

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MOBILEYE GLOBAL, INC.,

Petitioner,

v.

FACET TECHNOLOGY CORP.,

Patent Owner.

Case IPR2024-01111

Patent No. 9,671,328

**SUPPLEMENTAL REPLY DECLARATION OF
CHARLES E. THORPE, PH.D.**

TABLE OF CONTENTS

I.	INTRODUCTION AND SUMMARY OF OPINIONS.....	4
II.	BACKGROUND AND QUALIFICATIONS.....	5
III.	LEGAL STANDARDS	5
A.	Claim Construction.....	6
B.	Level of Ordinary Skill	6
C.	Obviousness.....	7
IV.	LEVEL OF ORDINARY SKILL IN THE ART.....	10
V.	RESPONSE TO PATENT OWNER’S ARGUMENTS AND DR. PAPANIKOLOPOULOUS’S TESTIMONY	11
A.	Ground 1: The Combination of Gallagher and Schofield.....	11
1.	“[9D] a computer processing system ... configured to detect objects of interest within the field of view and for each object of interest: [9E] 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” “[1E] a computer processing system ... configured to detect objects of interest within the field of view and for each object of interest: [1F] determine whether the object of interest includes a reflective surface based on the light intensity values”	13
a.	Gallagher discloses these features of claims 1 and 9	13
b.	Gallagher and Schofield render obvious “a computer processing system ... configured to detect objects of interest within the field of view and for each object of interest” ([1E]).....	20
2.	“[9F] 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” “[1H] determine a location of the road marker”	26
a. Gallagher discloses determining a location of each road marker.....	26
b. Gallagher and Schofield render obvious the “analyze” function of claim 9	27
3. “[1G] determine whether the reflective surface is a road marker based on an assessment of the reflective surface”	29
B. Ground 2: The Combination of Gallagher, Schofield, and Frank.....	30
VI. CONCLUSION.....	32

I. INTRODUCTION AND SUMMARY OF OPINIONS

1. I, Charles E. Thorpe, have been retained as an independent expert by Mobileye Global, Inc. (“Petitioner” or “Mobileye”) in connection with an inter partes review of U.S. Patent No. 9,671,328 (the “’328 patent”) (Ex. 1001).

2. I submitted a first declaration in connection with Petitioner’s Petition for Inter Partes Review (Paper No. 1), and I understand that my first declaration is marked as Exhibit 1003 in this proceeding. Since submitting my first declaration, Facet Technology Corporation (“Patent Owner”) filed its Preliminary Response (Paper No. 6) and Request for Director Review (Paper No. 18), and the Board instituted inter partes review for the ’328 patent (Paper No. 14). I understand that prior to institution, Patent Owner disclaimed claims 17-22 of the ’328 patent such that claims 1-16 are the remaining claims at issue in the inter partes review.

3. Following institution, I was deposed on May 29, 2025, regarding the ’328 patent. A transcript of my deposition is marked as Exhibit 2026. After my deposition, I understand that Patent Owner submitted a Response to the Board’s institution decision (Paper No. 25), which included a declaration by Dr. Nikolaos Papanikolopoulos, Ph.D., marked as Exhibit 2023.

4. I have reviewed the Board’s Institution Decision, Patent Owner’s Response, and Dr. Papanikolopoulos’s declaration. Based on my review of these materials, I offer the following supplemental remarks. My remarks address

arguments that Patent Owner and Dr. Papanikolopoulos raised with the Response and correct certain misstatements in Dr. Papanikolopoulos's declaration regarding my first declaration and the prior art.

5. The new documents that I have reviewed and Patent Owner's Response do not change my opinions I rendered in my first declaration. As I detailed in my first declaration, claim 1-16 of the '328 patent are invalid as obvious based on the combinations detailed in my first declaration.

II. BACKGROUND AND QUALIFICATIONS

6. My background and qualifications are set forth in my first declaration, Exhibit 1003. I incorporate that section of my first declaration herein by reference. Ex. 1003, ¶¶ 3-18.

III. LEGAL STANDARDS

7. I am not a lawyer. My understanding of the legal standards to apply in reaching the conclusions in this declaration and in my initial declaration is based on discussions with counsel for Petitioner, my experience applying similar standards in other patent-related matters, and my reading of the documents submitted in this proceeding. The following sections on the legal standards were included in my initial declaration and are reproduced here. In preparing this declaration, I sought to faithfully apply these legal standards to the remaining Challenged Claims.

A. Claim Construction

8. I have been instructed that the terms appearing in the '328 patent should be interpreted in view of the claim language itself, the specification, the prosecution history of the patent, and any relevant extrinsic evidence. The words of a claim are generally given their ordinary and customary meaning, which is the meaning that the term would have to a person of ordinary skill in the art at the time of the invention, which I am assuming here is August 12, 2000. While claim limitations cannot be read in from the specification, the specification is the single best guide to the meaning of a disputed term.

9. I have been instructed that certain elements in a patent claim may be expressed as a means for performing a specified function without the recital of structure, material, or acts in support and that such a claim is construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof. I have been instructed that a claim element that recites the word “means” is presumptively construed as a means-plus-function term.

10. I have followed these principles in reviewing the claims of the '328 patent and forming the opinions set forth in this declaration.

B. Level of Ordinary Skill

11. I understand a person of ordinary skill in the art is determined by looking at (i) the type of problems encountered in the art; (ii) the prior art solutions

to those problems; (iii) the rapidity with which innovations are made; (iv) the sophistication of the technology; and (v) the educational level of active workers in the field.

C. Obviousness

12. I have been told that under 35 U.S.C. § 103, a patent claim may be obvious if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.

13. I have been told that a proper obviousness analysis requires the following:

- i. Determining the scope and content of the prior art;
- ii. Ascertaining the differences between the prior art and the claims at issue;
- iii. Resolving the level of ordinary skill in the pertinent art; and
- iv. Considering evidence of secondary indicia of non-obviousness (if available).

14. I have been told that the relevant time for considering whether a claim would have been obvious to a person of ordinary skill in the art is the time of

invention. For purposes of my analysis, I assumed that the date of invention for the Challenged Claims is August 12, 2000.

15. I have been told that a reference may be modified or combined with other references or with the person of ordinary skill's own knowledge, if the person would have found the modification or combination obvious. I have also been told that a person of ordinary skill in the art is presumed to know all the relevant prior art, and the obviousness analysis may take into account the inferences and creative steps that a person of ordinary skill in the art would employ.

16. I have been told that whether a prior art reference renders a patent claim obvious is determined from the perspective of a person of ordinary skill in the art. I have also been told that, while there is no requirement that the prior art contain an express suggestion to combine known elements to achieve the claimed invention, and while a suggestion to combine known elements to achieve the claimed invention may come from the prior art as a whole or individually and may consider the inferences and creative steps a person of ordinary skill in the art would employ, as filtered through the knowledge of one skilled in the art, obviousness grounds cannot be sustained by mere conclusory statements and must include some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.

17. I have been told that there is no rigid rule that a reference or combination of references must contain a “teaching, suggestion, or motivation” to combine references. But I also have been told that the “teaching, suggestion, or motivation” test can be used in establishing a rationale for combining elements of the prior art. I have also been told to be aware of distortions caused by hindsight bias, and that reading into the prior art the teachings of the invention at issue is improper.

18. I am aware that a claim may be obvious where the claim represents nothing more than a combination of prior art elements according to understood methods that yields predictable results. I am further aware that a claim may be obvious where it merely involves the simple substitution of one known element for another to achieve predictable results. I am additionally aware that it may be obvious to try a particular combination of claim features if selecting them requires merely choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success.

19. I have been informed that, in an obviousness analysis, prior art must be analogous art to the patent being considered. I have been informed that a prior art reference is considered to be analogous, or in the same field of art, if the reference is either (1) in the same field of endeavor as the challenged patent, regardless of the

problems the challenged patent and the prior art address, or (2) reasonably pertinent to the particular problem being solved by the challenged patent.

IV. LEVEL OF ORDINARY SKILL IN THE ART

20. I provided my opinion about a person of ordinary skill in the art in my first declaration that I incorporate herein by reference (Ex. 1003, ¶¶ 30-32).

21. Dr. Papanikolopoulos responded that my proposed level of ordinary skill for the '328 patent was “an excessive level of ordinary skill.” Ex. 2023, ¶ 57. But the only discernable difference Dr. Papanikolopoulos identifies is that my proposed definition uses “four years of experience” while Dr. Papanikolopoulos would instead propose only “two years of experience.” I disagree. Four years appropriately accounts for the state of the art and that a person of ordinary skill in the art would have derived much of his knowledge regarding computer vision systems through work experience or higher education because many undergraduate curricula for the time did not include extensive coursework regarding computer vision systems. For this same reason, my first declaration provides that “[h]igher levels of education may offset less experience.” Ex. 1003, ¶ 31. For example, around this time, I supervised several Ph.D. students working on dissertations related to computer vision. In the approximately two decades leading up to the earliest claimed priority date of the '328 patent, computer vision systems were the topic of much research and development, and computer vision systems had become

much more sophisticated by the late 1990s. In my opinion, four years of work experience appropriately accounts for the type of experience that a typical person having ordinary skill in the art would have possessed at that time.

22. While I continue to find my initial definition more appropriate given the scope and description of the '328 patent, my analysis and my opinions would not change depending on the difference between the proposed levels of experience. Even assuming two years of experience, a POSITA would have found claims 1-16 obvious based on the teachings of the prior art discussed in my first declaration.

V. RESPONSE TO PATENT OWNER'S ARGUMENTS AND DR. PAPANIKOLOPOULOS'S TESTIMONY

A. Ground 1: The Combination of Gallagher and Schofield

23. Patent Owner and Dr. Papanikolopoulos argue that certain functions performed by the computer processing system must be performed separately and in a particular order. I have not been asked to opine on whether their proposed construction is correct. However, I would like to clarify certain factual inaccuracies from Dr. Papanikolopoulos. Dr. Papanikolopoulos states that "in the field of computer vision, it is well-understood that object detection—which tells you that there is an object (i.e. 'detect objects of interest')—is distinct from object recognition which tells you something about what an object is (i.e. 'determine whether the reflective surface is a road marker' or 'determine whether the object of interest includes at least one light intensity value associated with a reflective

surface of a road marker’).” Ex. 2023, ¶ 81. While detecting objects of interest could refer only to detecting that an object is present, processing techniques existed at the time that would both detect the presence of an object of interest and output information about the object simultaneously. One known technique for doing just that was neural net processing systems. These systems processed an image and directly output a result, without going through discrete steps of detection and recognition.

24. I have been asked to respond to Patent Owner’s arguments and Dr. Papanikolopoulos’s opinions regarding whether Gallagher and Schofield render obvious the disputed limitations of claims 1 and 9, assuming Patent Owner’s proposed construction is adopted by the Board. In my opinion, the claims are still obvious based on the teachings of Gallagher and Schofield.

1. **“[9D] a computer processing system ... configured to detect objects of interest within the field of view and for each object of interest: [9E] 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”**

“[1E] a computer processing system ... configured to detect objects of interest within the field of view and for each object of interest: [1F] determine whether the object of interest includes a reflective surface based on the light intensity values”

a. Gallagher discloses these features of claims 1 and 9

25. I disagree with Patent Owner and Dr. Papanikolopoulos that Gallagher does not disclose separately detecting objects of interest and, for each object of interest, performing the “determine” functions of [9E] and [1F].

26. I would like to clarify Patent Owner’s characterizations of certain disclosures from Gallagher. POR 23-25. For example, Patent Owner argues “no objects are ‘detect[ed]’ in Gallagher’s step (d)” because the visual indicator only informs the driver which light sensor is reading the highest reflectance reading. POR 25-26. Patent Owner misunderstands Gallagher’s disclosures about the visual indicator means.

27. Detecting objects of interest refers to detecting that an object is present but not necessarily what the object is. In my opinion, Gallagher’s visual indicator means is a visual alert to the driver of the vehicle based on Gallagher’s

computer detecting that an object is present. Ex. 1005 (“Gallagher”), [0010], [0060]-[0062].

28. To illustrate, I provide the annotated Figure 2 from Gallagher, below. Gallagher’s Figure 2 depicts a vehicle 3 traveling along a roadway adjacent to road markings that include raised pavement markers highlighted in red and painted lines highlighted in light blue. Gallagher, [0033], FIG. 2. Gallagher discloses that both the painted lines and the raised pavement markings may be reflective and that its apparatus may “test the reflectivity” of both. Gallagher, [0033]. As the vehicle travels along this roadway, Gallagher’s light sensor array and computer create a representation of the reflected light intensity values one row at a time like a push broom. In doing so, Gallagher’s system measures light intensity values from background areas of the road, from areas of the road including painted lines, and from areas of the road including raised pavement markings.

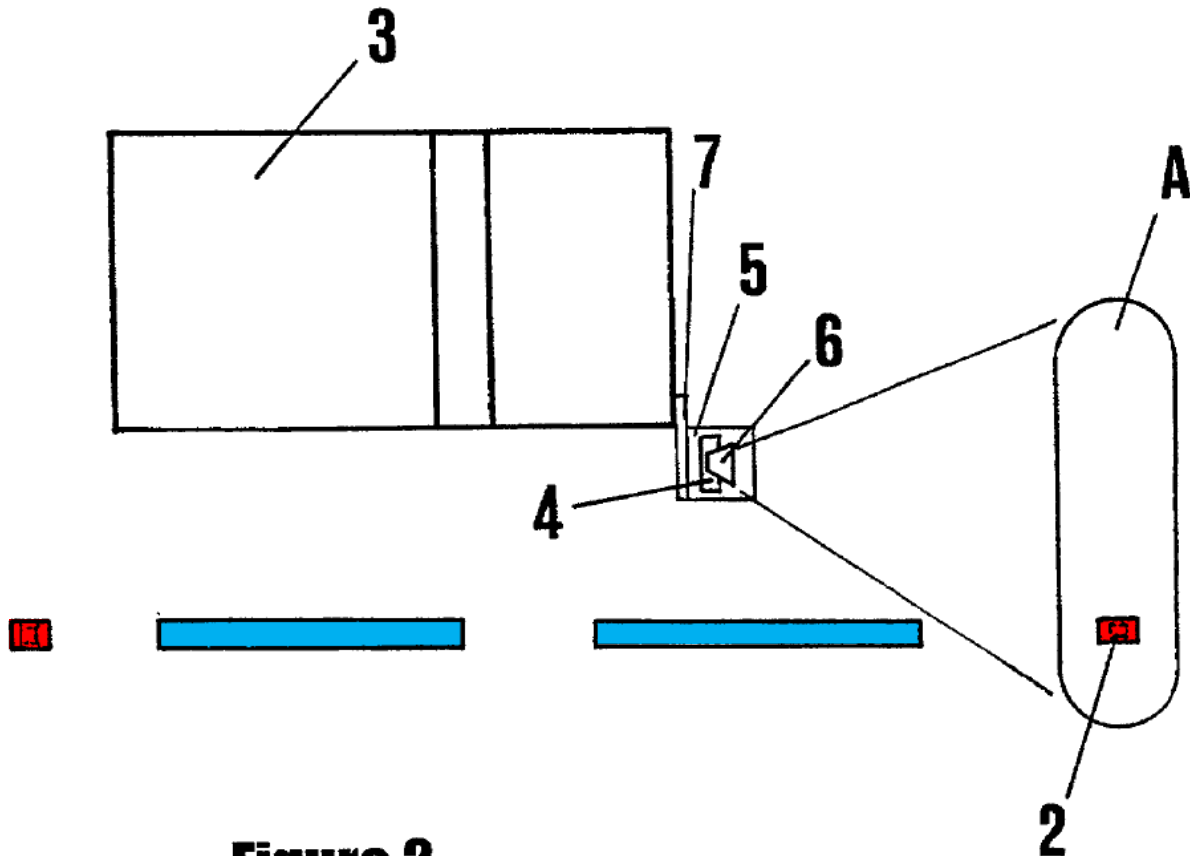


Figure 2

Gallagher, FIG. 2 (annotated).

29. After “filtering the data” from the light sensors to smooth out the data and calibrating the data, Gallagher’s step (d) discloses “determining the vehicle position on the road and providing” a “visual indicator means.” Gallagher, [0057]-[0062]. Gallagher discloses that this visual indicator indicates “the location of the said road markings relative to the vehicle.” Gallagher, [0010], [0060]-[0062]. In my opinion, that discloses detecting an object of interest because the computer, based on its processing, provides a visual alert to the driver that an object of interest (e.g., painted line or raised pavement marking) is present.

30. This visual indicator is not just “the raw output of the sensor with the current highest intensity reading.” POR 25. As I mentioned, the computer determines the presence of an object of interest after filtering and calibrating the data, so the visual indicator is not based on raw sensor data. Gallagher, [0057]-[0062]. When Gallagher’s computer “detect[s] which light sensor 6 is reading the highest reflectance reading,” a person of ordinary skill in the art would understand it to detect an object of interest because the computer is distinguishing between “background reflectance levels on non road marking sections of the road” and reflectance levels indicating a road marking. Gallagher, [0010], [0060]. Because the data is filtered and calibrated, a stretch of road without any reflective surfaces would ordinarily not result in any one sensor having the highest reflectance reading, and the visual indicator would not indicate the presence of an object. For that reason, I disagree with Dr. Papanikolopoulos that “at least one of the sensors will always have the highest reading among all of the sensors.” Ex. 2023, ¶ 102. A person of ordinary skill in the art reading Gallagher would understand the visual indicator’s purpose to be to inform the driver where in the field of view each object of interest is located to help the driver maintain the vehicle properly positioned on the road. Gallagher, ¶¶ [0010], [0060]-[0062].

31. Patent Owner and Dr. Papanikolopoulos also mischaracterize Gallagher’s description of step (e). POR 24; Ex. 2023, ¶ 101. Dr. Papanikolopoulos

characterizes this step as “merely a data collection step (collecting the gearbox data), without any analysis or determinations.” Ex. 2023, ¶ 101. I disagree, as data collection is only part of step (e). Gallagher discloses that this step gets the vehicle position data (gearbox data or, alternatively, GPS data based on other disclosures in Gallagher like [0048]) and “determin[es] the distance travelled from the start position of the road marking test *so as to determine the location of each road marking.*” Gallagher, [0063] (emphasis added). Gallagher discloses that “[t]his information is used to tag or *identify the road markers tested* along a stretch of road.” Gallagher, [0064] (emphasis added). Accordingly, after collecting the vehicle position data, Gallagher’s computer uses the vehicle position data to determine the location of each road marking, and this occurs right after detecting their presence. Gallagher, [0060]-[0064]. This is made even more apparent by Gallagher’s later disclosure, in step (j), of “storing ... the location and CIL levels of each road marker.” Gallagher, [0069]. The location of each road marker is what is determined in step (e). Gallagher, [0063]-[0064]. This conveys to a person of ordinary skill in the art that Gallagher’s computer detects objects of interest and then determines a location for each object detected. Gallagher, [0063]-[0064].

32. For the “determine” functions of [9E] and [1F], Patent Owner and Dr. Papanikolopoulos do not appear to dispute that Gallagher’s step (g) performs these functions but characterize step (g) as a “single step” for both detecting and

determining. POR 26-27, 30-31; Ex. 2023, ¶ 103. I disagree with their characterization of Gallagher as providing only a “single step” for detecting and determining for the reasons previously described. Looking at Figure 5 of Gallagher helps illustrate why they are mistaken. Figure 5, below, illustrates “the reflectance levels measured from a number of road markings on a stretch of road.” Gallagher, [0078]-[0079]. As shown in this figure, Gallagher’s computer stores (and then may graphically illustrate) the reflectance levels for the “Front Face” and “Rear Face” of each road marker tested, where the positive y-value refers to the reflectance level of the front face of the road marker and the negative y-value refers to the reflectance level of the rear face. Gallagher, [0079], FIG. 5. This figure helps illustrate the presence of a separate “detect” step because Gallagher’s computer is able to relate the reflectance value of two different surfaces of the same object of interest together. Gallagher’s computer detects road markers, determines their location, determines that they have front and rear reflective surfaces, determines the reflectance level in CIL of each reflective surface, and associates that information together in storage. Gallagher, [0060]-[0071], [0074], [0079], FIG. 5. This information can also “be viewed in real time.” Gallagher, [0070].

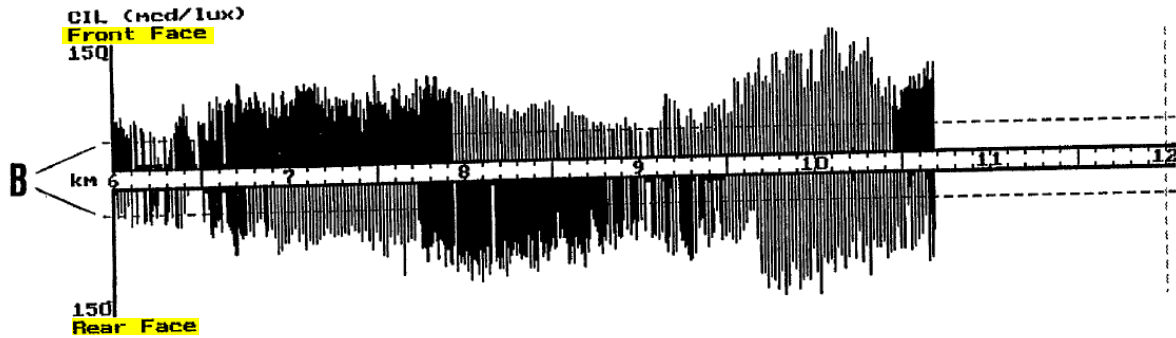


Figure 5

Gallagher, FIG. 5 (highlighted).

33. I also disagree with Patent Owner and Dr. Papanikolopoulos's characterizations of Gallagher's steps (f) and (g). POR 26; Ex. 2023, ¶ 103. Gallagher's step (f) discloses "determining the background reflectance level on the road and establishing non-marker reflectance levels." Gallagher, [0065]. Gallagher then uses those established non-marker levels to select "which reflectance levels indicate" a reflective surface of a road marker. Gallagher, [0065]-[0066]. Gallagher also uses pattern recognition throughout this process to note the location of missing markers if the light intensity values do not indicate a reflective surface where one should be. Gallagher, [0023], [0070]. In my opinion, Gallagher's step (g) is using the light intensity values to determine reflectance levels corresponding to a reflective surface associated with an object of interest so it can later associate the corresponding CIL value of the surface with the location of the object previously determined. And it does this by tracking the reflectance levels above non-marker reflectance levels as an object moves through the field of view.

34. For these reasons, I maintain my initial opinion that Gallagher discloses both the “detect” and the “determine” functions of claim 9, even under Patent Owner’s construction.

b. Gallagher and Schofield render obvious “a computer processing system ... configured to detect objects of interest within the field of view and for each object of interest” ([1E])

35. I also disagree with the separate argument that it would not have been obvious to combine Gallagher and Schofield to detect objects of interest. POR 31-32. According to Patent Owner, Schofield does not disclose, suggest, or “motivate determining the presence of a reflective surface on an already detected object of interest.” POR 31-32. In my initial declaration, I explained why a person of ordinary skill in the art would have been motivated to combine Gallagher and Schofield to detect objects of interest. Ex. 1003, ¶¶ 103-107, 111. For example, Schofield discloses “[p]attern recognition,” which “may be used to further assist in the detection of ... objects of interest.” Ex. 1006 (“Schofield”), 10:66-11:12. Schofield discloses that “[p]attern recognition identifies objects of interest based upon their shape, reflectivity, luminance, and spectral characteristics.” *Id.*, 11:1-3. A person of ordinary skill in the art would have seen these disclosures and been motivated to combine Gallagher and Schofield to detect objects of interest because Gallagher’s apparatus measures reflectivity, Schofield’s image capture system identifies objects based upon their shape and color, and Schofield discloses that

putting these together improves object detection. For example, one important aspect of Gallagher is providing a visual indicator to the driver of the location of objects of interest as the vehicle drives along the road. Gallagher, [0060]-[0062]. Combining Gallagher and Schofield would have improved the accuracy of Gallagher's visual indicator because it would incorporate data from multiple sensors and more advanced processing techniques. Gallagher, [0060]-[0062]; Schofield, 10:66-11:12. And a more accurate visual indicator would have improved the driver's ability to position the vehicle properly on the road, leading to better measurement results.

36. Patent Owner and its expert argue that "Schofield does not use 'pattern recognition' to *detect* objects of interest or to make a determination as to a reflective surface." POR 31-32; Ex. 2023, ¶ 114. I disagree. Schofield discloses that "[p]attern recognition may be used to further assist in the detection of ... objects of interest." Schofield, 10:66-11:1. I also disagree with Dr. Papanikolopoulos's opinion that Schofield only uses pattern recognition "to identify that a particular light source is one which may be ignored." Ex. 2023, ¶ 114. Schofield discloses the opposite, as it states that pattern recognition "could be used to assist in *qualifying* or *disqualifying* objects." Schofield, 10:66-11:12 (emphasis added). As for detecting a reflective surface, the combination of

Gallagher and Schofield relies on Gallagher for performing that detecting a reflective surface, not Schofield.

37. Patent Owner and Dr. Papanikolopoulos also argue against a motivation to combine Gallagher and Schofield, arguing that it would not be straightforward to integrate Schofield's camera-based approach with Gallagher to improve objection detection or recognition. POR 33-35; Ex. 2023, ¶¶ 92-97. I disagree. As I explained in my deposition, there are several ways that a person of ordinary skill in the art would have known to combine their teachings and why it would have been obvious to do so. Ex. 2026, 105:8-111:5. For example, object detection methods at the time routinely used data from multiple sensors to confirm the detection of an object. This would have been one way to combine Gallagher and Schofield. Schofield's camera would have provided a field of view that covered the field of view of Gallagher's light sensor array. Both of their fields of view remain fixed relative to the vehicle, so correlating their fields would have been a simple matter of calibration. Schofield's techniques would have then allowed for improved object detection by incorporating factors like shape and color, in addition to the reflectance levels from Gallagher's sensors, to distinguish between painted lines, raised pavement markings, and other detected objects. Schofield, 10:66-11:12, 12:1-11 (discussing the identification of signs based on their shape and color), 12:40-42 (discussing the ability "to detect lane markers").

For example, incorporating Schofield's camera data would have improved the system's ability to detect objects of interest with reflectance levels so far below the minimum acceptable level that using reflectance levels alone might mistake them for background.

38. I also disagree that the need for sensor fusion would have made the combination unworkable. Ex. 2023, ¶¶ 93-96. As I stated in my deposition, object detection using sensor fusion was well known and dated based to at least 1972. I personally worked on a vehicle that incorporated data from a camera and a laser rangefinder to detect objects from a moving vehicle well before the earliest claimed priority date. A person of ordinary skill in the art would have known exactly how to implement Schofield's pattern recognition using data from multiple sensors, particularly because Schofield's camera and Gallagher's sensor array each provide several pieces of information that Schofield teaches is helpful to detect objects of interest. Schofield, 10:66-11:12.

39. Dr. Papanikolopoulos takes my 2001 paper out of context to dismiss any sort of sensor fusion. Ex. 2023, ¶ 95. My 2001 paper was discussing general perception systems for use in autonomous robots and driver assistance systems operating in close proximity to people and vehicles. Ex. 2031. General perception was not perfect at the time of the disputed patent and still is not perfect now. Even the best perception systems make occasional mistakes. But the techniques involved

in the proposed combination do not deal with general perception in close proximity to people and do not require solutions to the general perception problem. The sensor fusion used in the prior art combination would have been much more accurate and much less error prone than general perception systems. Rather than trying to detect all objects around all sides of a vehicle (e.g., parked cars, bicycles, pedestrians, oncoming vehicles, overtaking vehicles, etc.), as discussed in my 2001 paper, the combination would have used information from multiple sensors to detect specific objects with known characteristics and in a specific area. Sensor fusion was indeed demonstrated successfully for particular combinations of sensors, well before the patent's earliest priority date.

40. One especially relevant example is fusing range and camera data. In the book *Vision and Navigation*, the Carnegie Mellon Navlab, (part of a series edited by Takeo Kanade, the advisor to Dr. Papanikolopoulos). Professor Hebert demonstrated combining 3-D range data with color vision to produce a “colored-range” image that can be rotated and viewed from any angle. Exhibit 1031 is a true and accurate copy of excerpts this book. As indicated on the cover of the book, I helped edit this book and have owned a copy since before the earliest priority date of the '328 patent.

41. Moreover, combining data from multiple imaging sensors is the core aspect of stereo vision. By the time of the '328 patent, numerous stereo vision

systems had been demonstrated. In order to measure depth to a point, it is first necessary to find the same point in two separate images (the image or feature matching problem) and then to know the relative positions of the imaging sensors relative to each other (the geometric calibration problem). Geometric calibration of imaging sensors is well covered in the textbooks of the time, such as Robot Vision by B. K. P. Horn (Chapter 13 on Photogrammetry and Stereo) and Computer Vision by D. Balland and C. Brown (appendix A.1.8, Camera Calibration and Inverse Perspective). Exhibits 1032 and 1033 are true and accurate copies of excerpts from these books, respectively, both of which predate the earliest claimed priority date of the '328 patent. Similar techniques would have allowed Gallagher's and Schofield's sensor data to be combined to improve object detection.

42. I also disagree with Dr. Papanikolopoulos's opinions about performing sensor fusion at highway speeds. Object detection techniques (e.g., the pattern recognition described in Schofield) based on a combination of data from Schofield's and Gallagher's sensors were simple enough to be done at highway speeds without expecting any issues with the processing speed.

2. “[9F] 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”

“[1H] determine a location of the road marker”

a. Gallagher discloses determining a location of each road marker

43. For claim 9’s “analyze” function and claim 1’s location-determination function, I disagree with Patent Owner and Dr. Papanikolopoulos that Gallagher only discloses giving “the location of *the vehicle* at the time the road marker is detected,” not the location of the road marker itself. POR 29, 33; Ex. 2023, ¶ 107. Gallagher discloses that its GPS “can be used to pinpoint the position of the vehicle” *and* the position of the “markers 2 as measurements are being taken.” Gallagher, [0048], [0063]. The field of view for measuring reflectivity is fixed relative to the vehicle during use. Gallagher, [0035]-[0036]. Gallagher’s computer, in addition to knowing where the vehicle is, knows the geometry of the sensor and its field of view relative to the sensor. So even though the GPS data is directly tied to the position of the vehicle, it would have been a simple matter of translation to convert the GPS location information to the location of the road marker. Instead of recording just the vehicle position, Gallagher’s computer records the position of each marker.

44. Gallagher’s determination of the location of the road marker is apparent because it tags non-compliant road marker with “a paint capsule dispenser

activatable by the processing means.” Gallagher, [0013], [0068]. This occurs at the location of the road marker. Moreover, Figure 5 shows that Gallagher determines the location of the road marker because, for each road marker, it combines the location information with the CIL level of the front surface, determined from data of a forward-facing array, and the CIL level of the rear surface, determined from data of a rear-facing array. Gallagher, [0074], [0079], FIG. 5. Since both of these arrays are measuring reflected light from different areas at any given time, Gallagher’s computer determines the location of the road markers to combine the CIL data for each road marker in storage. Gallagher, [0069], [0074].

b. Gallagher and Schofield render obvious the “analyze” function of claim 9

45. I disagree with Patent Owner’s argument that Schofield’s spatially separated regions are only used to eliminate objects of interest, rather than used to assist in identifying objects. POR 28-29. Schofield discloses “identifying point sources of light in any particular location within the scene” and applying “[a]dditional discrimination” by “taking into account the relative location of the source of light within the scene.” Schofield, 2:26-41, 9:24-29. Schofield does not just disclose eliminating erroneous detections using location, it uses the location of the light source within the scene to help *confirm* its identification. *Id.* As I explained in my initial declaration, it would have been obvious “to implement Schofield’s determination of a light source’s location within a field of view” to

assist with measuring side-by-side road markers and correctly identifying which one did not comply within the minimum acceptable reflectance level. Ex. 1003, ¶¶ 76-79.

46. As explained in Section V.A.1.b, I disagree with Patent Owner and Dr. Papanikolopoulos's arguments against a motivation to combine Gallagher and Schofield. Additionally, these arguments are largely premised on implementing Schofield's camera into Gallagher's apparatus. But for the combination I describe in claim 9, multiple sensors are not required, so the arguments about sensor fusion do not apply.

47. There are several ways for implementing Schofield's use of location within Gallagher's system that would have been routine to use. For example, in one of Gallagher's embodiments, the light sensors in the array are photodiodes. Gallagher, [0038]-[0040]. Schofield discloses that its processing works with an array of photodiodes. Schofield, 2:36-41, 5:50-52, 8:38-45, 9:26-32, 10:51-11:12. For example, when measuring side-by-side raised pavement markers in Gallagher, it would have been routine to implement Schofield's spatially separated regions with the data from Gallagher's photodiodes to distinguish between reflectance levels from each of the side-by-side sensors. Gallagher, [0039]-[0040]; Schofield, 2:36-41, 5:50-52, 8:38-45, 9:26-32, 10:51-11:12. This would involve implementing processing taught by Schofield based on data from Gallagher's photodiode array.

48. Moreover, Gallagher's light sensors are not limited to photodiodes.

Gallagher discloses that "[a] variety of light sensors are envisaged as being suitable in the apparatus 1," including "light sensors with different spectral responses or similar light sensors with different filters." Gallagher, [0039]. Accordingly, Gallagher contemplates using a sensor like Schofield's, which uses spectral responses or spectral filters to detect different colors. Schofield, 2:26-28, 4:16-21, 8:13-17, 14:58-62. One way to implement Gallagher's teaching of using a sensor like this is to use a single row of Schofield's sensor, which would have given a higher spatial resolution laterally across the roadway than some of the photodiode embodiments disclosed in Gallagher. In this combination, the system would be able to sense and classify different colored markers, as Gallagher desires. Gallagher, [0039] ("The data signals detected by the sensors will indicate the colour of a road marking being tested. This feature is useful in situations where the apparatus 1 is being used to test different coloured road markings simultaneously.").

3. "[1G] determine whether the reflective surface is a road marker based on an assessment of the reflective surface"

49. I disagree with Patent Owner and Dr. Papanikolopoulos's argument that Gallagher's step g does not teach both determining a reflective surface ([1F]) and determining whether it is a road marker ([1G]). POR 32; Ex. 2023, ¶ 115. Patent Owner and Dr. Papanikolopoulos oversimplify step (g) by referring to it as a

single step. In step (g), Gallagher's computer selects "which reflectance levels indicate" a reflective surface using the established "non-marker reflectance levels." Gallagher, [0065]-[0066], FIG. 2. This process, for example, determines whether painted lines and raised pavement markers include a reflective surface by distinguishing their reflectance levels from the non-marker reflectance levels. Gallagher then discloses determining which of those reflective surfaces are road markers by disclosing that, "[i]n the case of road markers[,] the peak responses sensed are determined as the highly reflective surfaces of a road marker." Gallagher, [0066]. This involves, for example, determining whether each reflective surface corresponds to a painted line or a raised pavement marker. Gallagher, [0033], [0066], FIG. 2 (depicting painted lines and raised pavement markers). Accordingly, Gallagher discloses both [1F] and [1G].

B. Ground 2: The Combination of Gallagher, Schofield, and Frank

50. I provide my responses below to certain arguments raised by Patent Owner and certain opinions from Dr. Papanikolopoulos regarding the motivation to combine Gallagher, Schofield, and Frank.

51. Patent Owner and Dr. Papanikolopoulos repeat their prior arguments regarding sensor fusion that they raised for the combination of Gallagher and Schofield. POR 41; Ex. 2023, ¶¶ 120-121. As I explained above, I disagree with the arguments raised regarding sensor fusion because the type of sensor fusion

involved in the combination was already proven at the time and would have been within the skill of a person of ordinary skill in the art to implement. The introduction of Frank's pulse-modulated light source and associated processing does not change my opinions. As I previously explained, sensor fusion techniques were already in use at this time. I personally used sensor fusion over a decade before the earliest claimed priority date based on data from a video camera and laser rangefinder. The type of processing involved in the combination of Gallagher, Schofield, and Frank was already known and would have been within the skill of a person of ordinary skill in the art to implement at the time.

52. I also disagree with Patent Owner's argument that Frank's laser radar is incompatible with Gallagher. POR 41-43. Patent Owner and Dr. Papanikolopoulos discuss the difference in the polling rates discussed in Frank and the sampling rate discussed in Gallagher. POR 42-43; Ex. 2023, ¶ 122. This would not have been an issue for a person of ordinary skill in the art. Setting the polling rate and sampling rate to align so that Gallagher's sensor array would sense the light pulses reflected back from the road markers would have been routine—certainly well within the skill of a person of ordinary skill. This is a simple matter of implementation details, not an issue of compatibility. Patent Owner and Dr. Papanikolopoulos also state that each photodiode in Gallagher's photodiode array covers “a wide portion of the field of view.” POR 41; Ex. 2023, ¶ 122.

Determining distance using an array with lower resolution would simply be less precise than an array with higher resolution, not incompatible. This is another matter of implementation details, as a person of ordinary skill in the art would have known how to pick the number of sensing elements needed for the particular application and the desired level of precision. Nothing in Gallagher limits the number of photodiodes to only 5 or 10. Other arrays like Schofield's were also well known and would have been compatible with Frank. Patent Owner and Dr. Papanikolopoulos also state that Frank's laser would increase the intensity measurements in Gallagher. This is not an issue of compatibility. Instead, a person of ordinary skill would have known to simply adjust the calibrations so that the calibration factors take the light source into account. This was contemplated by Gallagher, which discloses that "a wide variety of light sources can be suitable for this form of testing" and teaches how to calibrate the sensor data. Gallagher, [0037], [0058]-[0059].

VI. CONCLUSION

53. For the reasons set forth above as well as my first declaration, I stand by the opinions in my initial declaration that claims 1-16 would have been obvious.

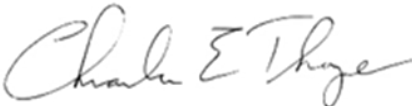
54. In signing this declaration, I understand that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be

subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

55. I declare that all statements made herein of my knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

56. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on this 15th day of September 2025.

By: 
Charles E. Thorpe