

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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MOBILEYE GLOBAL, INC.,  
Petitioner

v.

FACET TECHNOLOGY CORP.,  
Patent Owner

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IPR2024-01111  
U.S. Patent No. 9,671,328 B2

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**PATENT OWNER RESPONSE**

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**Patent Owner's Exhibit List**

| <b>Exhibit No.</b> | <b>Description</b>                                                                                                                                                                                                   |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 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. 9,671,328                                                                                                                            |
| 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> <a href="https://www.uscourts.gov/file/78884/download">https://www.uscourts.gov/file/78884/download</a>                |
| 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               | Intentionally Omitted                                                                                                                                                                                                |
| 2010               | Intentionally Omitted                                                                                                                                                                                                |
| 2011               | Intentionally Omitted                                                                                                                                                                                                |
| 2012               | Intentionally Omitted                                                                                                                                                                                                |
| 2013               | Intentionally Omitted                                                                                                                                                                                                |
| 2014               | Intentionally Omitted                                                                                                                                                                                                |
| 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-        |

| Exhibit No. | Description                                                                                                                                                                                                                                                                                                         |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|             | 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.)                                                                                                                                                                      |
| 2020        | Mobileye, “Fact Sheet: Mobileye Advanced Driver-Assistance Systems (ADAS)” (July 19, 2020) (available at <a href="https://www.mobileye.com/blog/fact-sheet-mobileye-advanced-driver-assistance-systems-adass/">https://www.mobileye.com/blog/fact-sheet-mobileye-advanced-driver-assistance-systems-adass/</a> )    |
| 2021        | SEC, “Mobileye to Offer User-Generated Mapping for Autonomous Driving” (January 6, 2016) (available at <a href="https://www.sec.gov/Archives/edgar/data/1607310/000157104916010521/t1600008_ex99-1.htm">https://www.sec.gov/Archives/edgar/data/1607310/000157104916010521/t1600008_ex99-1.htm</a> )                |
| 2022        | Joseph White, “GM Has 'Heightened Partnership' with Mobileye for Autonomous Cars” (October 1, 2015) (available at <a href="https://www.reuters.com/article/us-gm-investors-mobileye-idUSKCN0RV4ZC20151001/">https://www.reuters.com/article/us-gm-investors-mobileye-idUSKCN0RV4ZC20151001/</a> )                   |
| 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> , <a href="https://www.oxfordreference.com/display/10.1093/oi/authority.20110803100324432?p=emailAIVd1F">https://www.oxfordreference.com/display/10.1093/oi/authority.20110803100324432?p=emailAIVd1F</a> |

| <b>Exhibit No.</b> | <b>Description</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                    | /alp5o2&d=/10.1093/oi<br>/authority.20110803100324432&print                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 2028               | National Institute of Standards and Technology, OSAC Lexicon, Definition of “Lux,” <i>available</i> at <a href="https://www.nist.gov/glossary-term/26871">https://www.nist.gov/glossary-term/26871</a>                                                                                                                                                                                                                                                                                                                      |
| 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</i> at <a href="https://www.researchgate.net/publication/3090945_Characterization_and_Calibration_of_a_CCD_Detector_for_Light_Engineering">https://www.researchgate.net/publication/3090945_Characterization_and_Calibration_of_a_CCD_Detector_for_Light_Engineering</a> |
| 2030               | U.S. Patent No. 6,266,442 to Laumeyer et al.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 2031               | Thorpe, Chuck, et al. "Dependable perception for robots." (2001). <a href="https://kilthub.cmu.edu/articles/journal_contribution/Dependable_Perception_for_Robots/6552518/1/files/12033863.pdf">https://kilthub.cmu.edu/articles/journal_contribution/Dependable_Perception_for_Robots/6552518/1/files/12033863.pdf</a>                                                                                                                                                                                                     |
| 2032               | Nov. 5, 2024 NHTSA Investigation Notice of Tesla, <i>available</i> at <a href="https://static.nhtsa.gov/odi/inv/2024/INIM-PE24031-27346.pdf">https://static.nhtsa.gov/odi/inv/2024/INIM-PE24031-27346.pdf</a>                                                                                                                                                                                                                                                                                                               |

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

## **I. INTRODUCTION**

As discussed below, independent claims 1 and 9 recite a computer system which is configured to “detect objects of interest” and then subsequently “determine” whether those objects of interest include a reflective surface of a road marker. However, as Dr. Papanikolopoulos explains in detail, Gallagher uses a single-step method where road markers are identified as road markers based on “peak responses sensed” by light sensors, without any prior identification of potential objects of interest. Because the Gallagher reference’s single-step identification of road markers based on peak light sensor responses does not satisfy limitations [9D]-[9E] or [1E]-[1G], all of Petitioner’s obviousness grounds fail.

Petitioner’s theories for limitations [9F] and [1H], relating to determining the location of a road marker, also fail. As Petitioner admits, Gallagher’s GPS “corresponds to the location of the active sensor,” not the road marker, and thus “additional steps would have been necessary to also determine the location of the markers.” Pet., 70. And Schofield’s division of the scene into spatially separated regions has nothing to do with using intensity data to determine the location of an object. Rather, Schofield divides the field of view to prioritize different regions as part of its determination as to what intensity threshold to use to detect light sources,

which is essentially the opposite of this claim limitation.

In addition, Petitioner's motivation to combine theory is without merit. Neither Petitioner nor Dr. Thorpe articulate any reason explaining *how* they are combining Schofield's image-based approach with Gallagher's photodiode peak-sensing approach, or *why* it would improve the detection of objects. Indeed, Dr. Thorpe's deposition demonstrates that there are many, many different potential ways to combine—Patent Owner was entitled to notice and a reasonable opportunity to respond to one or more specific proposed ways for combining them. In any event, as Dr. Papanikolopoulos explains, any such proposed combination would stretch well beyond the capabilities of "sensor fusion" at the relevant time period, especially because their sensors are pointed at different FOVs, requiring transition of object tracking from one sensor to another at highway speeds.

Petitioner's theories in ground 2 for claims 15-16 also fail because Petitioner entirely ignores the claim language, which requires both: (i) that the determination of exemplary angular displacements is "*part of* the assessment of the discrete location of the road marker"; and (ii) that it determines multiple "exemplary angular displacements" for each light intensity measurement from a particular reference position. Moreover, adding a laser radar to a camera and a photodiode, as proposed, would only compound the sensor fusion problems.

Petitioner's theory in ground 3 for claim 14 fails for the additional reason that,

as Dr. Thorpe admitted during his deposition, the Petition identifies an angle in Frank that is entirely unrelated to the entrance angle. And even if Petitioner were permitted to point to a different angle in Frank—by law they are not—the other angle is also plainly not an entrance angle.

Finally Petitioner's ground 4 theory is an incomprehensible hodge-podge of prior art references combined for no apparent reason other than hindsight. Most notably, Petitioner's reliance on Popovich is entirely misplaced because Popovich's method for tracking a user's head a short-distance virtual reality system using converging light sources is entirely inapplicable to the problems of the '328 Patent, and is entirely incompatible with Gallagher's vehicle-based system. Moreover, Petitioner misapprehends Popovich's disclosures and combines distinct and incompatible embodiments of Popovich without explanation.

Thus, the Board should confirm the patentability of each remaining challenged claim.

## **II. OVERVIEW OF THE '328 PATENT**

The '328 Patent relates to recognizing road markers, such as road signs or pavement markings, using a video camera. Ex. 1001 ('328 Patent), Abstract; Ex. 2023, ¶¶59-60. Road markers are generally designed to be retroreflective, which allows them to be visible to drivers when lit by a vehicle's headlights at night. Ex. 1001, 1:64-2:15. 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.

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, 2:8-12; Ex. 2023, ¶¶61-62. Thus, it is important for highway maintenance departments to check that the reflective performance of installed road markers has not degraded and that they can continue to be seen by drivers. Ex. 1001, 2:16-27. 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*.

The '328 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. 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, 3:66-4:8. 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.*, 4:13-17, cls. 1, 9.

### 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. 2023 ¶63 (citing Ex. 1005 (Gallagher), Abstract, [0034]). 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 at which the sensors point. *Id.* (citing Ex. 1005, 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. *Id.* (citing Ex. 2027; Ex. 2026, 28:5-7).

In Gallagher, the operator must “initiate[] the measurement process,” which causes the light array and sensors to be turned on. Ex. 2023 ¶64 (citing Ex. 1005, [0046]). 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. *Id.* (citing 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.* (citing Ex. 1005, [0049]-[0053]).

In particular, Gallagher's algorithm uses a series labeled "step a" through "step l." In step (a), the computer collects the sensor data from the analog-to-digital converters (ADC) which are connected to each light sensor. Ex. 2023 ¶65 (citing Ex. 1005, [0056]). In step (b), the sensor values are smoothed by averaging values in a set of sample readings. *Id.* (citing Ex. 1005, [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.* (citing Ex. 1005, [0058]-[0059], [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 center the vehicle (and its sensors) on the path of the pavement markers. *Id.*, (citing Ex. 1005, [0060]-[0061]). That is, the indicator simply identifies, from the current readings, *which sensor is currently* "reading the highest reflectance reading" at any one time. *Id.* Dr. Thorpe does not dispute this. Ex. 2026, 15:9-11. Notably, the indicator means in step (d) of the currently highest-reading sensor does not appear to be 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. 2023 ¶66 (Ex. 1005, [0063]-[0064]). 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 so as to establish a cutoff where anything below the cutoff reflects no marker is present. *Id.* (citing 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.* (citing Ex. 1005, [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. *See also* Ex. 2026, 26:1-27:16.

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 performs any conversion necessary of the detected peak number so that it is in 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. *Id.* (citing Ex. 1005, [0067]). In step (i), that value is compared to the predetermined acceptable reflectance level, and tagged as acceptable or not acceptable. *Id.* (citing Ex. 1005, [0068]). In step (j), the location and reflectance levels of the tagged markers are saved on a storage medium. *Id.*

(citing Ex. 1005, [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.* (citing Ex. 1005, [0070]). The final results are provided in a user understandable graphical or numerical format. *Id.* (citing Ex. 1005, [0071]).

**B. Schofield (Ex. 1006)**

Schofield is directed to vehicle control systems, and, in particular, to controlling the “high-beam state” of a vehicle’s headlights by detecting the headlights or taillights of other vehicles. Ex. 2023, ¶68 (citing Ex. 1006, Abstract, 1:12-32). In particular, Schofield’s system focuses on identifying the unique characteristics of headlights and taillights so that the high-beam setting can be switched off, without having false positives from ambient lighting. *Id.* (citing Ex. 1006, 1:33-62). Such characteristics include the spectral characteristics of the light source (e.g., color or distribution of intensity of various wavelengths along the visible light spectrum) and the “spatial layout” of the light source (i.e., that headlights and taillights typically come in pairs which are spaced apart). *Id.* (citing Ex. 1006, 1:62-67). Schofield uses a solid-state camera (e.g. CCD or CMOS), and can spatially divide the camera image into different regions, so that it can ignore weak intensity headlights or taillights that are far off the axis of the headlights, as those lights reflect vehicles that are further away and thus unlikely to be affected by high-beam state. *Id.* (citing Ex. 1006, 2:36-46, 3:1-3).

In particular, Schofield's camera is mounted near the windshield so as to capture an area of the road ahead of the vehicle comparable to the view of a driver's view out the front windshield. Ex. 2023, ¶69 (Ex. 1006, 3:64-67, 4:8-10, Fig. 11a). It uses an array of 512 x 512 pixels and a filter array for separating light in specific spectral bands. *Id.* (citing Ex. 1006, 4:16-35, Fig. 2). In particular, the spectral characteristics can be isolated by alternating the color of the spectral filter on different frames of the camera. *Id.* (citing Ex. 1006, 5:50-55). The camera's output is sent to a digital signal processor 13, which includes an analog-to-digital converter that converts the camera's pixel values to digital values (i.e. integer numbers). *Id.* (citing Ex. 1006, 4:44-49).

The taillight detection circuit detects red light sources having an intensity about a pre-specified threshold: if a red pixel's red intensity exceeds a pre-specified multiplier above the intensity of adjacent green and blue pixels, it is classified as a red light source. Ex. 2023, ¶70 (Ex. 1006, 4:62-5:1, 6:50-7:4). If that red light source's intensity is above the pre-specified threshold, it is determined to be a tail light and a "tails found" signal is sent. *Id.* (citing Ex. 1006, 5:1-3, Fig. 3). Headlight detection circuit 78 detects white light sources by identifying where adjacent red, green and blue pixels all exceed a particular threshold. *Id.* (citing Ex. 1006, 5:4-11). The circuit then classifies the light source as white light source if those red, green and blue pixels are all close in intensity (e.g. within 20 percent of each other), and a

“heads found” signal is sent. *Id.*; *id.* (citing Ex. 1006, Fig. 3, 7:5-17). Different spectral filters and exposure periods can be used for detecting taillights versus headlights (e.g. using a filter that only passes red light to create red pixels for red light, and using a longer exposure period for the relatively weaker taillights than the stronger headlights). *Id.* (citing Ex. 1006, 5:52-16). The high-beam setting is controlled by how many red taillight pixels or white headlight pixel groups are counted and whether they exceed a specified threshold for a sufficient period of time (to avoid false detections). *Id.* (citing Ex. 1006, 6:57-58, 7:14-57).

Schofield discloses that its invention is “capable of identifying point sources of light.” Ex. 2023, ¶71 (citing Ex. 1006, 9:24-26). However, it can further eliminate some erroneous headlight/taillight detections by limiting detections of the point sources to only certain regions of the camera image. *Id.* (citing Ex. 1006, 9:26-38). That is, it can be configured to ignore off-axis headlights or taillights (i.e., lights not close to where the vehicle’s headlights are pointing) unless they are closer to the vehicle (and thus of greater intensity). *Id.* It discloses that it “detect[s] light sources at a lower threshold centrally of the scene and at a higher threshold at the periphery of the scene,” such as by requiring a higher intensity threshold value for detected white or red pixels located at the image’s periphery. *Id.* (citing Ex. 1006, 9:58-61, 10:6-12). It also discloses that it could use “pattern recognition” in the form of detecting that “headlights and taillights are usually occur in pairs.” *Id.* (citing Ex.

1006, 10:66-11:7). Schofield also mentions generally how its invention could be adapted to detect colored street lights, colored traffic signs, and lane markers, but does not contain any implementation details of how to do so. *Id.* (citing Ex. 1006, 11:58-12:5, 12:40-43).

**C. Frank (Ex. 1007)**

Frank is directed to a laser radar system used in an automatically steered vehicle to “look[] ahead” down the roadway to anticipate changes in roadway geometry (i.e. curves in the road ahead). Ex. 2023, ¶73 (citing Ex. 1007, Title, Abstract, 1:12-29, 2:66-3:3). Frank attempts to overcome the problems of prior art automated highway systems which only sensed areas close to the vehicle and thus had difficulty with rapid changes in roadway geometry. *Id.* (citing Ex. 1007, 2:3-16, 2:55-3:7). Frank accomplished this by using a laser radar system to measure the distance and angle of retroreflective markers placed along the side of a highway. *Id.*, (citing Ex. 1007, 3:8-13, 4:10-50, Figs. 1-2). By modulating the laser and noting differences in phase in the received signal, Franks’ system is able to calculate the transit time for light to travel to the retroreflector and back to a sensor on the same vehicle, and is then able to calculate distance by dividing the travel time by the speed of light. *Id.* (citing Ex. 1007, 7:37-41, 8:37-46, 9:49-10:1). In one of Frank’s embodiments using a single, wide-FOV light sensor, the laser radar system uses a servo-controlled mirror to physically control the direction of a laser beam, and

returns the angle  $\theta$  corresponding to the angle of beam at the time of the reading. *Id.*, (citing Ex. 1007, 7:42-47). In a different one of Frank's embodiments, as opposed to a servo controlled laser, a single "floodlight beam" laser is used instead of the servo-controlled scanning fan beam. *Id.* (citing Ex. 1007, 0:54-11:4). In that embodiment, an array of light sensors is used, and the angle  $\theta$  is calculated by the position of the received light pulse on the array. *Id.* In either embodiment, by identifying distance D and angle  $\theta$  for successive retroreflectors, the system is able to calculate road curvature. *Id.* (citing Ex. 1007, 5:41-65).

**D. Leonard (Ex. 1009)**

Leonard is directed to laser-based object detection systems used in vehicles. Ex. 2023, ¶72 (citing Ex. 1009, Title, Abstract, 1:7-9). In particular, Leonard addresses the problem that such systems typically want to illuminate a wide beam path reflecting the entire field of view of the road ahead, but prior solutions typically resulted in reduced intensity of illumination of objects—particularly distant objects, harming object detection. *Id.* (citing Ex. 1009, 1:19-43). Other prior art systems illuminate a relatively narrower area to detect retroreflectors in a particular space (e.g. Gallagher's area A pointed down at the road to detect pavement markers), but such systems can be harmed by changes in vehicle configuration, weight, etc. causing the scene to deviate from the intended field of view. *Id.* (citing Ex. 1009, 1:44-55). And simply increasing the intensity of a light beam can cause objects close

to the vehicle to become washed out or cause a false object detection by excessively illuminating the background. *Id.* (citing Ex. 1009, 1:55-65).

**E. Popovich (Ex. 1010)**

Popovich is directed to optical-based systems for detecting the position of a human head, especially of a device operator in front of a video display screen, such as for virtual reality game purposes. Ex. 2023, ¶74 (citing Ex. 1010, Title, Abstract, 1). In particular, Popovich attempts to provide a safe, cost-effective, and simplified way for measuring the head position by using optical triangulation. *Id.*, (citing Ex. 1010, 1). Popovich uses two beams (e.g. laser beams or comparable narrow-wavelength beams) designed to converge at somewhat opposing sides of the user's head, on which is mounted a specifically designed retroreflector device (e.g. on special glasses). *Id.* (citing Ex. 1010, 1-3, Figs. 1, 3). The reflections of each beam by the retroreflector are detected by two sets of light detection devices (e.g. depending on the embodiment, cameras or photodiodes). *Id.* By comparing differences in the readings from each light detection device (e.g., location of maximum intensity in a camera's pixel grid) Popovich's system is able to identify the position of the retroreflector, and thus the user's head. *Id.*

**IV. LEVEL OF ORDINARY SKILL IN THE ART**

A POSITA would have at least a bachelor's degree in mechanical engineering, electrical engineering, computer science, physics, or related discipline, and two

years of experience in research, design, or development in computer vision systems.

Ex. 2023 ¶57. However, none of Patent Owner’s arguments would change by adopting Petitioner’s proposal. *Id.*

## V. CLAIM CONSTRUCTION

**A. “configured to detect objects of interest within the field of view and for each object of interest ... determine whether the object of interest includes a reflective surface [and] ... determine whether the reflective surface is a road marker” (’328 Patent, cl. 1, [1E]-[1H])**

/

**“configured to detect objects of interest within the field of view and for each object of interest: determine whether the object of interest includes at least one light intensity value associated with a reflective surface of a road marker in the field of view” (’328 Patent, cl. 9, [9D]-[9F])**

The appropriate construction for each of these limitations requires that the “determin[ing]” steps be performed on “object[s] of interest” which have already been previously “detect[ed]” in the “detect object of interest” step. Additionally, the “detect” and “determine” steps cannot be simultaneously satisfied by the same act being performed on the same particular object of interest.

### **1. Under Federal Circuit Precedent, Patent Owner’s Constructions Are Required by the Logic and Structure of the Claims**

As demonstrated by the use of the antecedent basis “the object of interest” in [1F] and [9E], each of these claims recites that “determin[ing]” is performed on “object[s] of interest” which have already been “detect[ed].” This would immediately convey to a POSITA that the claims require a computer configured to

perform separate steps in a particular sequence. Ex. 2023, ¶¶75-80. Indeed, it is well understood in the field that object detection (i.e. “detect objects of interest”) is distinct from object recognition (i.e. “determine” whether something is “a road marker”). *Id.* ¶81.

Moreover, it is well-established that, as a matter of claim construction law, a claim should be interpreted to require an order where a subsequent step has a reference that logically indicates that a prior step had been performed. *See Mantech Env’t Corp. v. Hudson Env’t Servs., Inc.*, 152 F.3d 1368, 1375-76 (Fed.Cir.1998) (“Step (b) introduces acetic acid, via the wells provided in step (a) .... [h]ence, in order to accomplish step (b), the wells of step (a) must already have been provided.”); *E-Pass Tech., Inc. v. 3COM Corp.*, 473 F.3d 1213, 1222 (Fed. Cir. 2007) (“transferring a data set” must occur before “storing said transferred data set”); *Kaneka Corp. v. Xiamen Kingdomway Grp. Co.*, 790 F.3d 1298, 1306 (Fed. Cir. 2015) (“the oxidation step in claims 22 and 33 refers to the product of the previous step, and, therefore, at least some action resulting in oxidation must be applied to the product of the disruption step in claim 22”). Because “detect objects of interest ... and for each object of interest” provides the antecedent basis for the “object of interest” recitation upon which “determine whether *the object of interest* includes ... a reflective surface” is performed, this evidences the logical relationship between detection and determination requiring separate steps occurring in sequence.

Additionally, another bedrock claim construction principle is that “[w]here a claim lists elements separately, ‘the clear implication of the claim language’ is that those elements are ‘distinct component[s]’ of the patented invention.” *Becton, Dickinson & Co. v. Tyco Healthcare Grp., LP*, 616 F.3d 1249, 1255 (Fed. Cir. 2010). And, a claim is not satisfied when it “requires two separate structures and one such structure is missing.” *Regeneron Pharms., Inc. v. Mylan Pharms. Inc.*, 130 F.4th 1372, 1377 (Fed. Cir. 2025). Thus, because claims 1 and 9 separately recite “detect” and “determine,” elements, they require a computer system configured to perform different steps (and cannot be read on the same single step in the prior art).

A couple of cases are particularly instructive as to why Petitioner’s claim construction arguments are legally erroneous. In *Mformation Techs., Inc. v. Rsch. in Motion Ltd.*, the Federal Circuit held that a claim required a particular order of steps because “before the server can ‘transmit’ the command, it must first ‘establish a connection.’” 764 F.3d 1392, 1399 (Fed. Cir. 2014). The patentee had argued that a later step could be performed while the prior step was “is in progress,” i.e. concurrently. *Id.* The Federal Circuit rejected the argument, noting that doing so would ignore that the claim specifically recited separate steps in the claim, and would thus effectively render some of the language superfluous. *Id.* Likewise, Petitioner’s argument would effectively render “detect” superfluous to “determine” if the “detection” can be the same thing happening at the same time as the

“determine” step.

Similarly, in *Amgen Inc. v. Sandoz Inc.*, the Federal Circuit rejected an argument that two steps could be performed concurrently via the same single step in the accused instrumentality. 923 F.3d 1023, 1028–29 (Fed. Cir. 2019). It held that “the washing and eluting steps ... require discrete solutions” because they were recited as separate claim limitations and because the claim required a particular order due to later steps using the results of earlier steps. *Id.* Notably, the Federal Circuit concluded that separately recited steps could not be satisfied by a “process [which] only uses one step and one solution.” *Id.* Likewise, Petitioner’s argument improperly allows reading two claim steps on the same single step in the prior art.

Moreover, there is no reason to disregard the claim’s logical order simply because the claims are an apparatus or system claim. The configuration of a computer to perform a particular algorithm is a structural limitation. *WMS Gaming, Inc. v. International Game Technology*, 184 F. 3d 1339, 1348 (Fed. Cir. 1999); *see also In re Bernhart*, 417 F.2d 1395, 1399- 1400 (CCPA 1969). Even if these limitations were functional, functional limitations are required parts of a claim, no differently than other limitations. *In re Swinehart*, 439 F.2d 210, 212 (CCPA 1971); *In re Schreiber*, 128 F. 3d 1473, 1478 (Fed. Cir. 1997); *INVT SPE LLC v. Int’l Trade Comm’n*, 46 F.4th 1361, 1365 (Fed. Cir. 2022). Indeed, the Federal Circuit has applied the doctrine that a claim require an order where logically required to system

claims. *See, e.g., Function Media, LLC v. Google, Inc.*, 708 F.3d 1310, 1320 (Fed.Cir.2013) (“a claim that recites “processing” an “electronic advertisement” necessarily indicates that “the creation of the ad must happen before the processing begins”).

In summary, Petitioner presents the same argument that has been repeatedly rejected in a long line of Federal Circuit cases, most recently *Mformation* and *Amgen*. It argues that the “detect” step and all the “determine” steps can be the *same* single step in *Gallagher*, all performed at the same time. But that is simply a request that the Board improperly rewrite the claims to ignore what they clearly recite: separate steps that occur in a particular order. Because Petitioner’s construction improperly disregards the patentee’s intentional choice to recite a logical order of separate steps, it must be rejected as legally erroneous.

## **2. *Cybersettle* Does Not Support Petitioner’s Construction**

The Board’s institution decision accepted Petitioner’s argument that the non-precedential *Cybersettle* decision holds that steps can be performed concurrently regardless of the logical order of claim language. Paper 14, 28-29 (citing Paper 1, 2). However, that is simply a misinterpretation of *Cybersettle*. In *Cybersettle*, the claims recited a method for settling a claim “in rounds” that required “testing a pair of non-equal values in one of at least two rounds.” *Nat’l Arbitration Forum, Inc.*, 243 F. App’x 603, 605 (Fed. Cir. 2007). The court rejected defendant’s

interpretation that required that *all* demand and offer bids be received before any comparison of any bids could commence. *Id.*, 609. But it did affirm that, for each bid, “the comparison and testing steps logically cannot begin until an offer and a demand are received.” *Id.* Thus, Patent Owner is not requesting a construction inconsistent with *Cybersettle*, i.e. Patent Owner is not asking that the claim be construed to require *all* objects of interest be detected before the first determination take place. Rather, consistent with *Cybersettle*, Patent Owner requests that the logical order of the claim—that a particular object must be detected before the determine steps be performed *on that object*—be respected.

Indeed, other Courts have rejected arguments based on *Cybersettle* similar to Petitioner’s. *See, e.g., Collarity, Inc. v. Google Inc.*, No. CA 11-1103-MPT, 2013 WL 1897830, \*7–9, n.60 (D. Del. May 6, 2013). Moreover, after *Cybersettle*, the Federal Circuit has continued to find that when the logic of the claim requires a particular order, the steps must be performed in that order. *See, e.g., Function Media, LLC v. Google, Inc.*, 708 F.3d 1310, 1320 (Fed.Cir.2013) (a claim that recites “processing” an “electronic advertisement” necessarily indicates that “the creation of the ad must happen before the processing begins”); *TALtech Ltd. v. Esquel Apparel, Inc.*, 279 F. App’x 974, 978 (Fed. Cir. 2008); *Telit Cinterion Deutschland GmbH v. 3G Licensing, S.A.*, No. 2023-1497, 2025 WL 401647, \*3 (Fed. Cir. Feb. 3, 2025) (“Board erred by not requiring that the steps be performed in order” as the

“antecedent basis” relationship of the claims “require at least message A to precede messages C and D”).

### 3. The Specification Supports Patent Owner’s Constructions

The specification also supports Patent Owner’s construction. In particular, it recites that:

A computer processor 450 **identifies an object of interest 460** in a portion of the intensity frame 420 ... the objects of interest are identified **from the digital imagery stream 390 generated by the color image capture system 250** in the manner as taught by U.S. Pat. No. 6,266,442. ...

**For each object of interest 460, a background intensity measurement 470 and a foreground intensity measurement 480 is generated.** 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.** Based on the background luminance value 500, the foreground luminance value 510, a characterization of light source wavelength 540, the background sheeting color 505 and the foreground sheeting color 506 the computer processor 450 **characterizes a background  $R_A$  520 and a foreground  $R_A$  530** which are preferably reported separately **for that object of interest.**

Ex. 1001 (’328 Patent), 8:31-56 (emphasis added).

These passages—which closely correspond to the language of the claims—

make clear that identification / detection of objects of interest is distinct from the determination of reflectivity. Indeed, it cites to the '442 Patent—which recites image-based computer vision techniques for object *detection*—to identify the object of interest. Ex. 2030, 5:10-26; Ex. 2023 ¶82. Other portions of the '328 Patent similarly make clear that object detection uses the image capture system, and occurs prior to the determinations of reflectivity, which use the intensity measurement system. Ex. 2023 ¶¶83-84 (citing Ex. 1001, 7:67-8:6, 8:44-56, 9:7-11, 9:16-18, 10:56-11:1, 16:31-67).

In its preliminary reply, Petitioner argued that these limitations should be interpreted to permit “performing the determining step *concurrently* with the respective detecting steps of each claim.” Paper 7, 2. In particular, it argued that the “concurrent with or subsequent to” language of column 5 supports its construction, and that Patent Owner’s interpretation would improperly read out that embodiment. Paper 7, 3 (citing Ex. 1001, 5:41-45, 5:52-57). However, as Dr. Papanikolopoulos explains, Petitioner is misinterpreting these passages. Ex. 2023 ¶¶85-86. Indeed, the passages do not even mention “detection” or “determination.” Instead, they simply state that the identification of *colors* of a road sign can occur simultaneously with identification of the same road signs as objects of interest. Ex. 1001, 5:41-57. But that is not surprising—the preferred embodiment uses a “**color** image capture system 250” for object detection, as well as a separate **black**

**and white** “light intensity sensor 280” for determining whether an object has a reflective surface. Ex. 2023 ¶86 (citing ’328 Patent, 7:65-8:18, 8:35-56, 10:28-43; Figs. 3-4).

Thus, determining a set of color values” “concurrent with or subsequent with the identification of road signs” makes sense—color identification has to use the color camera, so you can readily do that at the same time as object detection (which uses the same color camera in the preferred embodiment). However, the determination of reflective surfaces is not a part of either color identification or object detection/identification—the preferred embodiment uses imagery obtained from the separate intensity sensors (e.g., black and white camera). ’328 Patent, 4:8-17, 8:44-56, 10:28-34; Ex. 2023 ¶86. Although later in column 5, there is a discussion of calculation of retroreflectivity values, nothing in the passage indicates that the calculation of retroreflectivity values is occurring during object detection. Ex. 2023 ¶87 (citing ’328 Patent, 5:57-60). Thus nothing in the specification suggests that the claimed “detect” and “determine” steps can happen concurrently.

**VI. PETITIONER HAS FAILED TO DEMONSTRATE THAT ANY REMAINING CHALLENGED CLAIM IS UNPATENTABLE**

**A. Ground 1: The Combination of Gallagher and Schofield Fails to Render Obvious Any Remaining Challenged Claims**

**1. Claim 9**

**(a) [9D]&[9E]: The References Fail to Disclose or Suggest the Claimed Two-Step Approach Where “Determin[ing]” is Performed on Already “Detect[ed]” “Objects of Interest”**

As discussed, the proper construction of these limitations provides: (i) the “determin[ing]” steps are performed on “object[s] of interest” which have already been previously “detect[ed]” in the “detect object of interest” step, and (ii) the “detect” and “determine” steps cannot be simultaneously satisfied by the same act being performed on the same particular object of interest. *Supra* V.A. The Petition fails to cite to any disclosure in the cited references that disclose or suggest limitations [9D] & [9E] as properly construed. Ex. 2023, ¶¶99-100.

In particular, Gallagher discloses an algorithm “for determining the integrity of particular road markings on a road being tested and storing and /or displaying the results.” Ex. 1005, [0054]. These steps are labeled steps (a)-(l). Ex. 1005, [0052]-[0071]. However, the Petition relies on steps (a)-(g). Pet., 21-23 (citing Ex. 1005, [0055]-[0056], [0060]-[0066]).

Gallagher’s “step a” is a data collection step. Ex. 1005, [0056] (“getting the data from the output of the ADC 13 on the reflected light detected by the light

sensors 6”). Thus, “step a” performs neither “detect[ing]” of objects of interest nor a “determin[ing]” performed on already detected objects of interest. Ex. 2023, ¶101; Ex. 2026, 85:3-86:6.

Gallagher’s “step b” is a data “filtering” step to “smooth out fluctuations” in the collected data caused by noise. Ex. 1005, [0057]. Thus, “step b” performs neither “detect[ing]” of objects of interest nor a “determin[ing]” performed on already detected objects of interest. Ex. 2023, ¶101; Ex. 2026, 85:3-86:6.

Gallagher’s “step c” is a data “calibrat[ion]” step to “to calibrate for different positions in the light sensor module 6 a.” Ex. 1005, [0058]-[0059]. Thus, “step c” performs neither “detect[ing]” of objects of interest nor a “determin[ing]” performed on already detected objects of interest. Ex. 2023, ¶101; Ex. 2026, 85:3-86:6.

Gallagher’s “step e” merely records the vehicle position from the vehicle gearbox revolution sensor. Ex. 1005, [0063]. Thus, “step e” performs neither “detect[ing]” of objects of interest nor a “determin[ing]” performed on already detected objects of interest. Ex. 2023, ¶101.

Gallagher’s “step f” “determin[es] the background reflectance level on the road and establishing non-marker reflectance levels.” This does not satisfy the limitations because “non-marker[s]” which are not “object[s] of interest”—the objects of interest in Gallagher are road markers. *See, e.g.*, Ex. 1005, Abstract, [0001]-[0002], [0033], [0064]. Thus, “step f” performs neither “detect[ing]” of

objects of interest nor a “determin[ing]” performed on already detected objects of interest. Ex. 2023, ¶101.

The remaining steps identified by Petitioner are Gallagher’s step (d) and step (g). Step (d) cannot satisfy these limitations for several reasons. Ex. 2023 ¶102. Gallagher’s “step d” provides an indicator to the vehicle operator to “enable[] the operator to maintain the vehicle 3 in a proper position on the road” for obtaining measurements. Ex. 1005, [0060]. This is not done by analyzing any recorded data, but merely by informing the driver “which light sensor 6 is [currently] reading the highest reflectance reading” at any point in time so that the driver can align the central sensor to capture the highest readings. Ex. 2023 ¶102 (citing Ex. 1005, [0060]-[0062]). Rather than detecting any objects of interest from the collected data, this is a continuous indicator provided to the driver derived from the raw output of the sensor with the current highest intensity reading to a visual indicator to the operator. *Id.*

Thus, no objects are “detect[ed]” in Gallagher’s step (d). Ex. 2023 ¶102. Indeed, since the indicator only indicates which photodiode currently has the highest reading, an indicator for one of the sensors would always be active, even on roadway with no reflectors. *Id.* Moreover, step (d) cannot satisfy, alone or in combination with the other steps, [9D] & [9E]’s requirement that an object of interest be detected and then a determination be performed on that object of interest. *Id.* That is because

the output of step (d)—the indicator—is never used again. *Id.* There is no disclosure or suggestion that the operator indicator in “step d” (or any information relating to the indicator) is provided to any of the later steps. *Id.* In particular, step (g) uses the data collected back in step (a) (and processed in steps (b) and (c)). *Id.* (citing Ex. 1005, [0066]). Thus, step (d) cannot “detect objects of interest” such that a later determination is performed “for each [such] object of interest,” as claimed.

That leaves Gallagher’s “step g, which recites “selecting, from data obtained in step a., which reflectance levels indicate a road marker.” Ex. 1005, [0066]. This is performed by recognizing that “the peak responses sensed are determined as the highly reflective surfaces of a road marker.” Ex. 1005, [0067]. That is, rather than the claimed “detect[ing]” of objects of interest and subsequent “determin[ing]” performed on already detected objects of interest, Gallagher’s “step g” reflects a single step approach. Ex. 2023, ¶103. Road markers are identified as being road markers from the light sensor data based simply on the presence of peak responses in the collected light sensor data, without any prior detection of objects of interest. *Id.* Indeed, the Petition itself admits that Gallagher merely “identif[ies] road markers based on ‘peak responses sensed’ by light sensors.” Pet., 14. Thus, step (g) cannot perform “*detect[ing]* objects of interest within the field of view” *and* “for each object of interest: determin[ing] whether the object of interest includes at least one light intensity value associated with a reflective surface” as required by [9D] and [9E] as

properly construed.

The other cited disclosures of Gallagher similarly fail to demonstrate a computer system recited in claim 9 of the '328 Patent. For example, the Petition's analysis of limitations 9D and 9E also cites to Gallagher's paragraphs [0023], [0033], [0045], and [0047]. Pet., 20-23. But those paragraphs are consistent with Gallagher merely performing a single-step identification of road markers based on peak responses in the collected light sensor data. Paragraph [0023] recites "determining the location of any missing road markers by recognizing patterns in existing road marker locations and with being provided with information on the spacing of known valid road markers." Ex. 1005, [0023]. That plainly occurs *after* Gallagher's determination as to where there are road markers (otherwise it would not know that road markers are *missing*). Paragraph [0033] merely notes that Gallagher can test "a wide variety" of road markers, signs, painted lines, etc. *Id.*, [0033]; Ex. 2023 ¶100. Paragraph [0045] merely notes that Gallagher uses a computer program to carry out testing of the integrity of road markings. Ex 1005, [0045]; Ex. 2023 ¶100. Finally, paragraph [0047] merely describes analogue to digital converter (ADC 13) and notes that its output is received by Gallagher's computer. Ex. 1005, [0047]; Ex. 2023 ¶100.

Thus, none of the cited portions of Gallagher demonstrate that the prior art discloses or suggests limitations [9D] or [9E].

**(b) [9F]: The Cited Disclosures Fail to Disclose or Suggest  
*Analyzing a Light Intensity Value to Determine an  
Assessment of a Discrete Location of the Road Marker  
Within the Field of View***

Petitioner has two alternative theories for this limitation. The first argues that Schofield discloses that its sensors “divide the scene forward of the vehicle into spatially separated regions, and light sources are identified, at least in part, according to their spatial distribution across the regions.” Pet, 23; Ex. 2023, ¶76 (citing Ex. 1006, 2:36-41, 9:26-32). As discussed, Schofield’s spatially separated regions are used to eliminate some erroneous headlight/taillight detections by limiting detections of the point sources to only certain regions of the camera image. Ex. 1006, 9:26-38; Ex. 2023, ¶¶70-71, 105. In particular, it “detect[s] light sources at a lower threshold centrally of the scene and at a higher threshold at the periphery of the scene,” such as by requiring a higher intensity threshold value for detected white or red pixels located at the image’s periphery. Ex. 1006, 9:58-61, 10:6-12; *see also* Ex. 2026, 56:4-8. Alternatively, a different pixel density can be used in different regions. *Id.* Or, as Dr. Thorpe describes it, “If you're not worried about things which are next to you but you're more worried about things straight in front of you, then you can have a lower resolution in your periphery than you have in your central field of view.” Ex. 2026, 55:22-56:1. But this has nothing to do with what this limitation requires: using light intensity value to assess the location of a road marker in the

field of view. Schofield discloses that you may have a lower resolution in your periphery and greater resolution in the center. This has to do with the process and not with what the claim limitation is. Ex. 2023, ¶106.

Petitioner's second, alternative theory is that Gallagher discloses this limitation by disclosing "determin[ing] the location of each road marking" using either the vehicle's "gearbox revolution sensor 14" or a "GPS interface 15" "as measurements are being taken." Pet., 25-26. But these disclosures only give the location of *the vehicle* at the time the road marker is detected. Ex. 2023 ¶107 (citing Ex. 1005, [0020], [0048], [0063]). That cannot be the same as the location of a road marker in Gallagher's field of view, as Gallagher's field of view is 2.3 meters ahead of the vehicle. *Id.* (citing Ex. 1005, [0035])). Indeed, in Ground 4, Petitioner admits that Gallagher's "GPS position of the vehicle corresponds to the location of the active sensor" and accordingly, a POSITA "would have recognized that additional steps would have been necessary to also determine the location of the markers." Pet., 70. Moreover, Gallagher contains no disclosure of using its photodiodes to identify where a road marker is within its field of view, but simply records the peak among the various photodiodes. Ex. 2023 ¶108 (citing Ex. 105, [009], [0035], [0038], [0079], Fig. 5). Indeed, Gallagher's GPS and light intensity data are simply two sets of data that are recorded together—Gallagher's light intensity data is not used to determine the location of a road marker within a field of view. *Id.*

**2. Claim 1**

**(a) [1E], [1F], [1G]: The References Fail to Disclose or Suggest the Claimed Multi-Step Approach Where “Determin[ing]” is Performed on Already “Detect[ed]” “Objects of Interest”**

Petitioner’s arguments for claim 1, [1E], [1F], and [1G] fail for the same reasons discussed above in claim 9, limitations [9D] and [9E]. *Supra* VI.A.1.a. Petitioner relies solely on Gallagher for limitation 1F and 1G. Pet., 39-41. Moreover, although the Petition cites Schofield in [1E], it relies on Schofield solely for the additional limitation recited in limitation [1E] (but not limitation 9D) that the computer processing system is operably connected to the “image capture sensor.” Pet., 39.

Just as for [9D] and [9E], Petitioner fails to cite to any disclosure in Gallagher of the computer system “*detect*[ing] objects of interest within the field of view” *and* performing the claimed determination “for each object of interest”. Indeed, like its analysis of limitation 9E in claim 9, Petitioner’s analysis of limitations 1F relies on the listing of steps (a)-(g) illustrated in Gallagher Fig. 4. Pet., 38-41 (citing Ex. 1005, [0055]-[0056], [0060]-[0066]). As discussed above in connection with claim 9, [9D] and [9E] Gallagher uses a single step approach which is inconsistent with the appropriate construction of these claims. *Supra*, VI.A.1.a; Ex. 2023, ¶112. Thus, none of Gallagher’s enumerated steps, or other cited disclosures, disclose or suggest performing a step of “*determin*[ing]” the presence of a reflective surface on already

detected objects of interest. *Id.*

Petitioner does conclusory assert, in connection with limitation [1E], that a POSITA would be motivated to use “Schofield’s imaging sensor module to further improve the detection of objects of interest.” Pet., 39. However, neither Petitioner nor its expert presents any evidence or argument that Schofield discloses, suggests, or would motivate determining the presence of a reflective surface on an already detected object of interest. *Id.*; Ex. 2023, ¶113. And they do not explain how the algorithm of the combined system works or is different from Gallagher’s algorithm other than to argue that it would be obvious to use Schofield’s camera and pattern recognition. Pet. at 38-39. Indeed, in addressing limitation [1F], Petitioner argues that this limitation is satisfied by Gallagher alone, and in particular, Gallagher’s disclosure of “selecting, from data obtained ..., which reflectance levels indicate” a reflective surface of a marker. Pet., 40.

Moreover, even if Petitioner were permitted to articulate a theory for [1E] based on Schofield disclosing or suggesting the claimed multi-step sequence, that theory would still fail. In particular, although Petitioner cites to Schofield’s “pattern recognition,” Schofield does not use “pattern recognition” to *detect* objects of interest or to make a determination as to a reflective surface. Ex. 2023, ¶114; Ex. 1006, 10:66-11:12. Indeed, Schofield does not mention measuring reflectivity nor attempt to identify a reflective nature among various light sources. Rather, Schofield

discloses using pattern recognition as part of spatial filtering to exclude potential point sources of light from being detected as taillights or headlights. Ex. 2023, ¶114 (citing Ex. 1006, 10:35-11:12). That is because Schofield performs a pixel-by-pixel analysis to identify the point sources of light, and identifying the pattern characteristics (e.g. shape, spectral characteristics) necessarily comes after identifying the pixels that correspond to that object. *Id.* (citing Ex. 1006, 4:62-5:11, 6:28-7:44). In short, Schofield discloses identifying point sources of light via a pixel-by-pixel analysis of intensity data, and then performing pattern recognition to exclude unwanted objects. That is entirely unrelated to the claim’s requirement to detect objects of interest, and then perform a determination as to the reflectivity of those objects.

As to [1G], as properly construed, this requires determining the presence of a reflective surface (i.e. limitation [1F]) prior to a separate step of determining whether it is a road marker (i.e. limitation 1[G]). Ex. 2023, ¶115. Petitioner and Dr. Thorpe rely solely on Gallagher’s step (g) (paragraph [0066]) in their analysis of limitation 1[G]. Pet. at 40-41; Ex. 1003 ¶ 115. However, that is the same disclosure in Gallagher of identifying road markers based on “peak” responses in intensity data that Petitioner relies on for limitation [1F] and [1E]. As discussed, reading the same single step in Gallagher on all the “detect” and both “determine” limitations—as petitioner proposes—is improper under the correct construction of these terms.

**(b) [1H]: The Cited Disclosures Fail to Disclose or Suggest  
“determine a location of the road marker”**

Petitioner’s theory for this limitation is essentially the same as its alternative “Gallagher” theory for limitation [9F]. *Compare* Pet., 23 *with* Pet., 41. That theory fails for the same reasons discussed above in connection with limitation [9F]. *Supra*, VI.A.2.b; Ex. 2023 ¶¶107-108, 116. In particular, as Petitioner admits in ground 4, Gallagher’s “GPS position of the vehicle corresponds to the location of the active sensor” and “[a]ccordingly, a POSITA would have recognized that additional steps would have been necessary to also determine the location of the markers.” Pet., 70; Ex. 1003 ¶176. Because Gallagher’s GPS and gearbox data only provides the location of the vehicle—rather than the road marker that is at least 2.3m ahead of the vehicle—it does not “determine a location of the road marker.” Ex. 2023 ¶116. And Petitioner presents no motivation to modify Gallagher to do so.

**3. Petitioner Has Failed to Demonstrate that a POSITA Would Be Motivated to Combine Gallagher and Schofield in the Manner Claimed**

As to claim 9, Petitioner proposes to combine Schofield’s purported determination of a light source’s location within a field of view with Gallagher’s apparatus in the manner recited by limitation [9F]. Pet., 23. Schofield’s technique uses a camera. Ex. 1006, Fig. 9, 9:5-11. As to claim 1, Petitioner proposes to combine Schofield’s camera with Gallagher’s apparatus to purportedly improve object detection or recognition. Pet., 36. As to either claim, Petitioner is proposing

to combine Schofield's camera-based approach with Gallagher to improve object detection or recognition. Pet., 24, 36; Ex. 2023, ¶¶91.

But, the Petition and Dr. Thorpe's declaration contain no details explaining *how* they would propose to integrate such disparate structures and functionalities. Nor is there one, straightforward way to do so. Indeed, as Dr. Thorpe himself repeatedly testified at his deposition, there are many potential ways of combining Gallagher and Schofield. Ex. 2026, 105:2-7, 106:22-25, 107:12-21, 110:13-14, 111:4-5 ("I'm saying there's multiple ways to combine them"). This uncertainty as to the proposed manner of combination improperly deprives Patent Owner of a reasonable opportunity to actually address the proposed manner of combination, and requires that the Board reject all of the grounds for Petitioner's failure to set forth a *prima facie* case of obviousness. *Personal Web Techs., LLC v. Apple, Inc.*, 848 F. 3d 987, 994 (Fed. Cir. 2017) (a *prima facie* case of obviousness must disclose the "contemplated workings of the [proposed] combination."); *Concepts, Inc. v. Smith & Nephew, Inc.*, 688 F. 3d 1342, 1368 (Fed. Cir. 2012); Ex. 2023, ¶¶92-93.

Moreover, the few details that the Petition does provide as to the proposed combination demonstrates that a POSITA would consider it unworkable as of the 2001 priority date of the '328 Patent. In particular, the combination of Gallagher's photodiode peak-sensing approach with Schofield's camera-based techniques would require "sensor fusion." Ex. 2023, ¶¶93. Sensor fusion is especially difficult here

because the sensors provide very different type of information. *Id.*, ¶94. Moreover, the two systems' sensors have different fields of view (FOV). Gallagher's sensors are pointed at the ground 2.3m in front of the vehicle, while Schofield's sensors are pointed out the windshield (i.e. like a vehicle's driver would see). *Id.* Thus, any combination would require tracking and correlating detected objects between two different FOVs (i.e. as an object passes from Schofield's windshield FOV to Gallagher's ground FOV). *Id.*, ¶97. But, each of Gallagher's photodiodes responds to light in a relatively large portion of the road—the 3 meter wide area is divided by five or ten sensors. *Id.* (citing Ex. 1005, [0035], [0038]). Thus, it would be difficult to confidently identify which particular light intensity reading in Gallagher at any point in time corresponds to a point light source previously detected by Schofield, particularly while travelling at highway speeds. At the very least, given the constantly moving vehicle's effect on the relative positioning of objects outside the vehicle, that would also require detailed speed and location information beyond what Gallagher or Schofield disclose. *Id.*, ¶97. Nor does Petitioner or Dr. Thorpe provide any motivation to make those modifications, or provide any explanation why any POSITA might think that the purported improvements to object detection would outweigh the cost and difficulty of those modifications. *Id.*

Moreover, both Gallagher and Schofield operate at highway speeds, which makes the processing requirements of sensor fusion even more difficult. Ex. 2023

¶95. As Dr. Papanikolopoulos opines, as of 2001, sensor fusion of Schofield’s vision based system (pointed out the windshield), with Gallagher’s system of photodiodes (pointed down at the road way) would have not had a reasonable expectation of success at the highway speeds using the hardware available or foreseeable at the time. *Id.* Indeed, as Dr. Thorpe himself said in a publication in 2001 “working outdoors, and at high speeds, and in close proximity to people, perception is still incomplete.” Ex. 2031, 1, 6. And sensor fusion had not yet reached success in solving those problems, as successful object detection in the vehicular space in 2001 was still in experimental development, and thus perception still had significant difficulties outside “clean” environment unless the “vehicles move slowly.” *Id.*, 1, 6.

But, Schofield and Gallagher are directed to operation on actual roadways—not a clean environment. Ex. 2023, ¶96. And modifying them to move slowly would violate the essential goals of those references. *Id.* (Ex. 1005, Abstract, [0032]; Ex. 1006, Title, Abstract, 1:14-32). Indeed, even today, over 20 years later, consistently reliable object detection and recognition at highway speeds using camera-based systems continues to be elusive. Ex. 2032. Thus, there is no motivation for the proposed combination, nor would such a combination be predictable or have a reasonable expectation of success. Ex. 2023, ¶98.

**4. Claims 2-4, 8, 10-13**

Claims 2-4 and 8 depend from claim 1, and claims 10-13 depend from claim 9. Petitioner's arguments in Ground 1 for alleged obviousness of these claims are based on Petitioner's obviousness arguments for Ground 1, claims 1 and 9, which fail as discussed above. Pet., 26-27, 41-42; *supra*, VI.A.1-VI.A.3. Thus, Petitioner has not demonstrated that any of claims 2-4, 8, or 10-13 are obvious. Ex. 2023 ¶¶110, 117.

**B. Ground 2: The Combination of Gallagher, Schofield, and Frank Fails to Render Obvious Any Remaining Challenged Claims**

**1. Petitioner's Arguments for Claims 15-16 in Ground 2 Fail for at Least the Same Reasons as to Claim 9 in Ground 1**

Claims 15-16 depend from claim 9. Ex. 1001, cls. 15-16. Petitioner's arguments in Ground 2 for alleged obviousness of claims 15-16 are based on Petitioner's arguments that Gallagher and Schofield render obvious claim 9, which fail as discussed above. Pet., 47, 51. Petitioner offers no argument or evidence that Frank cures any of the deficiencies of Ground 1. Thus, Petitioner's obviousness arguments in Ground 2 for claims 15-16 fail for the same reasons discussed above for claim 9 in Ground 1. *Supra* VI.A.1, VI.A.3; Ex. 2023 ¶119.

**2. Claim 15: The Cited Disclosures Fail to Disclose or Suggest Determining Exemplary Angular Displacements “as part of the assessment of the discrete location of the road marker within the field of view”**

Limitation [9F] recites, “analyze the at least one light intensity value to

determine an assessment of a discrete location of the road marker within the field of view.” As discussed, Petitioner presents alternative theories based on Schofield’s spatially separated regions or Gallagher’s GPS for [9F]. Pet., 23-26. Claim 15 depends from claim 9 and further requires, “determine exemplary angular displacements of incident light for each light intensity measurement from a reference position relative to the field of view as part of” the assessment of [9F]. However, Petitioner’s theories for claim 15 appear to wholly ignore the claim requirement that they be “part of” the assessment of [9F]. Ex. 2023 ¶¶125-126.

In particular, the theories do not mention Schofield’s spatially separated regions, and they only mention Schofield once in Ground 2 to suggest that Frank could be implemented using Schofield’s camera to receive Frank’s reflected laser. Pet., 51. Thus, Petitioner has articulated no reason how or why a POSITA would have combined Frank’s determination of a distance (or the calculation of an observation angle using that distance) as part of Schofield’s headlight/taillight recognition or division of the scene “into spatially separated regions.” Ex. 2023 ¶127; Ex. 2026, 128:10-22 (“it’s not bringing Schofield into the main analysis of claim 15”). And as Dr. Papanikolopoulos opines, there is no reason to incorporate Frank’s distance and angle measurements with the pixel-by-pixel analysis of Schofield’s headlight/taillight recognition and separation of the scene into spatially separated regions—the distance and angle information simply do not help that pixel

analysis. Ex. 2023 ¶127.

As to Petitioner’s alternative theory for [9F]—based on Gallagher’s GPS or gearbox data—Petitioner also presents no explanation for how Frank’s measurements could be used with Gallagher’s GPS to determine the location of a road marker within the field of view, or why a POSITA would be motivated to do so. Pet., 25-26. Indeed, as discussed, Gallagher’s GPS or gearbox data is not even in the field of view (*Supra*, VI.A.1.b, VI.A.2.b), and Petitioner presents no motivation to modify Gallagher to provide location data for items in the field of view. Ex. 2023 ¶128. Moreover, Petitioner’s obviousness theory for Ground 2—using Frank to ensure that Gallagher’s intensity measurements are made at the appropriate observation angle—only requires determining the relative distance between the marker and Gallagher’s vehicle. Ex. 2023 ¶125. It does require determining the location of the marker in the field of view. *Id.*

**3. Claim 15: The proposed combination does not, for a particular road marker, “determine” multiple “exemplary angular displacements” “for each light intensity measurement from a reference location”**

Petitioner also ignores that claim 15 requires determining multiple “exemplary angular displacements<sub>2</sub>”—plural—“*for each* light intensity measurement *from a reference location*” as part of the determination of the discrete location of one road marker in the field of view. Ex. 2023, ¶129. This is consistent with the

specification of the '328 Patent, which describes that the entrance angle (Fig. 12, item 160)—the angular displacement of the incident light relative to the normal vector from the sign's surface—affects retroreflectivity measurements. *Id.* (citing Ex. 1001, 5:19-23, 7:43-64, Fig. 12). Thus, by determining a sign's normal vector (i.e. what angle a sign is pointed at with respect to the roadway), one can determine the entrance angle, and thereby reliably extrapolate the retroreflectance values for various points along the roadway. *Id.*; Ex. 1001, 5:1-11, 7:55-61, 15:29-46, Figs. 9-10. By using a laser scanner “fast enough ... to capture at least several individual discrete measurements across the object's face surface,” the laser scanner produces many discrete locations on the road marker's surface which, combined with the vehicle's location and heading vector, can be used to determine the road marker's normal vector. Ex. 2023, ¶130 (citing Ex. 1001, 14:22-25, 14:32-51, 15:9-28).

However, the Frank reference contains no analogous disclosure of using a sufficiently fast laser radar system to take multiple angular displacement measurements for a single road marker from a single reference location—it does not even disclose if its laser radar is fast enough to do so. Ex. 2023 ¶130. And Petitioner does not articulate any method of combining, or reason to combine, the references so as to determine multiple exemplary angular displacements for a single light intensity measurement at a single reference location, as claimed. *Id.* Instead, they expressly articulate a proposed combination using *one* distance measurement from

Frank's laser radar system per each of Gallagher's intensity measurements to identify the specific intensity measurement that is taken at a distance corresponding to the specified 0.2 degree observation angle. Ex. 2023 ¶130 (citing Pet., 50; Ex. 1003 ¶¶135-136). Thus, the proposed combination does not satisfy this aspect of claim 15.

**4. Petitioner Has Failed to Demonstrate that a POSITA Would Be Motivated to Combine Gallagher, Schofield, and Frank in the Manner Claimed**

As discussed in Ground 1, a POSITA would not be motivated to combine Schofield's camera-based approach (looking out the windshield) with Gallagher's photodiodes (which look down at the road), especially due to the limitations of sensor fusion at the time. *Supra* VI.A.3. The proposed combination with Frank—adding Frank's laser radar to Schofield's camera and Gallagher's photodiode—would only exacerbate these problems. Ex. 2023, ¶¶120-121. However, again, Petitioner and Dr. Thorpe present no details regarding *how* the proposed combination actually works, and thus fail to demonstrate *prima facie* obviousness. Pet., 47; *supra* VI.A.3.

Moreover, Frank's laser radar is fundamentally incompatible with Gallagher's method for detecting road markers using the peak intensity data. Laser radar precisely measures the distance and angle from an exact point with a laser. Ex. 2023, ¶122. By comparison, Gallagher's photodiode array is imprecise in that each

photodiode provides a single intensity measurement, despite each sensor covering a wide portion of the field of view (i.e. depending on embodiment, 1/5 or 1/10<sup>th</sup> of the 3m x. 0.5m FOV area of Gallagher's area). Ex. 1005, [0035], [0038]; Ex. 2026, 133:8-11 (In Gallagher, "You may not know exactly where it is left and right because of the size of the field of view of the sensor, and that will have some effect on the observation angle."). Thus, Gallagher works by simply assuming that the "peak" (i.e. brightest) result will be the result at the correct observation angle—when the road marker's retroreflective surface is perfectly aligned to the photodiode to ensure maximum intensity of reflected light. Ex. 2023, ¶122 (citing Ex. 1005, [0040]-[0041], [0067]). Petitioner's combination would require abandoning Gallagher's method of operation—ignoring the peak result of Gallagher's photodiodes and instead looking at the photodiode measurements the laser radar indicates exactly a 0.2° observation angle. *Id.*; Pet., 49.

Moreover, combining the references in this way is especially not feasible since Frank's scanning rate is much higher than Gallagher's sampling rate. Ex. 2023 ¶122 (citing Ex. 1007, 13:25-31, Ex. 1005, [0047]). Because there would be many laser radar samples for each of Gallagher's samples, it would not be feasible to identify *one* specific intensity measurement in Gallagher as corresponding to the 0.2° observation laser radar. *Id.* Furthermore, Frank's laser radar system would interfere with Gallagher's intensity measurements because the laser would

unpredictably increase the intensity of reflections from the road markers, as sensed by Gallagher's photodiodes. *Id.* ¶123.

**5. Claim 16**

Claim 16 depends from claim 15. Petitioner's arguments for claim 16 are the same as their arguments for claim 15. Pet., 51. Thus, Petitioner's arguments for claim 16 fail for the same reasons as claim 15, discussed above. Ex. 2023, ¶131.

**C. Ground 3: The Combination of Gallagher, Schofield, Frank, and ASTM Fails to Render Obvious Any Remaining Challenged Claims**

**1. Petitioner's Arguments for Claim 14 in Ground 3 Fail for at Least the Same Reasons as to Claim 9 in Ground 1**

Claim 14 depends from claim 9. Petitioner's obviousness arguments in Ground 3 for alleged obviousness of claim 14 are based on Petitioner's arguments that Gallagher and Schofield render obvious claim 9, which fail as discussed above. Pet., 57. Petitioner offers no argument or evidence that Frank or ASTM cures any of the deficiencies of Ground 1. Thus, Petitioner's obviousness arguments in Ground 3 for claim 14 fails for the same reasons discussed above for claim 9 in Ground 1. *Supra* VI.A.1, VI.A.3.; Ex. 2023 ¶133.

**2. Claim 14: The Cited Prior Art Does not Disclose or Suggest “determine an entrance angle and an observation angle as part of the assessment of the discrete location of the road marker within the field of view.”**

As discussed above, Petitioner and Dr. Thorpe wholly failed to address the language “as part of the assessment of the discrete location” in their analysis of claim

15. *Supra* VI.B.2. The same language appears in claim 14, and again Petitioner and Dr. Thorpe wholly fail to explain how the cited disclosures or their obviousness theory satisfy that claim language. Pet., 57-60. Thus, Petitioner’s arguments fail for the same reasons discussed above in further detail in Ground 2 as to claim 15. *Supra* VI.B.2; Ex. 2023, ¶135. In particular, performing observation and entrance angle measurements to determine compliance with the ASTM standard provides no reason to determine an entrance angle and an observation angle *as part of the assessment of the discrete location of the road marker* as claimed. Pet., 58-49; Ex. 2023, ¶135; *see also* Ex. 2026, 143:10-144:20.

**3. Claim 14: The Cited Prior Art Does Not Disclose or Suggest a “computer processing system is further configured to determine an *entrance angle*”**

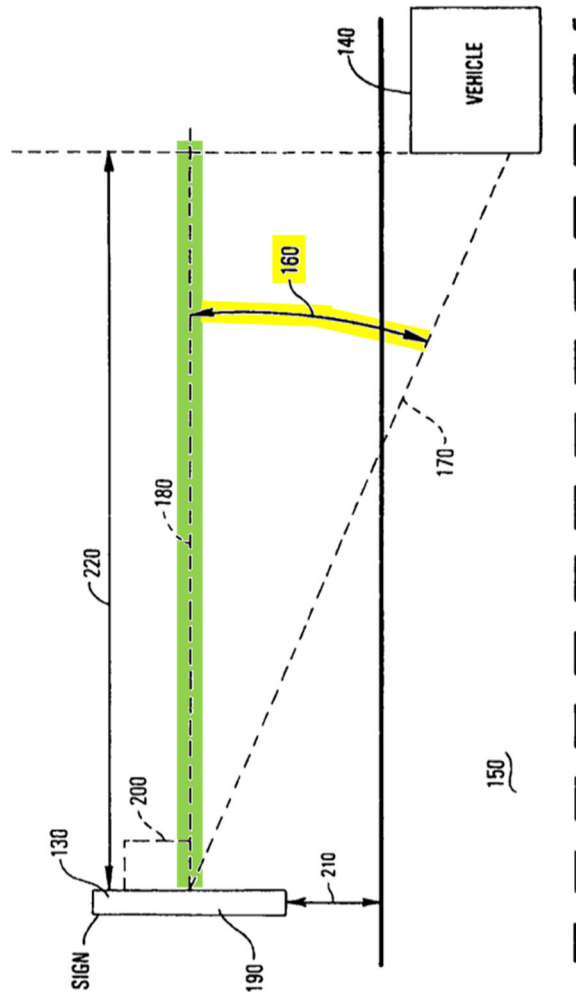
Petitioner identifies Frank’s angle  $\alpha$  (alpha) as corresponding to the claimed entrance angle. Pet., 59; Ex. 1003 ¶154. However, this theory fails because angle  $\alpha$  is not an angle “determined” by Frank’s system—angle  $\alpha$  has nothing to do with an entrance angle. Ex. 2023, ¶136. Rather, angle  $\alpha$  is the “scanning angle”—i.e. maximum angular sweep—of the laser in the embodiment of Frank using a servo-controlled scanning laser that sweeps back and forth in a scanned area in the arc defined by angle  $\alpha$ . *Id.* (citing Ex. 1007, Fig. 2A, 3, 5:22-40, 6:12-39). Indeed, Dr. Thorpe admitted this at his deposition. Ex. 2026, 140:14-17.

Nonetheless, at his deposition, Dr. Thorpe attempted to change his theory to

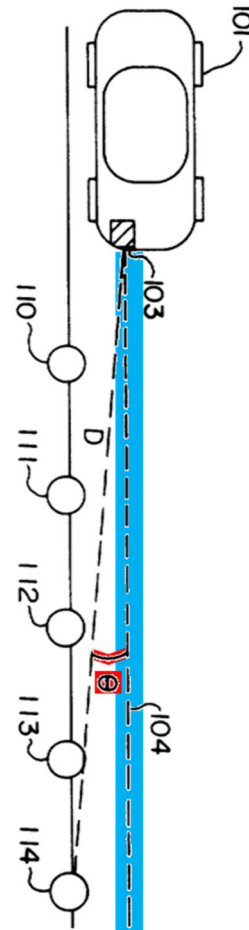
identify a different angle—Frank’s angle  $\theta$  (theta)—as the claimed entrance angle. Ex. 2026, 140:14-17 (“I believe you may be correct that alpha may be the full sweep and I should, instead of using Figure 2A, should have used Figure 2 to indicate theta which is the angle to the retroreflector.”). Petitioner should not be permitted to change its theory at this time, as it is well-established that the theories in the Petition are what govern the scope of an IPR proceeding. *See Henny Penny Corp. v. Frymaster LLC*, 938 F. 3d 1324, 1330-31 (Fed. Cir. 2019) (“It is of the utmost importance that petitioners in the IPR proceedings adhere to the requirement that the initial petition identify ‘with particularity’ the ‘evidence that supports the grounds for the challenge to each claim,’” thus “an IPR petitioner may not raise in reply ‘an entirely new rationale’ for why a claim would have been obvious”); *SAS Institute Inc. v. Iancu*, 584 U.S. 357, 1356-57 (2018) (“petitioner’s petition ... is supposed to guide the life of [IPR] litigation”); 37 C.F.R. § 42.23(b).

However, if Petitioner were allowed to rely on Dr. Thorpe’s new deposition theory for “entrance angle,” it would still fail. Ex. 2023 ¶ 137. In particular, Frank’s angle  $\theta$  (theta) is clearly not an entrance angle, as claimed. As Figure 2 of the ’328 Patent shows, an entrance angle—yellow in the below figure—is the “the angular displacement of the incident light 170 relative to the normal vector 180 [green] from the object face surface 130.” Ex. 1001, Fig. 2, 7:55-61(emphasis added). But Frank’s angle  $\theta$ —red in the below figure—is the angle “formed between axis 104

[blue] and an imaginary line drawn between vehicle 101 and a retroreflector.” Ex. 2023 ¶138 (quoting Ex. 1007, 4:37-42). That is, Frank’s angle  $\theta$  is the angle between the *vehicle’s normal vector* and the incident light on the sign. *Id.*



Ex. 1001 ('328 Patent), Fig. 2. (annotated)



Ex. 1007 (Frank), Fig. 12 (annotated & rotated)

These are two entirely different angles, measuring deviation from two entirely different normal vectors (the sign’s normal vs. the vehicle’s normal). Indeed, the ’328 Patent itself uses a “scanning laser,” (i.e. laser radar), which, like Frank’s laser radar, provides “both distance and direction of the measured point.” ’328 Patent, 15:16-17. But, as the ’328 Patent teaches, the scanning laser is insufficient on its

own to determine either the entrance angle or the normal vector of the sign. Ex. 2023 ¶139 (citing '328 Patent, 15:23-28). Instead, it also requires “the lateral series of discrete locations” of the sign, and “triangulation methods [] used to combine: (i) the vehicle location, (ii) vehicle heading vector, and (iii) scanned sign point[s].” *Id.*

The entrance angle and Frank’s angle  $\theta$  are only convertible when the vehicle and the sign *happens* to be pointing in specific orientations, such as when the sign is perfectly perpendicular to the road and the vehicle is driving straight down a straight road. Ex. 2023, ¶140. But, that is the “assumption” method—not a “determination” of an entrance angle. Indeed, the whole point of actually *determining* the entrance angle, as recited in claim 14, is because road signs are often not so perfectly aligned. *Id.* (citing Ex. 1001, 7:55-61, 14:16-22, 15:23-46; Ex. 2003, pdf. pp. 26-27, 50 (Fig. 14)). Thus, Petitioner has failed to show that the references disclose or suggest the computer processing system configured to determine an entrance angle.

**4. Petitioner Has Failed to Demonstrate that a POSITA Would Be Motivated to Combine Gallagher, Schofield, Frank, and ASTM in the Manner Claimed**

As discussed in Ground 1, a POSITA would not be motivated to combine Schofield’s camera-based approach (looking out the windshield) with Gallagher’s photodiodes (which look down at the road), especially due to the limitations of sensor fusion at the time. *Supra* VI.A.3. And as discussed in Ground 3, a POSITA would not be motivated to combine Frank’s laser radar system with the Gallagher-

Schofield combination. *Supra* VI.B.4. In Ground 3, Petitioner proposes the same combination of Gallagher, Schofield, and Frank, and provides no explanation why ASTM would solve those problems. Thus, their motivation to combine for Ground 3 fails for the same reasons as in Ground 2. *Supra* VI.B.4; Ex. 2023, ¶134.

**D. Ground 4: The Combination of Gallagher, Schofield, Leonard, and Popovich Fails to Render Obvious Any Remaining Challenged Claims**

**1. Petitioner’s Arguments for Claims 5-7 in Ground 4 Fail for at Least the Same Reasons as to Claim 1 in Ground 1**

Claims 5-7 depend from claim 1. Petitioner’s arguments in Ground 4 for alleged obviousness of claims 5-7 are based on Petitioner’s arguments that Gallagher and Schofield render obvious claim 1, which fail as discussed above. Pet., 47, 51. Petitioner offers no argument or evidence that Leonard or Popovich cures any of the deficiencies of Ground 1. Thus, Petitioner’s obviousness arguments in Ground 4 for claims 5-7 fail for the same reasons discussed above for claim 1 in Ground 1. *Supra* VI.A.2, VI.A.3.; Ex. 2023 ¶142.

**2. Popovich is Not Analogous Art**

Petitioner argues that Popovich is analogous art because it is “in the same field of endeavor” as the ’328 Patent, “namely, automated object recognition.” Pet., 64. However, this is an unduly broad identification of a field of endeavor. *See Wang Laboratories, Inc. v. Toshiba Corp.*, 993 F.2d 858, 864 (Fed. Cir. 1993); Ex. 2023, ¶¶143-144. More appropriately, the ’328 Patent is in the “field of automated object

recognition” and more specifically, identifying, measuring, and classifying road markers from a vehicle. Ex. 2023, ¶144 (citing Ex. 1001, 1:31-47, 3:51-4:30). By contrast, Popovich is in the field of “optical position sensing,” and in particular, head-position measurement for interactive television or software applications. *Id.* (citing Ex. 1010, 1). Moreover, Popovich cannot be in the field of object *recognition* because Popovich does not attempt to identify any particular type of object as distinguished from any other object. *Id.* Rather, it simply attempts to detect the location of one, pre-determined target in a static environment. *Id.*

Moreover, a POSITA would not find Popovich reasonably pertinent to the problems addressed by the ’328 Patent. Ex. 2023, ¶145. There are very significant differences in the structure and function of Popovich and the ’328 Patent that render Popovich’s methods inapplicable. In particular, as recited in claim 1 (from which claims 5-7 depend), the ’328 Patent is designed to be an “automated system” that operates “along a roadway that is being traversed by a vehicle.” Ex. 1001, cl. 1. By contrast, Popovich is trying to detect a target on a human head—at much shorter distances—in a relatively static environment. Ex. 2023, ¶145 (citing Ex. 1010, 1-4). For Popovich to work, it requires two light beams that are *angled* to converge to produce a relatively small, illuminated volume of space at a specific, close distance in which it can perform position detection. *Id.* (citing Ex. 1010, 6-7, 9-10, Fig. 1, 3). Such angles require a particular geometry where there is sufficient lateral spacing

of the light sources, as compared to the distance to the target, that two sides of the user's face are illuminated. *Id.* That configuration simply would not be applicable to a vehicle on a roadway, where targeted road markings are further away, and where the lateral spacing of light sources is limited by the maximum widths of the lanes on the road. Ex. 2023, ¶145.

Because Popovich is not in the same field of endeavor, and is not reasonably pertinent to the problems addressed by the '328 Patent, Popovich is not analogous art. Thus a POSITA would not be motivated to select it for combination and it is not proper for use in an obviousness theory. *In re Bigio*, 381 F.3d 1320, 1325, (Fed. Cir. 2004).

**3. Petitioner Improperly Combines the Incompatible Disclosures of Distinct Embodiments of Popovich Without Explanation or a Motivation to Combine**

Where a Petitioner relies on multiple, distinct embodiments, the Petitioner must explain how those embodiments were interchangeable or why the skilled person in the art would have found it obvious to combine the teachings of those embodiments. *See, e.g., Abiomed, Inc. v. Maquet Cardiovascular, LLC*, IPR2017-01205, Paper 8, 8-12 (PTAB Oct. 23, 2017); *In re Stepan Co.*, 868 F. 3d 1342, 1346 n.1 (Fed. Cir. 2017) (even where “combining multiple embodiments from a single reference ... there must be a motivation to make the combination and a reasonable expectation that such a combination would be successful.”)

However, Petitioner cites and combines distinct embodiments of Popovich without explanation nor an identified motivation to combine. Ex. 2023, ¶153. Popovich’s *first* embodiment discloses “measuring the position in the matrix of the sensor(s) of the peak of the spots intensity profile ... to define a ray vector that passes through the center of the retroreflector 3.” *Id.*; Ex. 1010, 6-7 (cited by Pet., 67). The first embodiment uses two cameras and two light sources to measure light intensity. *Id.* However, Popovich’s “angular intensity distribution profile” comes from Popovich’s “third embodiment” (illustrated in Fig. 3) which uses light sources of different wavelengths and angular intensity distribution profiles. Ex. 1010, 9-11 (cited by Pet., 71); Ex. 2023, ¶153. These are mutually exclusive disclosures of distinct embodiments—Popovich expressly states that this third embodiment *does not use* the disclosure on pages 6-7 from the first embodiment. *Id.*; Ex. 1010, 10 (“Unlike the aforementioned embodiments in which sensors 20 determine the trajectory of light 19, 23 reflected from retroreflector 3 by the position of ‘spots’ formed on the sensors, in this embodiment the sensors 200 measure the intensity of incident light” which “will be a function of the angular bearing with respect to each light source 5A, 5B and the distance of the retroreflector 3 from each light source”). Because Petitioner arbitrarily combines the mutually exclusive disclosures of distinct embodiments of Popovich, without explanation or a motivation to combine, Ground 4 fails to set forth a prima facie obviousness argument.

**4. Claim 5: The Cited Prior Art Does Not Disclose or Suggest “comparing the light vector to one of a plurality of predetermined vectors based on a light source angle characterization”**

Petitioner also fails to show that any of the references disclose or suggest this limitation. Rather than citing any such disclosure or suggestion, Petitioner and Dr. Thorpe only present the conclusory argument that “[b]ecause the intensity of the light source varies relative to its heading, a POSITA would have found it obvious to compare the determined light vector to one of a plurality of predetermined vectors based on a light source angle characterization.” Pet., 71; Ex. 1003 ¶178. However, they do not attempt to cite any prior art as creating a plurality of predetermined vectors based on a light source angle, or comparing those vectors to another vector, or make any non-conclusory argument that such a technique was even known or apparent; Ex. 2023 ¶150.

Petitioner and Dr. Thorpe do cite to Popovich’s “angular intensity distribution profile” (*id.*), but Popovich’s angular intensity distribution profile is not and does not contain a plurality of predetermined vectors, nor does Petitioner or Dr. Thorpe present any argument that it does. Ex. 2023 ¶151. Instead, as Dr. Thorpe admits, Popovich’s angular intensity distribution profile is simply a graph of light intensity in the Y-axis versus angle of illumination in the x axis. Ex. 1003 ¶162 (citing Ex. 1010, 5, 10, Fig. 3a). Moreover, Popovich does not disclose, suggest or mention

comparing *anything* to its angular intensity distribution profile to any vector. Instead, it simply describes its angular intensity distribution profile to describe the properties of a light source needed to make its invention work. Ex. 1010, 10 (requiring one of the light sources to have a “uniform angular intensity” as shown in Fig. 3b and the other to have a non-uniform symmetrical profile” as shown in Fig. 3a).

Petitioner and Dr. Thorpe do point to Popovich’s statement that “[b]y measuring the position in the matrix of the sensor(s) of the peak of the spot’s intensity profile or, in the case of a spot having a flat topped profile, its centroid and using the known orientation in space of the sensor camera it is possible to define a ray vector that passes through the center of the retroreflector.” Pet., 63; Ex. 1003 ¶171, Ex. 1010, 6-7. However, the “intensity profile” referenced there is not the angular intensity distribution profile of the *light*, it is the 8-bit (i.e. 256 value) grey level values output by the *sensor* a spot observed on a camera (or similar 2D sensor) that corresponds to Popovich’s head-mounted retroreflector. Ex. 2023 ¶152; Ex. 1010, 6-7 (“the sensor image is formed on a two-dimensional array of photodetectors” “spot intensity is characterised in terms of a number of grey levels - typically up to 256”). That is, the ray is identified as simply corresponding to the spot with the greatest intensity (or where the spot on the intensity map has relatively equal intensity throughout the spot—i.e. a “flat topped profile”—it is the centroid—

i.e. the center of the spot). *Id.*; *see also id.*, 7 (“The determination of the spot position in this embodiment is carried out by electronic circuitry 24,25 associated respectively with optical heads 1,2 and which each automatically locates the peak intensity in the matrix of associated sensor 20 by searching for the maximum intensity along each line of data in a frame as it is read out of that sensor”). Said simply, Popovich is just teaching that the location of the center of a retroreflector can be determined by identifying a bright spot in a camera, and that such center defines a line from the reflector to the camera. *Id.*, 6-7.<sup>1</sup> That has nothing to do with this claim limitation—which requires already having a light vector and comparing it to a plurality of vectors based on a light source angle characterization. Ex. 2023 ¶152.

**5. A POSITA Would Not be Motivated to Combine the Teachings of Gallagher, Schofield, Leonard, and Popovich in the Manner Claimed**

Like Grounds 2 and 3, Petitioner does not mention Schofield in their analysis of the motivation to combine, despite being part of the combination of Ground 4. Pet., 2, 61; Ex. 1003, p. 93 (identifying combination as “Gallagher, Schofield,

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<sup>1</sup> Popovich then discloses using such ray from each of the two cameras to calculate head position in 3D space, i.e.. that the two orthogonal 2D grids from each of the cameras can define the location of the reflector 3D space. Ex. 1010, 7.

Leonard, and Popovich”), ¶¶165-179 (not discussing Schofield). This creates several apparent contradictions. Ex. 2023, ¶ 146. In Ground 1, claim 1, Petitioner argues that a POSITA would be motivated to use Schofield and its camera-based approach to provide improved identification of objects of interest. Ex. 2023, ¶147 (citing Pet., 38-39; Ex. 1003 ¶103). But in Ground 4, they argue that Popovich and Leonard would be combined to improve detecting, locating, and measuring road markers. *Id.* (citing Pet., 64; Ex. 1003 ¶165). Petitioner does not provide any explanation of how the additions based on Leonard and Popovich provide benefits to the Gallagher-Schofield combination beyond what Schofield already provides. Ex. 2023, ¶ 147. Indeed, Dr. Thorpe was unable to provide a meaningful explanation at his deposition. Ex. 2026, 164:16-165:21 (“I do not think it necessary to bring Schofield in at this point”). Thus, Ground 4 is nothing more than the application of hindsight to map the limitations of claim 5 to arbitrary combinations of references with similar sounding terms.

Petitioner argues that a POSITA would be motivated to combine Leonard’s sub-field approach for expanding a field of view of a sensor to expand Gallagher’s “Area A” to use a wider FOV and thereby simultaneously measure multiple markers at once. Ex. 2023, ¶146 (citing Pet., 65-67; Ex. 1003 ¶¶166-168). But expanding Gallagher’s FOV to measure “multiple road markers at once” would render Gallagher inoperable. Ex. 2023, ¶148. Gallagher’s photodiode array sweeps a strip

of road ahead of the vehicle. *Id.*; Ex. 1005, [0015]-[0018], [0038]-[0039]. Gallagher identifies peak responses of light intensity measured by that array as corresponding to the presence of road markers. *Id.*, [0066]. Those readings are then converted into retroreflectivity values. *Id.*, [0067]-[0068]. Thus, Gallagher's 0.5m FOV is designed to ensure that only one road marker is within the FOV, as markers are usually spaced 5-20m apart. Ex. 2023, ¶148 (citing Ex. 1005, [0034]-[0035]). By expanding Gallagher's FOV to include multiple road markers—as Petitioner proposes—Gallagher's photodiodes would be receiving light intensity data from multiple road markers simultaneous. *Id.* This would prevent Gallagher from measuring the retroreflectivity of any one marker—Gallagher's whole purpose. *Id.*

In ground 4, Petitioner also argues that a POSITA would be motivated to modify Gallagher to use Popovich's technique for triangulating a retroreflector in space using a light detection device that receives light from two spaced beams to improve the detection of the location of the marker in that expanded field of view to “improve the accuracy of the determined location for each marker.” Pet., 67-69; Ex. 1003 ¶¶171-172. But, as discussed above (*supra* VI.D.2), Popovich's system—that tracks heads in static environments at close distances—is entirely inapplicable to the messy, real-world measurement of road markers on a non-linear roadway at roadway speeds and distances (e.g. the expanded FOV located 2.3m+ away from Gallagher's vehicle in the proposed combination). Ex. 2023, ¶¶145, 149.

**6. Claims 6-7**

Claims 6-7 depend from claim 5. Thus, Petitioner's arguments for claims 6-7 fail for the same reasons as claim 5, discussed above. *Supra* VI.D.1-VI.D.5.

**VII. CONCLUSION**

For the above reasons, Patent Owner requests that the Board hold each remaining challenged claim to be patentable.

Date: November 28, 2024

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

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