

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Koebler et al.

U.S. Patent No.: 10,850,616

Attorney Docket No. 49649-0021IP1

Issue Date: December 1, 2020

Appl. Serial No.: 15/693,899

Filing Date: September 1, 2017

Title: USING VEHICLE SYSTEMS TO GENERATE A ROUTE DATA-BASE

DECLARATION OF DR. VASSILIOS MORELLAS

I currently hold the opinions set expressed in this declaration. But my analysis may continue, and I may acquire additional information and/or attain supplemental insights that may result in added observations.

I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I further declare that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of the Title 18 of the United States Code.

Dated: 04/05/2024

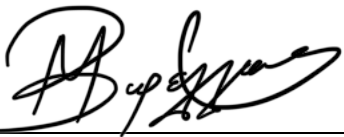
By: 
Vassilios Morellas

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I. QUALIFICATIONS AND BACKGROUND INFORMATION

1. My education and experience are described more fully in the attached curriculum vitae. For ease of reference, I have highlighted certain information below.

2. I am currently employed as a Research Professor of Electrical and Computer Engineering at the University of Minnesota, Twin Cities, Minnesota. I am currently also the Director of the National Science Foundation (“NSF”) Center on Robots & Sensors for Human Well Being at the University of Minnesota.

3. I believe that I am well qualified to serve as a technical expert in this matter based upon my educational and work experience.

4. I have been involved with the design and evaluation of computer vision systems, sensors, lasers for various automation tasks, for approximately 30 years. My academic research has been in the areas of computer vision, robotics, intelligent transportation systems, sensor networks, object recognition, and sensor-based control in transportation systems. I have also been involved in work since 1995 involving computer algorithms for vehicle tracking, camera calibration, inspection, object recognition, vehicle monitoring systems, and motion control devices. I have authored or co-authored a book and book chapters and numerous

peer-reviewed technical papers in these areas. My curriculum vitae details my degrees, employment history, teaching experience, publication list, scholarly accomplishments, professional contributions, grants, honors, and awards.

5. I received my Diploma of Engineering in Mechanical Engineering from the National Technical University of Athens in Greece in 1983. I obtained my Master of Science degree in Mechanical Engineering from the Columbia University in New York, New York in 1989. In 1995, I received my Ph.D. in Mechanical Engineering from the University of Minnesota. My research at the time was in robotics, computer vision and control, computer integrated manufacturing, and software engineering, and my Ph.D. thesis was titled “A Neuro-computational Mobile Robot Architecture for Mapping Localization and Navigation.” The work revolved around the use of neural networks and a suite of ultrasonic sensors to accomplish place recognition and autonomous navigation for a mobile robot.

6. After receiving my Doctorate degree, from 1995-1998, I was employed as a Research Associate at the Department of Mechanical Engineering at the University of Minnesota. My work as a research associate concerned autonomous driving of a tractor trailer using a combination of cameras, Differential Geographic Position Systems (DGPS), and magnetometers along with speed and steering control algorithms to achieve autonomous navigation. Autonomous driving of

this vehicle was successfully demonstrated at a testing facility of the Minnesota Department of Transportation (MnDOT).

7. Starting in 2003, and until 2014, I was an instructor at the Department of Mechanical Engineering at the University of Minnesota. As an instructor, I taught classes related to robotics and computer vision. I also conducted research and oversaw projects directed to camera-based security and surveillance. Network camera surveillance and tracking was field deployed at Philadelphia's train station.

8. From 2019 until the present, I have served as a Research Professor of Electrical and Computer Engineering at the University of Minnesota. While in this role, I have advised and mentored students related to image-based cancer recognition, precision agriculture automation, and vision-based techniques for early detection of autism spectrum disorders. I have mentored and advised student research related to Computer Vision, Artificial Intelligence, Algorithms and Data Structures, and Readings in Computational Vision. These cover a variety of topics that include 3D reconstruction, extraction of depth, inspection, tracking, light striping, lasers, structured light, structure from motion, occlusions, edge detection, and basic image processing. My academic research has continued in the fields of computer vision systems, sensors, and lasers, with primary specialties in robotics, intelligent transportation systems, and sensor-based control in transportation applications.

9. From 2006-2019, I was the Program Director of the Computer Science & Engineering of the University of Minnesota. While in this role, I continued research on various types of automation involving the integration of sensors of different modalities with electro-mechanical platforms.

10. I have received research grants for various projects involving computer vision as applied to the transportation industry, including the development of a camera-based solution to the Truck Parking Availability problem that uses 3D reconstruction of truck park stops.

11. In terms of my industrial experience, from 1998-2005, I was employed as a Principal Research Scientist, in the Advanced Technology Labs of Honeywell International Inc. From 2005-2006, I was employed as a Senior Principal Research Scientist, also in the Advanced Technology Labs of Honeywell. During my time at Honeywell, my work was primarily concerned with systems that enhanced security and surveillance. The pinnacle of this work was a demonstration of secure gate access of vehicles at a naval base, using a custom developed multi-spectrum camera and face recognition technologies.

12. From 2007-2014, I served as a Co-PI for the NSF Research Center on Safety, Security and Rescue at the University of Minnesota. While there, I was tasked with directing the University of Minnesota site research on various research

topics of interest to industrial partners that chose to join our center paying an annual fee.

13. From 2014 until the present, I have acted as the Director of the NSF center on Robots & Sensors for Human Well Being at the University of Minnesota. In this role, my work concerns organizing the center's activities attracting industrial financial support and directing research in intelligent transportation, medical research (cancer recognition, mental health disorders), precision agriculture, and robotics

14. I am listed as an inventor on numerous patents issued in the United States and foreign countries. My inventions concern technologies including computer and machine vision technologies. Examples of my issued U.S. patents include:

- US Pat. No. 9,858,816, titled "Determining Parking Space Occupancy Using a 3D Representation"
- US Pat. No. 7,907,750, titled "System and Method for Autonomous Object Tracking"
- US Pat. No. 7,602,942, titled "Infrared and Visible Fusion Face Recognition System"
- US Pat. No. 7,149,325, titled "Cooperative Camera Network"

- US Pat. No. 7,806,604, titled “Face Detection and Tracking in a Wide Field of View”
- US Pat. No. 7,606,425, titled “Unsupervised Learning of Events in a Video Sequence”

15. I have authored or co-authored over 130 articles or conference presentations, including numerous papers and presentations concerning computer or machine vision technologies. Of particular interest may be the following papers and presentations:

- Video Analytics for Security and Transportation Applications, Keynote talk at the 4th IEEE Computer Vision and Pattern Recognition Workshop on Object Tracking & Classification Beyond the Visible Spectrum (OTCBVS 2007), June 22, 2007
- Between the Lines: A Driver-Assistive Technology for Staying in the Lane, GPS World, Vol. 9, 1988
- Accurate 3D ground plane estimation from a single image, IEEE International Conference on Robotics and Automation, 2009

16. I have been actively involved in multiple technical communities, including the IEEE Society, and NSF Review panels. I have served in the organizing committee of many technical conferences, including, for example:

- Associate Editor, IEEE/RSJ International Conference on Intelligent Robots and Systems, 2019
- Technical Committee, 22nd International Conference on Pattern Recognition, ICPR 2014
- Program Area Chair, 5th IEEE International Conference on Advanced Video and Signal Based Surveillance, 2008

17. My research has been recognized by multiple organizations, universities, and institutions. The following is a small set of honors and awards that I have received:

- Center for Transportation Studies: CTS Research Partnership Award, 2016
- Best Student Paper Award, IEEE International Conference on Image Processing (ICIP), 2012
- Technical Achievement Award, for Technical Excellence in the area of “People Tracking in Camera Networks,” Highest Honorary Distinction from Automation and Control Solutions (ACS) of Honeywell International Inc., April 2003.

18. Overall, I have used my education, industry, teaching, writing, and membership and service experiences and my understanding of the knowledge, creativity, and experience of a person having ordinary skill in the art in forming the opinions.

19. My extensive experience in the transportation industry is applicable to analyzing the Asserted Patents.

20. I have been retained on behalf of Tesla, Inc. to offer technical opinions relating to U.S. Patent No. 10,850,616 (“the ’616 Patent”) and prior art references relating to its subject matter. I have reviewed the ’616 Patent, and relevant excerpts of the prosecution history of the ’616 Patent. I have also reviewed the following references:

- U.S. Patent No. 8,712,650 (“Koebler650”) (TESLA-1004)
- U.S. Pat. No. 11,065,977 (“Koebler977”) (TESLA-1005)
- U.S. Pat. No. 9,682,624 (“Koebler624”) (TESLA-1006)
- U.S. Pat. No. 8,972,162 (“Koebler162”) (TESLA-1007)
- U.S. Pat. No. 7,925,426 (“Koebler426”) (TESLA-1008)
- U.S. Pat. No. 7,516,011 (“Kabel”) (TESLA-1010)
- U.S. Pat. No. 7,148,648 (“Okano”) (TESLA-1011)
- U.S. Pat. No. 7,211,019 (“Kirkwood”) (TESLA-1012)
- U.S. Pat. No. 7,983,836 (“Breed”) (TESLA-1013)
- U.S. Pat. No. 7,752,188 (“Lagerstedt”) (TESLA-1014)
- U.S. Pat. No. 7,650,956 (“Hirata”) (TESLA-1015)
- U.S. Pat. No. 10,746,901 (“O’Brien”) (TESLA-1016)
- U.S. Pat. No. 10,703,162 (“Kanda”) (TESLA-1017)

- U.S. Pat. No. 5,848,378 (“Shelton”) (TESLA-1018)
- E.P. Pat. No. 3,475,729 (“Elkebetz”) (TESLA-1019)
- Wimmer A. & Schnessl E., “Effects of Humidity and Ambient Temperature on Engine Performance of Lean Burn Natural Gas Engines,” Proceedings of ICEF2006, ASME Combustion Engine Division 2006 Fall Technical Conference, Nov. 5-8, 2006, Sacramento, CA (“Wimmer”) (TESLA-1020)
- U.S. Pat. No. 6,505,123 (“Root”) (TESLA-1021)

21. I have also reviewed various supporting references and other documentation as further noted in my opinions below.

22. Counsel has informed me that I should consider these materials through the lens of one of ordinary skill in the art (POSITA) related to the ’616 Patent, and I have done so during my review. The ’616 patent was filed on September 1, 2017 and claims the benefit of priority from a series of applications that includes U.S. Patent No. 11,065,977 to Koebler (TESLA-1005), U.S. Patent No. 9,682,624 to Koebler (TESLA-1006), U.S. Patent No. 8,972,162 to Koebler (TESLA-1007), U.S. Patent No. 8,712,650 (TESLA-1004), and U.S. Pat. No. 7,925,426 to Koebler (TESLA-1008), with the ’426 patent having an earliest priority date of Nov. 17, 2005. TESLA-1001, cover. These documents are collected to referred to as the “Koebler-Priority-Documents” in this Declaration.

23. As explained in Section V.B below, the '616 patent is not entitled to the benefit of its priority claim, as the Koebler-Priority-Documents do not provide a sufficient written description demonstrating the patentee had possession of features recited in the Challenged Claims prior to the 9/1/2017 filing date.

24. I have no financial interest in the parties or in the outcome of this proceeding. I am being compensated for my work as an expert on an hourly basis. My compensation is not dependent on the outcome of these proceedings or the content of my opinions.

25. In writing this declaration, I have considered the following: my own knowledge and experience, including my work experience in the field of transportation systems; my experience in teaching those subjects; and my experience in working with others involved in those fields. In addition, I have analyzed various publications and materials, in addition to other materials I cite in my declaration.

26. My opinions, as explained below, are based on my education, experience, and expertise in the fields relating to the '616 Patent. Unless otherwise stated, my testimony below refers to the knowledge of one of ordinary skill in the art as of 9/1/2017, or before. Any figures that appear within this document have been prepared with the assistance of Counsel and reflect my understanding of the '616 Patent and the prior art discussed below.

I. OVERVIEW OF CONCLUSIONS FORMED

27. This declaration explains the conclusions that I have formed based on my analysis. To summarize those conclusions, based upon my knowledge and experience and my review of the prior art publications listed above, I believe that:

- Claims 1-16 are anticipated or rendered obvious by U.S. Pat. No. 8,712,650 to Koebler⁶⁵⁰; and
- Claims 1-16 are rendered obvious by Koebler⁶⁵⁰ in view of Kabel, Lagerstedt, Okano, Kirkwood, and Breed.

II. LEVEL OF ORDINARY SKILL IN THE ART

28. In my opinion, one of ordinary skill in the art relating to, and at the time of, the invention of the '616 patent would have had a bachelor's degree in electrical engineering, computer engineering, mechanical engineering, civil engineering (transportation systems), physics, or a related field, and at least four years of experience (or the academic equivalent) in the field of transportation systems.

29. Based on my experiences, I have a good understanding of the capabilities of one of ordinary skill. Indeed, I have taught, participated in organizations, and worked closely with many such persons over the course of my career. Based on my knowledge, skill, and experience, I have an understanding of the capabilities of one of ordinary skill. Furthermore, I possess those capabilities myself.

III. OVERVIEW OF THE '616 PATENT

A. The '616 Patent Family

30. The '616 Patent, titled "Using Vehicle Systems To Generate A Route Database" was filed on September 1, 2017, and issued as a U.S. Patent on 10,850,616. I understand that:

- the '616 Patent issued from U.S. Patent Application No. 15/693,899, and claims to be a continuation of U.S. Patent Application No. 15/626,676, filed on June 19, 2017, now U.S. Patent No. 11,065,977 (TESLA-1005);
- U.S. Patent No. 11,065,977 (TESLA-1005) is a continuation of U.S. Patent Application No. 14/566,848, filed on December 11, 2014, now U.S. Patent No. 9,862,624 (TESLA-1006);
- U.S. Patent No. 9,862,624 (TESLA-1006) is a continuation of U.S. Patent Application No. 14/206,138, filed on March 12, 2014, now U.S. Patent No. 8,972,162 (TESLA-1007);
- U.S. Patent No. 8,972,162 (TESLA-1007) is a continuation of U.S. Patent Application No. 13/066,189 filed on April 8, 2011, now U.S. Patent No. 8,712,650 (TESLA-1004);
- U.S. Patent No. 8,712,650 (TESLA-1004) is a continuation-in-part of U.S. Patent Application No. 11/283,137 filed November 17, 2005, now U.S. Pat. No. 7,925,426 (TESLA-1008)

B. Brief Description of the '616 Patent

31. Generally, the '616 patent purportedly provides “devices, systems, and methods for managing the power consumption of an automotive vehicle, and thereby optimizing the power consumption of the vehicle.” TESLA-1001, 2:19-22. The “devices and systems for managing the power consumption of the vehicle typically include power management logic that can calculate an applied power for the vehicle engine based on information provided from the external environment of the vehicle, the operational status of the vehicle, one or more command inputs from a driver, and one or more operational parameters of the vehicle.” TESLA-1001, 2:22-28.

32. The “information provided to the power management logic may come from data inputs (e.g., **sensors**, telemetries, etc.), memory, user commands, or it may be derived.” TESLA-1001, 2:28-31. The '616 patent explains that “[a]ny appropriate **sensors**, detectors or data inputs may be used with the power management devices and systems described herein.” TESLA-1001, 21:65-67. The “**sensors** for detecting external environmental information may be used (e.g., optical, mechanical, electrical, or magnetic sensors).” TESLA-1001, 21:67-22:2.

33. The '616 patent explains that these “[s]**sensors** may be monitored (e.g., polled) in real-time, as described above.” TESLA-1001, 22:2-3. In particular, the '616 patent explains that:

...polling logic may coordinate continuous or periodic polling of Global Positioning System (GPS) information (e.g., giving information on the vehicle's current location, current elevation, upcoming elevations, upcoming terrain, vehicle's destination, etc.), speedometer information (e.g., vehicle's current speed, motor speed), date and time information (e.g., the date and time may be used to determine personal driving habits and sun angle), gyroscope information (e.g., vehicle's current orientation, current slope/grade of road), RPM (e.g., motor and wheel rotations per minute), accelerator and brake pedal position (e.g., pressure applied and/or current angle of the pedals), the angle of sun (e.g., sensors may detect latitude, longitude, time of day, date), weather (e.g., wind direction and velocity, rain, sun, snow, etc.), battery state (e.g., voltage, amp hour meter, etc.), tire pressure (e.g., may be used to calculate the drag force due to rolling resistance), headway control information (e.g., the distance from a car in front of the vehicle), the weight of car (e.g., weight of cargo, passengers, driver), air-flow (e.g., the amount of air going to the engine), gas flow sensor (e.g., the amount of gas going to engine of a hybrid or ICE car), weight of driver (e.g., may be used identify the driver and linked to personal driving habits). Different detectors or **sensors** may be polled at different intervals, including continuously, or only occasionally. Polling may also depend upon the availability of a resource. For example, information may be available only when a telecommunications network (e.g., satellite, cellular, etc.) is available. TESLA-1001, 3-31; *see also* TESLA-1001, 8:43-62, 8:23-30, 8:43-62.

34. The '616 patent purports to process data from the aforementioned **sensors** or detectors in order to determine one or more **current conditions**. TESLA-1001, 2:22-31, 7:42-55. These **current conditions** can include:

... information about the external environment of the vehicle that is selected from the group consisting of: the current location of the vehicle, the elevation of the vehicle, upcoming elevations of the vehicle, the current slope/grade of the route, the predicted slope/grade of the next segments (or upcoming segments) of the route, speed limit information of the current route segment, speed limit information of upcoming route segments, the condition of the known or predicted route (or a portion thereof), traffic information or data, traffic surrounding the vehicle, the location of stoplights, the timing of stoplights, a map of the roadway, the present angle of the sun, the predicted angle of the sun for upcoming route segments, the weather around the vehicle, present wind direction, the predicted wind direction for upcoming route segments, present wind velocity, the predicted wind velocity for upcoming route segments, current temperature, the predicted temperature for upcoming route segments, current air pressure, predicted air pressure for upcoming route segments, time of day, date, day of week, visibility, present road conditions, predicted road conditions for upcoming route segments, and the distance to/from other vehicles.

TESLA-1001, 3:43-66.

35. Though the '616 patent describes obtaining certain types of **sensor data** from certain types of **sensors** (e.g., TESLA-1001, 3-31, 8:43-62, 8:23-30, 8:43-62) and determining certain types of **conditions** from the obtained sensor data

(e.g., TESLA-1001, 3:43-66), the '616 patent also explains that “in some variations, the power management system receives some of this information by telemetry with off-board information sources such as databases and the like.” TESLA-1001, 8:29-35. “For example, the power management system may communicate with a weather service, a map service, a traffic service, etc.” *Id.*

C. Prosecution History of the '616 Patent

36. During prosecution, claims 1-19 were first filed as original claims of the '616 patent. TESLA-1002, 258-62. The Examiner rejected claims 1-19 as being anticipated by U.S. Pat. No. 6,169,495 to Koike in a first office action having notification date of Jan. 2, 2019.

37. In response to this first office action, applicant amended the claims to recite that the “current conditions associated with said route segment are uploaded to said remote database to *create* historical route information” and argued that Koike does not teach these claim features. (emphasis added). TESLA-1002, 108-16.

38. The Examiner disagreed and pointed out, for example, that Koike provides a remote Vehicle Information and Communications System (VICS). TESLA-1002, 97-103. Applicant clarified and reiterated the arguments from the previous response in more detail regarding the remote creation of historical route information. *Id.*, 69-87.

39. The Examiner was not persuaded by these arguments and discussed proposed amendments with the Patent Owner during an examiner interview. TESLA-1002, 64. After the interview, applicant authorized an Examiner's amendment that led to the claims being amended into the form of the challenged claims. TESLA-1002, 28-34. These claims were then allowed. TESLA-1002, 23.

D. Claim Construction

40. I understand that when considering the meaning of claims subject to *inter partes* review, one must consider the claim language. I understand that claim terms are generally given their plain and ordinary meaning, as would be understood by a POSITA in the context of the specification, the prosecution history, and other claims. I have applied the above principles in forming my opinions provided in this declaration.

41. I also understand that formal claim constructions should be entered only to the extent necessary to resolve a controversy. Given this understanding, in my opinion, besides the claim terms discussed below, form claim constructions are not required for any other claim term of the '616 patent. As discussed below, the independent claims of the '616 patent each require analyzing *sensor data samples*¹ to determine 21 enumerated *current conditions* (e.g., *moisture*) ("Enumerated

¹ Claim terms are bolded and italicized throughout.

Current Conditions”). The *sensor data samples* are collected from 13 enumerated *sensor[s]* (e.g., *optical sensor*) (“Enumerated Sensors”).

1. Relevant Limitations

(a) *Interface* Configuration (Claims 1, 15)

42. Claims 1 and 15 include limitations ([1a-1], [1a-2], [15c-1], [15-2]) that recite a configuration of an *interface* that *receive[s] (i) sensor data samples during operation of a vehicle*. TESLA-1001, 27:33-36, 28:48-49. The *sensor data samples* recited in these limitations are later referenced in a first “wherein” clause of claims 1 and 15 ([1d], [15f]), which further requires that the *sensor data samples are received from at least one of* the Enumerated Sensors. Through antecedent basis, the wherein clause further limits the *interface* by requiring reception of *sensor data samples* that are *received from at least one of* several sensors enumerated in [1d] and [15f]. TESLA-1001, 27:33-56, 28:45-29:4.

43. The *interface* configuration for *receiving (i) sensor data samples during operation of a vehicle* should be construed to encompass “receiving sensor data samples from at least one of the sensors enumerated in [[1d]/[15f]] during operation of a vehicle.”

(b) *Memory/Storage Device* Configuration (Claims 1, 15)

44. Claims 1 and 15 include limitations ([1b], [15d]) that recite a configuration of a *memory /storage device* that *store[s] (a) said sensor data samples for*

different points in time along a route segment travelled by said vehicle. TESLA-1001, 27:37-39, 28:48-49. Through antecedent basis, the use of said sensor data samples in these limitations ([1b], [15d]) references the requirements of sensor data samples in the first “wherein” clause of claims 1 and 15 ([1d], [15f]), which further requires that the sensor data samples are received from at least one of the Enumerated Sensors. TESLA-1001, 27:50-56, 28:65-29:4.

45. The *memory/storage device* configuration for *stor[ing] (a) said sensor data samples for different points in time along a route segment travelled by said vehicle* should be construed to encompass “storing sensor data samples, received via the interface, from at least one of the sensors enumerated in [[1d]/[15f]] for different points in time along a route segment travelled by said vehicle.”

(c) **Processor** Configuration (Claims 1, 15)

46. Claims 1 and 15 include limitations ([1c-1], [15e-1]) that recite a configuration of a *processor* that *analyze[s] said sensor data samples stored in said [memory/said storage device] to determine current conditions.* TESLA-1001, 27:41-43, 28:56-58. As discussed above for the *interface* and *memory* limitations, the reference to *sensor data samples* in several other limitations collectively require the *sensor data samples* to be (1) received via the *interface... during operation of a vehicle* (per [1a-1], [15c-1]), (2) received *from at least one of* several sensors enumerated in [1d] and [15f], and (3) *store[d]...for different points in time*

along a route segment travelled by said vehicle (per [1b], [15d]). Because the *processor* is recited to *analyze* the *sensor data samples*, the *processor* configuration of [1c-1]/[15e-1] subsumes these three requirements.

47. The *processor* configuration for *analyz[ing] said sensor data samples stored in said [memory/said storage device] to determine current conditions* should be construed to encompass “analyzing sensor data samples to determine at least one of the current conditions enumerated in [1e], where the sensor data samples are: (1) received via the interface during operation of a vehicle, (2) received from at least one of several sensors enumerated in [[1d]/[15f]], and (3) stored for different points in time along a route segment travelled by said vehicle.”

(d) **Monitoring** Step (Claim 16)

48. Claim 16 includes a limitation ([16a]) that recites the step of *monitoring a plurality of sensors to generate sensor data during operation of a vehicle*. TESLA-1001, 29:16-17. Limitation [16a] further recites that the *plurality of sensors comprises at least one of* the Enumerated Sensors. Because the *plurality of sensors* are *monitor[ed]* to *generate sensor data during operation of a vehicle*, the *monitoring* is limited by the *plurality of sensors*.

49. The *monitoring* step should be construed to encompass “monitoring a plurality of sensors that comprise *at least one of* the sensors enumerated in [16a].”

(e) **Analyzing** Step (Claim 16)

50. Claim 16 includes a limitation ([16e]) that recites the step of *analyzing said sensor data to determine current conditions*. TESLA-1001, 30:6-7.

Through antecedent basis, the use of *said sensor data* in [16e] references the requirements of *sensor data* in [16a], i.e., that the *sensor data* is *generate[d]* by a *plurality of sensors comprises at least one of* the several sensors enumerated in [16a]. TESLA-1001, 30:6-7, 29:16-24.

51. The *analyzing* step should be construed to encompass “analyzing sensor data generated by monitoring *at least one of* the sensors enumerated in [16a] to determine *at least one of* the current conditions enumerated in [16e].” Because this configuration interrelates *current conditions* and *sensor data samples*, the *at least one of* twenty-one enumerated *current conditions* ([16e]) are required to be determined based on analyzing *sensor data samples* from the *at least one of* the Enumerated Sensors ([16a]).

2. *At least One Of...And* (Claims 1, 15, 16)

52. Claims 1, 15, and 16 include the phrase *at least one of . . . and* in two limitations: (1) *sensor data samples are received from at least one of* 13 Enumerated Sensors ([1d], [15f], [16a]),² and (2) that *current conditions comprise at least*

² Claim 16 includes a similar limitation ([16a]), which recites a *plurality of sensors comprise at least one of* the same sensors enumerated in [1d] and [15f].

one of 21 enumerated current conditions ([1e], [15g], [16e]). The *at least*

one...and phrase is included in two claim limitations and the same interpretation should be applied to each limitation.

Enumerated Sensors	Enumerated Current Conditions
<i>optical sensor</i>	<i>drag</i>
<i>position sensor</i>	<i>wind resistance</i>
<i>speed sensor</i>	<i>tire resistance</i>
<i>gyroscopic sensor</i>	<i>location relative to a destination</i>
<i>revolutions-per-minute sensor</i>	<i>traffic patterns</i>
<i>accelerator pedal position sensor</i>	<i>amount of light energy</i>
<i>brake pedal position sensor</i>	<i>position of the sun</i>
<i>battery state sensor</i>	<i>geographical information</i>
<i>tire pressure sensor</i>	<i>elevation of said vehicle</i>
<i>proximity sensor</i>	<i>grade of a road</i>
<i>weight sensor</i>	<i>location of stoplights</i>
<i>airflow sensor</i>	<i>timing of stoplights</i>
<i>gas flow sensor</i>	<i>weather</i>
	<i>wind direction</i>
	<i>wind velocity</i>
	<i>temperature</i>

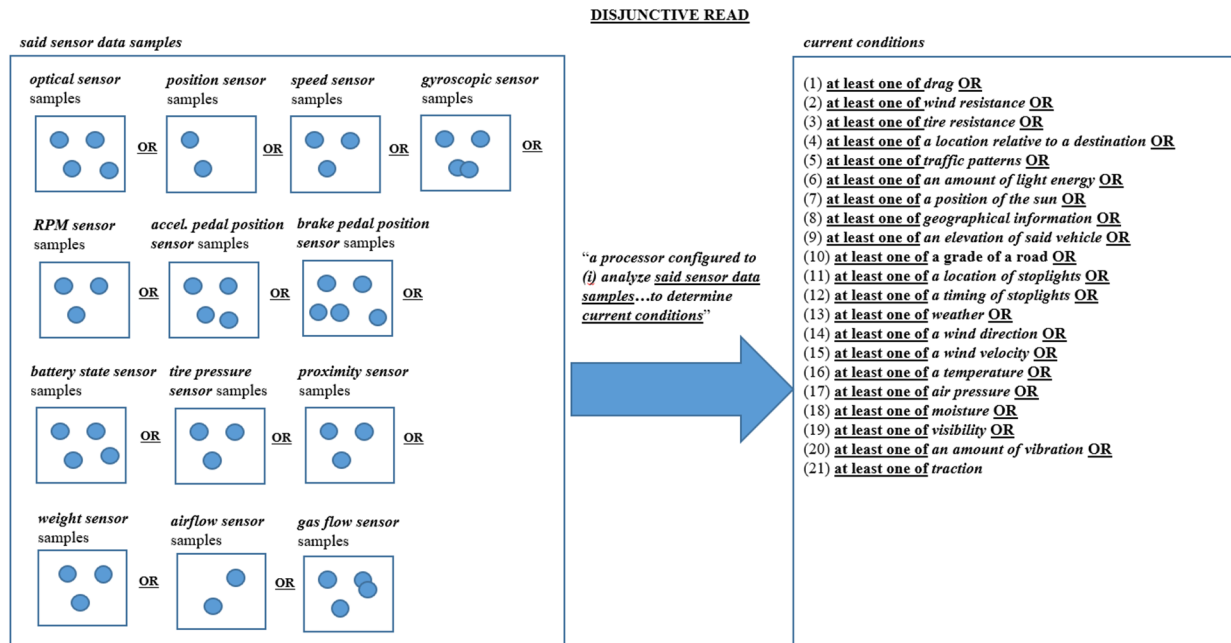
	<i>air pressure</i> <i>moisture</i> <i>visibility</i> <i>amount of vibration</i> <i>traction</i>
--	--

53. I understand from Counsel that, under the plain and ordinary meaning, the phrase at least one of...and” is a conjunctive list, but left open the possibility that its claim scope could be enlarged based on the prosecution history.

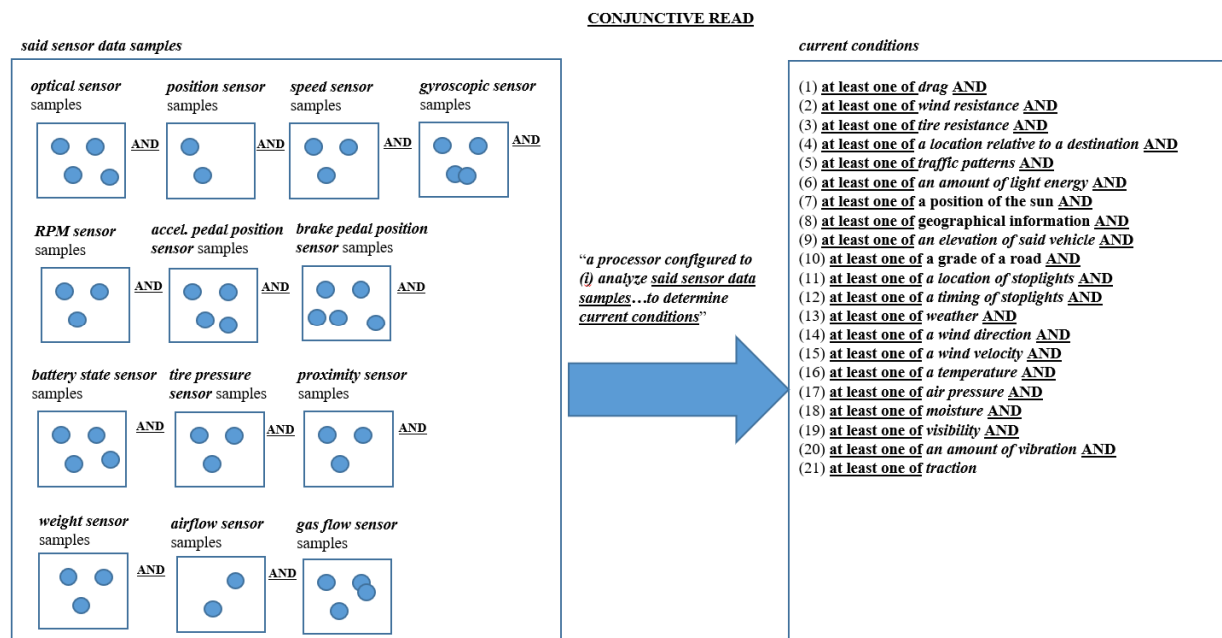
54. Under a *conjunctive read* of the *at least one...and* phrases, the relevant limitations would require all of the sensors recited in the limitation (e.g., thirteen sensors, twenty-one current conditions). Under a *disjunctive read* of the phrase, the limitations would only require one of the sensors recited in each of the two limitations. Further, because each of the independent claims include limitations interrelating *current conditions* and *sensor data samples/sensor data*,³ Enumerated Current Conditions are required to be determined based on analyzing *sensor data samples* from the Enumerated Sensors.

³ For claims 1 and 15, this limitation is the *processor* limitation ([1c-1], [15e-1]). For claim 16, the corresponding limitation is [16e], which recites the *analyzing* step.

55. A visualization of the relationship under the disjunctive read is shown below:



56. In contrast, a visualization of this relationship under the conjunctive read is shown below:



As shown above, the interpretation of the *at least one...and* phrases in the relevant limitations of claims 1, 15, and 16 meaningfully impacts claim scope and the availability of prior art. As explained in Section VI, because the asserted prior art in this Petition satisfies the Challenged Claims under *both* disjunctive and conjunctive constructions, no formal claim construction of the *at least one...and* phrases is required.

IV. THE 'PATENT IS NOT ENTITLED TO ITS EARLIEST CLAIMED PRIORITY DATE

A. Legal Standard

57. Counsel has explained to me that in order for the '616 patent to get the benefit of a claimed priority date, one skilled in the art, reading the original disclosure, must immediately discern the limitation at issue in the claims. In addition, Counsel has explained to me that entitlement to a filing date extends only to the subject matter that is disclosed; not to that which is obvious. The parent application must actually or inherently disclose the elements of the later-filed claims.

B. Analysis

58. I have reviewed the Koebler-Priority-Documents, and the original claims of each application as filed. Based on this review, the text of the Challenged Claims was not included in the text of original claims of any priority application. Furthermore, based on this review, the text of the Challenged Claims was not included anywhere in the Koebler-Priority-Documents.

59. Instead, my review of the Koebler-Priority-Documents, their respective prosecution histories, the '616 patent, and the prosecution history of the '616 patent indicates that the text of the challenged claims was first filed on September 1, 2017 when US. Patent Application No. 15/693,899 (which eventually issued as the '616 patent) was filed. TESLA-1002, 268. This September 1, 2017 filing date is almost 6 years after the earliest priority date claimed by the '616 Patent and over 3 years after the publication date of Koebler650.

60. Amongst the twenty-one Enumerated Current Conditions, Koebler650 fails to provide sufficient written description support for determination of the following ten *current conditions* based on analyzing *sensor data samples* received from at least one of thirteen enumerated sensors, as required by the claim language (see Section III.D.1).

61. As shown below, the Enumerated Current Conditions therefore include 11 current conditions that are supported by Koebler650 ("Supported Current Conditions") and 10 current conditions that are not supported by Koebler650 ("Unsupported Current Conditions"):

Supported Current Conditions	Unsupported Current Conditions
------------------------------	--------------------------------

<i>drag</i>	<i>location of stoplights</i>
<i>visibility</i>	<i>timing of stoplights</i>
<i>wind resistance</i>	<i>weather</i>
<i>tire resistance</i>	<i>wind direction</i>
<i>location relative to a destination</i>	<i>wind velocity</i>
<i>traffic patterns</i>	<i>temperature</i>
<i>amount of light energy</i>	<i>air pressure</i>
<i>position of the sun</i>	<i>moisture</i>
<i>geographical information</i>	<i>amount of vibration</i>
<i>elevation of said vehicle</i>	<i>traction</i>
<i>grade of a road</i>	

Amongst the Unsupported Current Conditions, Koebler650 does not mention *mois-
ture, amount of vibration*, and *traction*. Koebler650 also does not describe how
these current conditions are determined in the context of its contemplated vehicle
system. As to the seven other conditions, Koebler650 does not disclose how these
conditions are specifically determined based on *sensor data samples* collected by
at least one of the Enumerated Sensors.

62. Koebler650 also fails to provide sufficient written description support for the Challenged Claims regardless of whether a disjunctive or conjunctive read is applied to the limitations reciting the phrase *at least one...and*. See Section III.D.2. Each of the independent claims affirmatively recites determination of twenty-one enumerated *current condition* features. My understanding is that sufficient written description support not only requires disclosure of each of these enumerated conditions, but also requires disclosure of *how each* of these enumerated conditions is specifically determined in the manner recited in the claims, i.e., by analyzing *sensor data samples* received from at least one of the thirteen enumerated sensors.

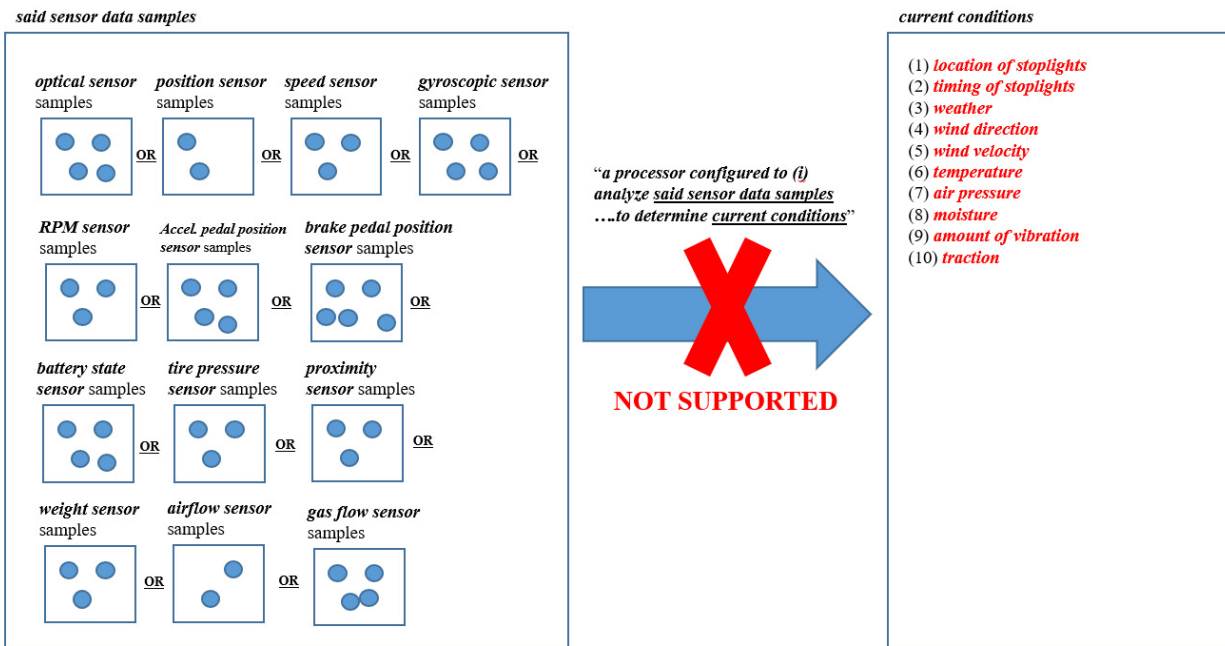
63. Based on the above, the Koebler-Priority-Documents do not provide a written description that shows the patentee had possession of the Challenged Claims prior to the filing of the '616 patent. I understand that, as a consequence of failing to provide such a written description, the '616 patent cannot claim the benefit of the Koebler-Priority-Documents and the priority claim to the Koebler-Priority-Documents is broken. The Koebler-Priority-Documents include Koebler650, which is published more than one year before the '616 patent. I understand that a finding that the Koebler-Priority-Documents do not provide written description

support for the Challenged Claims then involves assessing whether Koebler650 anticipates, or otherwise renders obvious, the Challenged Claims.⁴

64. As explained in Section III.D.1, through antecedent basis, the *current conditions* recited in claims 1 and 15 are required to be determined from *sensor data samples* received *from at least one of* the Enumerated Sensors. As to claim 16, the *current conditions* are required to be determined from *sensor data* collected generated by *a plurality of sensors* comprised of the Enumerated Sensors. Limitations [1d], [15f], and [16a] each list the same Enumerated Sensors, and thus, for simplicity, the analysis below addresses the requirements of *current conditions* in relation to *sensor data samples* (though the same principles apply to a *plurality*

⁴ In this Declaration, I explain that none of the Koebler-Priority-Documents include a written description that shows Patent Owner had possession of the Challenged Claims. However, this Declaration only cites to Koebler650 as prior art that anticipates, or otherwise renders obvious, the challenged claims. I understand that citation to Koebler650, alone, is sufficient, as without the benefit of a priority claim to *any* of the Koebler Priority Documents, the Koebler650 has a publication date of April 29, 2014 and the earliest priority date of the '616 patent is September 1, 2017. I also understand that Koebler650 qualifies as prior art under 35 U.S.C. 102(a)(1).

of sensors). Below is a visualization of the requirements imposed on the **current conditions** based on the limitations of claims 1, 15, and 16 discussed in Section III.D.1:



As explained in Section III.D.1, because each of the independent claims include limitations interrelating **current conditions and sensor data samples/sensor data**, twenty-one Enumerated Current Conditions (in [1e], [15g], [16e]) are to be determined from sensor data samples from thirteen Enumerated Sensors (in [1d], [15f], [16a]). As described in Section V.B(b) below, the Koebler-Priority-Documents fail to provide sufficient written description for various of the Enumerated Current Conditions, including **moisture**, **amount of vibration**, and **traction** due to lack of express and implicit disclosure of these conditions being determined from any of the thirteen Enumerated Sensors.

1. Disclosure Of Enumerated Sensors in Koebler650⁵

65. As explained below, Koebler650 expressly discloses each of the Enumerated Sensors.

(i) *Optical Sensor*

66. As described in Koebler650, “[t]he power management logic may determine an applied power for the vehicle engine based on command input information.” TESLA-1004, 4:19-21. Further, “[a]ny of this [command input information] may be acquired by...sensor[s] (e.g., optical detectors, etc.).” *Id.* Sensors, such as optical sensors, can also be used to “detect[] external environmental information,” (*id.*, 4:25-30) such as “intensity of sunlight, visibility, distance from nearby vehicles, etc.” (*id.*, 8:12-31). *See id.*, 21:29-62.

(ii) *Position Sensor*

67. The phrase “position sensor” does not appear in Koebler650, though the description addresses aspects of determining the position of a vehicle. TESLA-1004, 11:20-23, 13:41-45, 13:59-63, 14:1-23, 17:52-56, 21:33-39. Specifically, a

⁵ Because the specification of Koebler650 is identical to that of each of the other documents in the Koebler-Priority-Documents, the discussion of the disclosure of Koebler650 in this section is applicable to all documents in the Koebler-Priority-Documents. *See* TESLA-1004, TESLA-1005, TESLA-1006, TESLA-1007, TESLA-1008.

Global Positioning System (GPS) can be used to indicate “the current position of the vehicle.” *Id.*, 7:32-44, 13:41-45, 17:52-56, 21:29-62.

(iii) ***Speed Sensor***

68. The phrase “speed sensor” does not appear in Koebler650, though the description addresses aspects of determining the speed of a vehicle. TESLA-1004, 3:41-67, 4:1-18, 8:41-51, 11:64-12:3, 19:47-20:6, 21:29-62 (non-exhaustive list, as “speed” appears approx. 229 times in, e.g., Koebler650). For example, a “speedometer” can be used to provide “speedometer information” such as, “e.g., vehicle’s current speed, motor speed.” *Id.*, 21:39-40.

(iv) ***Gyroscopic Sensor***

69. The phrase “gyroscopic sensor” does not appear in Koebler650, though the description states, “sensors may be monitored (e.g., polled) in real-time” and the use of “polling logic [that] may coordinate continuous or periodic polling of ... gyroscope information.” TESLA-1004, 21:29-62. Examples of “gyroscope information” include a “vehicle’s current orientation” and “current slope/grade of road.” *Id.*

(v) ***Revolutions-Per-Minute Sensor***

70. The phrase “revolutions-per-minute sensor” does not appear in Koebler650, though the description states that “sensors may be monitored (e.g., polled) in real-time” and the use of “polling logic [that] may coordinate continuous or periodic polling of ... RPM (e.g., motor and wheel rotations per minute).”

TESLA-1004, 21:29-62. Examples of “RPM” include a “motor ... rotations per minute” and “wheel rotations per minute.” *Id*; *see also id.*, 4:1-18, 8:12-31, 8:41-51.

(vi) ***Accelerator Position Sensor***

71. The phrase “accelerator pedal position sensor” does not appear in Koebler650, though the description states that “sensors may be monitored (e.g., polled) in real-time” and the use of “polling logic [that] may coordinate continuous or periodic polling of ... accelerator ... pedal position.” TESLA-1004, 21:29-62. Examples of “accelerator ... pedal position” include a “pressure applied” and/or “current angle of the petals *[sic]*.” *Id.*

(vii) ***Brake Pedal Position Sensor***

72. The phrase “brake pedal position sensor” does not appear in Koebler650, though the description states that “sensors may be monitored (e.g., polled) in real-time” and the use of “polling logic [that] may coordinate continuous or periodic polling of ... brake pedal position.” TESLA-1004, 21:29-62. Examples of “break *[sic]* pedal position” include a “pressure applied” and/or “current angle of the petals *[sic]*.” *Id.*

(viii) ***Battery State Sensor***

73. The phrase “battery state sensor” does not appear in Koebler650, though the description states that “sensors may be monitored (e.g., polled) in real-time” and the use of “polling logic [that] may coordinate continuous or periodic

polling of ... battery state.” TESLA-1004, 21:29-62. Examples of “battery state” include a “voltage” and/or “amp hour meter.” *Id.*, 8:41-51.

(ix) ***Tire Pressure Sensor***

74. Koebler650 references “tire pressure sensor” by name, and explains that “if the tire pressure sensor notices that the tire pressure is low, a message to that effect will be displayed to the user.” TESLA-1004, 22:29-62. Further, “sensors may be monitored (e.g., polled) in real-time” and the use of “polling logic [that] may coordinate continuous or periodic polling of ... tire pressure.” *Id.* Additionally, polled “tire pressure ... may be used to calculate the drag force due to rolling resistance.” *Id.*

(x) ***Proximity Sensor***

75. The phrase “proximity sensor” does not appear in Koebler650, and the term “proximity” appears only once. TESLA, 1004, 23:19-30. As for “proximity,” the Koebler650 states that, in some variations, the headway cruise control detects the proximity of other vehicles or obstacles in the road ahead.” *Id.*; *see id.*, 7:32-44, 8:41-51, 22:29-62.

(xi) ***Weight Sensor***

76. Koebler650 discloses a “weight sensor,” and explains that “the power management device or system may include one or more weight sensors (to determine the load in the vehicle, including the driver’s weight). TESLA-1004, 8:61-64. Further, “sensors may be monitored (e.g., polled) in real-time” and the use of

“polling logic [that] may coordinate continuous or periodic polling of ... the weight of the car ... [or] weight of the driver.” *Id.*, 21:29-62. Additionally, the polled “weight of the car” may include “weight of cargo, passengers, [and/or] drivers” whereas the polled “weight of the driver” “may be used to “identify the driver and linked to personal driving habits.” *Id.*; *see id.*, 4:1-18, 8:41-51.

(xii) *Airflow Sensor*

77. The phrase “airflow sensor” does not appear in Koebler650, though the description states that “sensors may be monitored (e.g., polled) in real-time” and the use of “polling logic [that] may coordinate continuous or periodic polling of ... airflow.” TESLA-1004, 21:29-62. An example of “airflow” is “the amount of air going to the engine.” *Id.*

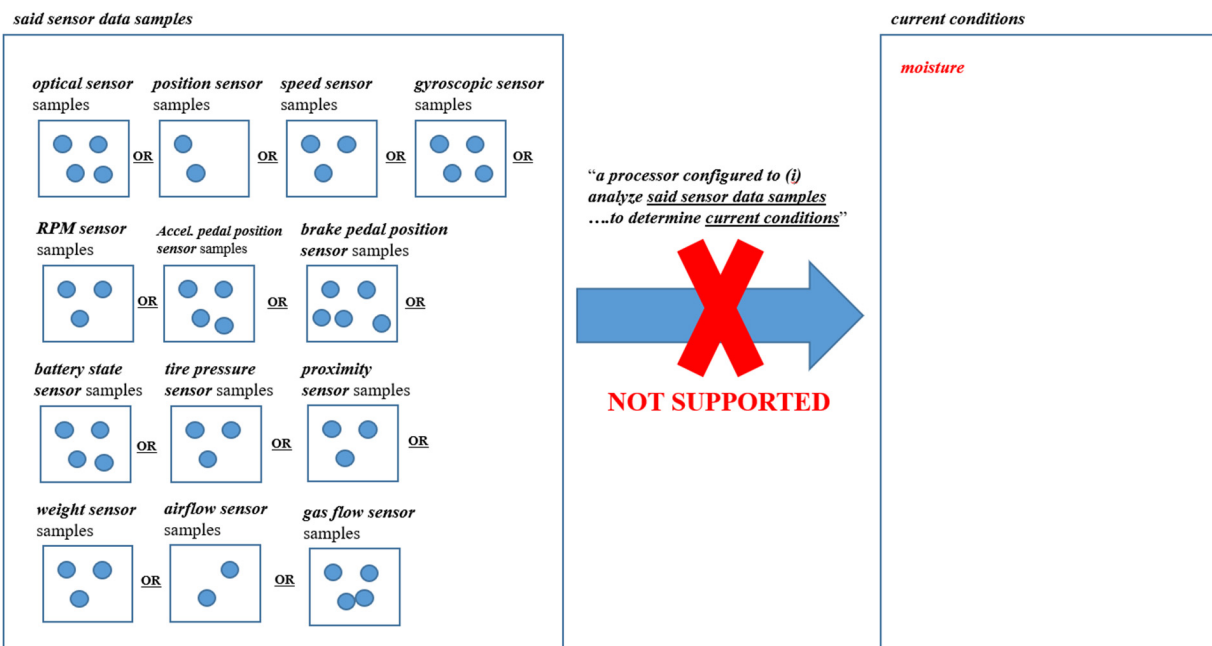
(xiii) *Gas Flow Sensor*

78. Koebler650 describes a “gas flow sensor,” and describes that “sensors may be monitored (e.g., polled) in real-time” and the use of “polling logic [that] may coordinate continuous or periodic polling of ... gas flow sensor.” TESLA-1004, 21:29-62. An example of “gas flow” includes a “the amount of gas going to [the] engine of a hybrid or ICE car.” *Id.*

2. Lack of Written Description Support

(i) *Moisture*

79. The word “moisture” is absent in Koebler650. TESLA-1004. Nothing in Koebler650, when read by a POSITA, would have caused the POSITA to immediately discern that the patentee had possession of a processor that *analyzes* the *sensor data samples* of the Enumerated Sensors to determine *moisture*. As shown below, there is no teaching or suggestion in Koebler650 that data collected by the Enumerated Sensors (i.e., any one of them under a disjunctive read or all of them under a conjunctive read) to determine *moisture* for the vehicle. A disjunctive read of the Enumerated Sensors, which is the most generous read with respect to claim support, is illustrated below.



80. Specifically, nothing in Koebler650 provides sufficient written description of a processor that *analyzes sensor data samples/sensor data* received from, or generated by, monitoring at least one of the Enumerated Sensors (i.e., any

one of them under a disjunctive read or all of them under a conjunctive read) to determine *moisture*. While the '616 patent describes configurations of a “power management system may communicate with a weather service,” it fails to describe the type of weather service, the type of information provided by the weather service, and how that information is received by the vehicle. APPLE-1001, 8:23-35.

81. There is also no inherent disclosure in Koebler650 that data collected by the Enumerated Sensors is used to determine *moisture*. For example, instead of using one or more of these sensors, a POSITA would have understood that *moisture* could have been determined, for example, by analyzing sensor data samples that are received from a moisture sensor (or sensor data generated by a moisture sensor). But a moisture sensor is not one of the Enumerated Sensors.

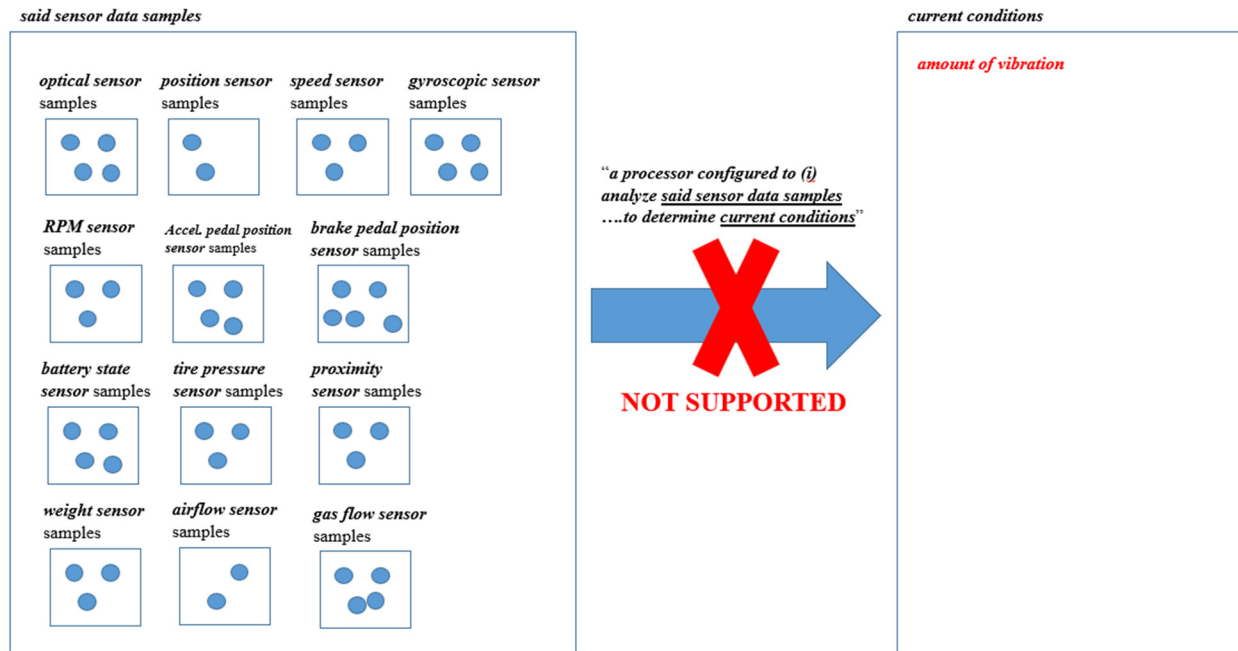
82. The '616 patent's disclosures of receiving weather information, e.g., from “weather sensors” or a “weather service,” also do not inherently disclose determining *moisture*. TESLA-1001, 8:23-35. In particular, the Enumerated Sensors ([1e], [15g], [16e]) do not include “weather sensors” or “moisture sensors.” Regarding “weather service,” it is not inherent for a weather service to provide moisture information, i.e., humidity information, to a recipient device. Indeed, as discussed in Section V.B.1(a), Kabel describes an example of a weather service that provides real-time weather information that does not include moisture information. See TESLA-1010, 3:39-44.

83. It is also not inherent for a weather service to provide weather information based on analyzing sensor data samples received from or generated by monitoring *at least one of* the Enumerated Sensors, such as, for example, the *position sensor*. Indeed, in some configurations of weather services, weather information for a geographic region is broadcast without the weather service or the vehicle tailoring the information based on a position of the vehicle detected by the vehicle's position sensor. *Id.*; TESLA-1018, 3:44-4:4. For example, radio broadcasters in a geographic region may broadcast weather information generated by a national weather service, which is received by those vehicles in the geographic region and positioned to receive the broadcast regardless of whether the vehicles have a position sensor. TESLA-1021, 1:31-39. It is not inherent for a weather service to provide moisture information, i.e., humidity information, to a recipient device, much less do so based on analyzing sensor data samples received from or generated by monitoring *at least one of* the Enumerated Sensors.

(ii) *Amount of Vibration*

84. The word "vibration" does not appear in Koebler650. TESLA-1004. Nothing in Koebler650, when read by a POSITA, would have caused the POSITA to immediately discern that the patentee had possession of a processor that *analyzes* the *sensor data samples* of the Enumerated Sensors to determine *amount of vibration*. As shown below, there is no teaching or suggestion in Koebler650 that

data collected by the Enumerated Sensors (i.e., any one of them under a disjunctive read or all of them under a conjunctive read) are used to determine *amount of vibration* for the vehicle. A disjunctive read of the Enumerated Sensors, which is the most generous read with respect to claim support, is illustrated below.

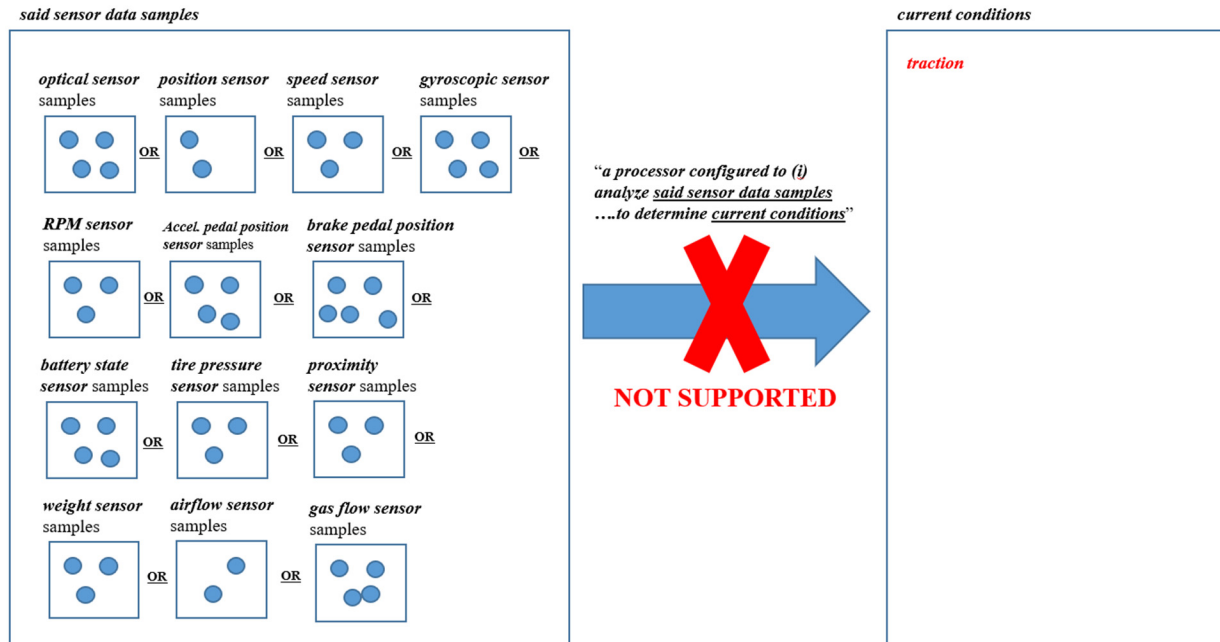


85. Specifically, nothing in Koebler650 provides sufficient written description of a processor that *analyzes sensor data samples/sensor data* received from, or generated by, monitoring at least one of the Enumerated Sensors (i.e., any one of them under a disjunctive read or all of them under a conjunctive read) to determine *amount of vibration*. For example, there is no disclosure of analyzing sensor data samples collected by a rotational speed sensor to determine the amount of vibration associated with the detection of wheel slippage.

86. There is also no inherent disclosure in Koebler650 that data collected by the Enumerated Sensors is used to determine ***amount of vibration***. For example, instead of using one or more of these sensors, a POSITA would have ***amount of vibration*** could have been determined, for example, by analyzing sensor data samples received from a vibration sensor and/or accelerometer (or sensor data generated by a vibration sensor and/or an accelerometer). But a vibration sensor and an accelerometer are not one of the Enumerated Sensors.

(iii) ***Traction***

87. The word “traction” does not appear in Koebler650. TESLA-1004. Nothing in Koebler650, when read by a POSITA, would have caused the POSITA to immediately discern that the patentee had possession of a processor that ***analyzes*** the ***sensor data samples*** of the Enumerated Sensors to determine ***traction***. As shown below, there is no teaching or suggestion in Koebler650 that data collected by Enumerated Sensors ((.e., any one of them under a disjunctive read or all of them under a conjunctive read) to determine ***traction*** for the vehicle. A disjunctive read of the Enumerated Sensors, which is the most generous read with respect to claim support, is illustrated below.



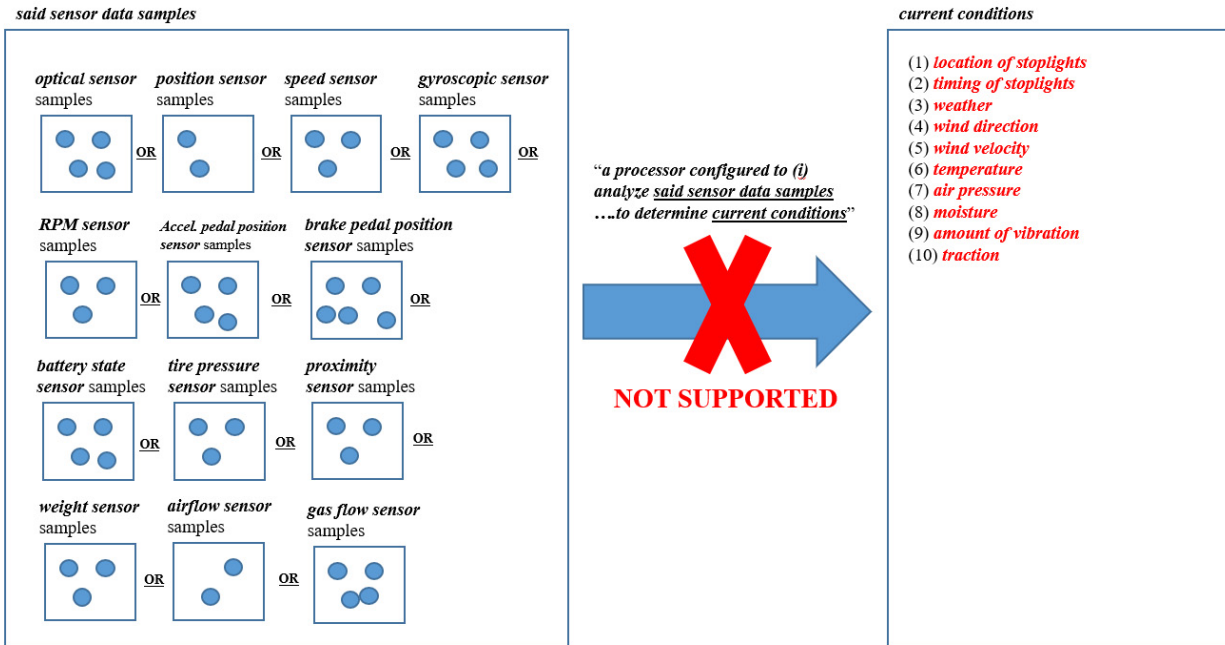
88. Specifically, nothing in Koebler650 provides sufficient written description of a processor that *analyzes sensor data samples/sensor data* received from, or generated by, monitoring at least one of the Enumerated Sensors (i.e., any one of them under a disjunctive read or all of them under a conjunctive read) to determine *traction*. For example, there is no disclosure of analyzing sensor data samples collected by a rotational speed sensor to determine traction associated with the detection of wheel slippage.

89. There is also no inherent disclosure in Koebler650 that data collected by the Enumerated Sensors is used to determine *traction*. For example, instead of using one or more of these sensors, a POSITA would have understood that *traction*

could have been determined, for example, by analyzing sensor data samples received from a friction sensor (or sensor data generated by a friction sensor). But a friction sensor is not one of the Enumerated Sensors.

(iv) Other Unsupported Current Conditions

90. Beyond those features identified above, Koebler650 also fails to provide sufficient written description of analyzing *sensor data samples/sensor data* received from, or generated by, monitoring at least one of the Enumerated Sensors (i.e., any one of them under a disjunctive read or all of them under a conjunctive read) to determine *temperature, weather, wind direction, wind velocity, air pressure, location of stoplights*, and *timing of stoplights*. As shown in the figure below, there is no teaching or suggestion in Koebler650 that data collected by the Enumerated Sensors are used to determine these *current conditions*. A disjunctive read of the Enumerated Sensors, which is the most generous read with respect to claim support, is illustrated below, which shows the ten Unsupported Current Conditions.



91. There is also no inherent disclosure in Koebler650 that data collected by the Enumerated Sensors is used to determine these *current conditions*. Indeed, as explained in Section V.B.3, the prior art applied in this petition renders obvious sensors not specifically disclosed in Koebler650. *See generally* TESLA-1004.

V. THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. Ground 1: Claims 1-16 are anticipated and/or rendered obvious by Koebler650

1. Overview of Koebler650

92. Koebler650 and the '616 patent share the same specification. In Koebler650, a vehicle has a "power management device" that uses "historical route information" to determine a "probable optimal speed" for a "route segment," e.g., a traveling vehicle speed that optimizes fuel efficiency along the route segment.

TESLA-1004, 16:65-17:17, 17:30-18:56, FIG. 5. In determining the probable optimal speed, the power management device accesses database records with historical route information for a particular route segment that further specify “*conditions*” under which those records were generated during past trips. TESLA-1004, FIG. 5 (steps 511, 513), 18:51-56; *see id.*, 16:66-17:17 (“The record of historical route information may include any information from information inputs...” including “time of day, weather conditions, road conditions, driver, etc.”), 8:19-24, 21:11-18; *see also id.*, 23:62- 24:5 (“The power management system may also contribute to a database of information about route, road conditions, and the like, such as a database of historical route information.”), 22:11-18 (“the memory may comprise a database for holding any of the route information (including historical route information) about the segments traveled, ...external environmental conditions while driving the route...”).

93. Additionally, “the more closely identifying information in the record matches the information about the current route (e.g., driver, weather conditions, traffic, etc.), the higher the setting of the reliability estimate [assigned to the determined probable optimal speed],” and “[i]n one variation, only the previous trips along the segment under approximately similar conditions are considered (e.g., similar cargo weight, headwinds, etc.).” TESLA-1004, 17:46-49, 18:51-56, FIG. 5

(steps 511, 513). Koebler⁶⁵⁰ thereby contemplates embodiments where the process for identifying a matching record for a route segment involves identifying a record that has *conditions* that are the same as or similar to the *current conditions* detected for the current trip.

94. A number of operations facilitate the aforementioned matching process. To enable such a matching process, the vehicle processes sensor data to *determine the current conditions* for the segment on which it is currently traveling in order to identify a record that most closely matches the conditions (e.g., “driver, weather conditions, traffic, etc.” and “cargo weight, headwinds”) of the current trip. TESLA-1004, 18:51-56, 17:46-49, 19:52-54, 19:61-65, 20:39-39-50, FIG. 6 (element 607). A POSITA would have understood that, in some variations where the historical database is remote from the vehicle, the vehicle would upload this *current condition* data for storage in records of the remote historical record database for later access to determine probable optimal speeds for future trips. TESLA-1004, 18:51-56; *see id.*, 16:66-17:17 (“The memory may comprise **a data-base**,...In some variations, a power management system communicates with a memory or other data structure that is located **remotely**. The record of historical route information may include...”); *see also id.*, 8:19-24, 23:62- 24:5, 21:11-18, 22:11-18.

95. In these variations, the power management device of the vehicle determines a probable optimal speed for the vehicle to travel over a given route segment by using, for example, the process of Figure 5, which includes identifying a corresponding record in the historical database for that route segment having conditions that most closely match the *current conditions* detected by the vehicle (by analyzing sensor data) for the current trip over that segment. TESLA-1004, 18:51-56, 3:63-67, 21:29-51, 8:14-18, 17:6-10, 17:46-18:14, 18:15-19:36, FIG. 5 (steps 511, 513). This record will provide a speed/energy used in the past to travel that segment under those conditions and from which a probable optimal speed/energy can be determined for traveling over that segment during the current trip. *Id.*

2. Analysis

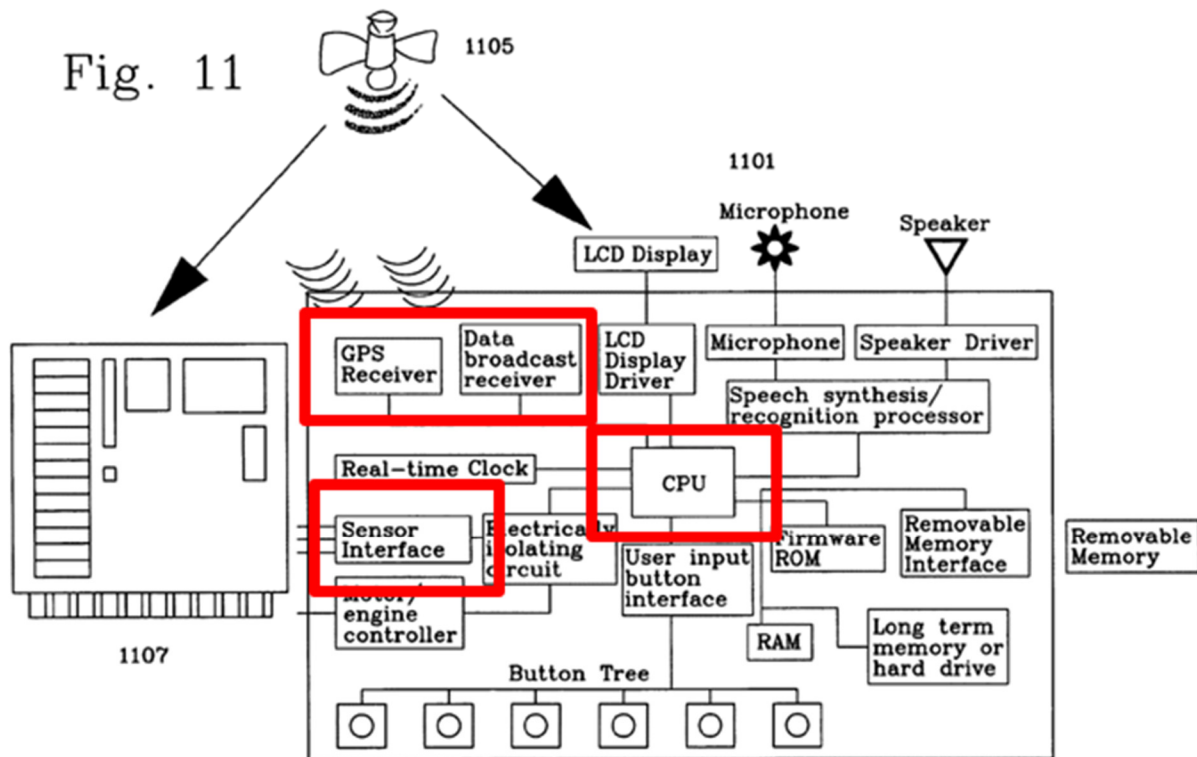
(a) Claim 1

[1pre] An apparatus comprising:

96. Koebler650 discloses element 1[pre] if the preamble is limiting. In Koebler650, a “power management device” (*apparatus*) includes “power management logic” for calculating “an applied power for [a] vehicle engine based on information provided from the external environment of the vehicle.” TESLA-1004,2:18-25, 10:4-7, 16:64-65, 3:30-40. The provided information includes “data from inputs (e.g., sensors, telemetries, etc.).” TESLA-1004, 2:27-30.

[1a-1] an interface configured to (a) receive (i) sensor data samples during operation of a vehicle and (ii) data from a telemetry system and

97. In Koebler650, a CPU (example shown in Figure 11 below) of a “power management device” uses “control logic for acquiring information inputs” from a sensor interface and a GPS receiver or telemetry data receiver (also referred to a data broadcast receiver). TESLA-1004, 5:64-67, 19:38-65, 20:39-50, 21:29-62, 23:40-61, FIG. 6 (element 607), FIG. 10 (elements 1005, 1001, 1007, 1009). The CPU also executes control logic functions by receiving sensor data samples during operation of a vehicle and data from a telemetry system. *Id.*



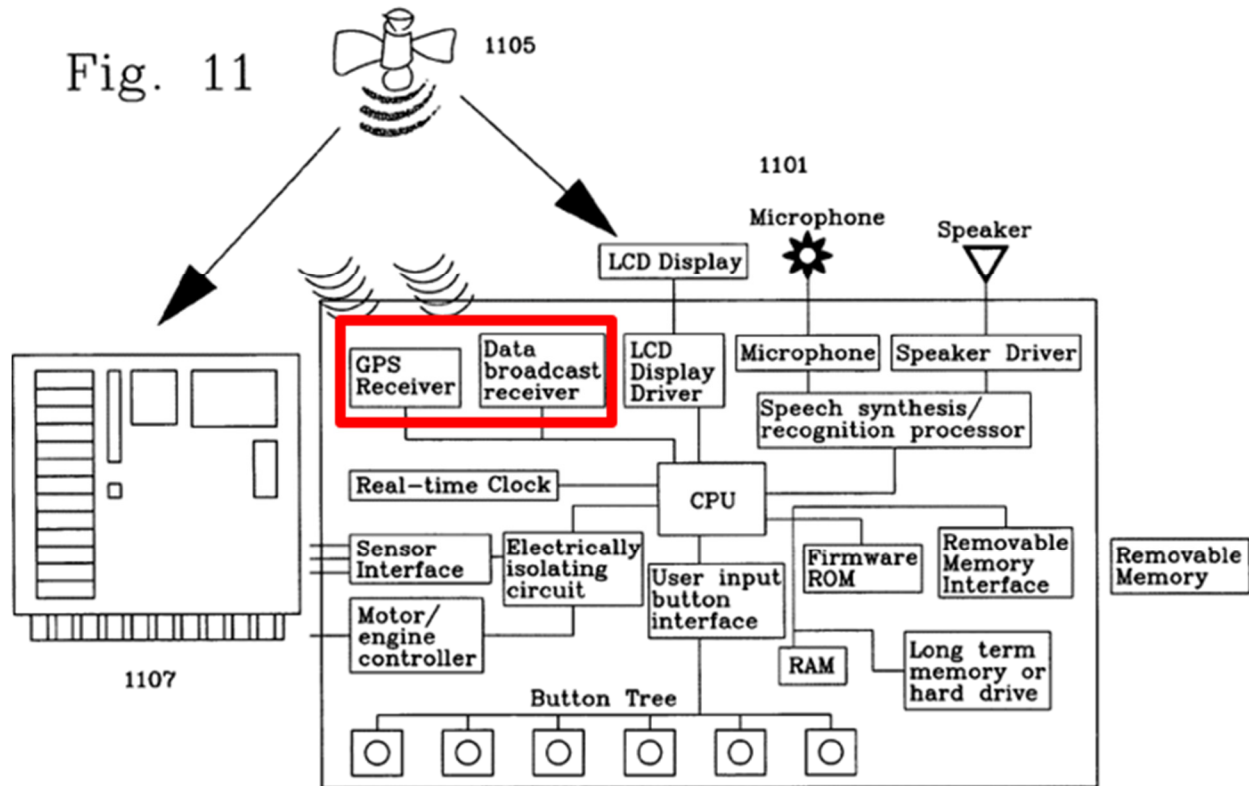
TESLA-1004, FIG. 11 (annotated)

98. The control logic can include “polling logic for acquiring information inputs.” TESLA-1004, 19:50-52. The polling logic “continuously poll[s] data

from external environmental sensors (e.g., detecting location, direction, elevation, traffic, weather, etc.) and operational status detectors (e.g., detecting vehicle speed, well velocity, motor speed etc.).” *Id.*, 19:61-65; *see id.*, 19:38-54. The polling logic (and/or compute elements used to implement the polling logic) acts as an *interface* by being configured to receive sensor data.

99. As to the interface configuration for *receiv[ing] (i) sensor data samples during operation of a vehicle*, the polling logic obtains sensor data from various sensors, e.g., a “vehicle’s current speed” from a speed sensor (speedometer), “RPM” data of the vehicle, “pressure applied” to an accelerator/brake, “tire pressure” from a tire pressure sensor, or data from optical sensors to determine “visibility.” TESLA-1004, 8:52-64; 21:29-62. Moreover, the polling logic monitors, polls, or obtains sensor data during operation of the vehicle. Examples include “recording decisions made at intersections” and “recording optimal speed or energy used to traverse a segment or other portion of a route.” *Id.*, 19:66-20:6. Thus, the polling logic (and/or compute elements used to implement the polling logic) acts as an *interface* by being configured to receive *sensor data samples* from at least one of the sensors enumerated in [1d] (e.g., *position sensor, speed sensor, tire pressure sensor, optical sensor*), thereby satisfying the interpretation discussed in Section III.D.1. Koebler650 also discloses each of the other Enumerated Sensors in [1d]. *See* Section V.B(a).

100. As to the interface configuration for *receiv[ing]...(ii) data from a telemetry system*, Koebler650 teaches a “telemetry data receiver 1009.” TESLA-1004, 23:50-57, 24:6-7 (“FIG. 11 shows a schematic illustrating the use of telemetry by the motor control system.”), FIG. 11 (data broadcast receiver) (reproduced below), FIG. 10 (element 1009). A POSITA would have understood that a “telemetry data receiver 1009” has an *interface* that *receives data from a telemetry system*.



TESLA-1004, FIG. 11 (annotated)

101. In some implementations, *data from said telemetry system* comprises a Global Positioning System (GPS) signal, e.g., wireless communications regarding a vehicle's locations sent by a satellite that are obtained by a GPS receiver. TESLA-1004, 2:63-3:4, 7:64-8:1, 8:19-22, 8:41-67, 11:45-57, 13:41-45, 17:52-58, 23:9-15, 23:25-30, 23:40-57, 23:62-65, 24:6-24, 24:32-39, 26:10-14, 27:27-30, 28:29-32, FIG. 3B, 307, FIGS. 10, 11. For example, "polling logic" provides "continuous or periodic polling of Global Position System (GPS) information (e.g., giving information on the vehicle's current location, current elevation, upcoming

elevations, upcoming terrain, vehicle's destination, etc. (*receiv[ing]... data from a telemetry system*). *Id.*, 21:29-39.

[1a-2] the interface configured to] (b) connect to a remote database;

102. In Koebler650, a “power management device” accesses “a record of historical route information” as part of determining a probable optimal speed for a vehicle to travel over a route segment. *See* Section V.A.1; TESLA-1004, 5:50-52, 8:5-11, 8:19-24, 10:15-19, 12:48-50, 13:38-40, 16:65-17:17, 17:50-58, 17:62-18:14, 19:54-57, 21:11-18, 22:11-19, 23:40-60, 23:66-24:14, FIG. 3B (element 309), FIG. 6 (element 605), FIG. 11 (elements 1101, which comprises CPU executing control logic, and element 1107). The historical route information may be held in a memory comprising “a database, register, or the like.” TESLA-1004, 17:3-4, 23:62-24:2. In some implementations, the “power management system communicates with a memory or other data structure that is located remotely” and the connection can be made using telemetry, e.g., using an interface of “telemetry data receiver 1009” (*interface configured to connect to a remote database*). TESLA-1004, 8:19-24, 17:3-6, 23:50-57. Further, in some implementations, historical route information from multiple vehicles may be “uploaded to, e.g., a centralized server where optimized speeds for [road] segments could be calculated.” *Id.*, 26:14-37. A POSITA would have found it obvious that such a centralized server

could store such information in a database, given that Koebler650 discloses storage of historical route information in database records. *See* Section IV.A.1.

[1b] a memory configured to store (a) said sensor data samples for different points in time along a route segment travelled by said vehicle and (b) said data from said telemetry system; and

103. In Koebler650, storage configurations involve polled data (including sensor data and GPS signal data) being stored by the “polling logic” in memory (*memory*). TESLA-104, 19:52-57. As to the storage configuration for *stor[ing]...said sensor data samples for different points in time along a route segment travelled by said vehicle*, “polling logic” stores “poll data from sensors, inputs, memories, or any other source of information data” (including *sensor data samples*) in memory. TESLA-1004, 19:52-54, 19:61-65, 20:39-39-50, FIG. 6 (element 607). Further, in Koebler650, records of “historical route information” that include “information[] from information inputs” are stored in association with “segments of a route.” TESLA-1004, 17:6-17. The “information inputs” (also *sensor data samples*) include information from sensors, e.g., an optical sensor, a tire pressure sensor. TESLA-1004, 21:29-61, 8:8-19, 8:19-24, 18:51-56, 19:61-65.

104. Additionally, because the polled data stored by “polling logic” includes data from at least one of the sensors enumerated in [1d] (e.g., *optical sensor, tire pressure sensor*) and are associated with different points along a route

segment traveled by said vehicle (*for different points in time along a route segment*), such a configuration satisfies the construction discussed in Section III.D.1. TESLA-1004, 17:6-17, 21:29-61. Koebler650 also discloses each of the other Enumerated Sensors in [1d]. *See* Section V.B(a).

105. As to the storage configuration for *stor[ing]...said data from said telemetry system*, data polled by “polling logic” includes data representing GPS signals sent by satellites (*said data from said telemetry system*). TESLA-1004, 21:29-62, 8:19-24, 19:61-65. As previously noted, GPS signal data received from a satellite represents data from a *telemetry system* because GPS is a system that transmits measurement data from a remote source. TESLA-1004, 8:19-24.

106. To the extent that Koebler650 is deemed insufficient to disclose the storage configurations of [1b], Koebler650 renders them obvious. A POSITA would have found it obvious that sensor data is polled by Koebler650’s “power management device” and stored in a memory for each segment. Historical records described in Koebler650 include sensor information and are generated for each segment of a route. TESLA-1004, 17:10-14, 10:15-17; 18:51-56 (“Generally, ... the more closely the identifying information in the record matches the information about the current route (e.g., driver, weather conditions, traffic, etc.), the higher the reliability estimate.”). Multiple historical records may also be generated for each segment. *Id.* Thus, where multiple records of historical route information are

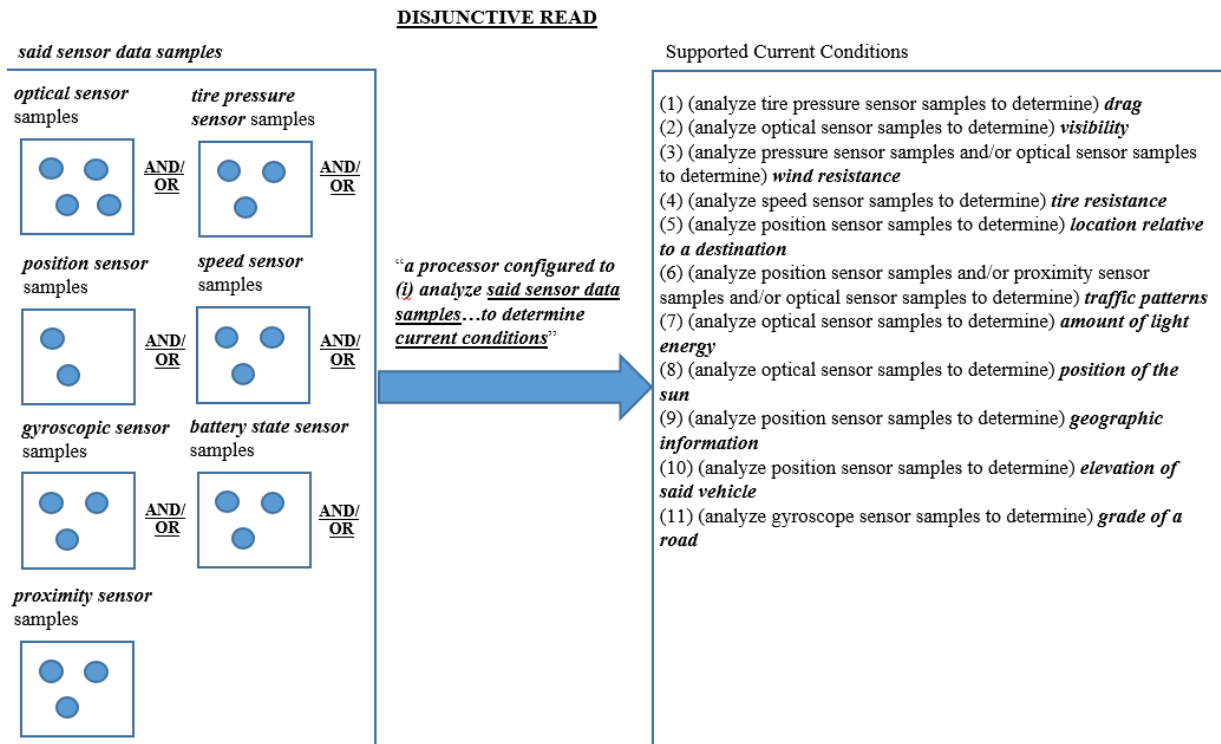
stored for each route segment, each record includes “information input” (e.g., optical sensor data, tire pressure sensor data, and GPS data) from sensor data. TESLA-1004, 17:6-17, 18:51-56, 21:29-61, 23:62-24:5. This results in sensor data samples being stored for different points along the route. *Id.*; see Section V.A.1.

[1c-1] a processor configured to (i) analyze said sensor data samples stored in said memory to determine current conditions and (ii) associate said current conditions with said route segment

107. Koebler650 discloses [1c-1] through various configurations, such as “power management logic” (*processor*), which derives “information about the external environment of the vehicle.” TESLA-1004, 3:63-67, 18:51-56, 23:62-24:5.

As to the processor configuration for *analyz[ing] said sensor data samples stored in said memory to determine current conditions*, Koebler650 generally contemplates analyzing sensor data samples to determine the Supported Current Conditions. TESLA-1004, 3:63-67, 18:51-56, 23:62-24:5; see Section IV.B (identifying Supported Current Conditions). For example, sensor data samples may be obtained from an *optical sensor* and *tire pressure sensor* and analyzed to determine *drag* and *visibility (determin[ing] current conditions)*. TESLA-1004, 21:29-62; see *id.*, 8:14-18; see Section V.B(a) (identifying examples of the Enumerated Sensors). More examples of the Supported Current Conditions that are determined by

analyz[ing]...said sensor data samples are listed in the figure below. The determination of any one of these conditions satisfies this limitation under a disjunctive read of [1d] and [1e] as discussed in Section III.D.1.



108. As to the processor configuration for *associating said current conditions with the route segment*, sensor data is stored in association with a vehicle route, e.g., in a “record of historical route information.” TESLA-1004, 17:6-10; 18:51-56, 23:62-24:5; see Section V.A.1. For example, information is stored in a record such that the Supported Current Conditions (e.g., *visibility* and *drag*) (*said current conditions*) are *associated with* a route segment (*said route segment*). TESLA-1004, 8:14-18, 16:66:17:17, 18:51-56, 21:29-51, 23:62-24:5. The record

includes “information about the time of day, weather conditions, road conditions, driver, etc.” (e.g., current conditions information), “route information (e.g., starting location and any intermediate locations” (e.g., route segment information), as well as other types of information, such as “information about the actual or optimized velocities,” “information[] from information inputs,” among others. *Id.*, 16:66-17:17, 22:8-19.

109. Given the various types of information stored in records of “historical route information,” a POSITA would have found it obvious that the information stored in the records, in some instances, includes current condition information (e.g., relating to **visibility** and **drag**). This is because current condition information is related and derived from external environmental information inputs, which are similarly described as being represented in the “historical route information.” TESLA-1004, 16:66-17:17 (“The record of historical route information may include any information from information inputs...”), 22:8-19. The current condition information would have also been understood to be stored in the records in association with route segment information. *Id.* 8:14-18, 16:66:17:17, 18:51-56, 21:29-51, 23:62-24:5. Thus, in these instances, “power management logic” (**processor**) is configured to associate the Supported Current Conditions (e.g., **visibility** and **drag** (**said current conditions**)) with a route segment (**said route segment**) in records of “historical route information.” *Id.*

110. The ***current conditions*** feature is relevant to several limitations of independent claim 1 ([1d], [1e]), claim 15 ([15e-1], [15e-3]), and claim 16 ([16a], [16e]). This feature is similarly recited in claims 2, 3, 6-8, and 14. As discussed below, the analysis of Koebler650's disclosure of several examples of ***current conditions*** is incorporated by reference to the discussion of this limitation.

[1c-2] wherein (a) said route segment is identified according to said data from said telemetry system and

111. In Koebler650, information about "current location of the vehicle" can be detected, or input via "telemetry" (***said telemetry system***). TESLA-1004, 3:41-67, 17:59-19:36. The information input via telemetry includes GPS signal data received from a satellite and may be used to identify a route segment. TESLA-1004, FIG. 5 (steps 501, 503), 17:50-58 ("...FIG. 5 shows that the location of the vehicle is periodically determined (e.g., via GPS, manual entry, etc.) and this location can then be used to determine a historical segment corresponding to the current location..."), 7:64-8:1, 23:40-57, 23:62-65, 24:6-24, 8:41-67, FIGS. 10, 11. Specifically, "polling logic may coordinate continuous or periodic polling of ... (GPS) information" that gives the vehicle's "current location, current elevations, upcoming elevations, upcoming terrain, and vehicle's destination." TESLA-1004, 21:29-40. This GPS signal data is data from a telemetry system because, for example, in some implementations, wireless communications regarding a vehicle's locations

are obtained from a satellite 1105 of Figure 11 using a GPS receiver. TESLA-1004, 24:6-24, 8:41-67, FIGS. 10, 11.

112. A “record of historical route information” can include “information inputs” and derived conditions based on those information inputs “for ... segments of a route.” TESLA-1004, 16:66-17:17. The power management device has access to map data of the vehicle’s navigation system that includes route segments. TESLA-1004, 11:39-40. Likewise, generation of a record of historical route information for a particular route segment would have involved identifying a vehicle’s location (*said route segment is identified*). This can be accomplished using GPS signals received from a satellite or other telemetry-based system and using that location to select the route segment with which the “information input” or derived condition is to be associated therewith (*said route segment is identified according to said data from said telemetry system*). TESLA-1004, 17:50-58; 3:41-67; 8:41-67, 18:51-56, 21:29-40, 24:6-24, FIG. 5 (steps 501, 503), FIGS. 10, 11.

[1c-3] (b) said current conditions associated with said route segment are uploaded to said remote database to create historical route information for a plurality of route segments;

113. As discussed for [1c-1] and in Section V.A.1, records of “historical route information” are configured to store various types of information. In some implementations, it would have been understood to store information, such that the Supported Current Conditions (e.g., *visibility* and *drag*) (*said current conditions*)

are *associated with* a route segment (*said route segment*). TESLA-1004, 8:14-18, 16:66:17:17, 18:51-56, 21:29-51, 23:62-24:5. The *current conditions* feature is relevant to several limitations of independent claim 1 ([1d], [1e]), claim 15 ([15e-1], [15e-3]), and claim 16 ([16a], [16e]). This feature is similarly recited in claims 2, 3, 6-8, and 14. As discussed below, the analysis of Koebler650's disclosure of several examples of *current conditions* is incorporated by reference to the discussion of this limitation.

114. Records of "historical route information" may be stored in a variety of storage configurations, including within a "memory or a data structure" of the "power management device," and/or within "a memory or other data structure that is located remotely" from the power management device, such as a remote database. TESLA-1004, 16:66:17:17 ("The memory may comprise a database, ... In some variations, a power management system communicates with a memory or other data structure that is located remotely. The record of historical route information may include..."). Thus, Koebler650 teaches information specified within a record of historical route information (*said current conditions associated with said route segment*) being *uploaded to a remote database*, which creates records (*create historical route information*) for storage in the remote database. Because these records are stored in association with particular route segments and would

have been understood to be accumulated over time for different routes with different route segments, Koebler⁶⁵⁰ teaches the uploading of current conditions to create historical route information *for a plurality of route segments*. TESLA-1004, 18:51-56, 16:66-17:17, 8:19-24, 23:62- 24:5, 21:11-18, 22:11-18 (“the memory may comprise a database for holding any of the route information (including historical route information) about the segments traveled, ...external environmental conditions while driving the route...”), FIG. 5 (steps 511, 513).

115. Koebler⁶⁵⁰ also discloses variations of its system where records are “uploaded to, e.g., a centralized server.” *Id.*, 26:14-37. In this example, a POSITA would have understood that the “centralized server” is associated with “a memory or other data structure that is located remotely” from the power management device. *Id.*, 16:66:17:17, 26:14-37. A POSITA would have found it obvious that such a centralized server could store such information in a database, given that Koebler⁶⁵⁰ discloses storage of historical route information in database records. *See* Section V.A.1. Thus, in this example, information specified within a record of historical route information (*said current conditions associated with said route segment*) is *uploaded* to a centralized server, which creates records (*create historical route information*) in an associated remote database (*said remote database*). TESLA-1004, 16:66-17:6. Further, because the remote database associated with the centralized server may store information of multiple vehicles (e.g., “vehicles

travelling overlapping route segments”), the remote database may store records for

a plurality of route segments. Id., 26:22-37.

[1d] wherein the sensor data samples are received from at least one of an optical sensor, a position sensor, a speed sensor, a gyroscopic sensor, a revolutions-per-minute sensor, an accelerator pedal position sensor, a brake pedal position sensor, a battery state sensor, a tire pressure sensor, a proximity sensor, a weight sensor, an airflow sensor, and a gas flow sensor; and

116. As discussed in Section III.D.2, the *at least one...and* phrase within [1d] may be interpreted under conjunctive or disjunctive reads. Under a disjunctive read, the requirements of [1d] may be satisfied by receipt of *sensor data samples* from one of the Enumerated Sensors.

117. Koebler650 discloses [1d] under a disjunctive read.⁶ For example, “polling logic” is used to “poll data from sensors, inputs, memories, or any other source of information data.” TESLA-1004, 18:51-56, 19:52-54, 19:61-65, 19:52-54, 20:39-39-50, FIG. 6 (element 607). Sensors that are polled for information input using “polling logic” include an “optical” sensor and a “tire pressure” sensor.

⁶ Ground 1A applies a disjunctive read of the *at least one...and* phrase, while Ground 1B addresses the conjunctive read. As explained in Section V.2, Koebler650 also satisfies [1d] under a conjunctive read, and thus, the disclosures of Koebler650 referenced in that section are incorporated by reference into this section.

TESLA-1004, 21:29-51; *see id.*, 19:61-65, 8:8-19. This satisfies the disjunctive read of [1d] because *sensor data samples* are received from various sensors (e.g., the *optical sensor* and the *tire pressure sensor*), as shown in [1c-1] with respect to the Supported Current Conditions. Koebler650 also discloses each of the other Enumerated Sensors in [1d].⁷ *See* Section V.B(a).

[1e] wherein said current conditions comprise at least one of: drag, wind resistance, tire resistance, a location relative to a destination, traffic patterns, an amount of light energy, a position of the sun, geographical information, an elevation of said vehicle, a grade of a road, a location of stoplights, a timing of stoplights, weather, a wind direction, a wind velocity, a temperature, air pressure, moisture, visibility, an amount of vibration, and traction.

118. As discussed in Section III.D.2, the *at least one...and* phrase within [1e] may be interpreted under conjunctive or disjunctive reads. Under a disjunctive read, the requirements of [1e] is satisfied by determination of one of twenty-one enumerated current conditions based on analysis of *sensor data samples* from one of thirteen Enumerated Sensors.

119. Koebler650 discloses [1e] under a disjunctive read. For example, “power management logic” “information about the external environment of the

⁷ The Enumerated Sensors in [1d] are also recited in claims 15 ([15f]) and 16 ([16a]). Koebler650’s disclosure of several examples of sensors (*See* Section V.B(a)) are incorporated by reference to mappings to each of these claim limitations.

vehicle” based on other information. TESLA-1004, 3:63-67. As described in [1c-1], each of the Supported Current Conditions is determined by analyzing sensor data samples received from one or more of the Enumerated Sensors. For example, Koebler650 discloses determining a current drag condition by “calculating the drag force due to rolling resistance” by processing sensor data samples from a tire pressure sensor and determining a current visibility condition from sensor data samples from an optical sensor. TESLA-1004, 21:29-51; 8:14-18. This satisfies the disjunctive read of [1e] because *current conditions* (comprised of *drag* and *visibility*) are determined by “power management logic” (*processor*) based on analyzing data received from an optical sensor (*sensor data samples* received from *optical sensor*). TESLA-1004, 21:29-51, 19:61-65, 8:8-19. Koebler650 also discloses determining the other Supported Current Conditions (i.e., *drag, wind resistance, tire resistance, location relative to a destination, traffic patterns, amount of light energy, position of the sun, geographic information, elevation of said vehicle, grade of a road*, and *visibility*), based on analysis of sensor data samples from at least one Enumerated Sensors in [1d]. See Section V.B.3(a)(i).⁸

⁸ The *current conditions* feature is relevant to several limitations of independent claim 1 ([1d], [1e]), claim 15 ([15e-1], [15e-3]), and claim 16 ([16a], [16e]). This feature is similarly recited in claims 2, 3, 6-8, and 14. Koebler650’s disclosure of

(b) Claim 2

[2] The apparatus according to claim 1, wherein said current conditions associated with said route segment are stored in said remote database with previously stored conditions associated with said route segment

120. As discussed for [1c-1] and [1c-3], in Koebler650, a determined current condition (e.g., ***velocity, drag, visibility***) is associated with a route segment. See Section V.A.1. A remote database where the current conditions associated with said route segment are stored (as discussed for [1c-1] and [1c-3]) includes other historical records related to the driver's driving habit. TESLA-1004, 17:6-24, 18:51-56, 23:62-24:5. The derived current condition for each record of historical route information is also a ***previously stored condition*** associated with a route segment by the record of "historical route information." TESLA-1004, 17:6-17 ("Multiple records for the same route segment (or segments of a route) may be included as part of the record of historical information."). *Id.*, 22:8-19. The ***current condition associated with a route segment*** (e.g., drag associated with a route segment or visibility associated with a route segment) is associated with these other historical records of the driver because they are stored in the same remote database for the same driver. *Id.*, 17:6-17, 18:51-56; 26:14-37.

several examples of ***current conditions*** are incorporated by reference to mappings to each of these claims.

121. The ***current conditions*** feature is relevant to several limitations of independent claim 1 ([1d], [1e]), claim 15 ([15e-1], [15e-3]), and claim 16 ([16a], [16e]). This feature is similarly recited in claims 2, 3, 6-8, and 14. As discussed below, the analysis of Koebler650's disclosure of several examples of ***current conditions*** is incorporated by reference to the discussion of this claim.

(c) **Claim 3**

[3] The apparatus according to claim 2, wherein said historical route information comprises said current conditions and said previously stored conditions associated with said plurality of route segments

122. As discussed for [1c-1] and [1c-3], in Koebler650, a determined current condition (e.g., ***velocity, drag, visibility***) is associated with a route segment. See Section V.A.1. A remote database where the current conditions associated with said route segment are stored (as discussed for [1c-1] and [1c-3]) includes other historical records related to the driver's driving habit. TESLA-1004, 17:6-24, 18:51-56, 23:62-24:5.

123. The derived current condition for each record of historical route information is also a ***previously stored conditions associated with said plurality of route segments*** by the record of "historical route information." TESLA-1004, 17:6-17 ("Multiple records for the same route segment (or segments of a route) may be included as part of the record of historical information."). *Id.*, 22:8-19. Ad-

ditionally, *current conditions* (e.g., drag associated with a route segment or visibility associated with a route segment) are associated with these other historical records of the driver because they are stored in the same remote database for the same driver. *Id.*, 17:6-17, 18:51-56; 26:14-37; *see also* Section IV.A.1.

(d) Claim 4

[4] The apparatus according to claim 1, wherein said data from said telemetry system comprises a Global Positioning System (GPS) signal.

124. As discussed for [1c-1] and [1c-2], Koebler650 describes information may be input to a power management via telemetry (*said telemetry system*), which includes GPS signal data received from a satellite (*Global Positioning System (GPS) signal*). TESLA-1004, 2:63-3:4, 7:64-8:1, 11:45-57, 13:41-45, 17:52-58, 23:9-15, 23:25-30, 23:40-57, 23:62-65, 24:6-24, 24:32-39, 26:10-14, 27:27-30, 28:29-32, FIG. 3B (element 307), FIG. 5, (element 501), FIG. 10, FIG. 11, 8:41-67; *see also* Section IV.A.1.

125. Specifically, the GPS signal data received from a satellite may be used to identify a route segment. TESLA-1004, FIG. 5 (steps 501, 503), 17:50-58 (“...FIG. 5 shows that the location of the vehicle is periodically determined (e.g., via **GPS**, manual entry, etc.) and this location can then be used to determine a historical segment corresponding to the current location...”), 7:64-8:1, 23:40-57, 23:62-65, 24:6-24, 8:41-67, FIGS. 10, 11. Specifically, “polling logic may coordi-

nate continuous or periodic polling of...**(GPS) information**” that gives the vehicle’s “current location, current elevations, upcoming elevations, upcoming terrain, and vehicle’s destination.” TESLA-1004, 21:29-40, 24:6-24, 8:41-67, FIGS. 10, 11.

(e) Claim 5

[5] The apparatus according to claim 1, wherein said data from said telemetry system comprises at least one of a map service and a traffic service

126. In Koebler650, “the power management system receives Information by telemetry...” TESLA-1004, 8:19-22. Koebler650 states that examples of receiving information by telemetry include “the power management system ... communicat[ing] with a weather service, **map service, [and] a traffic service.**” TESLA-1004, 8:22-24.

127. A POSITA would have understood that reception of data from a map service and a traffic service, as described in Koebler650 is an example of obtaining data from telemetry because these services collect and transmit real-time data regarding geographical locations and traffic conditions. The transmission of data from remote sources to the vehicle involves the use of telecommunications technology, e.g., remote collection and transmission of data for monitoring purposes, such as a vehicle’s receipt of map and traffic updates. TESLA-1004, 8:22-24.

(f) Claim 6

[6] The apparatus according to claim 1, wherein said current conditions comprise information about an environment (a) surrounding said vehicle and (b) acting on said vehicle.

128. See discussion of element [1e] above. In Koebler650, the Supported Current Conditions satisfy this limitation. For example, ***visibility*** is determined by analyzing sensor data samples from an ***optical sensor*** and comprises information about an ***environment surrounding the vehicle***. TESLA-1004, 21:29-51, 8:14-18, 8:51-56, 23:62-24:5; *see also* Section V.A.1. Further, ***drag force*** is determined by analyzing sensor data samples from a ***tire pressure sensor*** and comprises information about an ***environment acting on said vehicle***.

129. The ***current conditions*** feature is relevant to several limitations of independent claim 1 ([1d], [1e]), claim 15 ([15e-1], [15e-3]), and claim 16 ([16a], [16e]). This feature is similarly recited in claims 2, 3, 6-8, and 14. As discussed below, the analysis of Koebler650's disclosure of several examples of ***current conditions*** is incorporated by reference to the discussion of this claim.

(g) Claim 7

[7] The apparatus according to claim 1, wherein said current conditions are determined by deriving inferences from said sensor data samples.

130. See discussion of [1c-1], [1d], and [1e] above. In Koebler650, the Supported Current Conditions satisfy this limitation. For example, ***visibility*** is determined by deriving inferences from sensor data samples of an ***optical sensor*** and

drag force is determined by deriving inferences from sensor data samples of a *tire pressure sensor*. TESLA-1004, 3:41-67, 4:1-18, 8:14-18, 8:53-64, 21:29-51.

131. The *current conditions* feature is relevant to several limitations of independent claim 1 ([1d], [1e]), claim 15 ([15e-1], [15e-3]), and claim 16 ([16a], [16e]). This feature is similarly recited in claims 2, 3, 6-8, and 14. As discussed below, the analysis of Koebler650's disclosure of several examples of *current conditions* is incorporated by reference to the discussion of this claim.

(h) Claim 8

[8] The apparatus according to claim 1, wherein said historical route information comprises said current conditions received from a plurality of vehicles each using one of said apparatuses

132. As discussed for [1c-1] and [1c-3], in some implementations, records of "historical route information" (*said historical route information*) would have been understood and/or found obvious to store information relating to the Supported Current Conditions (e.g., *visibility* and *drag*) (*said current conditions*) that are associated with a route segment. TESLA-1004, 8:14-18, 16:66:17:17, 18:51-56, 21:29-51, 23:62-24:5. Further, in one example of a remote storage configuration, records are "uploaded to, e.g., a centralized server." *Id.*, 16:66:17:17, 26:14-37. A POSITA would have found it obvious that such a centralized server could store such information in a database, given that Koebler650 discloses storage of historical route information in database records. *See* Section V.A.1.

133. Because the centralized server may obtain information of multiple vehicles (e.g., “vehicles travelling overlapping route segments”), the remote database, in some examples, stores records with historical route information for multiple overlapping route segments (*plurality of route segments*). For example, “[i]f many cars drive along overlapping route segments, their energy usage for those segments could be uploaded to, e.g., a centralized server where optimized speeds for those segments could be calculated.” TESLA-1004, 26:14-37. In such implementations, a POSITA would have found it obvious to further configure the remote database to store historical information representing the Supported Current Conditions (e.g., *visibility, drag*) associated with vehicles traveling along overlapping route segments. This configuration would have been advantageous as it would have enabled the historical information to include “identifying information” that “more closely” matches “the information about the current route (e.g., the driver, weather conditions, traffic, etc.), which enables a “higher setting of the reliability estimate” assigned to calculations of “probable optimal speed.” TESLA-1004, 18:45-56. Thus, in such implementations, the Supported Current Conditions (e.g., *visibility, drag*) (*said current conditions*) are received from different vehicles driving along overlapping route segments (*plurality of vehicle using one of said apparatuses*). *Id.*

134. The ***current conditions*** feature is relevant to several limitations of independent claim 1 ([1d], [1e]), claim 15 ([15e-1], [15e-3]), and claim 16 ([16a], [16e]). This feature is similarly recited in claims 2, 3, 6-8, and 14. As discussed below, the analysis of Koebler650's disclosure of several examples of ***current conditions*** is incorporated by reference to the discussion of this claim.

(i) **Claim 9**

[9] The apparatus according to claim 1, wherein said apparatus is configured to receive said historical route information for said plurality of route segments.

135. As discussed for [1c-1] and [1c-3], in some implementations, records of “historical route information” (***said historical route information***) would have been understood to upload information relating to the current conditions that are associated with a route segment to a remote database. TESLA-1004, 8:14-18, 16:66:17:17, 18:51-56, 21:29-51, 23:62-24:5. In the technique shown in Figure 5, the “power management device” (***said apparatus***) determines a “probable optimal speed” “as the current segment changes (e.g., as the vehicle moves)” where the “probable optimal speed is [also] identified from the historical route information.” *Id.*, 18:15-25. For example, the historical route information may be “queried,” e.g., by a “database [being] examined [by the power management device] to find the historical information about [a] segment.” *Id.*, 17:50-14. In this example, a POSITA would have understood that the power management device is configured to query records of “historical route information” that were previously created and

stored in the remote database (*receive said historical route information*). TESLA-1004, 3:63-67, 8:14-18, 17:6-21, 18:51-56, 21:29-51, 23:62-24:5, 26:14-37. Further, as discussed for [1c-3], because these records are stored in association with particular route segments and would have been understood to be accumulated over time for different routes with different route segments, Koebler⁶⁵⁰ teaches the uploading of current conditions to create historical route information *for a plurality of route segments*. TESLA-1004, 8:19-24, 16:66-17:17, 18:51-56, 23:62-24:5, 21:11-18, 22:11-18, FIG. 5 (steps 511, 513).

136. Additionally, because the Figure 5 technique is “most accurate when there are many similar previous trips in the database,” a POSITA would have recognized and/or found obvious certain scenarios in which the historical route information discussed in [1c-1] and [1c-3] and previously uploaded by the power management device to the remote database is the same historical route information that is later queried by that same power management device in determining a probable optimal speed condition (*apparatus is configured to receive said historical route information*). *Id.*, 17:50-18:14. For example, when the power management device is determining a driver-specific probable optimal speed, the power management device may receive driver-specific historical route information that was previously uploaded by that same power management device because drivers typically drive the same vehicle (having the same power management device) multiple times. *Id.*,

17:30-49 (“...For example, in the past, a driver may have driven a particular segment 1000 times....the power may be estimated by taking an average of all of the previous times the driver drove that segment....”).

(j) Claim 10

[10] The apparatus according to claim 9, where operational parameters of said vehicle are adjusted for said route segment based on said historical route information

137. As discussed for [1c-1] and [1c-3], in some implementations, records of “historical route information” (*said historical route information*) would have been understood and/or found obvious to upload information relating to the current conditions that are associated with a route segment to a remote database. TESLA-1004, 8:14-18, 16:66:17:17, 18:51-56, 21:29-51, 23:62-24:5. Further, “operational parameters” may be used to determine the optimal power to apply to the vehicle.” TESLA-1004, 9:65-67, 4:31-42, 1:58-63. Examples of operational parameters include “aerodynamic parameters (CDA), rolling resistance parameters (Crr1 and Crr2), drive train efficiency parameters, motor efficiency parameters, battery model parameters, battery charge and discharge relationships, type of battery.” *Id.* Moreover, a vehicle speed would have been understood to represent another example of an operational parameter, e.g., by being used to identify the probable optimal speed to apply to the vehicle.

138. Operational parameters may also be “changed,” i.e., *adjust[ed]*.

TESLA-1004, 10:13-15, 9:65-10:40. Further, the operational parameters “may be derived ... based on ... historical information” and can relate to “historical performance.” TESLA-1004, 4:31-42; TESLA-1004, 1:58-63, 15:7-16:50. Using Koebler650’s Figure 5 technique, for example, vehicle speeds for distinct drivers of a vehicle (*operational parameters*) would have been adjusted to driver-specific probable optimal speeds of the vehicle to thereby apply an optimal power. *Id.* The driver-specific probable optimal speeds are also identified based on the historical information discussed above, e.g., driver-specific route information that accounts for visibility and drag (*said historical route information*). *Id.*, 17:20-18:14; 18:45-56.

139. The *current conditions* feature is relevant to several limitations of independent claim 1 ([1d], [1e]), claim 15 ([15e-1], [15e-3]), and claim 16 ([16a], [16e]). This feature is similarly recited in claims 2, 3, 6-8, and 14. As discussed below, the analysis of Koebler650’s disclosure of several examples of *current conditions* is incorporated by reference to the discussion of this claim.

140. Moreover, Koebler650 discloses the power management device discloses using environmental inputs, such as air resistance, to *adjust* a maximum fuel volume (*an operational parameter*) to prevent engine flooding through use of a “memory having a table of maximum fuel volume for a given velocity, resistance,

and temperature.” TESLA-1004, 25:20-51. A POSITA would have found it obvious for such an adjustment to also factor in drag (*adjusting ... based on said historical route information*) because drag, like air resistance, impacts the fuel consumption of the vehicle.

(k) Claim 11

[10] The apparatus according to claim 10, wherein adjusting said operational parameters for said route segment based on said historical route information is performed to optimize power consumption of said vehicle.

141. As for [9] and [10], in Koebler650, operational parameters may be adjusted, and such operational parameters include aerodynamic parameters (CDA), rolling resistance parameters (Crr1 and Crr2), drive train efficiency parameters, motor efficiency parameters, battery model parameters, battery charge and discharge relationships, type of battery. TESLA-1004, 9:65-67, 4:31-42, 1:60-63. A vehicle speed would have been understood to represent another example of an operational parameter, e.g., by being used to identify the probable optimal speed to apply to the vehicle.

142. Operational parameters may also “be used to determine the optimal power to apply to the vehicle.” TESLA-1004, 9:65-67, 1:60-63. In some implementations, operational parameters “may be derived (e.g., based on other information including historical information or other operational parameter information).” TESLA-1004, 31-42. For example, in the Figure 5 technique, vehicle

speeds for distinct drivers of the vehicle would have been adjusted to driver-specific probable optimal speeds of the vehicle to thereby apply an optimal power (*optimize power consumption of said vehicle*). *Id.*, 18:15-19:36. The probable optimal speed may also identified based on historical information, e.g., driver-specific route information that accounts for visibility and drag (*adjusting ... based on said historical information*). *Id.*, 17:20-18:14; 18:45-56.

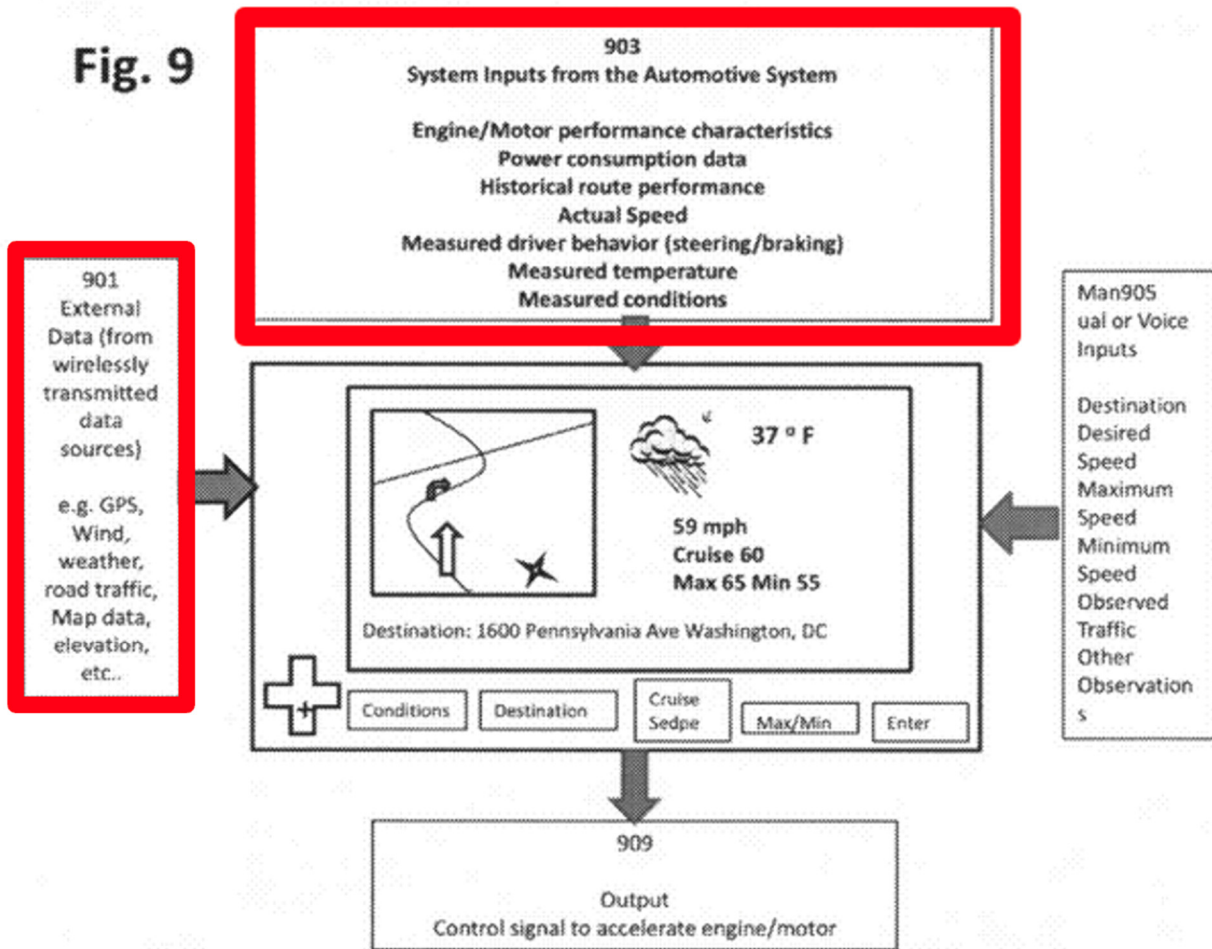
143. The *current conditions* feature is relevant to several limitations of independent claim 1 ([1d], [1e]), claim 15 ([15e-1], [15e-3]), and claim 16 ([16a], [16e]). This feature is similarly recited in claims 2, 3, 6-8, and 14. As discussed below, the analysis of Koebler650's disclosure of several examples of *current conditions* is incorporated by reference to the discussion of this claim.

144. Koebler650 discloses the power management device discloses using environmental inputs, such as air resistance, to *adjust* a maximum fuel volume (*an operational parameter*) to prevent engine flooding through use of a "memory having a table of maximum fuel volume for a given velocity, resistance, and temperature." TESLA-1004, 25:20-51. A POSITA would have found it obvious for such an adjustment to also factor in drag (*adjusting ... based on said historical route information*) because drag, like air resistance, impacts the fuel consumption of the vehicle. A POSITA would have understood that reducing engine flooding *optimizes power consumption of the vehicle*.

(I) Claim 12

[12] The apparatus according to claim 1, wherein said interface is configured to receive from a bus of said vehicle at least one of (a) said sensor data samples and (b) said data from said telemetry system.

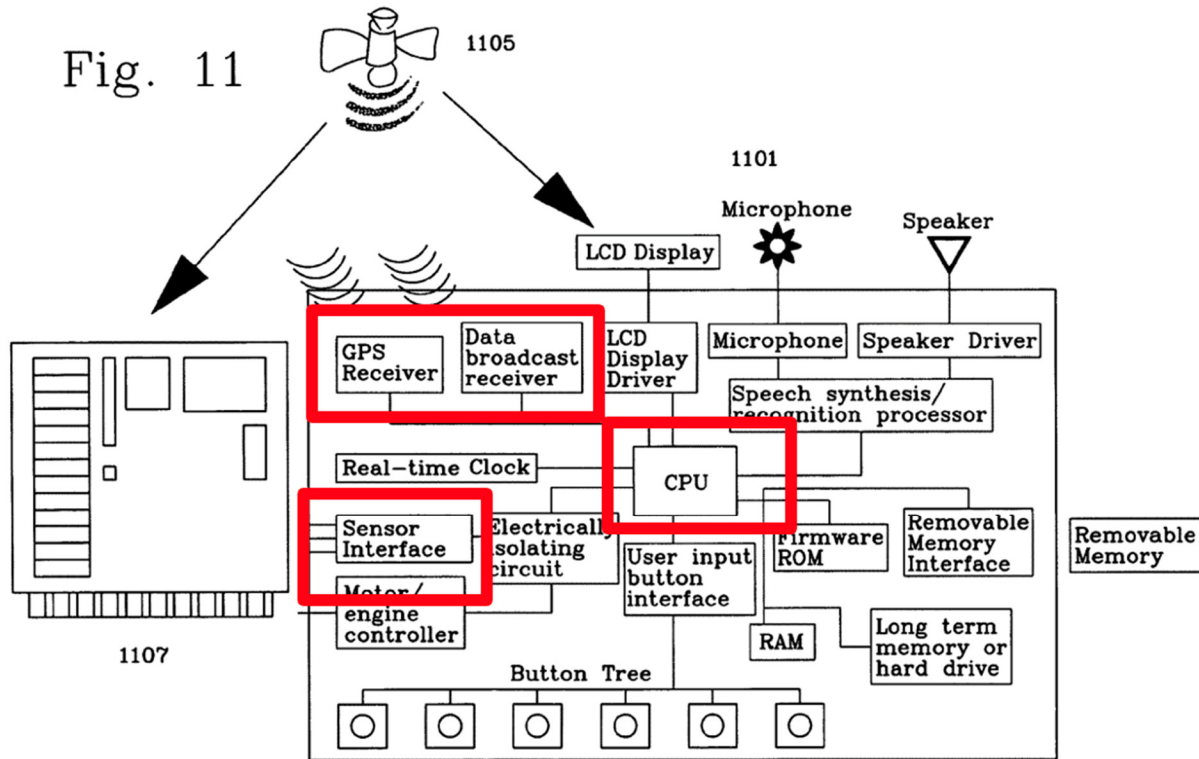
145. In Koebler650's Figure 9 (below) technique, sensor data samples are received from a bus of the vehicle. TESLA-1004, FIG. 9 (element 903). As shown below, certain system inputs such, as sensor data (e.g., power consumption, actual speed, steering / braking, temperatures, etc.), are received from an automotive system, which would result in the values being delivered via some form of local bus.



TESLA-1004, FIG. 9 (annotated)

146. A POSITA would have understood that the technique shown above would be implemented using a power management system, as shown in Figures 10 and 11. TESLA-1004, 23:40-24:14, FIGS. 10, 11. As shown in these figures (Figure 11 is reproduced below), the CPU executing control logic can receive sensor data from a “sensor interface” and telemetry data from a “GPS receiver” or “telem-

entry data receiver.” *Id.* These figures show that each of these components is connected via a bus (e.g., the line connecting each component in the schematic drawings).



TESLA-1004, FIG. 11 (annotated)

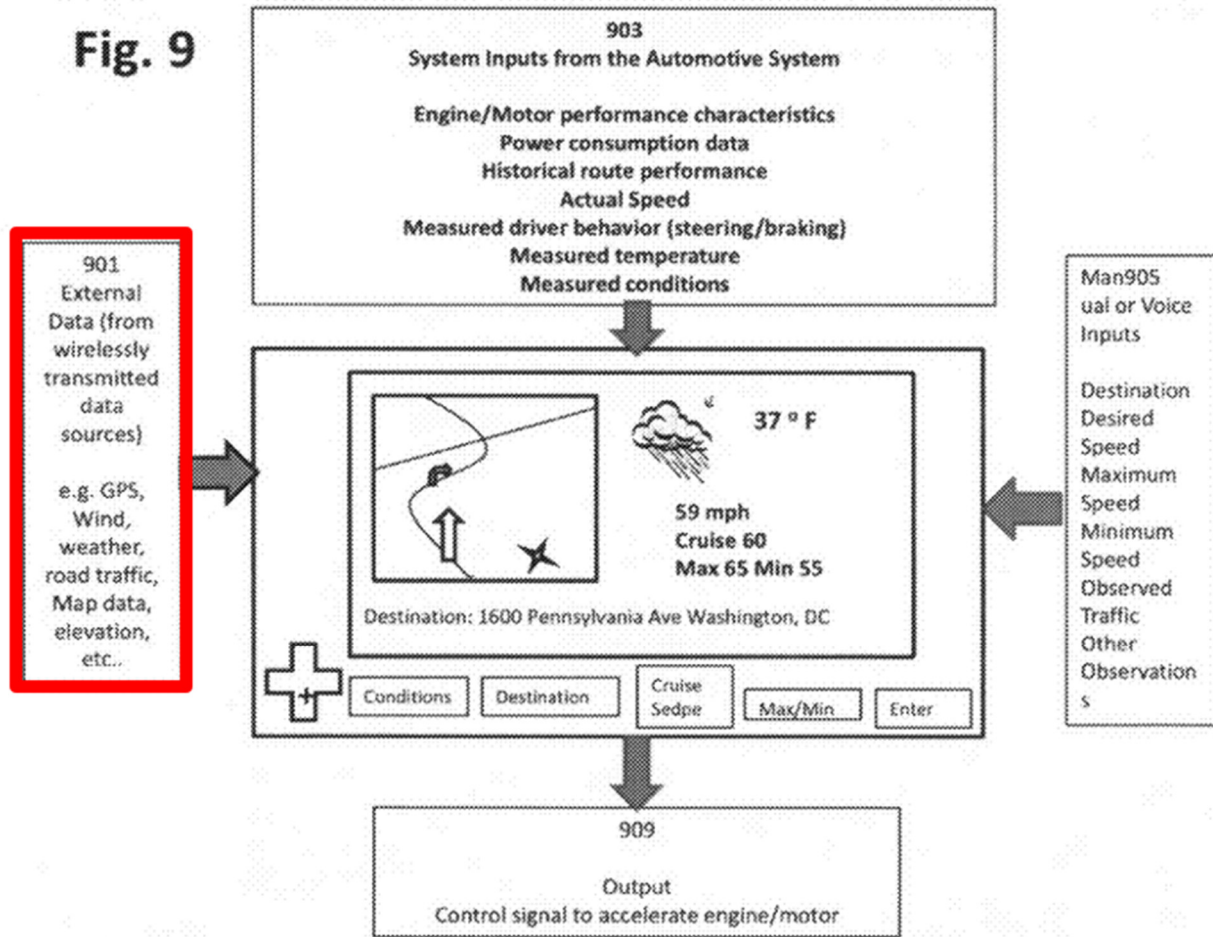
(m) Claim 13

[13] The apparatus according to claim 1, wherein said interface is configured to receive from an external device at least one of (a) said sensor data samples and (b) said data from said telemetry system

147. As shown in Koebler650’s Figure 9 (below), a power management system receives “external information inputs 901” from an *external device*.

TESLA-1004, 22:63-23:18, 23:40-24:14. The inputs 901 include data, e.g., GPS data signals, wind, weather, road traffic, map data, elevation, etc. *Id.*

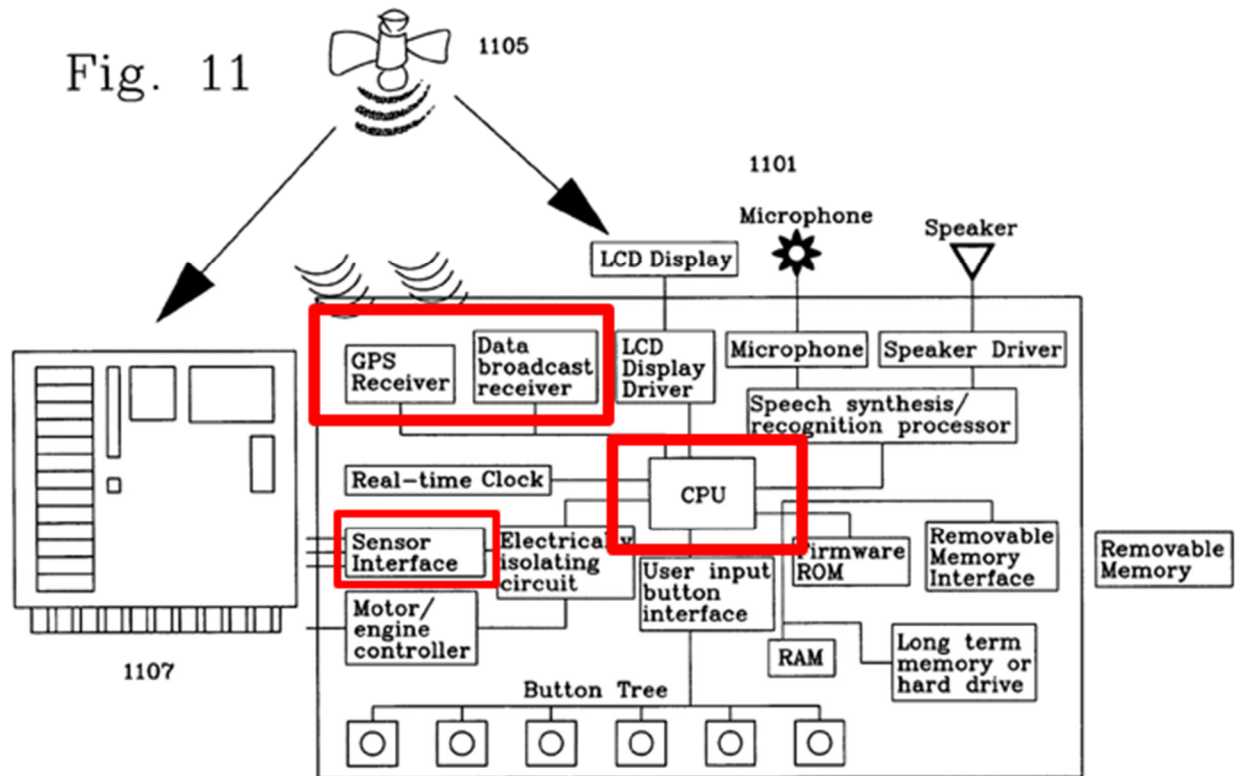
Fig. 9



TESLA-1004, FIG. 9 (annotated).

The “external information inputs 901” would have been understood to be received via wireless transmission using telemetry and thus represents *data from said telemetry system*. 8:19-24, 24:6-22, S11. As shown in Figure 11 (below), a power management device 1101 receives telemetry data from an *external device*, i.e., a device external from the device 1101 and the vehicle, using the “GPS receiver” or “data broadcast receiver” (each of which provide connectivity to a *telemetry system*). *Id.*, 24:6-22.

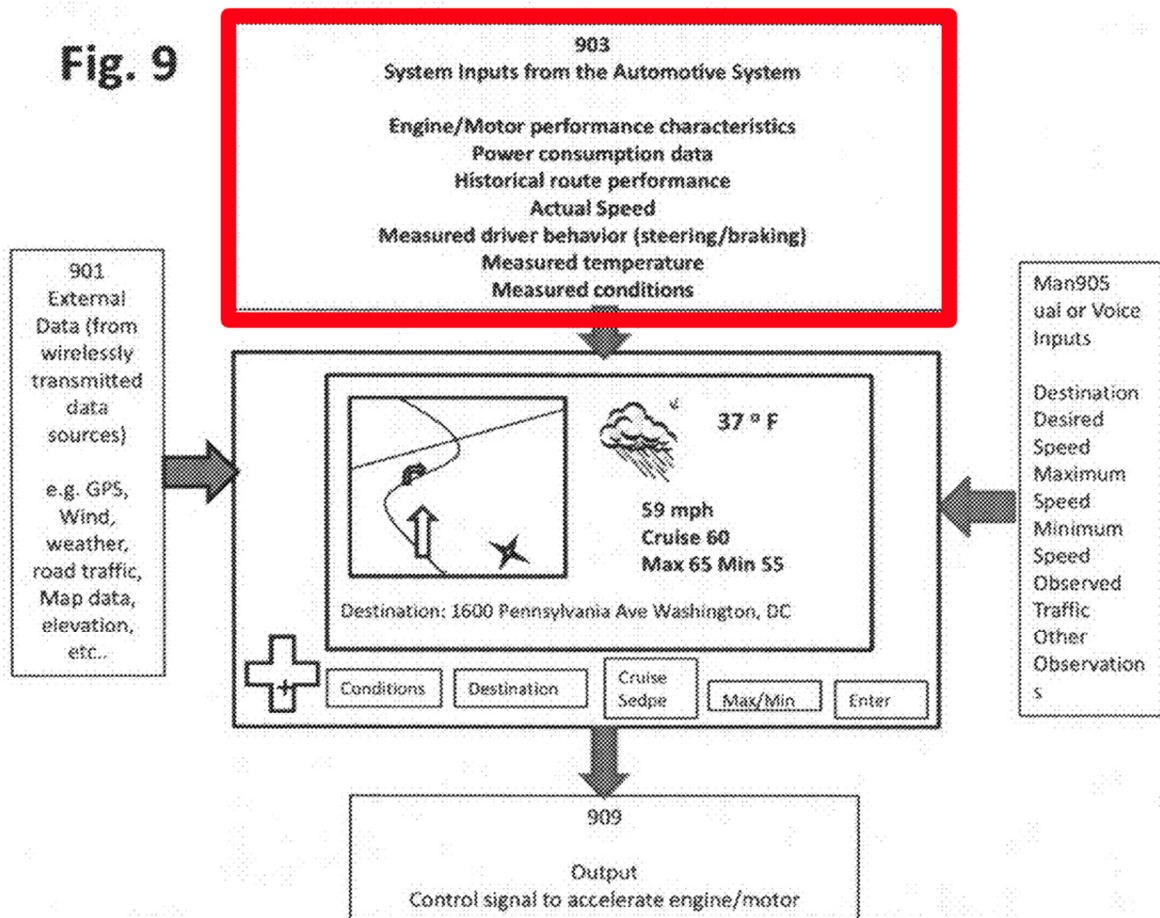
148. Additionally, the device 1101 also receives sensor data from sensor devices external to the device 1101 (*external device*) via the sensor interface shown in Figure 11.



TESLA-1004, FIG. 11 (annotated)

149. As shown in Koebler650’s Figure 9 (below), the power management system receives “actual speed,” “measured driver behavior (steering/braking),” “measured temperature,” and “measured conditions” from “system inputs from the automotive system,” which a POSITA would understand would be received as *sen-*

sor data samples reflecting measurements from sensors external to the power management system (*external device*) via, for example, the sensor interface of Figure 11.



TESLA-1004, FIG. 9 (annotated)

(n) Claim 14

[14] *The apparatus according to claim 1, wherein said current conditions comprise at least one of: energy requirements, a speed of said vehicle, road conditions, and traffic.*

150. As discussed for [1e], **current conditions** (Supported Current Conditions, e.g., **drag**, **visibility**) are determined by “power management logic” (**processor**) based on analyzing data from various sensors (e.g., an optical sensor and tire pressure sensor) (**sensor data samples** received from an **optical sensor** and **tire pressure sensor**). TESLA-1004, 21:29-51, 19:61-65, 8:8-19. The Supported Current Conditions include examples (e.g., **visibility** and **drag**) of “present road conditions” (**road conditions**). *Id.*, 7:32-34, 7:46-62, 8:41-52, 18:51-56, 23:62-24:5. Further, the Koebler650 systems determines each of “amount of light energy” (**energy requirements**), “velocity” (**speed**), “traffic information data,” “traffic surrounding a vehicle,” the “location of stoplights” (**traffic**). *Id.*

(o) **Claim 15**

151. Koebler650 anticipates and/or renders claim 15 obvious in the same manner as explained above for the corresponding claim 1 limitations below and based on the same corresponding evidence.

Claim 1 Limitation	Claim 15 Limitation
[1a-1]	[15c-1]
[1a-2]	[15c-2]
[1b]	[15d]
[1c-1]	[15e-1]
[1c-2]	[15e-2]

[1c-3]	[15e-3]
[1d]	[15f]
[1e]	[15g]

[15pre] A vehicle comprising

152. To the extent the preamble is limiting, Koebler650 discloses [15pre]. In Koebler650, “[t]he devices and systems described herein” are used with “any appropriate vehicle (***vehicle***). TESLA-1004, 4:49-55, 18:51-56, 23:62-24:5.

[15a] a power train

153. In Koebler650, a vehicle may include an “internal combustion engine,” a “hybrid internal combustion/electric vehicle[,],” an “electric vehicle[,],” or a “hydrogen fuel cell vehicle[.]. TESLA-1004, 4:49-55. A POSITA would have understood these types of vehicles include a ***power train*** and a ***drive train***. TESLA-1004, 6:21-25.

[15b] A drive train

154. In Koebler650, a vehicle may include an “internal combustion engine,” a “hybrid internal combustion/electric vehicle[,],” an “electric vehicle[,],” or a “hydrogen fuel cell vehicle[.]. TESLA-1004, 4:49-55. These types of vehicles include a ***power train*** and a ***drive train***. TESLA-1004, 6:21-25.

(p) Claim 16

155. Koebler650 anticipates and/or renders claim 16 obvious in the same manner as explained above for the corresponding claim 1 limitations below and based on the same corresponding evidence.

Claim 1 Limitation	Claim 16 Limitation
[1a-1]	[16b]
[1a-2]	[16c]
[1b]	[16d]
[1c-1]	[16f-1]
[1c-2]	[16f-2]
[1c-3]	[16f-3]

[16pre] A method performed by a processor for creating a database of route conditions, comprising the steps of:

156. To the extent the preamble is limiting, Koebler650 discloses [16pre]. In Koebler650, “a memory” or other “data structure” stores “a record of historical information.” TESLA-1004, 17:3-6. These “record[s] of historical information” include conditions, such as “optimized velocities” and/or “applied power” as well as “information inputs” (e.g., sensor data) corresponding to vehicle use during a route segment. TESLA-1004, 17:6-17, 18:51-56, 23:62-24:5; *see* Section V.A.1. These descriptions relate contents of a data record with an associated database,

which would have been understood to involve *creating a database of route conditions*.

[16a] (A) monitoring a plurality of sensors to generate sensor data during operation of a vehicle, wherein the plurality of sensors comprise at least one of an optical sensor, a position sensor, a speed sensor, a gyroscopic sensor, a revolutions-per-minute sensor, an accelerator pedal position sensor, a brake pedal position sensor, a battery state sensor, a tire pressure sensor, a proximity sensor, a weight sensor, an airflow sensor, and a gas flow sensor;

157. See [1a-1], [1d]. Further, as discussed in Section III.D.2, the *at least one...and* phrase of [16a] may be interpreted under conjunctive or disjunctive reads within the construction of the *monitoring* step requiring “monitoring a plurality of sensors that comprise at least one of the sensors enumerated in [16a]” (discussed in Section III.D.1).

158. Under a disjunctive read, the requirements of [16a] may be satisfied by monitoring *a plurality of sensors* that includes one of the Enumerated Sensors. Koebler650 discloses the *monitoring* step under the disjunctive read through disclosure of monitoring various sensors (e.g., an *optical sensor* and a *tire pressure sensor*) to determine the Supported Current Conditions. TESLA-1004, 8:8-19, 19:61-65, 19:47-20:6, 21:29-51 (“Sensors may be monitored (e.g., polled) in real time,” e.g., through “the polling logic may coordinate continuous or periodic polling of ... tire pressure ...”). Koebler650 also discloses each of the other Enumerated Sensors in [16a]. See Section V.B(a).

[16e] (E) analyzing said sensor data to determine current conditions, wherein said current conditions comprise at least one of: drag, wind resistance, tire resistance, a location relative to a destination, traffic patterns, an amount of light energy, a position of the sun, geographical information, an elevation of said vehicle, a grade of a road, a location of stoplights, a timing of stoplights, weather, a wind direction, a wind velocity, a temperature, air pressure, moisture, visibility, an amount of vibration, and traction; and

159. See [1c-1], [1e]. Further, as discussed in Section III.D.2, the **at least one...and** phrase of [16e] may be interpreted under conjunctive or disjunctive reads within the construction of **analyzing** step requiring “analyzing sensor data generated by monitoring at least one of the Enumerated Sensors in [16a] to determine at least one of the current conditions enumerated in [16e]” (discussed in Section III.D.1).

160. Under a disjunctive read, the requirements of [16e] may be satisfied by analyzing sensor data generated by monitoring one Enumerated Sensor to determine one enumerated current condition. Koebler650 discloses the **analyzing** step as construed. Koebler650 discloses the **analyzing** under the disjunctive read through an example of sensor data being generated and monitored by various of the Enumerated Sensors (e.g., **optical sensor**) to determine the Supported Current Conditions (e.g., **visibility**) (**current condition**). TESLA-1004, 19:52-54, 19:61-65, 8:14-18. Another example involves monitoring sensor data generated by a monitored **tire pressure sensor** to determine **drag**. TESLA-1004, 19:52-54, 19:61-65, 21:29-51.

161. The ***current conditions*** feature is relevant to several limitations of independent claim 1 ([1d], [1e]), claim 15 ([15e-1], [15e-3]), and claim 16 ([16a], [16e]). This feature is similarly recited in claims 2, 3, 6-8, and 14. As discussed below, the analysis of Koebler650's disclosure of several examples of ***current conditions*** is incorporated by reference to the discussion of this limitation.

B. Ground 2: Claims 1-16 are rendered obvious over the combination of Koebler650, Kabel, Lagerstedt, Okano, Kirkwood, and Breed

1. References

(a) Kabel

162. Kabel describes systems and techniques for acquiring “[r]eal-time weather information” for presentation and display within a vehicle display. TESLA-1010, Abstract. A vehicle includes a navigation device on which a “real-time weather interface service is loaded and processed.” *Id.*, 3:4-11. The navigation device is a device “capable of acquiring current positioning information for itself and capable of providing route guidance from a given start position to a desired position.” *Id.*, 3:4-11. The navigation device is “interfaced to a positioning system, such as a Global Positioning Satellite (GPS) service.” *Id.*, 3:12-23.

163. The real-time weather interface “communicates with [a] real-time weather service for the purposes of acquiring real-time weather characteristics for given geographic locations.” TESLA-1010, 3:12-23. In the Kabel system, posi-

tion information of a vehicle (e.g., GPS coordinates) is determined by the positioning system and provided to the real-time weather service through the real-time weather interface of the navigation device. *Id.* The real-time weather service uses the position information to identify real-time weather characteristics for a geographic location associated with the position information. *Id.* The real-time weather characteristics associated with the geographic location are then provided for output to navigation system (e.g., “presented on a display associated with the navigation device”). *Id.*, 3:45-59. The “real-time weather information” includes a “variety of weather characteristics,” such as “temperature, wind speed, wind direction, water temperature, wave periods, wave directions, wave height, barometric pressure, lightening, rain, hail, snow, front information, and others.” *Id.*, 3:39-44. Kabel is analogous art to the ’616 patent because it is from the same field of endeavor (e.g., vehicle systems) and is reasonably pertinent to a problem the ’616 patent was trying to solve (e.g., inefficiencies associated with information acquisition by a vehicle). *See* TESLA-1001, 1:20-2:15.

(b) Lagerstedt

164. Lagerstedt describes techniques for obtaining weather information for software applications, e.g., a calendar application. TESLA-1014, 5:3-15. In one example, “weather information 160” may be provided on a “user device 110” as, for instance, “a visual, audio, and/or textual representation of the weather.” *Id.*,

6:3-20. In Lagerstedt’s systems, weather information is provided by a “weather module” and examples of the provided weather information include “sun, rain, showers, drizzle, cloudy, partly cloudy, snow, sleet, freezing rain, flurries, barometric pressure, temperature..., wind chill, dewpoint, humidity, heat index, and/or any other information associated with weather.” *Id.*, 9:23-37. Lagerstedt is analogous art to the ’616 patent because it is from the same field of endeavor (e.g., information retrieval) and is reasonably pertinent to a problem the ’616 patent was trying to solve (e.g., inefficiencies associated with information acquisition). *See* TESLA-1001, 1:20-2:15.

(c) Breed

165. Breed generally relates to “systems and methods for timely conveying information from or about traffic control devices, such as stoplights and stop signs, to vehicles, e.g., as the vehicle approaches the traffic control device.” TESLA-1013, 2:16-20. Specifically, a “vehicle control arrangement” includes “at least one traffic control device and a communication system arranged in a vehicle and communicating with each traffic control device,” e.g., by enabling the vehicle to “receive information about a status of the traffic control device(s).” *Id.*, 2:47-56. One example involves “establishing communications between the traffic control devices and vehicles approaching the traffic control devices, and providing information about travel of the vehicle to the traffic control devices to operation based

on the provided information and/or providing information about a status of the traffic control device to the vehicles to enable the vehicles to operate based on the provided information.” *Id.*, 3:12-31. Breed also contemplates a “traffic control device” being a “stoplight” with a transmitter capable of providing status information relating to the stoplight, such as “how much time remains before the stoplight changes color” (*id.*; 3:1-11) and “the color” of the stop light (*id.*, 2:47-56). Thus, in the Breed system, position information of a vehicle (e.g., travel information) is provided to a traffic control device (e.g., stoplight). *Id.*, 2:47-56. The traffic control device uses the position information to identify status information for a geographic location associated with the position information. *Id.* The status information is then provided to the vehicle, e.g., providing a warning that the vehicle will be running a stoplight). *Id.*, 3:12-31, 77:8-26.

166. One exemplary system in Breed (shown in Figure 4) includes a “map database 48” and a “navigation system 46 [] coupled to [a] GPS and DGPS processing system 42.” TESLA-1004, 77:8-26. Map database 38 works in conjunction with navigation system 46 to provide information, e.g., warnings, to a driver of a vehicle. *Id.* Map database 48 stores “location of all stop signs and stop lights and other traffic control devices, such as other types of road signs.” *Id.* In this system, a sensor “provides input to [a] vehicle indicating that an approaching stoplight is red, yellow or green[,]” and a “navigation system 46” coupled to a “GPS

and DGPS processing system 42.” *Id.*; *see id.*, 77:27-58, 79:17-28. Breed is analogous art to the ’616 patent because it is from the same field of endeavor (e.g., vehicle systems) and is reasonably pertinent to a problem the ’616 patent was trying to solve (e.g., inefficiencies associated with vehicle operation). TESLA-1001, 1:20-2:15.

(d) Okano

167. Okano relates to “a controller for controlling a motor operated actuator device.” TESLA-1011, 1:13-16. The controller “improves the silence and comfort in the vehicle.” *Id.*, 1:54-2:2. In some embodiments, an “electronic control unit” 100 is “sectioned into four principal sections,” including “an information input section 150, a pump-device control section 152, a brake control section 154 and data storage section 156.” *Id.*, 23:10-31. The brake control section 154 executes the “anti-lock brake (ABS) control, traction control (TRC) and vehicle stability control (VSC).” *Id.* A vehicle motor is controlled based on “a target number r^* of revolutions of the motor,” which is determined based on a “acoustic wave intensity characteristic” and a “vibrational wave intensity characteristic.” *Id.*, 23:36-55. Further, “intensity of [a] acoustic or vibrational wave can be measured...by using a sensor (e.g., a device capable of measuring an acoustic pressure level, and a vibrometer capable of measuring a vibrational amplitude)...” *Id.*, 15:16-40. Okano is analogous art to the ’616 patent because it is from the same field of endeavor

(e.g., vehicle systems) and is reasonably pertinent to a problem the '616 patent was trying to solve (e.g., inefficiencies associated with vehicle operation). *See* TESLA-1001, 1:20-2:15.

(e) Kirkwood

168. Kirkwood generally relates to “power transfer systems for controlling the distribution of drive torque between the front and rear drivelines of a four-wheel drive vehicle and/or the left and right wheels of an axle assembly.” TESLA-1012, 1:15-24. For example, in Figure 11, a “four-wheel drive vehicle 10” includes a “power transfer unit 560” and a “torque distribution mechanism 566.” *Id.*, 16:40-56. The “torque distribution mechanism 566” is “operably associated with traction control system 416 for providing [an] adaptive traction control feature.” *Id.* For example, a “front-rear drive torque distribution ratio” may be varied based on “tractive needs of the front and rear wheels as detected by [] various sensors.” *Id.*, 17:19-27. Kirkwood is analogous art to the '616 patent because it is from the same field of endeavor (e.g., vehicle systems) and is reasonably pertinent to a problem the '616 patent was trying to solve (e.g., inefficiencies associated with vehicle operation). TESLA-1003, ¶168; *see* TESLA-1001, 1:20-2:15.

2. Proposed Combination

169. As discussed in Section V.A.1, Koebler650 teaches techniques for calculating a “probable optimal speed” based on matching records of “historical record information.” TESLA-1004, 18:45-56; *see also* Section V.B(a). The “historical record information” includes “information about the time of day, weather conditions, road conditions, driver, etc.” (e.g., current conditions information), “route information (e.g., starting location and any intermediate locations)” (e.g., route segment information), and other types of information, such as “information about the actual or optimized velocities,” “information[] from information inputs,” among others. *Id.*, 16:66-17:17, 22:8-19.

170. A POSITA looking to implement the teachings of Koebler650 would have sought to implement a wide variety of current conditions to be captured in the “historical record information” because this would have increased the “identifying information” that “more closely” matches “the information about the current route (e.g., the driver, weather conditions, traffic, etc.), which enables a “higher setting of the reliability estimate” assigned to calculations of “probable optimal speed.” TESLA-1004, 18:45-56. In doing so, the POSITA would have recognized that Koebler650 fails to provide details regarding how various of these current conditions are determined from particular sensors or the output of such sensors.

171. A POSITA would have therefore turned to disclosures beyond Koebler650, that describe certain examples of particular techniques of detecting current conditions using the sensors disclosed within Koebler650. *See* TESLA-1004, 21:29-62; *see* Section V.B(a). In doing so, the POSITA would have recognized that these teachings would have improved Koebler650, e.g., by increasing the types of current conditions that are uploaded to a remote database as “historical route information,” and thereby available to be used to improve the reliability of calculating a “probable optimal speed.”

(a) Koebler650-Kabel-Lagerstedt

172. As noted above, a POSITA would have recognized that Koebler650 fails to provide details regarding how weather-related current conditions are determined from analysis of data samples collected by the particular sensors disclosed in Koebler650. For example, while “the power management system may communicate with a weather service” such that the “weather service” may be a source of weather-related current condition information to a vehicle, Koebler650 fails to describe or suggest what type of information is obtained from the “weather service,” how the “weather service” is configured to collect weather-related condition information and provide it to the vehicle, or how the vehicle determines current conditions based on information received from the “weather service.” *Id.*, 8:12-24.

173. A POSITA would have therefore turned to Kabel, which describes certain examples of particular techniques of detecting the current conditions of weather, wind direction, wind velocity, and air pressure using a position sensor. TESLA-1012, Abstract, 3:4-44. Kabel teaches examples of weather information (e.g., *temperature, weather, wind direction, wind velocity, air pressure, moisture*), such as “temperature, wind speed, wind direction, water temperature, wave periods, wave directions, wave height, barometric pressure, lightening, rain, hail, snow, front information, and others.” *Id.* Beyond these examples, Kabel teaches that its weather information “includes a variety of real-time weather characteristics” and therefore is “not limited to” the identified examples. *Id.*, 3:39-44. For instance, while Kabel describes identifying “dewpoint” within weather information, it does not specifically indicate that the weather information includes moisture information relating to dewpoint. *See id.*, 15:41-40, FIG. 23. Weather information in Kabel includes moisture information, such as humidity and dew point. For example, Lagerstedt describes that examples of “weather information” includes both “humidity” and “dew point.” TESLA-1014, 10:10-35, 16:20-34.

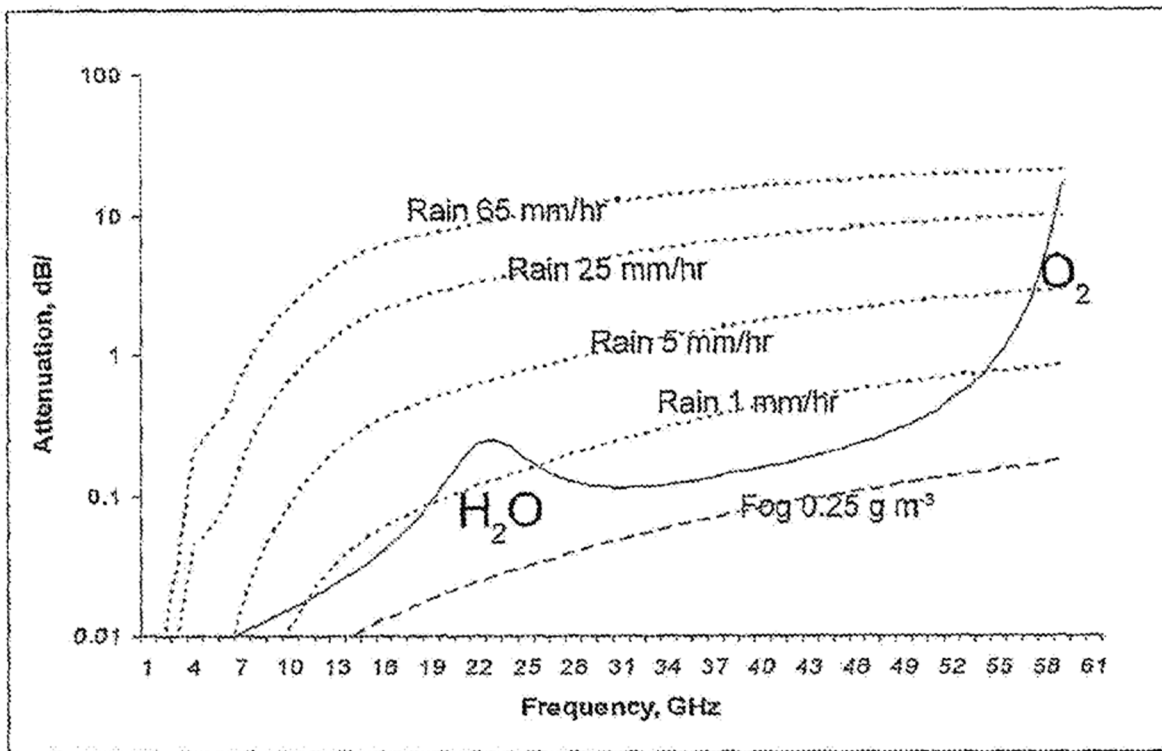
174. As another example, Elkebetz describes that “weather sensors and related weather data” that may be “obtained from various external data sources” includes, for example, “humidity” and “dew point”:

TABLE 7: Weather Sensors and Related Weather Data

#	Sensor Modality	Temporal Resolution	Spatial Resolution
1	Radar	3-10 min	1 km
2	Microwave Links	1 min	300m
3	Satellite	30 min - 3 hr	
4	Rain Gauges and Meters	60 min	
5	Barometers	60 min	
6	Temperature	60 min	
7	Humidity	60 min	
8	Dew Point	60 min	
9	Visibility	60 min	

TESLA-1019, [0110]

Elkebetz also describes measurements relating to weather information that relate to “atmospheric moisture,” which is shown in Figure 1. *Id.*, [0040].



TESLA-1019, Figure 1

A POSITA would have recognized that the teachings of Kabel would have improved Koebler650, e.g., by increasing the types of current conditions that are uploaded to a remote database as “historical route information,” and thereby available to be used to improve the reliability of calculating a “probable optimal speed.”

175. A POSITA would have also found it beneficial to incorporate functionality relating to determining the current conditions of moisture information (humidity, dew point) by the Koebler650-Combination since moisture information was known to impact aspects of vehicle operation relating to fuel efficiency (e.g.,

engine burn rate characteristics impacting thermal efficiency). For example, a publication by Wimmer explained that “[v]ariations in humidity influence the engine’s burn rate characteristics,” and specifically that “[a]n increase in humidity reduces the burn rate and increases the combustion duration[,]” and that “[t]his increase I combustion duration has the same effect as retarding the time of ignition[,]” thereby “the thermal efficiency is reduced.” TESLA-1020, Abstract. Indeed, “the engine is more likely to misfire as humidity increases.” *Id.* A POSITA would have therefore been motivated to monitor moisture information (e.g., humidity) to account for these impacts when determining a probable optimal speed. By using moisture information in determining the probable optimal speed, the Koebler650-Combination would have thereby advanced Koebler650’s overall objective of improving fuel efficiency through use of probable optimal speed determinations. *Id.*; see TESLA-1004, 1:63-2:9. Such a combination would have involved incorporating prior art elements according to known methods in a vehicle to yield predictable results. A POSITA would have also reasonably expected to succeed in combining the teachings of Koebler650, Kabel, and Lagerstedt. Implementation of the combination would have required only routine knowledge because the addition of Kabel’s weather service to Koebler650’s vehicle would have involved modifications of software well within the POSITA’s skill.

(b) Koebler650-Breed

176. As noted above, a POSITA would have recognized that Koebler650 fails to provide details regarding how traffic-related current conditions are determined from analysis of data samples collected by the particular sensors disclosed in Koebler650. For example, while “the power management system” may communicate with a “map service” or a “traffic service” such that either of these services may be a source of traffic-related current condition information (e.g., *location of stoplights, timing of stoplights*) to a vehicle, Koebler650 fails to describe or suggest what type of information is obtained from the services, how the services are configured to collect traffic-related condition information and provide it to the vehicle, or how the vehicle determines current conditions based on information received from the services. *Id.*, 8:12-24.

177. A POSITA would have therefore turned to Breed, which describes certain examples of particular techniques of detecting traffic-related current conditions, such as the location of stoplights and the timing of stoplights using a positioning system arranged within a vehicle. TESLA-1013, 2:16-20, 2:47-56, 3:1-11, 3:32-42, 77:8-26, 79:17-28. In doing so, the POSITA would have recognized that the teachings of Breed would have improved Koebler650, e.g., by increasing the types of current conditions that are uploaded to a remote database as “historical route information,” and thereby available to be used to improve the reliability of calculating a “probable optimal speed.” Such a combination would have involved

incorporating prior art elements according to known methods in a vehicle to yield predictable results. A POSITA would have also reasonably expected to succeed in combining the teachings of Koebler650 and Breed. Implementation of the combination would have required only routine knowledge because the addition of Breed's traffic service to Koebler650's vehicle would have involved modifications of software well within the POSITA's skill.

(c) Koebler650-Okano

178. As noted above, a POSITA would have recognized that Koebler650 fails to provide details regarding how current conditions related to the external factors of a vehicle are determined from analysis of data samples collected by the particular sensors disclosed in Koebler650. For example, Koebler650 recognizes that “[m]any parameters may impact the optimal power consumption of a vehicle, including external factors (e.g., forces and conditions that act on the vehicle” and “current status of the vehicle and it’s [sic] component parts)...” TESLA-1004, 1:53-62. However, Koebler650 fails to describe or suggest how external factor information (e.g., vibrations caused by forces and conditions acting on a vehicle) is determined based on information received from the sensors. *Id.*, 8:12-24.

179. A POSITA would have therefore turned to Okano, which describes certain examples of particular techniques of detecting intensity of acoustic or vi-

brational waves by a vehicle stability control system, which would have been understood to include a rotational speed sensor. TESLA-1011, 15:16-39. In doing so, the POSITA would have recognized that the teachings of Okano would have improved Koebler650, e.g., by increasing the types of current conditions that are uploaded to a remote database as “historical route information,” and thereby available to be used to improve the reliability of calculating a “probable optimal speed.” Further, because vibration information is an example of “operational status information” that “impact the optimal power consumption of a vehicle,” this information is useful to improve the calculation of the “probable optimal speed.” TESLA-1004, 4:31-42. Such a combination would have involved incorporating prior art elements according to known methods in a vehicle to yield predictable results. A POSITA would have also reasonably expected to succeed in combining the teachings of Koebler650 and Okano. Implementation of the combination would have required only routine knowledge because adding aspects of Okano’s control systems to Koebler650’s vehicle would have involved modifications of software well within the POSITA’s skill.

(d) Koebler650-Kirkwood

180. As noted above, a POSITA would have recognized that Koebler650 fails to provide details regarding how current conditions related to the external fac-

tors of a vehicle are determined from analysis of data samples collected by the particular sensors disclosed in Koebler650. For example, Koebler650 recognizes that “[m]any parameters may impact the optimal power consumption of a vehicle, including external factors (e.g., forces and conditions that act on the vehicle” and “current status of the vehicle and it’s [sic] component parts)...” TESLA-1004, 1:53-62. However, Koebler650 fails to describe or suggest how external factor information (e.g., traction) is determined based on information received from the services. *Id.*, 8:12-24.

181. A POSITA would have therefore turned to Kirkwood, which describes certain examples of particular techniques of detecting parameters relating to traction by a traction control system of a vehicle (e.g., ***traction***), which would have been understood to further include a rotational speed sensor. TESLA-1012, 16:40-56, 17:19-27; *see* TESLA-1015, 1:30-54. In doing so, the POSITA would have recognized that the teachings of Kirkwood would have improved Koebler650, e.g., by increasing the types of current conditions that are uploaded to a remote database as “historical route information,” and thereby available to be used to improve the reliability of calculating a “probable optimal speed” and associated fuel efficiency. After all, a vehicle having less traction may consume more fuel to move the same distance than a vehicle having more traction. Further, because traction is an exam-

ple of “operational status information” that “impact the optimal power consumption of a vehicle,” this information is useful to improve the calculation of the “probable optimal speed.” TESLA-1004, 4:31-42.

3. Analysis

(a) Claim 1

182. The Koebler650-Combination incorporates the teachings of Koebler650 and therefore discloses the following limitations of claim 1 in the same manner as discussed above for corresponding limitations in Ground 1A based on the same corresponding evidence.

Claim 1 Limitation	Corresponding Section
[1pre]	Section V.A.2(a) (addressing [1pre])
[1a-2]	Section V.A.2(a) (addressing [1a-2])
[1c-2]	Section V.A.2(a) (addressing [1c-2])

[1a-1], [1b], [1c-1]

183. As discussed in Section III.D.1, these limitations recite configurations of an *interface*, *memory*, and *processor* that, through antecedent basis, are further limited by requirements of each of the *sensor data samples* recited in [1d] and the *current conditions* recited in [1e]. Further, as discussed below, because the Koebler650-Combination satisfy each of the requirements of [1d] and [1e] under a

conjunctive read, the Koebler650-Combination similarly satisfies the requirements of the configurations recited in [1a-1], [1b], and [1c-1] under a conjunctive read.

[1d]

184. The Koebler650-Combination discloses [1d] under a conjunctive read because, as discussed in Section V.B(a), Koebler650 expressly discloses each of the thirteen Enumerated Sensors.

[1e]

185. The Koebler650-Combination discloses and/or renders obvious [1e] under a conjunctive read. As discussed in Section III.D.1, because [1c-1] recites *analyzing said sensor data samples...to determine current conditions*,⁹ a conjunctive read of [1e] requires each of the twenty-one enumerated current conditions to be determined from *sensor data samples* from thirteen Enumerated Sensors in [1d]. In the Koebler650-Combination, each of twenty-one enumerated current conditions are determined from sensor data samples from at least one of the thirteen Enumerated Sensors in [1d].

(i) *Current Conditions Expressly Disclosed in Koebler650*

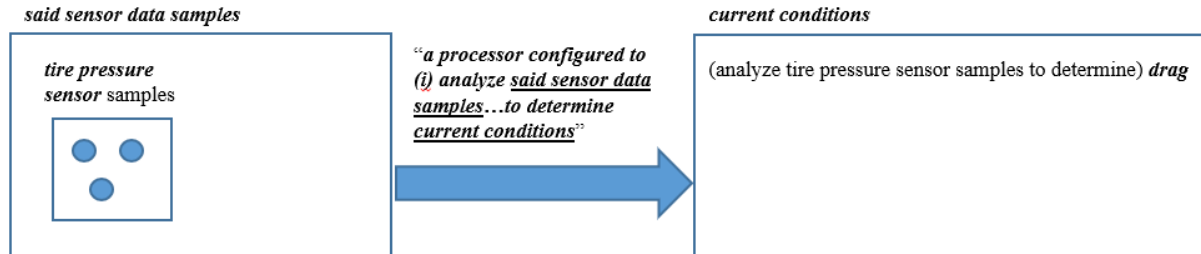
⁹ For claims 1 and 15, this limitation is the *processor* limitation ([1c-1], [15e-1]).

For claim 16, the corresponding limitation is [16e], which recites the *analyzing* step.

186. The figures below show determination of the Supported Current Conditions to be determined based analyzing *sensor data samples* from one of the Enumerated Sensors.

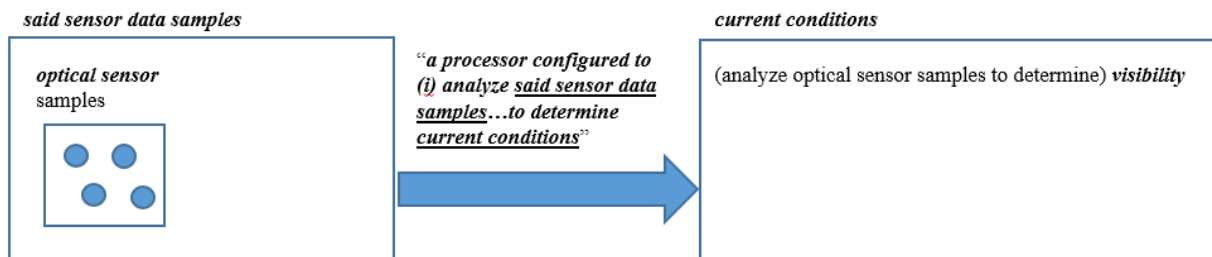
a. *Drag*

187. As shown below, this current condition is disclosed in Koebler650 to be determined based on analyzing sensor data samples received from a *tire pressure sensor*. See, e.g., TESLA-1004, 7:32-44, 8:41-51, 21:29-62.



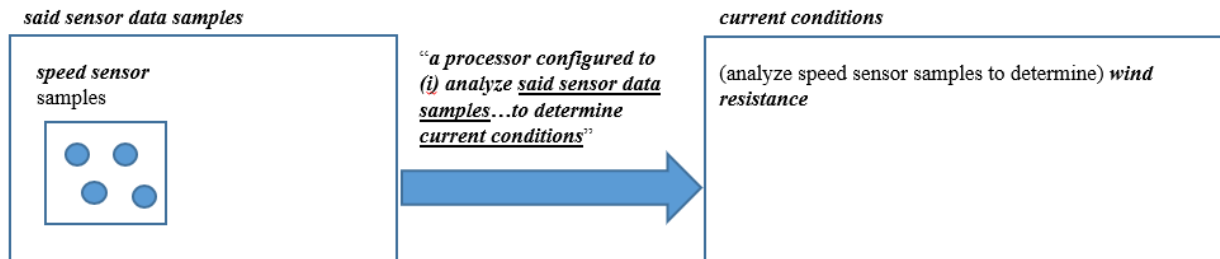
b. *Visibility*

188. As shown below, this current condition is disclosed in Koebler650 to be determined based on analyzing sensor data samples received from an *optical sensor*. See, e.g., TESLA-1004, 7:45-62, 8:12-31; see also Section V.A.2(a) (addressing [1e]).



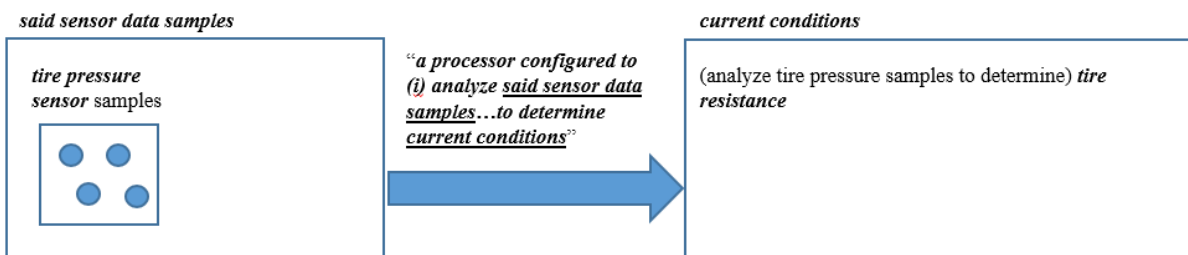
c. *Wind Resistance*

189. As shown below, this current condition is disclosed in Koebler650 to be determined based on analyzing sensor data samples received from a ***speed sensor***. See, e.g., TESLA-1004, 16:13-26, 21:29-62, FIG. 4B.



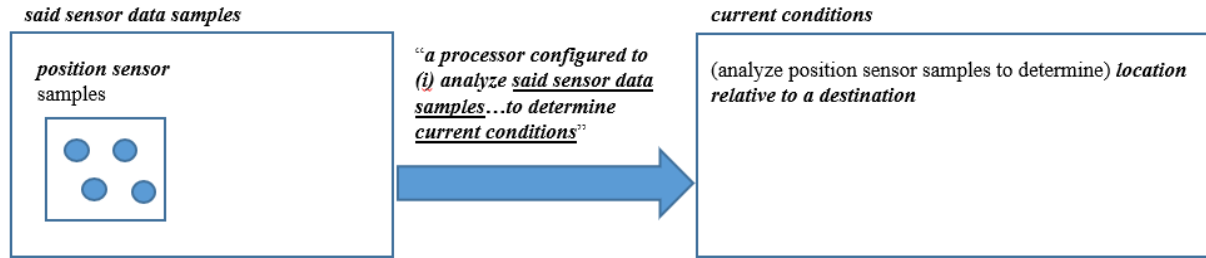
d. ***Tire Resistance***

190. As shown below, this current condition is disclosed in Koebler650 to be determined based on analyzing sensor data samples received from a ***tire pressure sensor***. See, e.g., TESLA-1004, 7:32-44, 21:29-62; see Section V.2(a) (addressing [1e]).



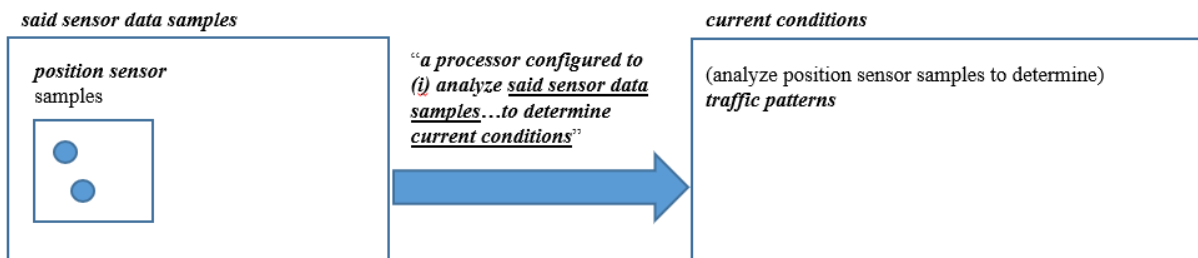
e. ***Location Relative to a Destination***

191. As shown below, this current condition is disclosed in Koebler650 to be determined based on analyzing sensor data samples received from a ***position sensor***. See, e.g., TESLA-1004, 3:41-67, 7:32-44, 21:29-62.



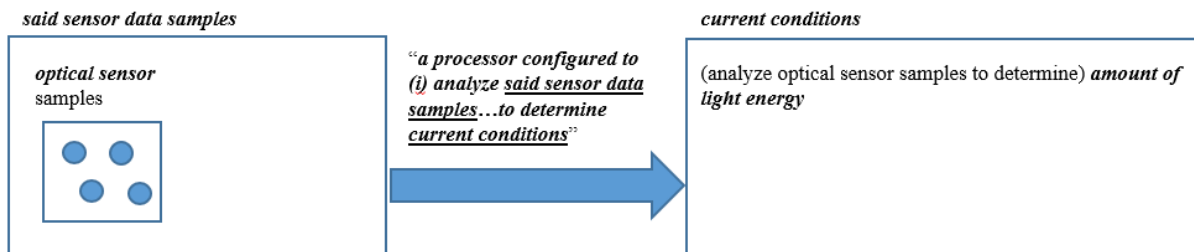
f. *Traffic Patterns*

192. As shown below, this current condition is disclosed in Koebler650 to be determined based on analyzing sensor data samples received from a ***position sensor***. See, e.g., TESLA-1004, 3:41-67, 7:32-44, 7:63-8:11, 8:12-31, 19:47-20:6, 23:19-30.



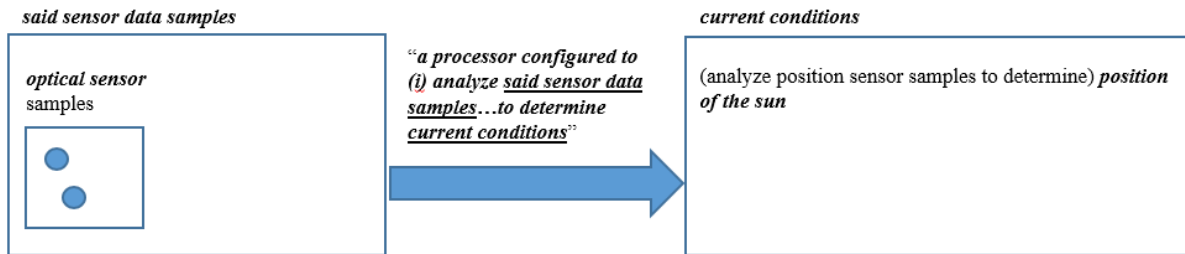
g. *Amount of Light Energy*

193. As shown below, this current condition is disclosed in Koebler650 to be determined based on analyzing sensor data samples received from an ***optical sensor***. See, e.g., TESLA-1004, 7:32-44, 8:12-31.



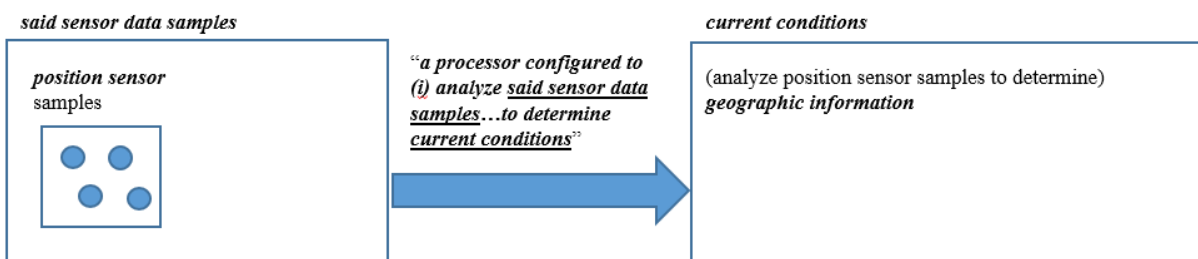
h. ***Position of the Sun***

194. As shown below, this current condition is disclosed in Koebler650 to be determined based on analyzing sensor data samples received from an ***optical sensor***. See, e.g., TESLA-1004, 3:41-67, 7:32-62, 8:12-31.



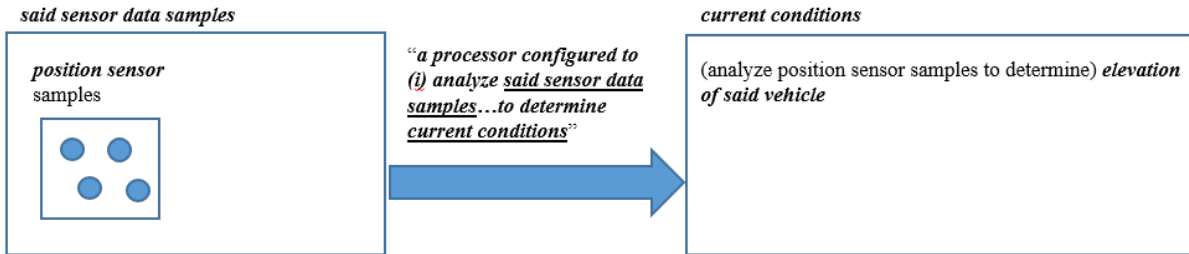
i. ***Geographic Information***

195. As shown below, this current condition is disclosed in Koebler650 to be determined based on analyzing sensor data samples received from a ***position sensor***. See, e.g., TESLA-1004, 7:45-8:11.



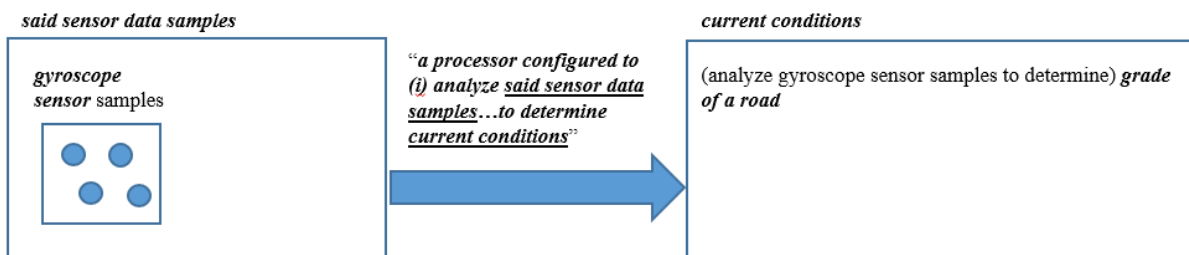
j. ***Elevation of Said Vehicle***

196. As shown below, this current condition is disclosed in Koebler650 to be determined based on analyzing sensor data samples received from a ***position sensor***. See, e.g., TESLA-1004, 3:41-67, 7:45-8:11, 19:47-20:6, 21:29-62.



k. *Grade of a Road*

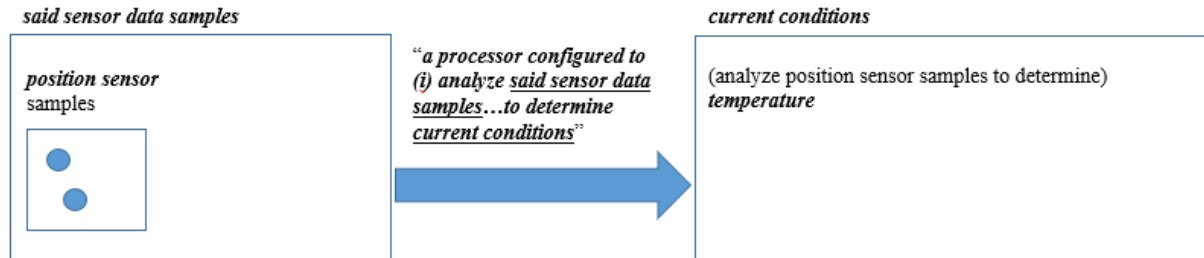
197. As shown below, this current condition is disclosed in Koebler650 to be determined based on analyzing sensor data samples received from a **gyroscope sensor**. See, e.g., TESLA-1004, 21:29-62.



(ii) *Current Conditions Renders Obvious By The Koebler650-Combination*

a. *Temperature*

198. As shown below, in the Koebler650-Combination, this current condition is determined based on analyzing sensor data samples received by Kabel's GPS service (**position sensor**). See, e.g., TESLA-1004, 3:41-67, 7:45-62, 8:12-31, 21:29-62; TESLA-1010, Abstract, 3:4-44.



199. As discussed in Section V.B.1(a), in Kabel, a real-time weather interface of a vehicle “communicates with [a] real-time weather service for the purposes of acquiring real-time weather characteristics for given geographic locations.” TESLA-1010, 3:12-23. Further, “real-time weather characteristics” include “temperature, wind speed, wind direction, water temperature, wave periods, wave directions, wave height, barometric pressure, lightening, rain, hail, snow, front information, and others.” *Id.*, 3:39-44. Kabel also describes a method of displaying “real-time weather information on a display with other information” on, for example, a navigation device associated with a land vehicle. *See id.*, 7:48-61, 13:20-25.

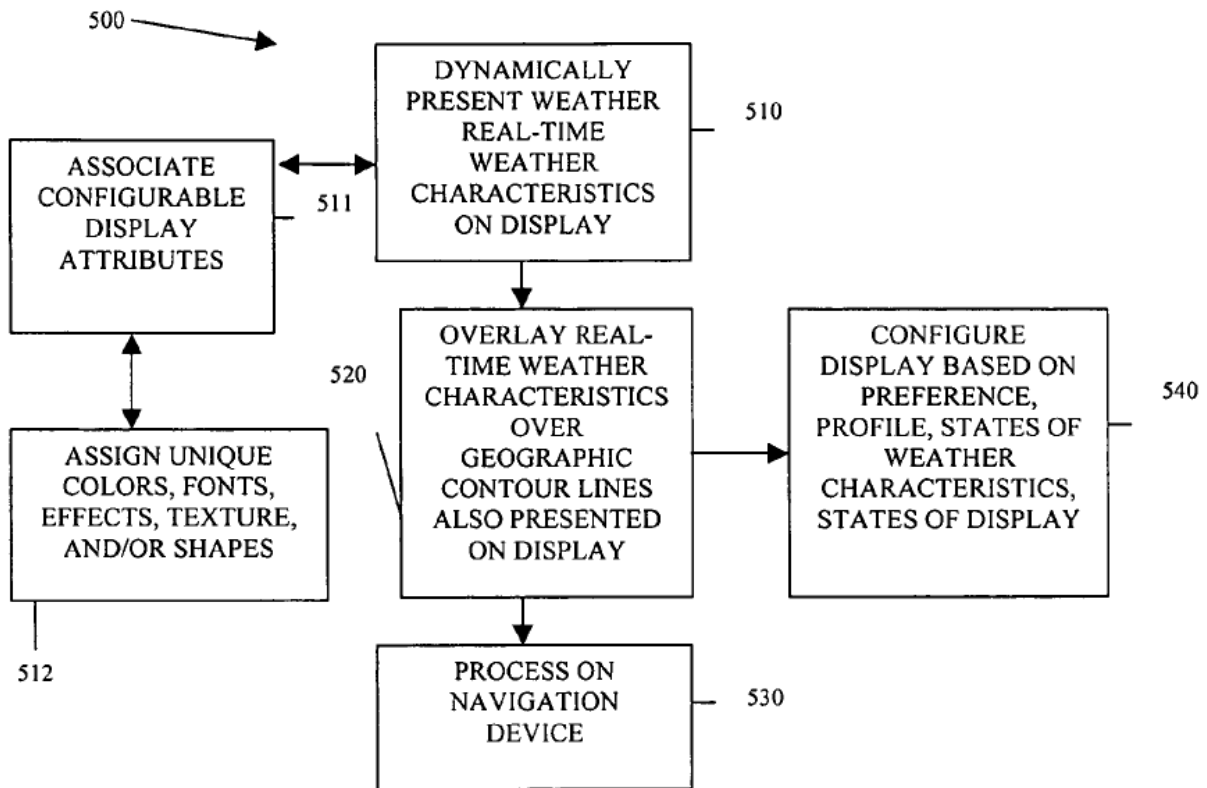
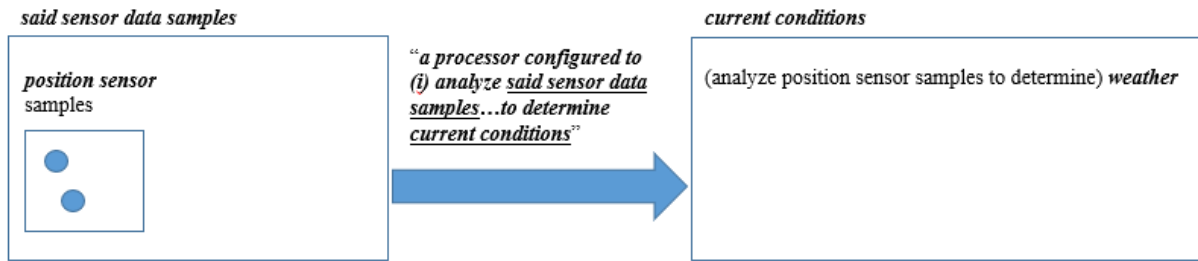


FIG. 5

TESLA-1010, FIG. 5

b. *Weather*

200. As shown below, in the Koebler650-Combination, this current condition is determined based on analyzing sensor data samples received by Kabel's GPS service (*position sensor*). See, e.g., TESLA-1004, 3:41-67, 7:45-62, 8:12-31, 21:29-62; TESLA-1010, Abstract, 3:4-44; see Section V.B.(a).



201. As discussed in Section V.B.1(a), in Kabel, a real-time weather interface of a vehicle “communicates with [a] real-time weather service for the purposes of acquiring real-time weather characteristics for given geographic locations.” TESLA-1010, 3:12-23; *see id.*, 3:39-44. Kabel also describes a method of displaying “real-time weather information on a display with other information” on, for example, a navigation device associated with a land vehicle. *See id.*, 7:48-61, 13:20-25.

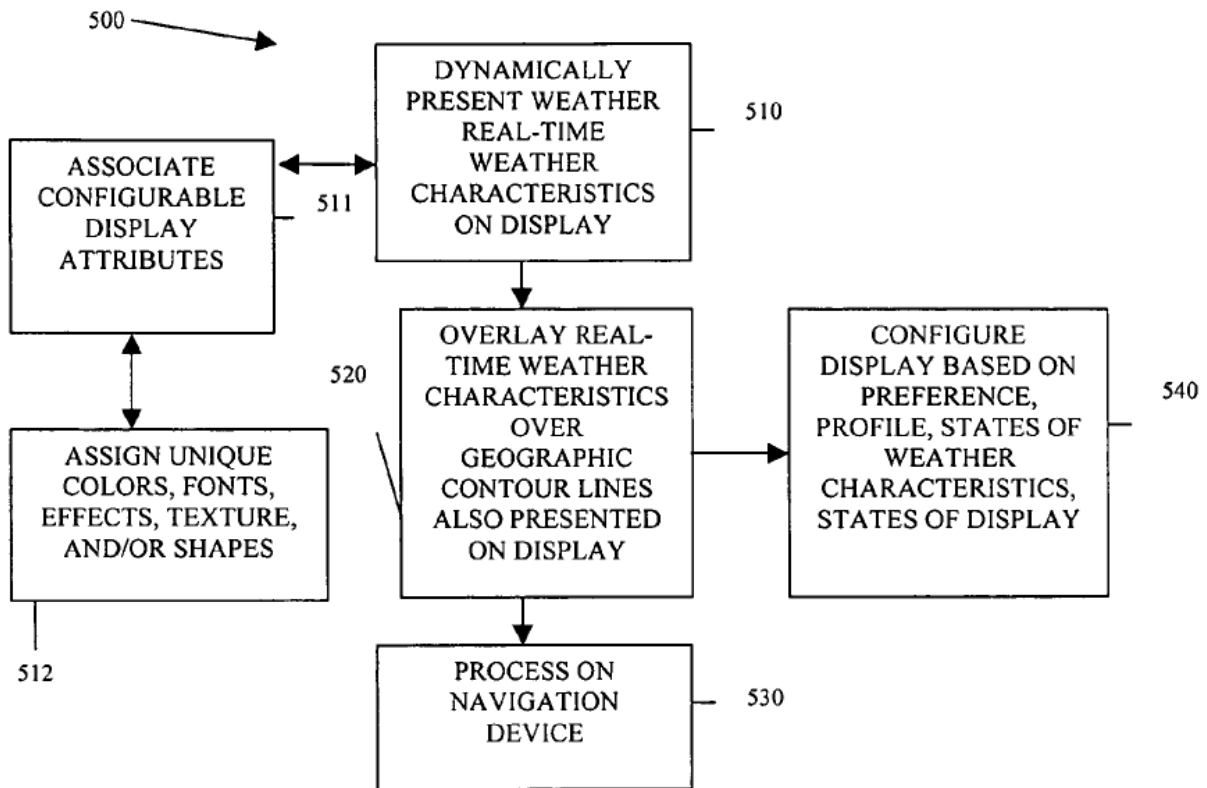
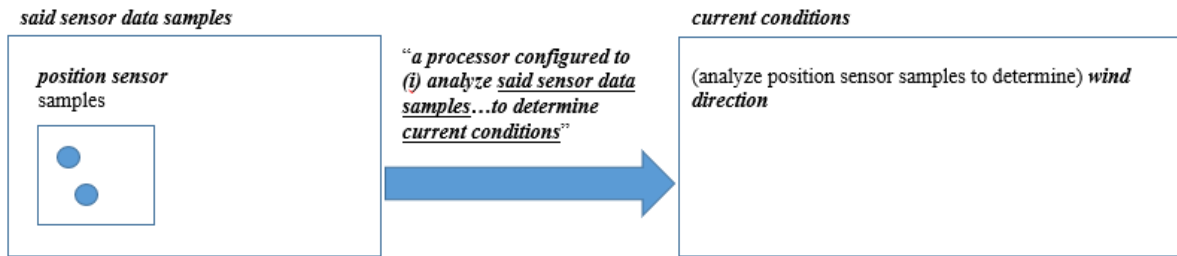


FIG. 5

TESLA-1010, FIG. 5

c. Wind Direction

202. As shown below, in the Koebler650-Combination, this current condition is determined based on analyzing sensor data samples received from Kabel's GPS service (*position sensor*). See, e.g., TESLA-1004, 3:41-67, 7:45-62, 8:12-31, 21:29-62; TESLA-1010, Abstract, 3:4-44.



203. As discussed in Section V.B.1(a), in Kabel, a real-time weather interface of a vehicle “communicates with [a] real-time weather service for the purposes of acquiring real-time weather characteristics for given geographic locations.” TESLA-1010, 3:12-23. Further, “real-time weather characteristics” include “temperature, wind speed, **wind direction**, water temperature, wave periods, wave directions, wave height, barometric pressure, lightening, rain, hail, snow, front information, and others.” *Id.*, 3:39-44. Kabel also describes a method of displaying “real-time weather information on a display with other information” on, for example, a navigation device associated with a land vehicle. *See id.*, 7:48-61, 13:20-25.

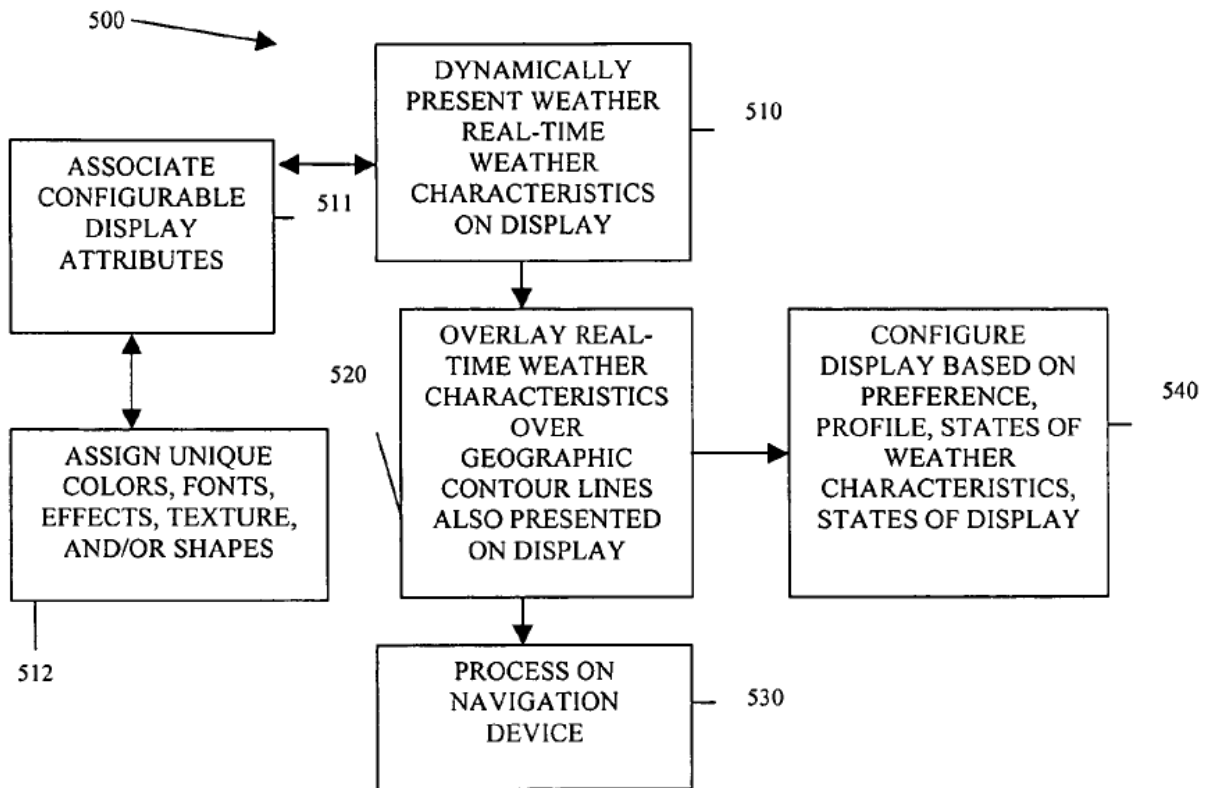
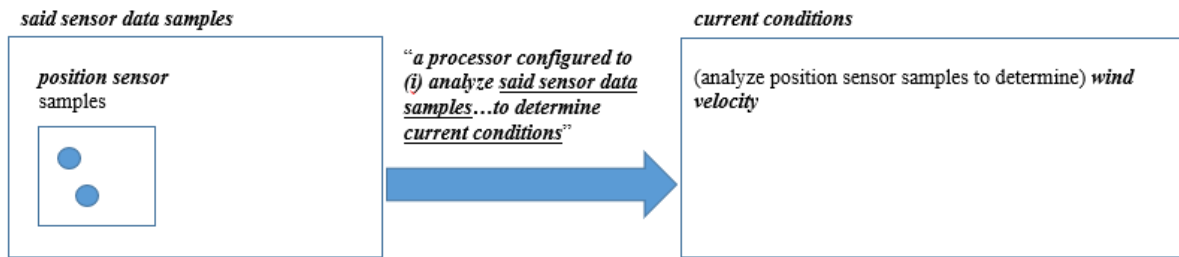


FIG. 5

TESLA-1010, FIG. 5

d. *Wind Velocity*

204. As shown below, in the Koebler650-Combination, this current condition is determined based on analyzing sensor data samples received from Kabel's GPS service (*position sensor*). See, e.g., TESLA-1004, 3:41-67, 7:45-62, 8:12-31, 21:29-62; TESLA-1010, Abstract, 3:4-44.



205. As discussed in Section V.B.1(a), in Kabel, a real-time weather interface of a vehicle “communicates with [a] real-time weather service for the purposes of acquiring real-time weather characteristics for given geographic locations.” TESLA-1010, 3:12-23. Further, “real-time weather characteristics” include “temperature, wind speed, wind direction, water temperature, wave periods, wave directions, wave height, barometric pressure, lightening, rain, hail, snow, front information, and others.” *Id.*, 3:39-44. A POSITA would have understood that wind velocity is determined from wind speed and wind direction because speed provides the magnitude of the wind's movement, while direction specifies the vector's orientation in space. Together, these components form a vector that fully describes the wind's velocity. *See* TESLA-1016, 6:30-57 (“...wind data provide[s] both wind velocity vector measurements including speed and direction...”). Kabel also describes a method of displaying “real-time weather information on a display with other information” on, for example, a navigation device associated with a land vehicle. *See id.*, 7:48-61, 13:20-25.

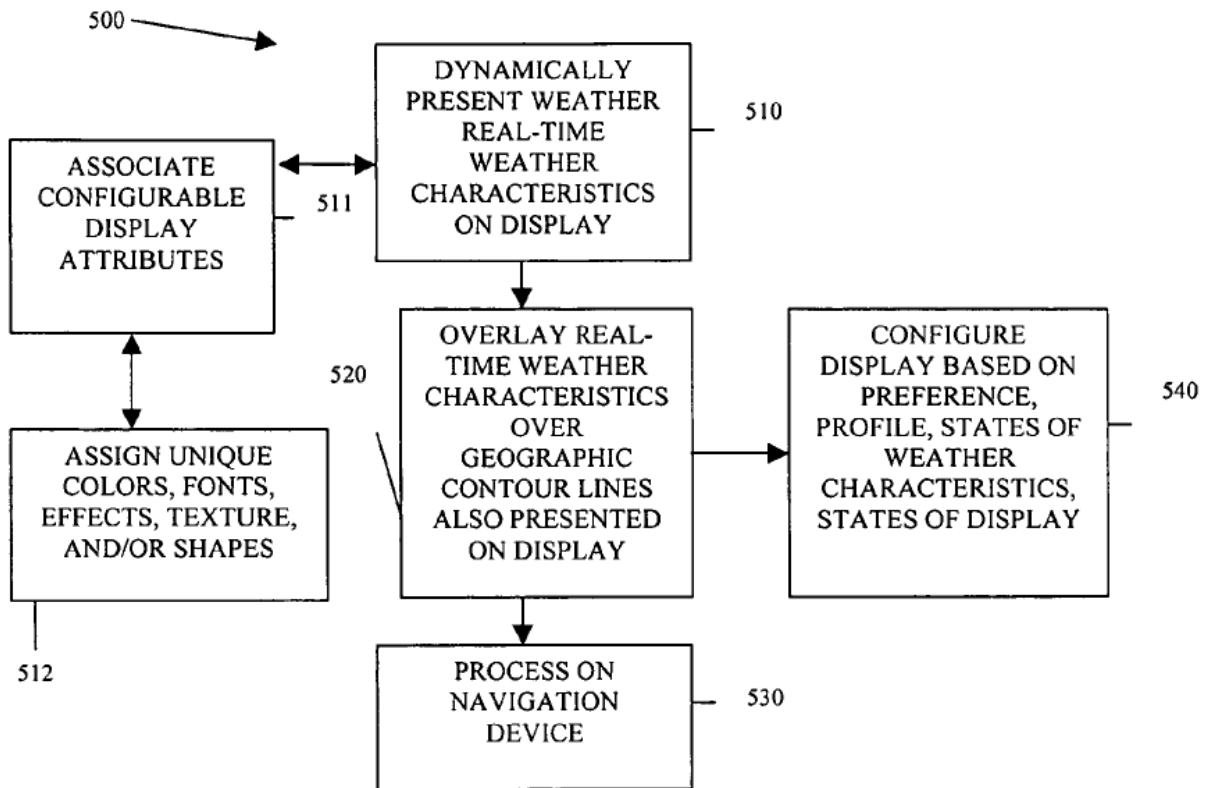
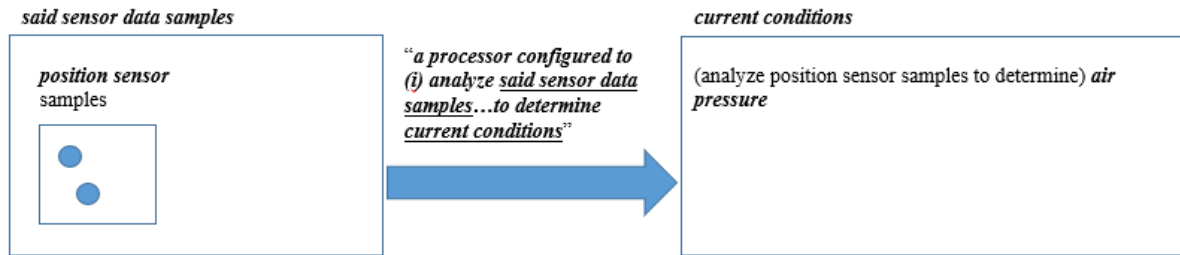


FIG. 5

TESLA-1010, FIG. 5

e. Air Pressure

206. As shown below, in the Koebler650-Combination, this current condition is determined based on analyzing sensor data samples received from a Kabel's GPS service (*position sensor*). See, e.g., TESLA-1004, 3:41-67, 7:45-62, 8:12-31, 21:29-62; TESLA-1010, Abstract, 3:4-44.



207. As discussed in Section V.B.1(a), in Kabel, a real-time weather interface of a vehicle “communicates with [a] real-time weather service for the purposes of acquiring real-time weather characteristics for given geographic locations.” TESLA-1010, 3:12-23. Further, “real-time weather characteristics” include “temperature, wind speed, wind direction, water temperature, wave periods, wave directions, wave height, **barometric pressure**, lightening, rain, hail, snow, front information, and others.” *Id.*, 3:39-44. Kabel also describes a method of displaying “real-time weather information on a display with other information” on, for example, a navigation device associated with a land vehicle. *See id.*, 7:48-61, 13:20-25.

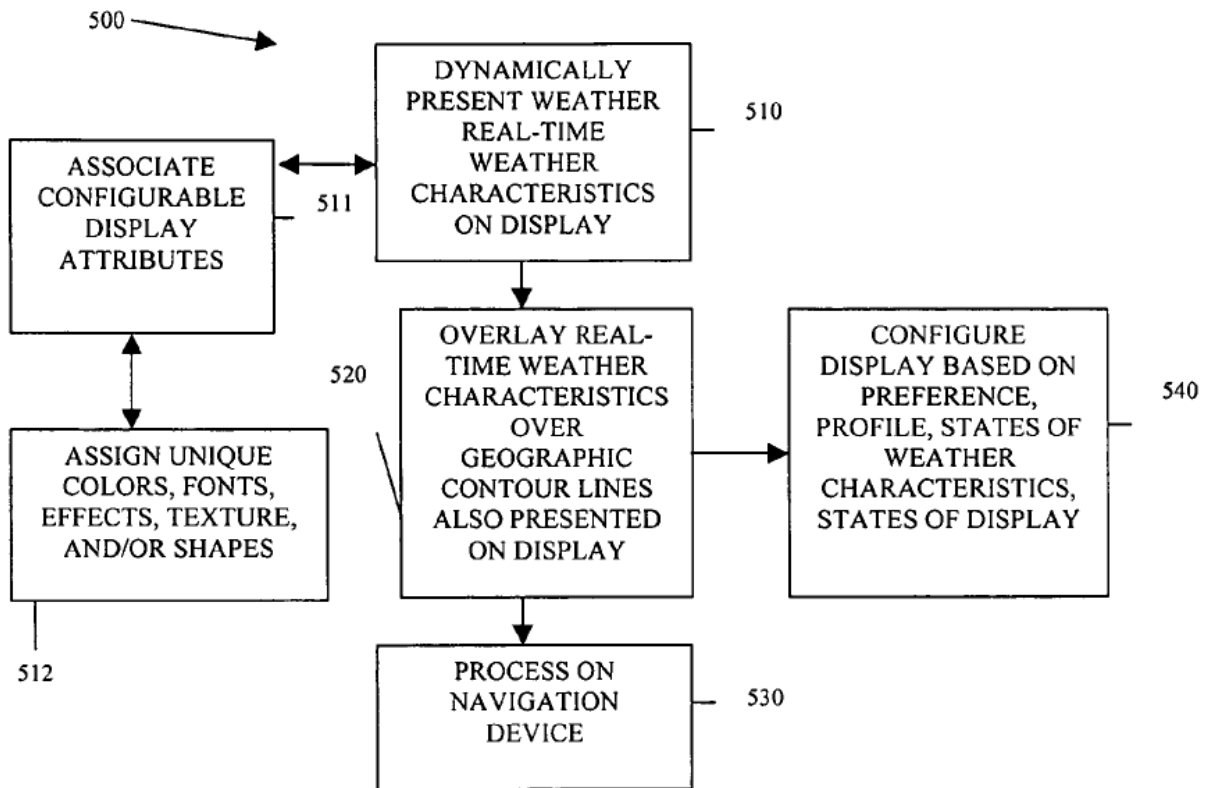
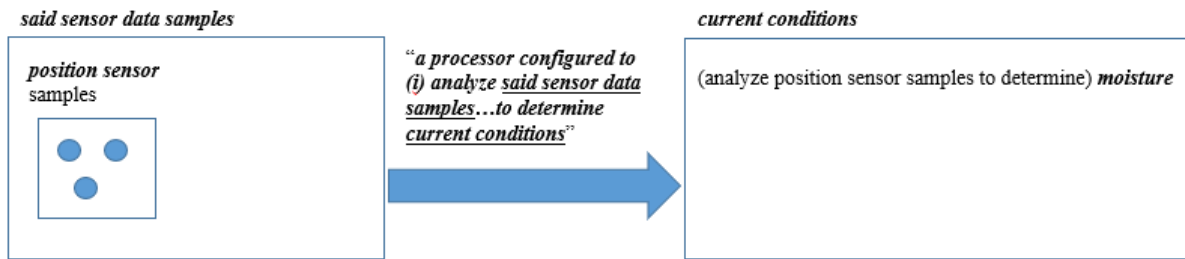


FIG. 5

TESLA-1010, FIG. 5

f. *Moisture*

208. As shown below, in the Koebler650-Combination, this current condition is determined based on analyzing sensor data samples received from Kabel's GPS service (*position sensor*). See, e.g., TESLA-1004, 3:41-67, 7:45-62, 8:12-31, 21:29-62; TESLA-1010, Abstract, 3:12-23, 3:39-44; TESLA-1014, 9:23-37 (examples of weather information include "humidity" and "dew point").



209. As discussed in Section V.B.1(a), in Kabel, a real-time weather interface of a vehicle “communicates with [a] real-time weather service for the purposes of acquiring real-time weather characteristics for given geographic locations.” TESLA-1010, 3:12-23. Further, Kabel describes that its weather service may be used to obtain dew point information. *Id.*, 15:41-45, FIG. 23.

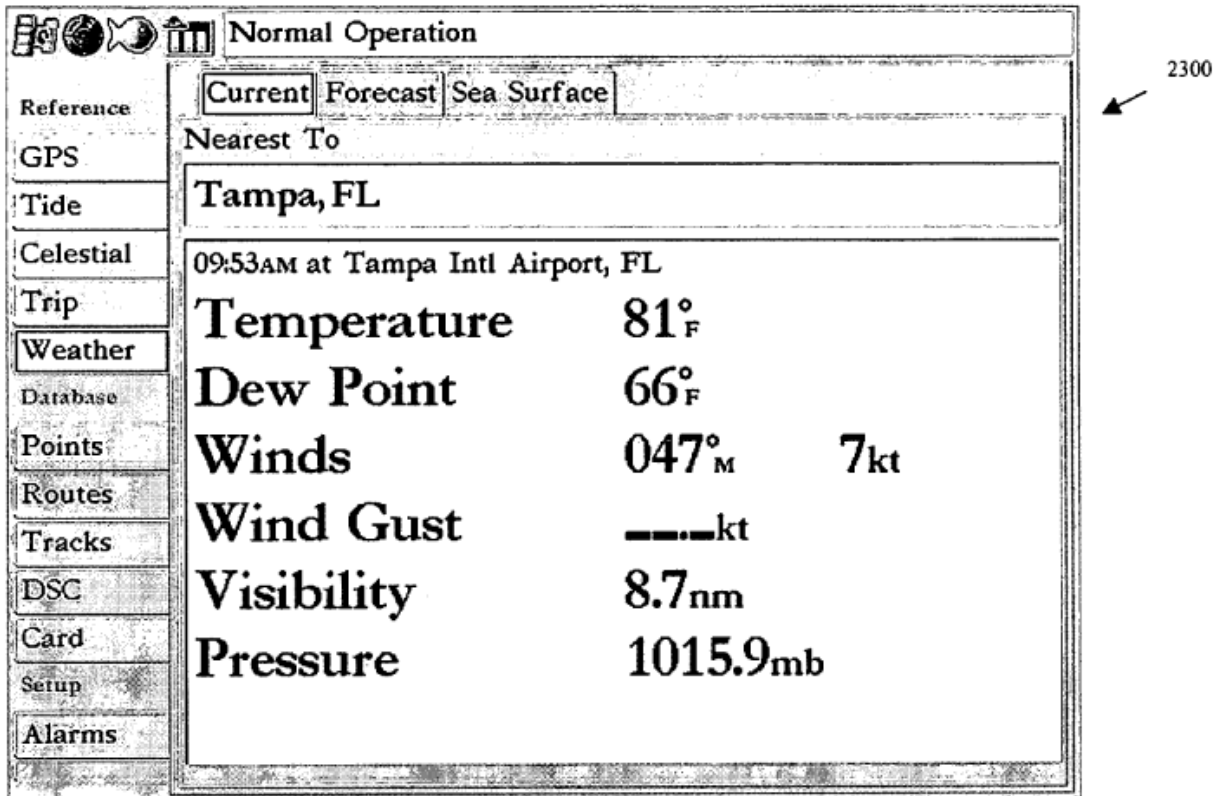


FIG. 23

TESLA-1010, FIG. 23

A POSITA would have understood that humidity and dew points are examples of moisture information. *See, e.g.,* TESLA-1019, [0110]. Humidity and dew point each quantify the amount of water vapor present in the air. Humidity typically measures the current amount of water vapor in the air relative to the maximum it can hold at a given temperature. Dew point indicates the temperature to which air must be cooled for water vapor to condense into dew, offering a direct measure of the atmospheric moisture content. Kabel also describes a method of displaying

“real-time weather information on a display with other information” on, for example, a navigation device associated with a land vehicle. *See id.*, 7:48-61, 13:20-25.

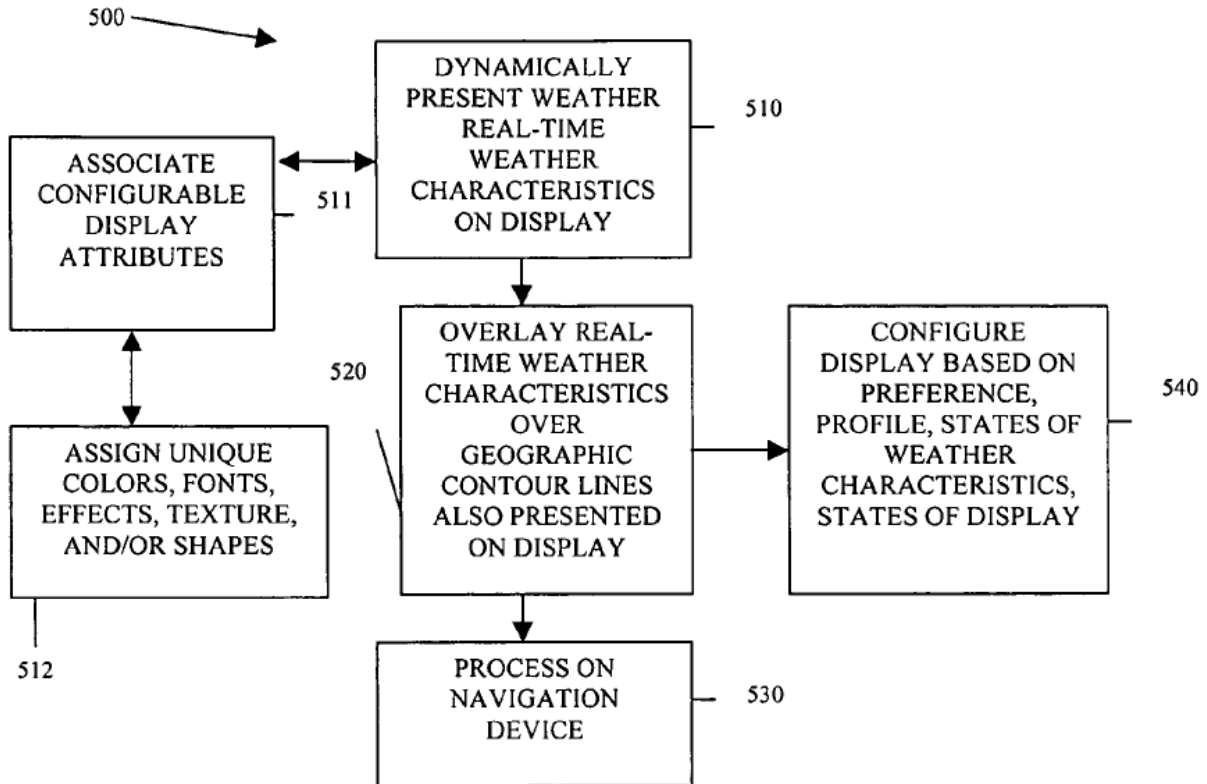


FIG. 5

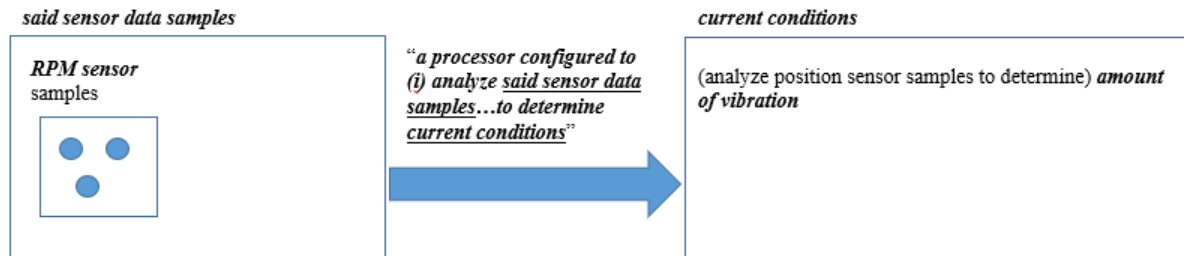
TESLA-1010, FIG. 5

g. Amount of Vibration

210. As shown below, in the Koebler650-Combination, this current condition is determined based on analyzing sensor data samples received from Okano’s vehicle stability control system, which includes a rotational speed sensor (*RPM*

sensor). See, e.g., TESLA-1004, 3:30-40, 4:56-5:3, 20:30-60, 21:7-28, 23:31-39;

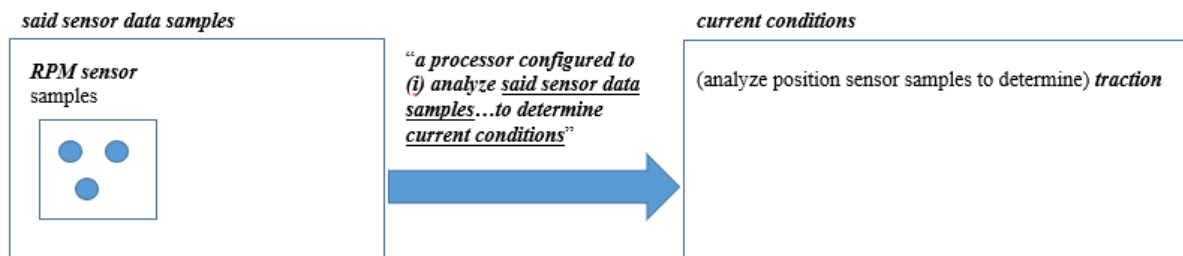
TESLA-1011, 15:16-40, 23:10-31, 23:36-55.



211. As discussed in Section V.B.1(d), Okano’s vehicle stability control system includes a rotational speed sensor as part of “anti-lock brake (ABS) control, traction control (TRC) and vehicle stability control (VSC).” TESLA-1011, 23:10-31. Vehicle control systems were also known to be “configured to determine the slipping of the wheel by detecting the deviations of the detected value of the wheel rotational speed sensor...” TESLA-1017, 8:17-31. The process of detecting wheel slippage by observing deviations in the values from a wheel rotational speed sensor involves determining an amount of vibration because the sensor’s readings reflect changes in the wheel's rotation speed, which can be affected by vibrations. When a wheel begins to slip, there is often a discrepancy between the expected rotational speed, based on the vehicle's speed and gear, and the actual rotational speed, influenced by road conditions and tire grip. This discrepancy can manifest as vibrations due to the rapid changes in speed and traction, which the sensor detects as deviations from normal rotational speeds, indicating slippage.

h. ***Traction***

212. As shown below, in the Koebler650-Combination, this current condition is determined based on analyzing sensor data samples received from Kirkwood's traction control system, which would have been understood to include a rotational speed sensor (***RPM sensor***). *See, e.g.*, TESLA-1004, 6:59-7:11, 13:52-58, 16:25-35; TESLA-1012, 1:15-24, 16:40-56, 17:19-27

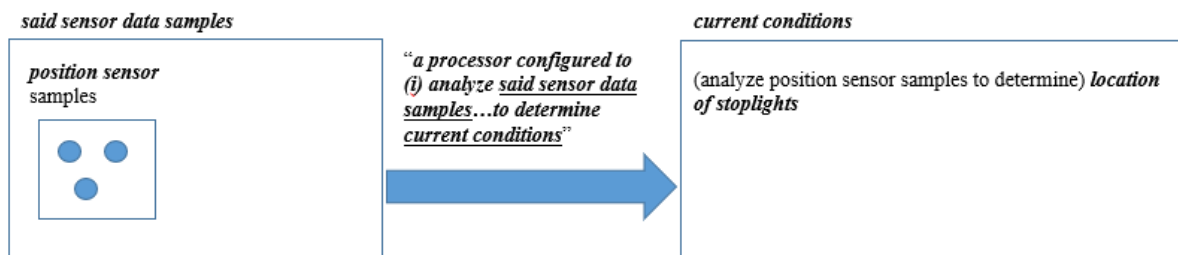


213. As discussed in Section V.B.1(e), Kirkwood's traction control system provides an "adaptive traction control feature." TESLA-1012, 16:40-56. Kirkwood's traction control system would have been understood to include an RPM sensor because traction control systems were configured to "control[] [a] slip ratio of associated wheels to be within a desired range by adjusting the output torque of an associated engine." TESLA-1015, 1:30-54. To accurately monitor and adjust the slip ratio, a traction control system accesses real-time data on how fast the wheels are turning, which involves collection of data by a rotational speed sensor. The rotational speed sensor allows the traction control system to detect discrepancies between the wheel's speed and the car's speed, enabling it to intervene and

minimize wheel slip to maintain traction. Kirkwood's traction control system would have also been understood to provide adaptive traction control features (which involve measuring traction based on sensor data samples collected by a rotational speed sensor), e.g., by determining "slipping of the wheel by detecting the deviations of the detected value of the wheel rotational speed sensor..." TESLA-1017, 8:17-31; *see also* TESLA-1015, 1:30-54.

i. *Location of Stoplights*

214. As shown below, in the Koebler650-Combination, this current condition is determined based on analyzing sensor data samples received from Breed's GPS positioning system (*position sensor*). *See, e.g.*, TESLA-1004, 3:41-67, 7:45-8:11; TESLA-1013, 2:16-20, 2:47-56, 3:1-11, 77:8-26, 79:17-28.

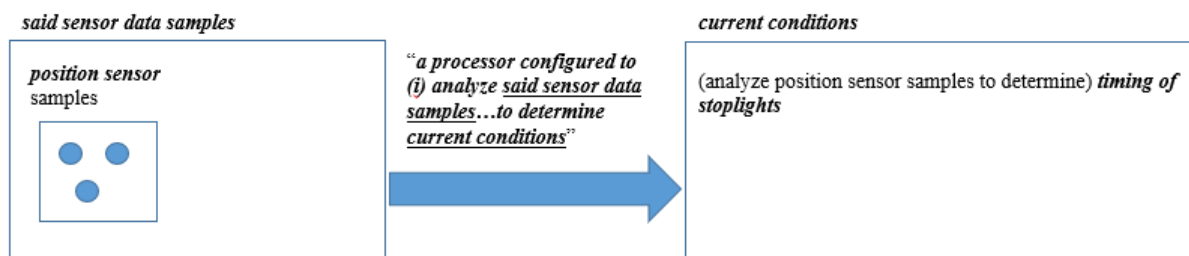


215. As discussed in Section V.B.1(c), in Breed, position information of a vehicle (e.g., travel information) is provided to a traffic control device (e.g., stoplight). TESLA-1013, 2:47-56. The traffic control device uses the position information to identify status information for a geographic location associated with the position information, such as "location of all stop signs and stop lights." *Id.*, 77:8-

26; *see id.*, 3:12-31. Breed also contemplates a “traffic control device” being a “stoplight” with a transmitter capable of providing status information relating to the stoplight, such as “how much time remains before the stoplight changes color” (*id.*; 3:1-11) and “the color” of the stop light (*id.*, 2:47-56). Thus, in the Breed system, position information of a vehicle (e.g., travel information) is provided to a traffic control device (e.g., stoplight). *Id.*, 2:47-56. The traffic control device uses the position information to identify status information for a geographic location associated with the position information. *Id.* The status information is then provided to the vehicle, e.g., providing a warning that the vehicle will be running a stoplight). *Id.*, 3:12-31, 77:8-26.

j. *Timing of Stoplights*

216. As shown below, in the Koebler650-Combination, this current condition is determined based on analyzing sensor data samples received from Breed’s GPS service (*position sensor*). *See, e.g.*, TESLA-1004, 3:41-67, 7:45-62, 8:12-31, 21:29-62; TESLA-1013, 2:16-20, 2:47-56, 3:1-11, 77:8-26, 79:17-28.



217. As discussed in Section V.B.1(c), in Breed, a traffic control device uses position information of a vehicle to identify status information for a geographic location associated with the position information, such as “how much time remains before the stoplight changes color.” TESLA-1013, 3:1-11; *see id.*, 3:12-31. Breed also contemplates a “traffic control device” being a “stoplight” with a transmitter capable of providing status information relating to the stoplight, such as “how much time remains before the stoplight changes color” (*id.*; 3:1-11) and “the color” of the stop light (*id.*, 2:47-56). Thus, in the Breed system, position information of a vehicle (e.g., travel information) is provided to a traffic control device (e.g., stoplight). *Id.*, 2:47-56. The traffic control device uses the position information to identify status information for a geographic location associated with the position information. *Id.* The status information is then provided to the vehicle, e.g., providing a warning that the vehicle will be running a stoplight). *Id.*, 3:12-31, 77:8-26.

(b) Claims 2-14

218. The Koebler650-Combination incorporates the teachings of Koebler650 and therefore discloses claims 2-14 in the same manner as discussed in Sections V.A.2(b)-(n) for corresponding claims in Ground 1A based on the same corresponding evidence.

(c) Claim 15

219. The Koebler650-Combination renders the following limitations of claim 15 obvious in the same manner as explained above for the corresponding claim 1 limitations below and based on the same corresponding evidence.

Claim 1 Limitation	Claim 15 Limitation
[1a-1]	[15c-1]
[1a-2]	[15c-2]
[1b]	[15d]
[1c-1]	[15e-1]
[1c-2]	[15e-2]
[1c-3]	[15e-3]
[1d]	[15f]
[1e]	[15g]

[15pre], [15a], [15b]

220. The Koebler650-Combination also incorporates the teachings of Koebler650 and therefore discloses these limitations in the same manner as discussed in Section IV.A.2(o) for corresponding claim limitations in Ground 1A based on the same corresponding evidence.

(d) Claim 16

221. The Koebler650-Combination renders the following limitations of claim 16 obvious in the same manner as explained above for the corresponding claim 1 limitations below and based on the same corresponding evidence.

Claim 1 Limitation	Claim 16 Limitation
[1a-1]	[16b]
[1a-2]	[16c]
[1b]	[16d]
[1c-1]	[16f-1]
[1c-2]	[16f-2]
[1c-3]	[16f-3]

[16pre], [16a]

222. The Koebler650-Combination also incorporates the teachings of Koebler650 and therefore discloses these limitations in the same manner as discussed in Sections V.A.2(p) for corresponding limitations in Ground 1A based on the same corresponding evidence. The Koebler650-Combination also discloses [16a] under a conjunctive read because, as discussed in Section V.B.(a), Koebler650 expressly discloses each of the thirteen Enumerated Sensors in the limitation for generating *sensor data*.

[16e]

223. The Koebler650-Combination discloses and/or renders obvious [16e] under a conjunctive read. As discussed in Section III.D.1, because [16a] recites *analyzing said sensor data samples...to determine current conditions*,¹⁰ a conjunctive read of [16e] requires each of the twenty-one enumerated current conditions to be determined from *sensor data* from thirteen Enumerated Sensors in [16a]. As discussed for [1e], in the Koebler650-Combination, each of twenty-one enumerated current conditions are determined from sensor data from one of the thirteen Enumerated Sensors in [16a].

VI. LEGAL STANDARDS

A. Terminology

224. I have been informed by Counsel and understand that the best indicator of claim meaning is its usage in the context of the patent specification as understood by one of ordinary skill. I further understand that the words of the claims should be given their plain meaning unless that meaning is inconsistent with the patent specification or the patent's history of examination before the Patent Office. Counsel has also informed me, and I understand that, the words of the claims

¹⁰ For claims 1 and 15, this limitation is the *processor* limitation ([1c-1], [15e-1]). For claim 16, the corresponding limitation is [16e], which recites the *analyzing* step.

should be interpreted as they would have been interpreted by one of ordinary skill at the time of the invention was made (not today). Because I do not know at what date the invention as claimed was made, I have used the Critical Date as the point in time for claim interpretation purposes.

B. Legal Standards for Anticipation

225. I have been informed by Counsel and understand that documents and materials that qualify as prior art can render a patent claim unpatentable as anticipated. I am informed by Counsel and understand that all prior art references are to be looked at from the viewpoint of a person of ordinary skill in the art.

226. I am informed by Counsel and understand that a challenged claim is unpatentable as “anticipated” under 35 U.S.C. § 102 if it is determined that all the limitations of the claim are described in a single prior art reference. I am informed by Counsel and understand that, to anticipate a claim, a prior art reference must disclose, either expressly or inherently, each and every limitation of that claim and enable one of ordinary skill in the art to make and use the invention.

227. I have been informed by Counsel and understand that in an *inter partes* review, “the petitioner shall have the burden of proving a proposition of unpatentability,” including a proposition of anticipation, “by a preponderance of the evidence.” 35 U.S.C. § 316(e).

C. Legal Standards for Obviousness

228. I have been informed by Counsel and understand that documents and materials that qualify as prior art can render a patent claim unpatentable as obvious. I am informed by Counsel and understand that all prior art references are to be looked at from the viewpoint of a person of ordinary skill in the art at the time of the invention, and that this viewpoint prevents one from using his or her own insight or hindsight in deciding whether a claim is obvious.

229. I have been informed by Counsel and understand that a claim is unpatentable for obviousness under 35 U.S.C. § 103 “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.” I am informed by Counsel and understand that obviousness may be based upon a combination of references. I am informed by Counsel and understand that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. However, I am informed by Counsel and understand that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art.

230. I am informed by Counsel and understand that when a patented invention is a combination of known elements, a court must determine whether there

was an apparent reason to combine the known elements in the fashion claimed by the patent at issue by considering the teachings of prior art references, the effects of demands known to people working in the field or present in the marketplace, and the background knowledge possessed by a person having ordinary skill in the art.

231. I am informed by Counsel and understand that a patent claim composed of several limitations is not proved obvious merely by demonstrating that each of its limitations was independently known in the prior art. I am informed by counsel for the Patent Owner and understand that identifying a reason those elements would be combined can be important because inventions in many instances rely upon building blocks long since uncovered, and claimed discoveries almost of necessity will be combinations of what, in some sense, is already known. I am informed by Counsel and understand that it is improper to use hindsight in an obviousness analysis, and that a patent's claims should not be used as a "roadmap."

232. I am informed by Counsel and understand that an obviousness inquiry requires consideration of the following factors: (1) the scope and content of the prior art; (2) the differences between the claims and the prior art; (3) the level of ordinary skill in the pertinent art; and (4) any objective indicia of non-obviousness,

such as commercial success, long-felt but unresolved need, failure of others, industry recognition, copying, and unexpected results. I understand that the foregoing factors are sometimes referred to as the “Graham factors.”

233. I have been informed by Counsel and understand that an obviousness evaluation can be based on a combination of multiple prior art references. I understand that the prior art references themselves may provide a suggestion, motivation, or reason to combine, but that the nexus linking two or more prior art references is sometimes simple common sense. I have been informed by Counsel and understand that obviousness analysis recognizes that market demand, rather than scientific literature, often drives innovation, and that a motivation to combine references may be supplied by the direction of the marketplace.

234. I have been informed by Counsel and understand that if a technique has been used to improve one device, and a person of ordinary skill at the time of invention would have recognized that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill.

235. I have been informed by Counsel and understand that practical and common sense considerations should guide a proper obviousness analysis, because familiar items may have obvious uses beyond their primary purposes. I have been informed by Counsel and understand that a person of ordinary skill looking to

overcome a problem will often be able to fit together the teachings of multiple prior art references. I have been informed by Counsel and understand that obviousness analysis therefore takes into account the inferences and creative steps that a person of ordinary skill would have employed at the time of invention.

236. I have been informed by Counsel and understand that a proper obviousness analysis focuses on what was known or obvious to a person of ordinary skill at the time of invention, not just the patentee. Accordingly, I understand that any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed.

237. I have been informed by Counsel and understand that a claim can be obvious in light of a single reference, without the need to combine references, if the elements of the claim that are not found explicitly or inherently in the reference can be supplied by the common sense of one of skill in the art.

238. I have been informed by Counsel and understand that secondary indicia of non-obviousness may include (1) a long felt but unmet need in the prior art that was satisfied by the invention of the patent; (2) commercial success of processes covered by the patent; (3) unexpected results achieved by the invention; (4) praise of the invention by others skilled in the art; (5) taking of licenses under the patent by others; (6) deliberate copying of the invention; (7) failure of others to

find a solution to the long felt need; and (8) skepticism by experts. I understand that evidence of secondary indicia of non-obviousness, if available, should be considered as part of the obviousness analysis.

239. I have been informed by Counsel and understand that there must be a relationship between any such secondary considerations and the invention, and that contemporaneous and independent invention by others is a secondary consideration supporting an obviousness determination.

240. In sum, my understanding is that prior art teachings are properly combined where one of ordinary skill having the understanding and knowledge reflected in the prior art and motivated by the general problem facing the inventor, would have been led to make the combination of elements recited in the claims. Under this analysis, the prior art references themselves, or any need or problem known in the field of endeavor at the time of the invention, can provide a reason for combining the elements of multiple prior art references in the claimed manner.

241. I have been informed by Counsel and understand that in an *inter partes* review, “the petitioner shall have the burden of proving a proposition of unpatentability,” including a proposition of obviousness, “by a preponderance of the evidence.” 35 U.S.C. § 316(e).

D. Legal Standards for Priority

242. I understand that in order to get the benefit of a priority claim, 35 U.S.C. § 120 requires that the earlier application include a disclosure that complies with the written description requirement of 35 U.S.C. § 112. I also understand that to comply with the written description requirement, the specification must describe the inventions sufficiently to convey to a person of skill in the art that the patentee **had possession** of the claimed invention at the time of the application, i.e., that the patentee invented what is claimed. I also understand that in order to satisfy the written description requirement, the disclosure as originally filed does not have to provide exact literal support for the claimed subject matter at issue.

VII. CONCLUSION

243. I reserve the right to supplement my opinions to address any information obtained, or positions taken, based on any new information introduced throughout this proceeding.

244. I declare under penalty of perjury that the foregoing is true and accurate to the best of my ability.

APPENDIX A

Education

- 1995 Ph.D. in Mech. Eng. University of Minnesota, Twin Cities.
1988 M.Sc. in Mech. Eng. Columbia University, New York, NY.
1983 Diploma Mech. Eng. National Technical University of Athens, Greece.

Current & Past Positions

- 2020- **Research Professor**, Electrical & Computer Engineering, U. of Minn., Twin Cities.
2014- **Director**, NSF center on Robots & Sensors for Human Well Being, U. of Minn., Twin Cities.
2006-2020 **Program Director**, Computer Science & Engineering, U. of Minn., Twin Cities.
2007-2014 **Co-PI**, NSF Research Center on Safety, Security and Rescue, U. of Minn., Twin Cities.
2003-2014 **Instructor**, Dept. of Mech. Eng., University of Minnesota, Twin Cities.

Industrial and Professional Experience

- 2005-2006 **Sr. Principle Research Scientist**, Adv. Tech. Labs, Honeywell Int., Inc.
1998-2005 **Principle Research Scientist**, Adv. Tech. Labs, Honeywell Int., Inc.
1995-1998 **Research Associate**, Dept. of Mech.Eng., U. of Minn., Minneapolis, MN.

Legal Experience

- **Finnegan, Henderson, Farabow, Garrett & Dunner, LLP**
August 2022: Pavemetrics vs Tetra Tech
Location: UNITED STATES DISTRICT COURT, CENTRAL DISTRICT OF CALIFORNIA
Role: Expert witness in computer vision, algorithms, and software engineering.
Provided testimony on software development practices and code analysis in a patent infringement case.

Honors and Awards

- Center for Transportation Studies: CTS Research Partnership Award, 2016.
- Best Student Paper Award, IEEE International Conference on Image Processing (ICIP), 2012.
- Technical Achievement Award, for Technical Excellence in the area of **People Tracking in Camera Networks**, *Highest Honorary Distinction* from Automation and Control Solutions (ACS) of Honeywell International Inc., April 2003.
- Technical Achievement Award, for Technical Excellence for development and installation of the **SGATE: Secure Gate Access Technology Evaluation**, *Highest Honorary Distinction* from Automation and Control Solutions (ACS) of Honeywell International Inc., April 2003.
- Technical Achievement Award, for Technical Excellence in the area of **Outdoor Visual Surveillance**, *Highest Honorary Distinction*, Honeywell International Inc., December 2001.
- Second Prize, ITS World Magazine's, GPS Applications Showcase, 1997.

- First Prize, Pan-Hellenic competition on “Heat Pumps” presented by the Rotary Club of Athens, Greece (sponsored by Toshiba), 1984.
- Fellowship from the Greek Ministry of Education for academic excellence during undergraduate studies, 1982.

Research Grants

- *Maintenance for the Truck Parking Availability System of the State of Kansas*
Role: Co-PI.
Sponsors: Kansas DOT.
Performance period: January 1, 2024 – December 31, 2029 - **Total amount:** \$725,000
- *A Real-Time Truck Parking Availability System of the State of Kansas*
Role: Co-PI.
Sponsors: Kansas DOT.
Performance period: October 1, 2016 – December 31, 2019 - **Total amount:** \$1,265,000
- *I/UCRC Phase II: Robots and Sensors for the Human Well-being*
Role: PI.
Sponsors: National Science Foundation (NSF).
Performance period: December 2019 - December 2024 - **Total amount:** \$725,000
- *MRI: Development of an Instrument that Performs Behavioral Analysis for Neurological Disorders like the Tourette Syndrome*
Role: Co-PI.
Sponsors: National Science Foundation (NSF).
Performance period: September 2019 - August 2024 - **Total amount:** \$1,823,000
- *NRI: INT: COLLAB: Robot Teams for Precision Agriculture and Plant Health Management*
Role: Senior personnel
Sponsors: National Science Foundation (NSF).
Performance period: September 2019 - August 2022 - **Total amount:** \$933,000
- *SCH: Active Learning for Medical Applications*
Role: Co-PI.
Sponsors: NIH/NCI.
Performance period: February 1, 2018 – January 31, 2022 - **Total amount:** \$1,320,000
- *CPS: TTP Option: Synergy: Collaborative Research: Dynamic Methods of Traffic Control that Impact Quality of Life in Smart Cities*
Role: Co-PI.
Sponsors: National Science Foundation (NSF).
Performance period: September 15, 2015 – February 29, 2020 - **Total amount:** \$1,248,000
- *Maintenance for the Truck Parking Availability System of the State of Kansas*
Role: Co-PI.
Sponsors: Kansas DOT.
Performance period: January 1, 2019 – December 31, 2023 - **Total amount:** \$649,000
- *A Real-Time Truck Parking Availability System for the State of Wisconsin*
Role: Co-PI.
Sponsors: MN DOT.
Performance period: June 30, 2016 – December 31, 2019 - **Total amount:** \$395,000
- *A Real-Time Truck Parking Availability System of the State of Kansas*
Role: Co-PI.
Sponsors: Kansas DOT.
Performance period: October 1, 2016 – December 31, 2019 - **Total amount:** \$1,265,000

- *I/UCRC Phase I: Robots and Sensors for the Human Well-being*
Role: PI.
Sponsors: National Science Foundation (NSF).
Performance period: September 2014–September 2019.
Total amount: \$854,600
- *MNDRIVE RSAM: Utilizing Computer Vision Technology for Cross-Cultural Developmental Screening in Early Childhood*
Role: Co-PI (with Suma Jacob, MD, PhD Department of Psychiatry, UMN).
Sponsors: University of Minnesota (MnDRIVE).
Performance period: September 2014.
Total amount: \$50,000
- *MRI: Development of an Instrument that Monitors Behaviors Associated with OCD and Schizophrenia*
Role: Co-PI (with prof. N. Papanikolopoulos, G. Bernstein, U of Minnesota).
Sponsors: National Science Foundation (NSF).
Performance period: November 2013–September 2017.
Total amount: \$560,000
- *A Comprehensive System for Assessing Truck Parking Availability*
Role: Co-PI (with N. Papanikolopoulos, U of Minnesota).
Sponsors: FHWA and MN DOT.
Performance period: January 11, 2012 – November 30, 2016.
Total amount: \$2,267,711
- *MRI: Development of a Video-Based Robotic Instrument for Behavioral Analysis and Diagnosis of at Risk Children*
Role: Co-PI (with N. Papanikolopoulos, K. Lim (U of Minnesota) and G. Sapiro (Duke University)).
Sponsors: National Science Foundation (NSF).
Performance period: October 1, 2010 – September 30, 2019.
Total amount: \$1,725,730
- *CDI-II: Computational Tools for Behavioral Analysis Diagnosis and Intervention of at Risk Children*
Role: Co-PI (with N. Papanikolopoulos, K. Lim (U of Minnesota) and G. Sapiro (Duke University)).
Sponsors: National Science Foundation (NSF).
Performance period: September 2010–September 2015.
Total amount: \$1,578,897
- *ComputerAided Cancer Diagnosis in Surgical Pathology*
Role: Co-PI, with N. Papanikolopoulos, et al.
Sponsors: Institute for Engineering in Medicine (IEM) Seed Grant
Performance period: January 2012–December 31, 2012.
Total amount: \$39,508.
- *I/UCRC: Collaborative Research: Detecting Cancer Using Advanced Computer Vision Techniques*
Role: Co-PI (with N. Papanikolopoulos, A. Banerjee, U of Minnesota).
Sponsors: NSF.
Performance period: August 2009–July 2013.
Total amount: \$99,998
- *Collaborative Research: I/UCRC for Safety, Security, and Rescue Research*
Role: Co-PI (with N. Papanikolopoulos, U of Minnesota).
Sponsors: National Science Foundation (NSF).
Performance period: August 2009–July 2013.

Total amount: \$330,000

- *Video Detection and Classification of Pedestrian Events at Roundabouts and Crosswalks*
Role: PI (with T. Morris and J. Hourdos, U of Minnesota).
Sponsors: Intelligent Transportation Systems (ITS) Institute (RITA).
Performance period: September 2011–June 2013.
Total amount: \$75,000
- *I/UCRC Basic Research Grant: A New Miniature Ground/Water Robot*
Role: Co-PI (with prof. N. Papanikolopoulos, U of Minnesota).
Sponsors: National Science Foundation (NSF).
Performance period: August 2009–July 2013.
Total amount: \$128,000
- *Sensing for HOV/HOT Lanes Enforcement*
Role: Co-PI (with prof. N. Papanikolopoulos, U of Minnesota).
Sponsors: Minnesota Dept of Transportation (MnDoT).
Performance period: July 2013–October 2013.
Total amount: \$97,200
- *Mass Transit Surveillance and Early Warning System*
Role: Principal Co-Investigator (with prof. N. Papanikolopoulos, U of Minnesota).
Sponsors: U. S. Department of Homeland Security.
Performance period: August 2004–September 2011.
Total amount: \$4.5 M
- *Appearance Models for Tracking across Multiple Cameras*
Role: Program Manager and Principal Co-Investigator (joint with prof. Larry Davis and Rama Chellappa, U of Maryland).
Sponsors: HSARPA (Homeland Security ARPA)/COTR ONR.
Performance period: May 2005–May 2007.
Total amount: \$1.3 M
- *Secure Gate Access Technology Evaluation (SGATE)*
Role: Principal Investigator.
Sponsors: Jointly sponsored by ONR and Honeywell Laboratories.
Performance Period: June 2002 – June 2003.
Total amount: \$900 K.
- *Detection of Events for Threat Evaluation and Recognition (DETER)*
Role: Principal Co-Investigator (joint with prof. I. Pavlidis of U of Houston).
Sponsors: Honeywell Laboratories.
Performance Period: June 1999–August 2002.
Total amount: \$700 K.
- *Digital Integration of Video for Airport Security (DIVAS)*
Role: Principal Investigator.
Sponsors: Honeywell Laboratories and Federal Aviation Administration (FAA).
Performance Period: June 1999–August 2004.
Total amount: \$1.2 M

Books

1. I. Pavlidis, V. Morellas and P. Roeber. *Programming cameras and pan-tilts with DirectX and Java*, Morgan Kaufmann Publishers Inc., 2003.

Book Chapters

1. I. Pavlidis and V. Morellas. *Two examples of indoor and outdoor surveillance systems*, In Video-based Surveillance Systems: Computer Vision and Distributed Processing, Kluwer Academic Publishers, Boston, pp. 39–51, 2002.

Refereed Journal Publications

1. L. Guzman, V. Morellas and N. Papanikolopoulos, *Robotic Embodiment of Human-Like Motor Skills via Reinforcement Learning*, in IEEE Robotics and Automation Letters, vol. 7, no. 2, pp. 3711–3717, April 2022, doi: 10.1109/LRA.2022.3147453.
2. A. Cherian, P. Stanitsas, J. Wang, M. Harandi, V. Morellas, and N. Papanikolopoulos. *Learning Log-Determinant Divergences for Positive Definite Matrices*, IEEE Pattern Analysis and Machine Intelligence, (PAMI), 2021.
3. P. Stanitsas, A. Cherian, V. Morellas, R. Tejpal, N. Papanikolopoulos and A. Truskinovsky. *Image Descriptors for Weakly Annotated Histopathological Breast Cancer Data*, Frontiers in Digital Health, 2020.
4. D. Zermas, V. Morellas, D. Mulla, and N. Papanikolopoulos. *3D Model processing for high-throughput phenotype extraction - The case of corn*, Journal of Computers and Electronics in Agriculture, 2020.
5. N. Walczak, J. Fasching, K. Cullen, V. Morellas, and N. Papanikolopoulos. *Toward Identifying Behavioral Risk Markers for Mental Health Disorders: An Assistive System for Monitoring Children's Movements in a Preschool Classroom*, Machine Vision and Applications, 29(3), pp 703–717, 2018.
6. G. Bernstein, T. Hadjiyanni, K. Cullen, M. Robinson, E. Harris, A. Young, J. Fasching, N. Walczak, S. Lee, V. Morellas, and N. Papanikolopoulos. *Use of Computer Vision Tools to Identify Behavioral Markers of Pediatric Obsessive-Compulsive Disorder: A Pilot Study*, J Child Adolesc Psychopharmacol.; 27(2):140-147. doi: 10.1089/cap.2016.0067. Epub 2016 Nov 10., 2017.
7. E. Harris, G. Bernstein, K. Cullen, S. Lee, T. Hadjiyanni, J. Robinson, A. Young, V. Morellas, and N. Papanikolopoulos. *1.64 Exploring Visual Design preferences in Youths with Obsessive-Compulsive Disorder*, In Journal of the American Academy of Child and Adolescent Psychiatry, 55(10) 2016.
8. A. Cherian, V. Morellas, and N. Papanikolopoulos. *Bayesian non-parametric clustering of positive definite tensors*, In IEEE Transactions on Pattern Analysis and Machine Intelligence, 38(5), pp.862-874, 2015.
9. R. Sivalingam, D. Boley, V. Morellas, and N. Papanikolopoulos. *Tensor Dictionary Learning for Positive Definite Matrices*, In IEEE transactions on Image Processing, 24(11), pp.4592–4601 2016.
10. G. Somasundaram, A. Cherian, V. Morellas and N. Papanikolopoulos. *Action recognition using global spatio-temporal features derived from sparse representations*, Computer Vision and Image Understanding, 123: pp.1–13, 2014.
11. A. Cherian, S. Sra V. Morellas, and N. Papanikolopoulos. *Efficient nearest neighbors via robust sparse hashing*, In Transactions on Image Processing, Volume:23, Issue:8, pp.3646–3655, 2014.
12. J. Hashemi, T. V. Spina, M. Tepper, A. Esler, V. Morellas, N. Papanikolopoulos, H. Egger, G. Dawson and G. Sapiro. *Computer vision tools for low-cost and non-invasive measurement of autism-related behaviors in infants*, Autism Research and Treatment, Volume 2014, <http://dx.doi.org/10.1155/2014/935686>, 2014.
13. R. Sivalingam, D. Boley, V. Morellas and N. Papanikolopoulos. *Tensor sparse coding for positive definite matrices*, In IEEE Transactions on Pattern Analysis and Machine Intelligence, 36(3): pp.592–605, 2014.

14. G. Somasundaram, R. Sivalingam, V. Morellas and N. Papanikolopoulos. *Classification and counting of composite objects in traffic scenes using global and local image analysis*, In IEEE Transactions on Intelligent Transportation Systems (ITS), Volume:14, Issue:1, pp.69–81, 2013.
15. K. A. Patwardhan, G. Sapiro and V. Morellas. *Robust foreground detection in video using pixel layers*, In IEEE Transactions on Pattern Analysis and Machine Intelligence, Volume 30, pp. 746–751, 2008.
16. V. Morellas, I. Pavlidis and P. Tsiamyrtzis. *Deter: detection of events for threat evaluation and recognition*, In Machine Vision and Applications, Springer-Verlag, volume 15, pp. 29–45, 2003.
17. I. Pavlidis, V. Morellas, P. Tsiamyrtzis and S. Harp. *Urban surveillance systems: from the laboratory to the commercial world*, In Proceedings of the IEEE, volume 89, pp. 1478–1497, 2001.
18. I. Pavlidis, V. Morellas and N. Papanikolopoulos. *A vehicle occupant counting system based on near-infrared phenomenology and fuzzy neural classification*, In IEEE Transactions on Intelligent Transportation Systems, Volume 1, pp. 72–85, 2000.
19. C. Nevrinceanu, V. Morellas and M. Donath. *Automated process planning: reasoning from first principles based on geometric relation constraints*, In Artificial Intelligence for Engineering, Design, Analysis and Manufacturing, Cambridge Univ Press, volume 7, pp. 159–179, 1993.
20. N. Zabaras, V. Morellas and D. Schnur. *Spatially regularized solution of inverse elasticity problems using the BEM*, In Communications in applied numerical methods, Wiley Online Library, Volume 5, pp. 547–553, 1989.

Referred Conference Publications

1. D. Zermas, V. Morellas, D. Mulla, and N. Papanikolopoulos. *Extracting Phenotypic Characteristics of Corn Crops Through the Use of Reconstructed 3D Models*, In IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2018.
2. P. Stanitsas, A. Cherian, M. Harandi, V. Morellas, and N. Papanikolopoulos. *Learning Discriminative Alpha-Beta Divergences for Positive Definite Matrices*, In IEEE International Conference of Computer Vision (ICCV), 2017.
3. P. Stanitsas, A. Cherian, V. Morellas, and N. Papanikolopoulos. *Clustering Positive Definite Matrices by Learning Information Divergences*, In Workshop on Manifold Learning: from Euclid to Riemann (ICCV), 2017.
4. P. Stanitsas, A. Cherian, A. Truskinovsky, V. Morellas, and N. Papanikolopoulos. *Active Convolutional Neural Networks for Cancerous Tissue Recognition*, In IEEE International Conference on Image Processing (ICIP), 2017.
5. N. Heller, P. Stanitsas, V. Morellas, and N. Papanikolopoulos. *A Web-Based Platform for Distributed Annotation of Computerized Tomography Scans*, 6th Joint International Workshops, CVII-STENT 2017 and 2nd International Workshop, LABELS 2017 Held in Conjunction with MICCAI 2017, Proceedings. Springer Verlag, Vol. 10552 LNCS, p. 136-145 10 p. (Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics); vol. 10552 LNCS), 2017.
6. D. Zermas, V. Morellas, D. Mulla, and N. Papanikolopoulos. *Estimating the Leaf Area Index of crops through the evaluation of 3D models*, In IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), pp. 6155-6162, 2017.
7. P. Stanitsas, A. Cherian, X. Li, A. Truskinowski, V. Morellas, and N. Papanikolopoulos. *Evaluation of feature descriptors for cancerous tissue recognition*, In IEEE 3rd International Conference on Pattern Recognition, ICPR, pp. 1490-1495, 2016.

8. P. Stanitsas, A. Cherian, V. Morellas, and N. Papanikolopoulos. *Active Constrained Clustering via non-iterative uncertainty sampling*, In IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), pp.4027-4033, 2016.
9. J. Fasching, N. Walczak, G. Bernstein, T. Hadjiyanni, K. Cullen, V. Morellas, and N. Papanikolopoulos. *Automated coding of activity videos from an OCD study*, In IEEE International Conference on Robotics and Automation (ICRA'16), pp. 5638-5643, 2016.
10. J. Fasching, N. Walczak, T. Hadjiyanni, G. Bernstein, K. Cullen, M. Mikkelsen, N. Studanski, V. Morellas, and N. Papanikolopoulos. *Exploring video descriptions for handwashing activities as part of an obsessive-compulsive disorder study*, In IEEE 24th Mediterranean Conference on Control and Automation, pp.1174-1179, 2016.
11. D. Zermas, D. Teng, P. Stanitsas, M. Bazakos, D. Kaiser, V. Morellas, D. Mulla, and N. Papanikolopoulos. *Automation solutions for the evaluation of plant health in corn fields*, In IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), pp.6521-6527, 2015.
12. J. Fasching, N. Walczak, V. Morellas, and N. Papanikolopoulos. *Classification of motor stereotypes in video*, In IEEE International Conference on Robotics and Automation (ICRA'15), 2015.
13. D. Zermas, M. Bazakos, V. Morellas, D. Mulla, and N. Papanikolopoulos. *A Robotics framework for the detection of nitrogen deficiencies in corn fields*, In IEEE International Conference on Robotics and Automation (ICRA'15), 2015.
14. D. J. Cook, T. Morris, V. Morellas, and N. Papanikolopoulos. *An automated system for persistent real-time truck parking detection and information dissemination*, In IEEE International Conference on Robotics and Automation (ICRA'14), pp.3989-3994, 2014.
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17. G. Somasundaram, V. Morellas and N. Papanikolopoulos. *Object classification with efficient global self-similarity descriptors based on sparse representations*, In 19th IEEE International Conference on Image Processing (ICIP), pp. 2165-2168, 2012.
18. J. Fasching, N. Walczak, R. Sivalingam, K. Cullen, B. Murphy, G. Sapiro, V. Morellas and N. Papanikolopoulos. *Detecting risk-markers in children in a preschool classroom*, In IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), pp.1010-1016, 2012.
19. N. Walczak, J. Fasching, W. D. Toczyski, R. Sivalingam, N. D. Bird, K. Cullen, V. Morellas, B. Murphy, G. Sapiro and N. Papanikolopoulos. *A nonintrusive system for behavioral analysis of children using multiple RGB+depth sensors*, In IEEE Workshop on the Applications of Computer Vision (WACV), pp. 217-222, 2012.
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21. R. Sivalingam, A. Cherian, J. Fasching, N. Walczak, N. Bird, V. Morellas, B. Murphy, K. Cullen, K. Lim, G. Sapiro, and N. Papanikolopoulos. *A multi-sensor visual tracking system for behavior monitoring of at-risk children*, In IEEE International Conference on Robotics and Automation (ICRA), pp. 1345-1350, 2012.

22. D. Fehr, A. Cherian, R. Sivalingam, S. Nickolay, V. Morellas and N. Papanikolopoulos. *Compact covariance descriptors in 3d point clouds for object recognition*, In IEEE International Conference on Robotics and Automation (ICRA), pp. 1793–1798, 2012.
23. J. Fasching, N. Walczak, R. Sivalingam, K. Cullen, B. Murphy, G. Sapiro, V. Morellas, N. Papanikolopoulos. *Detecting risk-markers in children in a preschool classroom*, In IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), pp. 1010–1016, 2012.
24. A. Cherian, V. Morellas and N. Papanikolopoulos. *Robust Sparse Hashing*, In 19th IEEE International Conference on Image Processing (ICIP), pp. 2417–2420, 2012. (**Best Student Paper Award**)
25. R. Sivalingam, D. Boley, V. Morellas and N. Papanikolopoulos. *Positive definite dictionary learning for region covariances*, In IEEE International Conference on Computer Vision (ICCV), pp. 1013–1019, 2011.
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28. P. K. Gali, V. Morellas and N. Papanikolopoulos. *A novel framework for annotating videos using text*, In 19th Mediterranean Conference on Control Automation (MED), pp. 1403–1408, 2011.
29. A. Cherian, V. Morellas, N. Papanikolopoulos and S. J. Bedros. *Dirichlet process mixture models on symmetric positive definite matrices for appearance clustering in video surveillance applications*, In IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pp. 3417–3424, 2011.
30. A. Cherian, V. Morellas and N. Papanikolopoulos. *Approximate nearest neighbors via dictionary learning*, In Proc. SPIE 8058, Independent Component Analyses, Wavelets, Neural Networks, Biosystems, and Nanoengineering IX, 80581M; doi:10.1117/12.887484, 2011.
31. V. Bhatawadekar, D. Fehr, V. Morellas and N. Papanikolopoulos. *A dynamic sensor placement algorithm for dense sampling*, In Proceedings of the 14th International Conference on Information Fusion (FUSION), pp. 1–7, 2011.
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33. E. Ribnick, V. Morellas and N. Papanikolopoulos. *Human motion patterns from single camera cues for medical applications*, In IEEE International Conference on Robotics and Automation (ICRA), pp. 5102–5107, 2010.
34. A. Cherian, J. Andersh, V. Morellas, B. Mettler and N. Papanikolopoulos. *Motion estimation of a miniature helicopter using a single onboard camera*, In American Control Conference (ACC), 2010, pp. 4456–4461, 2010.
35. G. Somasundaram, V. Morellas and N. Papanikolopoulos. *Counting pedestrians and bicycles in traffic scenes*, In 12th International IEEE Conference on Intelligent Transportation Systems (ITSC’09), pp. 1–6, 2009.
36. R. Sivalingam, V. Morellas, D. Boley and N. Papanikolopoulos. *Metric learning for semi-supervised clustering of region covariance descriptors*, In Third ACM/IEEE International Conference on Distributed Smart Cameras (ICDSC), pp. 1–8, 2009.

37. D. Fehr, R. Sivalingam, V. Morellas, N. Papanikolopoulos, O. Lotfallah and Y. Park. *Counting people in groups* , In Sixth IEEE International Conference on Advanced Video and Signal Based Surveillance AVSS'09, pp. 152–157, 2009.
38. A. Cherian, J. Andersh, V. Morellas, N. Papanikolopoulos and B. Mettler. *Autonomous altitude estimation of a UAV using a single onboard camera* , In IEEE/RSJ International Conference on Intelligent Robots and Systems, pp. 3900–3905, 2009.
39. A. Cherian, V. Morellas and N. Papanikolopoulos. *Accurate 3D ground plane estimation from a single image* In IEEE International Conference on Robotics and Automation, pp. 2243–2249, 2009.
40. V. Morellas, C. Johnston, A. Johnson, S. D. Roberts, G. L. Francisco. *Day, night and all-weather security surveillance automation*, In Proceedings of SPIE, volume 5778, Sensors, and Command, Control, Communications, and Intelligence (C3I) Technologies for Homeland Security and Homeland Defense IV, 757, 2005.
41. B. Schiller, V. Morellas and M. Donath. *Collision avoidance for highway vehicles using the virtual bumper controller*, In Proceedings of the IEEE International Symposium on Intelligent Vehicles, 1998.
42. V. Morellas, T. Morris, L. Alexander and M. Donath. *Preview based control of a tractor trailer using DGPS for preventing road departure accidents*, In IEEE Conference on Intelligent Transportation Systems, pp. 797–805, 1997.
43. V. Morellas, J. Minners and M. Donath. *Implementation of real time spatial mapping in robotic systems through self-organizing neural networks*, In Proceedings of IEEE/RSJ International Conference on Intelligent Robots and Systems, volume 1, pp. 277–284, 1995.
44. S. Kieffer, V. Morellas and M. Donath. *Neural network learning of the inverse kinematic relationships for a robot arm*, In Proceedings of IEEE International Conference on Robotics and Automation, pp. 2418–2425, 1991.

Workshop and Other Publications

1. N. Heller, N. Papanikolopoulos, V. Morellas, and A. Truskinovsky. *Class saliency maps reveal computer vision's basis for diagnosing metastatic carcinoma in lymph nodes*, Annual Meeting of the US and Canada Academy of Pathology (USCAP), 2019.
2. N. Heller, M. Tradewell, J. Dean, V. Morellas, N. Papanikolopoulos, N. Sathianathan, and C. Weight. *A balance cascade of deep neural networks for CT renal segmentation*, Poster Annual Meeting of the Engineering Urology Society, 2018.
3. X. Li, V. Morellas, N. , A. M. Truskinovsky. *The Use of Computer Vision in the Differential Diagnosis of Ovarian Carcinomas*, Annual Meeting of the United States and Canadian Academy of Pathology (USCAP), 2016.
4. T. Morris, D. J. Cook, V. Morellas and N. Papanikolopoulos. *A comprehensive truck parking space availability system for real-time information and parking facilities performance monitoring*, Logistics, Trade and Transportation Symposium, 2014.
5. A. Kaplan, X. Li, R. Sivalingam, G. Somasundaram, A. Banerjee, V. Morellas, N. Papanikolopoulos and A. Truskinovsky. *Computer vision methods in surgical pathology: diagnosing carcinoma of the breast* , Annual Meeting of the United States and Canadian Academy of Pathology (USCAP), volume 93, pp. 380A-380A, 2013.
6. T. V. Spina, M. Tepper, A. Esler, V. Morellas, N. Papanikolopoulos, A. X. Falcao, and G. Sapiro. *Video human segmentation using fuzzy object models and its application to body pose estimation of toddlers for behavior studies*, In arXiv preprint arXiv:1305.6918, 2013.

7. N. Walczak, J. Fasching, W. Toczyski, R. Sivalingam, N. Bird, K. Cullen, V. Morellas, B. Murphy, G. Sapiro and N. Papanikolopoulos. *A nonintrusive system for behavioral analysis of children using multiple RGB+ depth sensors*, In IEEE Workshop on Applications of Computer Vision (WACV), pp. 217–222, 2012.
8. R. Sivalingam, G. Somasundaram, X. Li, J. C. Henriksen, A. Banerjee, V. Morellas, N. Papanikolopoulos, A. Truskinovsky. *Diagnosing adenocarcinoma of the prostate by computer vision methods*, Annual Meeting of the United States and Canadian Academy of Pathology (USCAP), volume 92, pp. 394A-394A, 2012.
9. R. Sivalingam, G. Somasundaram, A. Ragipindi, A. Banerjee, V. Morellas, N. Papanikolopoulos, A. Truskinovsky. *Diagnosing endometrial carcinoma via computer-assisted image analysis*, Annual Meeting of the United States and Canadian Academy of Pathology (USCAP), 2011.
10. K. A. Patwardhan, G. Sapiro and V. Morellas. *A graph-based foreground representation and its application in example based people matching in video*, Institute of Mathematics and its Applications (IMA), University of Minnesota, preprint series No. 2154, 2007.
11. K. A. Patwardhan, G. Sapiro and V. Morellas. *Pixel layering and layer propagation for video modeling and foreground detection*, In Institute of Mathematics and its Applications (IMA), University of Minnesota, preprint series No. 2080, 2005.
12. V. Morellas, T. Morris, L. Alexander and M. Donath. *Between the lines: A driver-assistive technology for staying in the lane*, In GPS World, volume 9, 1998.
13. R. Bodor, M. Donath, V. Morellas and D. Johnson. *In-Vehicle GPS-Based Lane Sensing to Prevent Road Departure*, In Abstracts of the Third World Congress on Intelligent Transport Systems, Intelligent Transportation: Realizing the Future, 1996.

Technical Reports

1. T. Morris, X. Li, V. Morellas and N. Papanikolopoulos. *Video detection and classification of pedestrian events at roundabouts and crosswalks*, Technical report, Intelligent Transportation Systems Institute, Center for Transportation Studies, 2013.
2. E. Holec, G. Somasundaram, N. Papanikolopoulos and V. Morellas. *Monitoring the use of HOV and HOT lanes*, Technical report, Intelligent Transportation Systems Institute, Center for Transportation Studies, 2013.
3. G. Somasundaram, V. Morellas and N. Papanikolopoulos. *Deployment of practical methods for counting bicycle and pedestrian use of a transportation facility*, Technical report, Intelligent Transportation Systems Institute, Center for Transportation Studies, 2012.
4. P. Modi, V. Morellas and N. Papanikolopoulos. *Counting Empty Parking Spots at Truck Stops Using Computer Vision*, Technical report, Intelligent Transportation Systems Institute, Center for Transportation Studies, 2011.
5. G. Somasundaram, V. Morellas and N. Papanikolopoulos. *Practical methods for analyzing pedestrian and bicycle use of a transportation facility*, Technical report, Intelligent Transportation Systems Institute, Center for Transportation Studies, 2010.
6. I. Pavlidis, P. Symosek, V. Morellas, B. Fritz, N. Papanikolopoulos and R. Sfarzo. *Automatic passenger counting in the HOV Lane*, Technical report No. Mn/DOT 2000-06, Intelligent Transportation Systems Institute, Center for Transportation Studies, 1999.
7. L. Alexander, S. Bajikar, H. M. Lim, V. Morellas, T. Morris and M. Donath. *Safetruck: sensing and control to enhance vehicle safety*, Technical report No. Mn/DOT 1998-29, Intelligent Transportation Systems Institute, Center for Transportation Studies, 1997.

8. L. Alexander, M. Donath, M. Hennessey, V. Morellas and C. Shankwitz. *A lateral dynamic model of a tractor-trailer experimental validation*. Technical report No. Mn/DOT 1997-18, Intelligent Transportation Systems Institute, Center for Transportation Studies, 1996.
9. R. Bodor, L. Alexander, C. Liao, S. Bajikar, V. Morellas and M. Donath. *Analysis of a differential global positioning system as a sensor for vehicle guidance*, Technical report No. Mn/DOT 1997-17, Intelligent Transportation Systems Institute, Center for Transportation Studies, 1996.

Patents

- **Crop Models and Biometrics**, (Dimitris Zermas, Vassilios Morellas, David Mulla, Nikos Papanikolopoulos, Mike Bazakos), OTC Docket No.: 20180265, University of Minnesota, 2019.
- **Automated Detection of Nitrogen Deficiency in Corn**, (Dimitris Zermas, Vassilios Morellas, David Mulla, Nikos Papanikolopoulos, Daniel Kaiser), OTC Docket No.: 20160058, University of Minnesota, 2015.
- **Computer vision approach using 3D reconstruction as a basis for parking space occupancy detection in parking facilities**, (Doug Cook, Vassilios Morellas, Ted Morris, Nikos Papanikolopoulos), OTC Docket No.: 20140124, University of Minnesota, 2014.
- **System and method for autonomous object tracking**, (Kartik B Ariyur, Saad J Bedros, Dennis W Strelow, Vassilios Morellas), 2011. (US Patent 7,907,750)
- **Object tracking system**, (Vassilios Morellas, Michael E Bazakos, Yunqian Ma, Andrew Johnson), 2010. (US Patent 7,720,257)
- **Face detection and tracking in a wide field of view**, (Michael E Bazakos, Vassilios Morellas), 2010. (US Patent 7,806,604)
- **Distributed stand-off ID verification compatible with multiple face recognition systems (FRS)**, (Michael E Bazakos, David W Meyers, Vassilios Morellas), 2010. (US Patent 7,817,013)
- **Infrared and visible fusion face recognition system**, (Michael E Bazakos, Vassilios Morellas, Yunqian Ma), 2009. (US Patent 7,602,942)
- **Unsupervised learning of events in a video sequence**, (Michael E Bazakos, Yunqian Ma, Vassilios Morellas, others), 2009. (US Patent 7,606,425)
- **Tracking a moving object from a camera on a moving platform**, (Kartik B Ariyur, Saad J Bedros, Vassilios Morellas, others), 2009. (US Patent 7,541,565)
- **Monitoring devices**, (Karen Z Haigh, Vassilios Morellas, Liana M Kiff), 2008. (EP Patent 1,782,406)
- **Infrared face detection and recognition system**, (Michael E Bazakos, Vassilios Morellas, Andrew Johnson, Yunqian Ma), 2008. (US Patent 7,469,060)
- **Tracking a moving object from a camera on a moving platform**, (Kartik B Ariyur, Saad J Bedros, Vassilios Morellas, others), 2008. (US Patent 7,411,167)
- **Face detection and tracking in a wide field of view**, (Michael Bazakos, Vassilios Morellas), 2007. (WO Patent 2,007,047,719)
- **Cooperative camera network**, (Ioannis Pavlidis, Vassilios Morellas), 2006. (US Patent 7,149,325)

- **High fidelity target identification and acquisition through image stabilization and image size regulation**, (Kartik B Ariyur, Vassilios Morellas, Saad J Bedros), 2006. (US Patent App. 11/562,563)
- **Deception detection booth**, (Ioannis Pavlidis, Vassilios Morellas, Michael Bazakos, others), 2006. (WO Patent 2,006,078,344)
- **Imaging methods and systems for concealed weapon detection**, (Donald R Singh, Vassilios Morellas), 2006. (EP Patent 1,721,192)
- **Controlled environment thermal image detection system and methods regarding same**, (Ioannis Pavlidis, Michael E Bazakos, Vassilios Morellas), 2006. (US Patent 7,138,905)
- **Method for monitoring a moving object and system regarding same**, (Ioannis Pavlidis, Vassilios Morellas), 2004. (EP Patent 1,399,889)
- **Method and apparatus for tracking with identification**, (Anthony E Faltesek, Vassilios Morellas), 2004. (EP Patent 1,388,140)

Invited Talks

- **Key Note Talk:** *Video analytics for security and transportation applications*, 4th Joint IEEE International Workshop on Object Tracking and Classification Beyond the Visible Spectrum (OTCBVS'07), June 22, 2007.
- *A pragmatic view on modern video surveillance systems*, Advanced Transportation Technologies Seminar Series, Institute for Transportation Studies (ITS), University of Minnesota, October 9, 2007.
- *Imaging methods for surveillance*, IMA/MCIM Industrial Problems Seminar, Institute for Mathematics and Its Applications (IMA), University of Minnesota, March 3, 2006.
- *Advanced technology for homeland security applications*, Institute for Transportation Studies (ITS), University of Minnesota, June 2, 2003.

Student Advising and Mentoring

Master Thesis

- Haoyuan Du, Haoyi Shi, MS 2023
Thesis: *Advancing the Functionalities of a Socially-Assistive Robot as a Companion for Aging Adults.*
- Doug J. Cook, MS 2012
Thesis: *Parking space occupancy detection utilizing 3D reconstruction techniques.*
- Luis Guzman, MS 2021
Thesis: *Robotic Embodiment of Human-Like Motor Skills via Sim-to-Real Reinforcement Learning.*
- Matthew Tlachac, MS 2021
Thesis: *Tumbling Robot Optimization Using a Learned Control Policy.*

Doctoral Dissertations

- Anoop Cherian, PhD 2013
Thesis: *Similarity search in visual data.*
Current Appointment: Mitsubishi Electric Research Laboratories, Boston, MA.
- Ravishankar Sivalingam, PhD 2013
Thesis: *Tensor sparse coding for positive definite matrices.*
Current Appointment: 3M, St. Paul, Minnesota.

- Guruprasad Somasundaram, PhD 2012
Thesis: *Salient image regions for enhancing segmentation object detection and intra-class diversity.*
Current Appointment: 3M, St. Paul, Minnesota.
- Panagiotis Stanitsas, PhD 2018
Thesis: *Machine Learning Methods with Emphasis on Cancerous Tissue Recognition.*
Current Appointment: 3M, St. Paul, Minnesota.
- Dimitrios Zermas, PhD 2018
Thesis: *Combining Machine Learning with Computer Vision for Precision Agriculture Applications.*
Current Appointment: Accepted a job offer from Sentra LLC, Bloomington MN.

PhD Thesis Committees

- Kedar Patwardhan, Jon Andersh.

Synergistic Activities

- Associate Editor, IEEE/RSJ International Conference on Intelligent Robots and Systems, 2019.
- Technical Committee, 22nd International Conference on Pattern Recognition (ICPR 2014).
- Program Committee, IEEE International Symposium on Safety, Security, and Rescue Robotics, (Years 2012, 2013).
- Program Area Chair, 5th IEEE International Conference on Advanced Video and Signal Based Surveillance, 2008.
- Program Committee, IEEE Workshop on Computer Vision Beyond the Visible Spectrum: Methods and Applications, in conjunction with CVPR (Years 2000, 2001).