combining the references so as to “determin[e] a luminance value,” as opposed to retroreflectance values

First, Petitioner’s motivation to combine theory fails because it provides no motivation whatsoever for a POSITA to combine Gallagher and Lumia in a manner that “determin[es] a *luminance* value” as recited by claim 15. Ex. 2023, ¶89. Petitioner identifies certain road authority standards specified in minimum *retroreflectivity* values as the motivation to combine. Pet. 45. Naturally, that would only motivate creating a system that results in calculating *retroreflectivity* values. But “luminance” as recited in claim 15 is entirely distinct and different from

retroreflectivity. Ex. 2023, ¶75. In particular, the luminance values as claimed are distinct from the specific retroreflectivity figures in Gallagher (Ex. 1005, [0067]) or Lumia (i.e. Ex. 1014, 16). Ex. 2023, ¶89. Indeed, at his deposition, Dr. Thorpe admitted that retroreflectivity and luminance “use different units” and did not dispute that they are different. Ex. 2025, 39:10-20. Moreover, neither Gallagher nor Lumia disclose determining luminance values as part of an automated process for calculating retroreflectivity. Ex. 2023, ¶90.

As discussed above, in Gallagher, to determine whether a marker has adequate retroreflectivity values, Gallagher’s computer:

(i) receives values from analog-to-digital converters connected to each of its photodiode light sensors (Ex. 1005, [0056], [0016]),

(ii) averages the numeric values over a period of time to smooth out fluctuations (Ex. 1005, [0057]),

(iii) multiplies the resulting average by a calibration factor (Ex. 1005, [0058], [0017]),

(iv) identifies peak values above a non-marker reflectance level (Ex. 1005, [0065]-[0066]), and

(v) compares the calibrated number value for a peak result with the “reflectance level” or CIL (coefficient of luminance intensity) permitted by the standard (Ex. 1005, [0067]-[0068]). *Supra* III.A.

A POSITA would not understand any of these disclosures as being consistent with determining a luminance value. Ex. 2023, ¶90. Rather, Gallagher’s photodiodes (as converted by the ADC) output numeric light *intensity* values. Ex. 1005, [0039], [0046]-[0047], [0056]; Ex. 2027; Ex. 2023 ¶91. Because Gallagher’s steps (h) and (i) perform a comparison against “predetermined” acceptable reflectance level defined by CIL (coefficient of luminance intensity) in millicandela per lux, a POSITA would understand that the result of the calibration in Gallagher’s step (c) would similarly result in values with the same units. Ex. 1005, [0057], [0067]-[0068]; Ex. 2023, ¶91. Gallagher discloses does not manipulate the calibrated data values output by step (c) before the comparison with the predetermined acceptable reflectance level in steps (h) and (i). Thus the comparison in steps (h) and (i) would require the calibrated values to CIL values in the same units. As is well established, the coefficient of luminous intensity—which is what Gallagher calculates—is a measurement of *retroreflectivity* (usually expressed in candelas, or millicandelas, per lux per square meter, i.e., cd/lx/m^2), not luminance (usually expressed in candelas per square meter, i.e., cd/m^2). Ex. 1008, 451 (§ 3.1.1); Ex. 1005, [0067]; Ex. 2010, 2 (note 8); Ex. 2023, ¶91. Thus, Gallagher only discloses *directly* converting light intensity values to retroreflectivity values without ever determining a luminance value.

Similarly, Lumia teaches directly converting light intensity values to retroreflectivity values, rather than determining luminance values. Ex. 2023, ¶92. As discussed in further detail above, Lumia's system calculates the retroreflectivity of a sign by:

(i) a human operator manually aims a video camera at a sign and activates a range finder (Ex. 1014, 20);

(ii) when the vehicle is at a pre-specified distance from the sign, the rangefinder triggers an electronic flash and the camera's capture of an image of the sign (Ex. 1014, 18, 20 (Fig. 8));

(iii) software extracts the sign (i.e. crops) from the captured image (Ex. 1014, 16, 17 (Fig. 3(a)));

(iv) software creates a histogram of the numeric frequency of different light intensity values of the pixels in the cropped image (i.e. how many pixels of each 8-bit grey value between 0 to 255 appear in the image) (Ex. 1014, 16-17);

(v) software identifies gray level values corresponding to peaks in the histogram, excluding the first four grey levels as likely being associated with the capture of areas surrounding the sign (as opposed to the sign itself) (*Id.*);

(vi) software identifies the greatest-quantity peak in the histogram as the sign background (i.e. the red part of a stop sign) and the smaller-quantity peak with greater intensity as the sign legend (*Id.*);

(vii) software averages the grey values associated with each of the two peaks to create an average grey value for the sign legend and an average grey value for the sign background (*Id.*); and

vii) the coefficient of retroreflectivity of the sign legend and background are calculated by multiplying the average 8-bit grey value for each against a pre-calculated “scale factor” (Ex. 1014, 24). Ex. 2023, ¶92; *supra* III.B.

In particular, Lumia discloses that the “scale factor” directly “convert[s] the 8-bit digital gray levels of the calibration target image to R' values” i.e. it is a multiplication operation converts the 8-bit grey levels to coefficient of retroreflection values in candelas per footcandle per square foot. Ex. 1014, 24, 16. As discussed further above, none of these steps involve the determination of a luminance value. Ex. 2023, ¶92; *supra* III.B

In the Board’s decision on institution, the Board noted that “Patent Owner defines ‘luminance’ as ‘the luminous intensity projected on a given area and direction, i.e. the amount of visible light leaving a point on a surface in a given direction’” and “[b]y measuring the intensity of light reflected off a traffic sign, Lumia measures the sign’s luminance.” Paper 16, 27. Patent Owner respectfully disagrees. Lumia’s camera does not measure luminance because luminance represents the intensity of light directed in a particular direction *per unit area* (Ex. 2010, 1, 2, note 8), whereas Lumia’s camera can merely determine the *intensity* of

light received at each pixel of the camera's sensor. Ex. 1014, 16; *see also* Ex. 2029, 171 ("CCD detectors are integrating devices: the number of charges stored in each pixel is directly proportional to exposure time and to array irradiance"). Thus, Lumia's CCD sensor has no sense of the direction of how photons reach each of its pixels, or the area covered—it merely outputs raw light intensity information for each pixel. Ex. 1014, 18; Ex. 2023, ¶93.

Although certainly one *could* create a scale factor to convert the light intensity factor from a camera sensor into *luminance* values, that requires specific techniques. *See* Ex. 2029, 171 (discussing, to create a CCD luminance meter, using a "camera calibration procedure ... that links the A/D converter output with the luminance of the pixel-framed surface (luminance calibration coefficient)"). Lumia simply does not disclose those techniques. Ex. 2023, ¶94. Rather, Lumia's system only discloses converting from 8-bit grey value light intensity values into retroreflectivity values without ever determining a luminance value. Ex. 1014, 24.

Petitioner points to Lumia's disclosure that "[t]he use of a video camera effectively divides the FOV defined by the system magnification into smaller FOV's, thereby creating individual luminance meters at each sensing element site." Ex. 1014, 16. However, as shown by the word "effectively," a POSITA would not understand that the sensing element sites in Lumia's camera are *luminance* meters, but only that they could be used for measuring luminance. Ex. 2023, ¶94. But,

Lumia does not actually disclose or suggest using the camera pixel's values to determine luminance values. Rather, as discussed, Lumia bypasses "determining a luminance value" to directly convert the 8-bit grey level light intensity values into retroreflectance measurements. *Id.*

Indeed, this understanding of Lumia was confirmed by Dr. Thorpe during his deposition. In particular, Dr. Thorpe explained that in Lumia:

Q. So is Lumia converting the gray scale image on -- in Figure 3(a) into a number that goes from zero to 255?

A. Each pixel in 3(a) has a recorded brightness from 0 to 255. These brightnesses have not been calibrated as luminances scale values from the camera.

The histogram records how many of the pixels in image 3(a) have brightness zero, how many have brightness 1, how many have brightness 2, et cetera, up through how many have brightness 255.

Q. And so those are light intensity values; is that correct?

A. Those are the sensed intensity values from the camera. That is correct.

Ex. 2025, 17:18-18:9.

Dr. Thorpe testified at his deposition that a POSITA *could* use Lumia's equation (2) that includes luminance and the coefficient of retroreflectivity to calculate a luminance value. Ex. 2025, 8:8-13, 12:2-12, 40:1-13; *see also id.*, 32:2-4 (testifying that Gallagher's sensors could be "calibrated to create ... a luminance value, if desired"). There are several flaws in such a theory. Ex. 2023, ¶96.

First, a theory based on modifying Lumia to actually calculate a luminance value and use that luminance value to calculate retroreflectivity is a new theory, not disclosed in the Petition, and is thus improper to raise at this time. *See Henny Penny Corp. v. Frymaster LLC*, 938 F. 3d 1324, 1330-31 (Fed. Cir. 2019); 37 C.F.R. § 42.23(b).

Second, such a theory is evidently a product of hindsight rather than actually identifying a motivation for a POSITA to combine the systems in the manner claimed at the time of invention—it is not enough that a POSITA *could*, the inquiry is whether a POSITA *would*. Indeed, when asked “Do you identify somewhere in your declaration, for your theories for claim 15, a need to determine luminance?” Dr. Thorpe answered “Since claim 15 says determining a luminance, Lumia teaches how the luminance can be determined” and explained that “I was responding to [claim] 15 determining a luminance value, then saying it's obvious to do so.” Ex. 2025, 40:14-41:2. That is plainly hindsight reasoning, not a motivation to determine a luminance value. Ex. 2023, ¶96.

Third, Dr. Thorpe’s new theory at his deposition fails because it would require undisclosed modifications to the references without any apparent motivation. Ex. 2023, ¶97. As discussed, Lumia’s equation (2) is related to the “Background” concepts, not how Lumia’s system actually works. Thus, Dr. Thorpe’s equation (2) theory is beyond Lumia’s disclosures relating to any ostensibly “automated method”

as recited in claim 15. Consequently, rather than merely combining aspects of Gallagher and Lumia's disclosures, Dr. Thorpe's theory newly disclosed at his deposition would instead require modifying an automated system to use Lumia's equation (2) instead of the scale factor that Lumia actually uses (which calculates retroreflectivity values). But, neither the Petition nor Dr. Thorpe's declaration mentions such a modification or any motivation for such a modification.

Third, the alleged motivation to combine identified in Dr. Thorpe's declaration—retroreflectivity standards—would motivate *against* modifying Lumia to calculate luminance values. Ex. 2023, ¶97. Lumia itself already *directly* calculates retroreflectivity values—the ultimate goal identified in Dr. Thorpe's declaration's motivation to combine section for claim 15. Ex. 1014, 16-17; Ex. 1003 ¶116. Calculating luminance values prior to calculating retroreflectivity values would simply waste computing resources with no benefit toward the goal of calculating retroreflectivity values.

Fourth, equation (2) in Lumia also recites—in addition to the coefficient of retroreflection and the luminance— E_n or the “normal illumination incident of the retroreflector,” i.e. how much light is striking the sign, and thus using equation (2) to calculate luminance would also require determining the E_n value. Ex. 1014, 16. But, Lumia contains no description of how to actually measure or calculate E_n in its automated system. Ex. 2023, ¶97. At his deposition, Dr. Thorpe pointed to section

5.3 of Lumia as containing a discussion relevant to calculating E_n , noting that Lumia has “a very detailed discussion of the amount of illumination needed.” Ex. 2025, 12:20-13:8. However, that theory does not appear in Dr. Thorpe’s declaration, and thus is an improper new theory. Moreover, section 5.3 of Lumia only teaches how much intensity must be provided by a light source to “provide an adequate amount of additional exposure above the ambient signal.” Ex. 1014, 23. That is, as Lumia itself acknowledges, ambient light will be present—and will vary. Thus the mere knowledge of the minimum required intensity for the light source in Lumia is insufficient to actually calculate E_n , which measures *all* illumination incident of the retroreflector, including illumination from ambient sources of unknown and varying amplitudes. Ex. 2023, ¶97. Because Lumia does not disclose how to determine E_n , Lumia does not disclose or suggest how to calculate a luminance value using Lumia’s equation (2).

For all of these reasons, there is no motivation to combine the references so as to, in an “automated method,” “determin[e] a luminance value,” as opposed to retroreflectance values.

(b) There is no motivation to combine Gallagher and Lumia because Gallagher already calculates retroreflectivity and does not benefit from combination with Lumia's disclosures

Second, Petitioner's motivation to combine theory—that road authorities publish minimum retroreflectivity levels for road markers (Ex. 1003 ¶116)—also fails because Gallagher already teaches determining whether road markers meet published standards for minimum retroreflectivity levels. Ex. 2023, ¶98. Indeed, as Petitioner and Dr. Thorpe readily acknowledge, the entire point of Gallagher is “assessing the integrity of road markers and markings” “to ensure they continue to meet minimum standards of reflectivity/retroreflectivity” by comparing “data measured on the reflectance level” of road markings to a “predetermined acceptable reflectance level” for such marking. Pet., 9; Ex. 1003 ¶55, 57; Ex. 1005, [0001], [0003], [0012]; *see also id.*, [0067]-[0068][0049], [0077], [0079]. Thus, Petitioner's theory raises the question—how does combining Lumia's teachings with Gallagher better serve this goal of calculating retroreflectivity of road markers? Neither the Petition nor Dr. Thorpe's declaration provide any explanation for that. Pet. 46-47; Ex. 1003 ¶¶55, 57, 114-117; Ex. 2023, ¶98.

Moreover, the inadequacy of Petitioner's theory was further demonstrated at Dr. Thorpe's deposition. In particular, when asked “If Gallagher already discloses a system for assessing whether markers meet the retroreflectivity standards, how is

Lumia improving Gallagher in [Petitioner’s] proposed combination?” Dr. Thorpe pointed to Lumia’s equations as purportedly allowing one of skill in the art to calibrate for various different distances and also contended that Lumia “provides for higher precision.” Ex. 2025, 60:5-61:5. However, those alleged benefits are beyond the scope and entirely unrelated to the alleged motivation to combine identified in the Petition and Dr. Thorpe’s declaration. Pet. 46-47 (citing Ex. 1003 ¶¶114-117); Ex. 2023, ¶99. Indeed, Dr. Thorpe admitted that he “did not spell it out in [his] declaration.” Ex. 2025, 64:25-2. Accordingly, this new, previously undisclosed theory is outside the scope of this proceeding.

Moreover, even if Petitioner were permitted to rely on such new theories, they also fail to provide a motivation to combine. Ex. 2023, ¶100. In particular, Gallagher operates by sweeping photodiodes along the road in a narrow window ahead of the vehicle as the vehicle drives down the road. Ex. 1005, [0035], Fig. 1; Ex. 2025, 55:13-18. The angle of the unit containing Gallagher’s sensor and light (and thus the distance of the sensor’s window on the road from the front of the vehicle) can be varied between 1 to 30 degrees. Ex. 1005, [0036]. Moreover, Gallagher’s calibration factor can accommodate “different tracking distances.” *Id.*, [0039], [0058]-[0059]. Thus, Dr. Thorpe’s new theory at his deposition still provides no apparent benefit obtained from combining Lumia with Gallagher—Gallagher already can handle various distances. Ex. 2023, ¶100.

Thus, because Gallagher already teaches determining whether road markers meet published standards for minimum retroreflectivity levels, Petitioner's identified motivation to combine provides no reason to combine Lumia's teachings with Gallagher. Ex. 2023, ¶101.

(c) There is no motivation to combine Gallagher and Lumia—and such combination would not be predictable—because Lumia's teachings are fundamentally incompatible with Gallagher's apparatus

Third, Lumia's teachings are fundamentally incompatible with Gallagher's apparatus. Ex. 2023, ¶102. In particular, Petitioner identifies Lumia's teachings relating to its histogram as being combined with Gallagher. Pet. 45; Ex. 1003 ¶114. And, as noted, the proposed combination uses Gallagher's photodiode light sensor array in the proposed combination as the claimed "light intensity sensor". Ex. 1003 ¶¶87, 116 ("Gallagher's apparatus"), Ex. 2025, 29:23-331:25, 33:13-34:4; Ex. 1005, [0039]. And nowhere did Dr. Thorpe or Petitioner articulate a reason to modify Gallagher to use Lumia's video camera.

Notably, neither Petitioner nor Dr. Thorpe provides any technical explanation for how Lumia's teachings are applicable to Gallagher's apparatus. Pet. 46; Ex. 1003 ¶¶114-117; Ex. 2023, ¶103. To the contrary, a POSITA would not recognize Lumia's histogram method as being applicable to Gallagher's apparatus. Gallagher's apparatus divides a field of view of a roadway via five or ten photodiode

sensors. Ex. 1005, [00398]-[0040]. Each of those sensors must be sufficiently wide scope to be able to capture enough reflected light to detect “peaks” above the background non-marker reflectance level, which Gallagher uses to infer the presence of a retroreflective pavement marker. *Id.*, [0065]-[0066]; Ex. 2023, ¶103.

By contrast, as discussed, Lumia’s histogram method relies on a CCD camera, which has a resolution of 491 x 384 pixels (Ex. 1014, 18), which totals 188,544 individual pixel sensing cites. Ex. 1014, 18. Lumia needs so many individual pixels because it has to have adequate granularity in its data to be able to aggregate grey values to find peaks in a histogram. Ex. 1014, 17; ; Ex. 2023, ¶104. But even in Gallagher’s embodiment with the most disclosed sensors, Gallagher’s ten photodiodes provide an order of 18,000 times fewer light intensity readings than Lumia’s camera at any point in time. That is far too few to use Lumia’s histogram method. Ex. 2023, ¶104. One cannot identify and differentiate sharp peaks in a histogram (as disclosed in Lumia) if you only have a handful of total data points in the histogram (as would be generated by Gallagher’s photodiode array). *Id.* Nor would it be practical to modify Gallagher to use thousands of photodiodes. *Id.* Without the granularity provided by the thousands of sensing sites in Lumia’s camera, one cannot identify peaks in a histogram, little less precisely average the grey-level values around the identified peaks, as Lumia requires. *Id.*; Ex. 1014, 17. Because that is critical for how Lumia operates and obtains precise results, a

POSITA would recognize Lumia's teachings as entirely inapplicable to Gallagher's system. Ex. 2023, ¶104

Lumia's teachings are also inapplicable because, as discussed, Lumia requires precise aiming (by an operator) and framing of a traffic sign's image, with a precisely timed xenon bulb, at a particular distance (determined precisely by laser rangefinder) to provide a high quality image on which its histogram method can be performed. Ex. 1014, 17-20, 24; Ex. 2023, ¶105. Manual aiming is distinct from the "automated method" as recited in claims 12 and 15. It is also distinct from Gallagher's system where the photodiodes' outputs are continuously recorded once the operator "initiates the measurement process." Ex. 1005, [0046], [0056], Fig. 5. And, as discussed, Lumia relies on capturing images at an "appreciable distance" (e.g. 100 to 200 feet) to minimize the effect of entrance angles, which is inconsistent with the proposed combination, which Dr. Thorpe admits to involve pointing the camera "down" at the roadway ahead. Ex. 1014, 20, 21; Ex. 2025, 56:7-9.

In contrast to Lumia's precise, aimed capture of discrete images of individual signs, Gallagher continually sweeps the roadway for pavement markers. In doing so, Gallagher's photodiodes capture a wide FOV area located 2.3 meters in front of the vehicle to ensure it does not miss any pavement markers. Ex. 1005, [0032], [0035], [0046]-[0047]. This sweeping approach also requires a sufficient dwell time over each pavement marker so its peak responses can be detected. Ex. 1005, [0066];

Ex. 2023, ¶106. But, such a wide FOV and long dwell time are inconsistent with Lumia's approach of precisely calibrating the pixel values using a single, cropped image taken at an exact distance. Ex. 2023, ¶106. In particular, each of Gallagher's photodiodes has a wide enough FOV to receive a blend of light coming from many more points on the roadway within the FOV. Ex. 1005, [0040]. This simply would not work with Lumia's histogram approach, which requires precise intensity measurements (i.e. 0 to 255) corresponding to precise points (i.e. pixels) in an image of a single road marker to be able to quantify the relative frequency of different light intensity values. Ex. 2023, ¶106.

Indeed, unlike Lumia's camera, a photodiode array (such as in Gallagher), by itself, cannot even form coherent images, as it lacks the optical elements necessary to focus and direct light onto the sensing elements in a controlled manner. Ex. 2023, ¶107. Because Gallagher's array lacks such components, it could not perform Lumia's method even if it were somehow modified to use thousands of times more photodiodes and used photodiodes with an extremely narrow FOV angle. *Id.* Additionally, a POSITA would recognize that Gallagher's photodiodes would be too polluted by ambient light sources (i.e. sources other than retroreflector) to be effective at the longer distances described at Lumia to obtain useful values for calculating retroreflectivity values. Ex. 2023, ¶108. Petitioner articulates no way

for cropping the results from Gallagher's photodiode array, as Lumia teaches is necessary for its histogram approach to work.

For all of these reasons, a POSITA would recognize Lumia's teachings as entirely inapplicable to Gallagher's system. *Id.* Thus, a POSITA would not be motivated to make the combination, and such a combination would not be predictable or have a reasonable expectation of success.

(d) Petitioner's motivation to combine theory lacks the specificity required by law

As discussed above, the Petition's motivation to combine theory simply lacks explanation as to a number of points. In particular, it does not provide a meaningful technical explanation for how the proposed combination is supposed to work (i.e., *how* Lumia's camera-based histogram approach is proposed to be adapted to Gallagher's apparatus). But, Federal Circuit precedent requires clear, evidence-supported account of the contemplated workings of the proposed combination. *Personal Web Techs., LLC v. Apple, Inc.*, 848 F. 3d 987, 994 (Fed. Cir. 2017); *Kinetic Concepts, Inc. v. Smith & Nephew, Inc.*, 688 F. 3d 1342, 1368 (Fed. Cir. 2012). Thus, the theories in the Petition are legally insufficient to make a prima facie case of obviousness, and requires rejecting Petitioner's theory for claim 15. It would also be improper for Petitioner to fill in the details in a reply, since that would

be an improper new theory, to Patent Owner. *Henny Penny*, 938 F. 3d at 1330-31; 37 C.F.R. § 42.23(b).

* * *

For all of these reasons, Petitioner has failed to articulate a motivation to combine Lumia and Gallagher in the manner claimed.

2. Claim 15

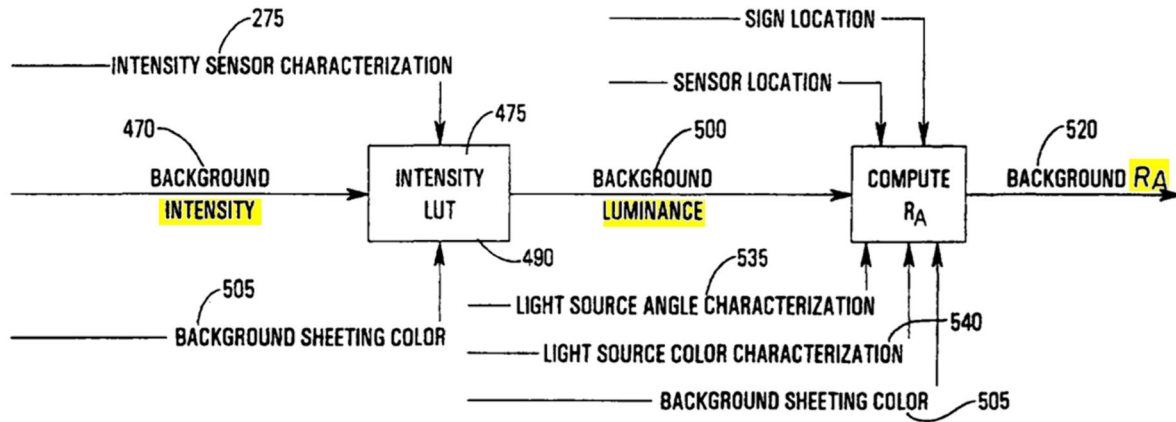
(a) Neither reference discloses or suggests “The *automated method of claim 12, further comprising determining a luminance value*”

The cited disclosures do not disclose or suggest “[t]he automated method of claim 12, further comprising determining a luminance value” as recited in claim 15 of the ’255 Patent. Petitioner identifies this disclosure as being purportedly provided by Lumia. Pet., 44-45; Ex. 1003 ¶114. In particular, Petitioner cites to Lumia’s “Background” section which, mentions that a camera can “effectively” “creat[e] individual luminance meters.” *Id.* (citing Ex. 1014, 16); Ex. 2023 ¶110.

However, as discussed in further detail above, the cited disclosures of Lumia do not disclose or suggest this claim element. *Supra* III.B, V.A.1.a. In particular, as noted by the use of “effectively” in Lumia’s section of “Background” principles—this is simply a discussion of how one can conceptualize how to calculate retroreflectance. Ex. 1014, 16. But simply mentioning the existence of equations

which recite luminance does not disclose or suggest an “automated method” that “determine[s] a luminance value.” Ex. 2023, ¶111.

To the contrary, Lumia’s “scale factor” directly converts 8-bit gray level light *intensity values* into coefficient of *retroreflectivity values* without ever “determining” any luminance values. Ex. 1014, 24; Ex. 2023, ¶112.³ As shown in Figure 7 of the ’255 Patent, this is very different from the operation of the ’255 Patent:



‘255 Patent, Fig. 7 (cropped and annotated)

As this shows, in a preferred embodiment, first a “background intensity” measurement is obtained, then “background luminance” is calculated using that

³ Dr. Thorpe admits the 8-bit grey level values of Lumia’s histogram are light intensity values, not luminance values. Ex. 2025 at 17:18-18:9.

measurement, and then “background luminance” is used to calculate “Background R_A [retroreflectance].” Ex. 2023, ¶112

Petitioner articulates no reason for modifying the operation of Lumia (either alone or in combination with Gallagher) to determine a luminance value instead of the direct conversion of light intensity values to retroreflectance values disclosed in both Gallagher and Lumia. Ex. 2023, ¶112. Thus, the cited references do not disclose or suggest this limitation.

(b) Neither reference discloses or suggests “utilizing ... a characterization profile of the at least one light intensity sensor”

The cited disclosures also do not disclose or suggest “utilizing ... a characterization profile of the at least one light intensity sensor” as recited in claim 15. Petitioner points to Lumia’s “calibration” for this limitation. Pet., 45; Ex. 1003, ¶115.

However, as discussed above, Lumia’s calibration uses a single “scale factor” which is calibrated based on a single sign, measured at a single distance. *Supra*, III.B; Ex. 1014, 24; Ex. 2023, ¶¶113-115. And, as discussed above, the appropriate construction of “a characterization profile of the at least one light intensity sensor” is **“a compilation, presented in a usable format, of the description of the properties and performance characteristics of a sensor across various conditions.”** *Supra*, V.A; Ex. 2023, ¶115. Because Lumia’s calibration procedure

only measures a single sign at a single distance, it is not describing the properties or performance characteristics of Lumia's sensor (i.e. video camera) across *various* conditions. Ex. 1014, 24; Ex. 2023, ¶115. Thus, the cited references neither disclose nor suggest this claim limitation as properly construed.

VII. CONCLUSION

For the above reasons, Patent Owner requests that the Board hold that all challenged claims are patentable.

Date: June 18, 2025

Respectfully submitted,

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Certificate of Service 37 C.F.R. § 42.6(e)

The undersigned certifies that on June 18, 2025, I will cause true and correct copies of the foregoing Patent Owner's Response, and all associated exhibits or appendices referred to therein, to be served electronically upon the following attorneys who have consented to service via email. Pet. at 75-76.

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Certificate of Compliance Pursuant to 37 C.F.R. § 42.24

This paper complies with the type-volume limitation of 37 C.F.R. § 42.24.

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