United States Court of Appeals for the Federal Circuit

2008-1129, -1160

WAVETRONIX,

Plaintiff-Appellant,

v.

EIS ELECTRONIC INTEGRATED SYSTEMS,

Defendant-Cross Appellant.

Brent P. Lorimer, Workman Nydegger, of Salt Lake City, Utah, argued for plaintiff-appellant. With him on the brief were Thomas R. Vuksinick and David R. Todd. Of counsel were Chad E. Nydegger and L. David Griffin.

Richard D. Rochford, Nixon Peabody LLP, of Rochester, New York, argued for defendant-cross appellant. Of counsel on the brief were Michael F. Orman and Wendell W. Harris.

Appealed from: United States District Court for the District of Utah

Senior Judge Bruce S. Jenkins

United States Court of Appeals for the Federal Circuit

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WAVETRONIX,

Plaintiff-Appellant,

v.

EIS ELECTRONIC INTEGRATED SYSTEMS,

Defendant-Cross Appellant.

Appeal from the United States District Court for the District of Utah in Case No. 2:05-CV-73, Senior Judge Bruce Jenkins.

DECIDED: July 29, 2009

Before NEWMAN and SCHALL, Circuit Judges, and PATEL, District Judge.*

PATEL, District Judge.

Wavetronix LLC ("Wavetronix") brought this patent infringement action against EIS Electronic Integrated Systems ("EIS"). The patent in suit is United States Patent No. 6,556,916 ("the '916 patent"), entitled "System and Method for Identification of Traffic Lane Positions." Wavetronix and EIS both develop systems for monitoring the

* The Honorable Marilyn Hall Patel, United States District Court for the Northern District of California, sitting by designation.

flow of automobile traffic on thoroughfares. Wavetronix accuses the automatic setup feature of EIS's Remote Traffic Microwave Sensor ("RTMS") X3 monitoring device of infringing one independent claim and several dependent claims of the '916 patent, literally or under the doctrine of equivalents.

The district court granted summary judgment of non-infringement to EIS. Wavetronix appeals the judgment of non-infringement, and EIS cross-appeals dismissal of its counterclaims of invalidity and unenforceability. We conclude that summary judgment of non-infringement is proper, and we affirm the district court's judgment.[1]

I. BACKGROUND

A. The Patent in Suit and Its Technological Field

Urban planners require accurate counts of vehicular traffic in order to plan the construction of new thoroughfares as well as to determine the optimal ways to use existing thoroughfares. It is often useful to know how much traffic travels in a particular lane, for instance a High-Occupancy Vehicle (HOV) lane, as compared to other lanes on the same thoroughfare. Numerous sensor devices using, for example, radar or acoustic signals have been developed to monitor the flow of vehicle traffic across several lanes of a road or highway. The '916 patent's Figure 5 illustrates a roadside sensor unit with a field of vision extending across several lanes of a street.

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[1] Wavetronix argues that there are legal and factual errors in the district court's opinion and that such errors warrant reversal. The existence of any such errors does not, in itself, compel reversal. This court sits to review judgments, not opinions. Stratoflex, Inc. v. Aeroquip Corp., 713 F.2d 1530, 1540 (Fed. Cir. 1983). The party that prevailed below may defend a judgment on any ground which the law and record permit that would not expand the relief it has been granted. United States v. N.Y. Tel. Co., 434 U.S. 159, 166 n.8 (1977).

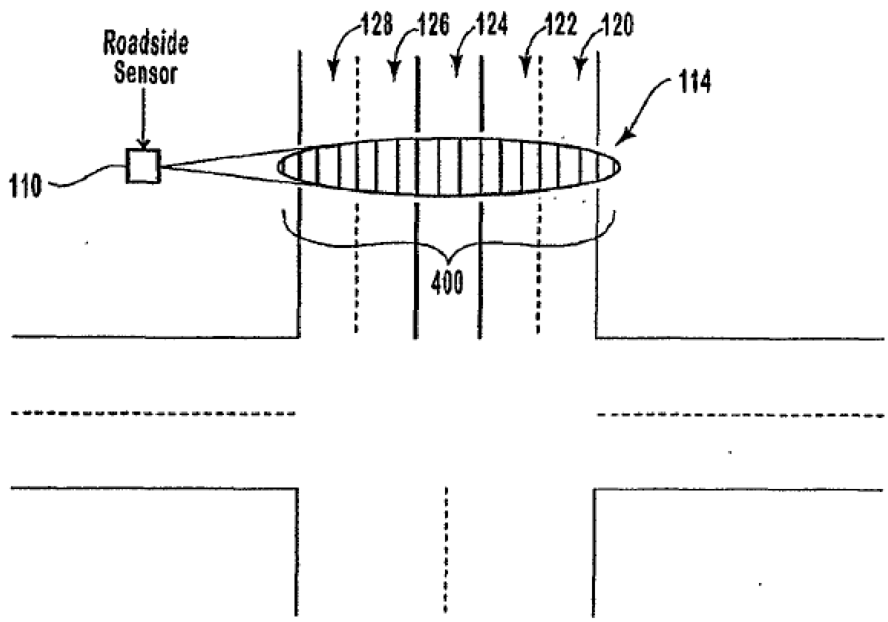

Fig. 5

For these devices to accurately tally the number of vehicles traveling in each lane, they must "know" where the lane boundaries are located. While a human being can simply look at a highway and see where the lanes of traffic are located, a sensing device must be "taught" the location of the lanes before it can begin to serve its monitoring function. One way to achieve this is to allow the device to detect some number of vehicles driving on the road and to extrapolate the locations of the lanes from an examination of where the detected vehicles have actually tended to drive. The underlying assumption (which highway patrol officers may dispute) is that drivers will more often than not drive near the centers of lanes, rather than near or over lane boundaries. If this assumption holds, then detecting where some number of vehicles have actually been driven can assist in identifying the centers of lanes; likewise, the places on the road on which automobiles have tended not to drive can be identified as lane boundaries. The patent in suit is directed to a method of performing the initial step of "teaching" a monitoring device the location of the traffic lanes on a given thoroughfare using detection and observation of actual automobile traffic.

In 2000, Wavetronix undertook the development of a new radar-based traffic monitoring system. Many of the prior art systems required manual adjustment to define the locations of the traffic lanes on the highway to be monitored. Wavetronix sought to improve the capability for automated lane definition. On September 27, 2001, three inventors filed the application for what became the '916 patent, naming Wavetronix as the assignee. The patent issued on April 29, 2003. Only claim 1 is at issue on appeal.[2] That claim reads, in its entirety:

> 1. In a traffic monitoring system having a sensor, a method for defining traffic lanes, comprising the steps of:
>
> a. for a selectable plurality of vehicles,
>
> i. detecting each of said selectable plurality of vehicles present within a field of view of said sensor;
>
> ii. estimating a position of said each of said selectable plurality of vehicles;
>
> iii. recording said position of said each of said selectable plurality of vehicles;
>
> b. generating a probability density function estimation from each of said position of said each of said selectable plurality of vehicles; and
>
> c. defining said traffic lanes within said traffic monitoring system from said probability density function estimation.

The specification discloses several preferred embodiments, all of which are described through the use of histograms. Each of these histograms displays, in some form, a two-

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[2] Wavetronix has also accused EIS of infringing claims 2, 8, 9, 15 and 16. Each of these is dependent upon claim 1's limitations.

dimensional grid with peaks and valleys representing the relative heaviness of vehicle traffic across a set of "range bins" representing spatial distances from the sensor. These histograms, which are Figures 6, 7 and 8 in the patent, are shown below.

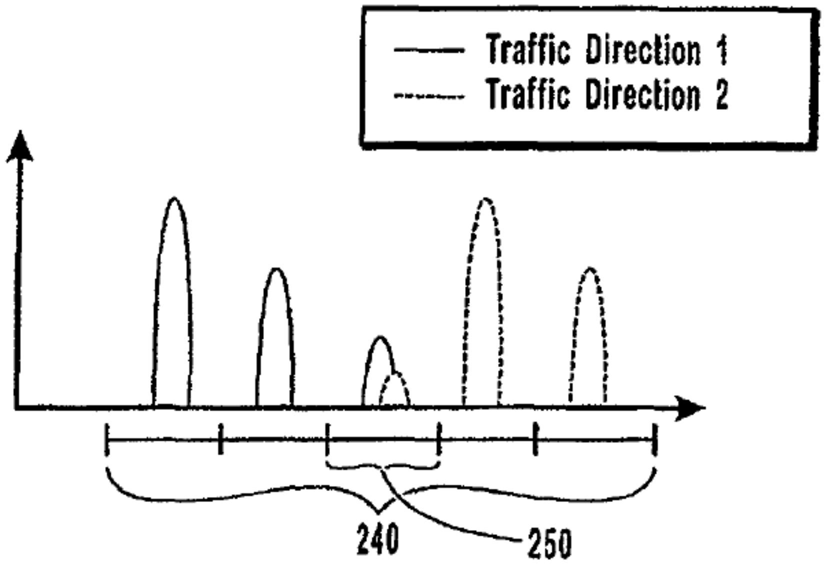


Fig. 6

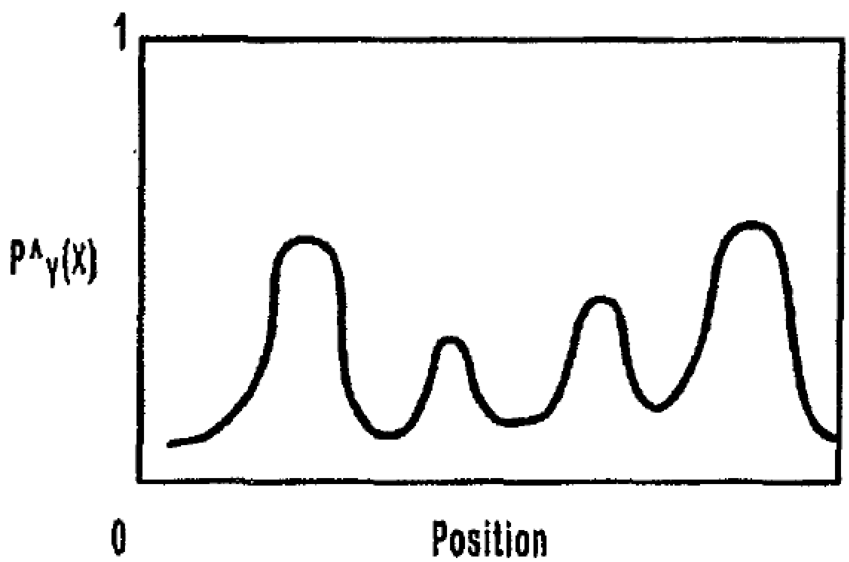


Fig. 7

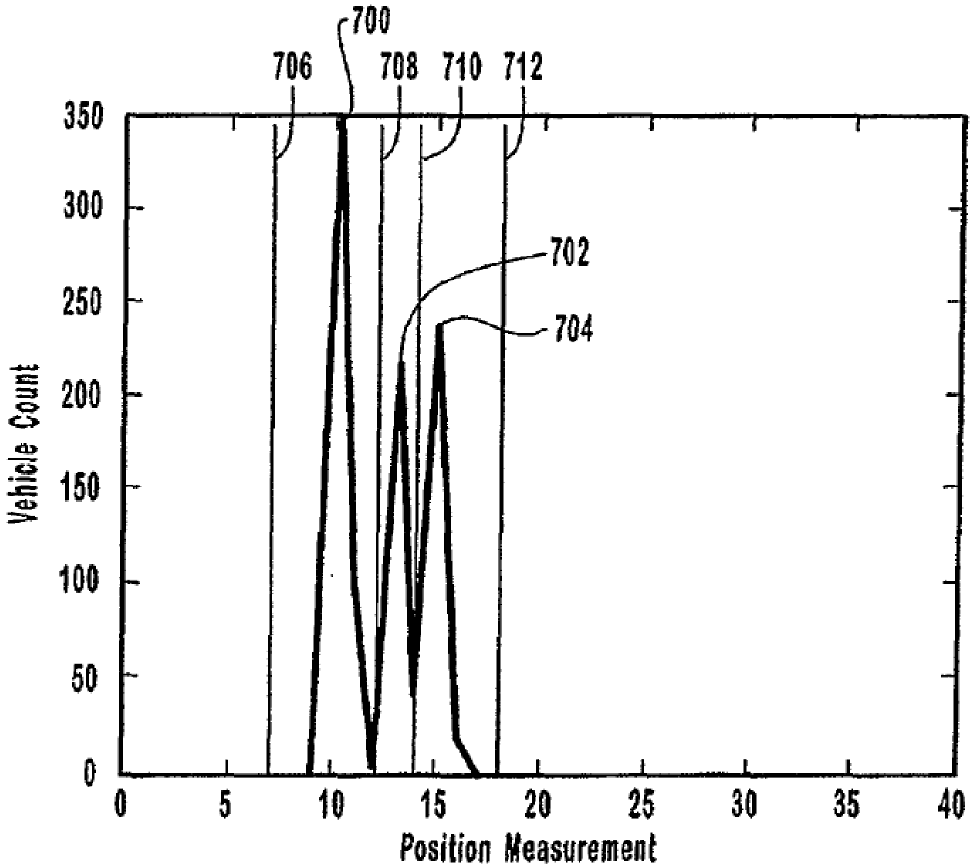


Fig. 8

The specification teaches that these histograms exemplify the kind of "probability density function estimation" recited in steps (b) and (c) of claim 1, and that the "peaks of the PDF represent the center of each lane and the low spots (or valleys) of the PDF represent the lane boundaries (or regions where cars don't drive)." '916 patent col.6 ll.15-18. The specification also explains that statistical techniques are used to identify the boundaries between lanes, and that these boundaries are then used to define the lanes for the purpose of detecting where vehicles drive. See id. col.7 l.51-col.9 l.6.

B. The Accused Device

As do prior art systems, EIS's RTMS X3 detects and counts vehicles in several lanes of a thoroughfare over an extended period of time. The initial determination of lane locations may occur manually or may be assisted by the auto set-up feature of a program called the "Setup Wizard." It is this auto set-up feature of the RTMS X3's Setup Wizard that Wavetronix accuses of infringement. While the parties emphasize different aspects of the system, there is no material dispute of fact as to how the accused system operates.

The RTMS X3 sensor unit, or transceiver, has a field of view that extends across a given roadway. The field of view is divided into thirty-two "range slices," each having a width of about three meters, i.e., the approximate width of a normal traffic lane. The transceiver is attached to a pole alongside the road, and a human installer connects the transceiver to a laptop computer. The transceiver detects passing automobiles, and a graphic on the computer screen displays small images to represent them. The system cannot accurately assign any particular automobile to a lane until range slices are matched up with actual lanes in the transceiver's field of vision. The human installer may define lanes manually by aligning the lane boundaries on the computer's screen with the spaces between blips displayed on the laptop that represent passing automobiles. Alternatively, the installer may choose to use the Setup Wizard's auto set-up feature. If this feature is chosen, the installer tells the RTMS X3 how many lanes to expect. The RTMS X3 then monitors and records automotive traffic for one minute.[3]

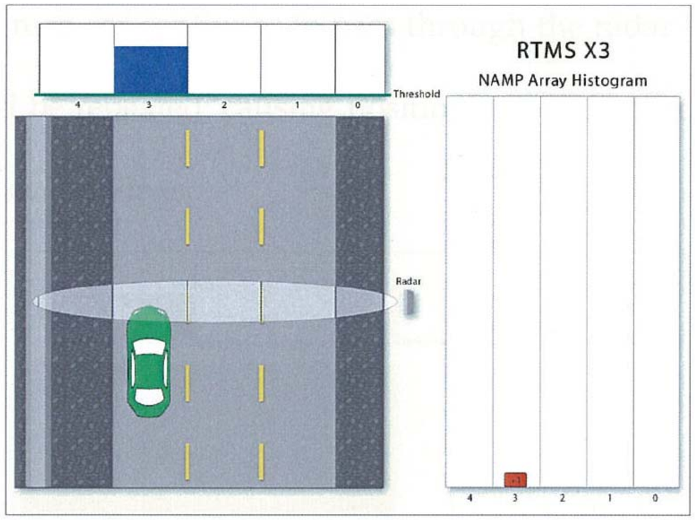
[3] Naturally, this process will not work on an empty road but must rather be used at a time and place in which it may be expected that a significant number of automobiles will pass through the lanes on the road.

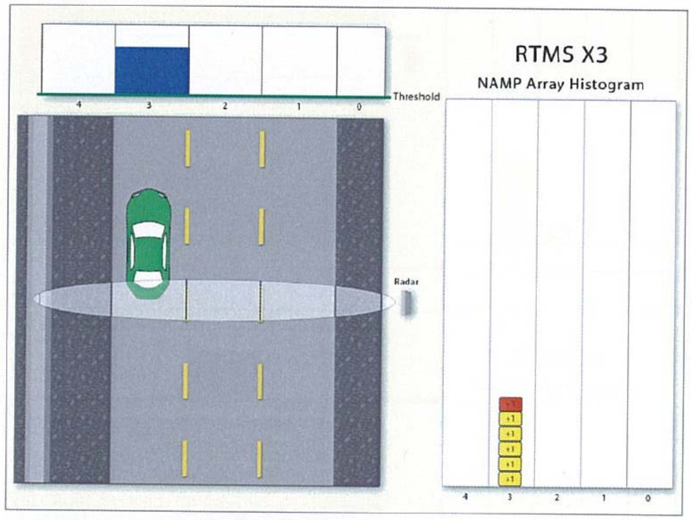
During that one minute, the transceiver continuously transmits radar signals toward the roadway and detects the reflected signals, while the Setup Wizard processes the data so generated in several steps. First, every ten milliseconds the system generates a series of thirty-two numbers corresponding to the strength of the reflected radar signal in each of the thirty-two range slices. A processor independently compares each of the thirty-two values to a particular "detection threshold." The results of this comparison are stored in a thirty-two position array, i.e., a sequence of thirty-two locations in the transceiver's memory called the "Q-vector." The Q-vector stores, for each range slice, the difference between its reflected radar strength and the detection threshold. Only if an automobile has driven in a particular range slice within the preceding ten milliseconds will the Q-vector contain a positive value corresponding to the position of that range slice. The values in the Q-vector are replaced every ten milliseconds as new signal measurements are taken by the sensor. During the one-minute set-up process, the contents of the Q-vector array are continuously sent to the laptop, where they are replicated in an array called the "REQ array." The REQ array processes only about twenty percent of the Q-vector data that is generated, because the transceiver generates data faster than it can be transmitted to the laptop.

As data is sent to the laptop's REQ array, the Setup Wizard software identifies "local maxima" for each ten-millisecond increment of time. A local maximum is identified when the value at a particular position in the thirty-two position REQ array is greater than the values at the positions to the immediate left or right. After identifying all of the local maxima present in the REQ array during a given ten-millisecond interval, the Setup Wizard software ignores everything except the "first" local maximum, which is the local maximum nearest to the sensor. The various stages of processing so far described result in the production of one “first local maximum” corresponding to one of the thirty-two range bins every ten milliseconds.

The next step involves an array called the “NAMP array.” Wavetronix contends that it is the NAMP array that “generat[es] a probability density function estimation” as described in claim 1, step (b), of the ’916 patent. As a first local maximum is produced every ten milliseconds, the NAMP array, which like the other arrays has thirty-two positions, adds up the number of first local maxima per position over the course of the one-minute set-up period. The system records first local maxima, not discrete automobiles. Unless an automobile is exceedingly fast or small, it is likely to produce multiple first local maxima when passing through the sensor’s field of vision. The following illustrations depict two notional automobiles driving through the RTMS X3 field of vision. Only five range slices, numbered 0 through 4, are depicted. Range slices 1-3 correspond to lanes, while range slices 0 and 4 correspond to shoulders. As each automobile drives through the field of vision in a given lane, a number of first local maxima register in the NAMP array.[4]

[4] These illustrations, taken from Wavetronix’s principal brief, describe the graph on the right of each illustration as a “NAMP Array Histogram.” The court does not necessarily adopt the description of the NAMP array as a “histogram.”


RTMS X3
NAMP Array Histogram
Threshold
Radar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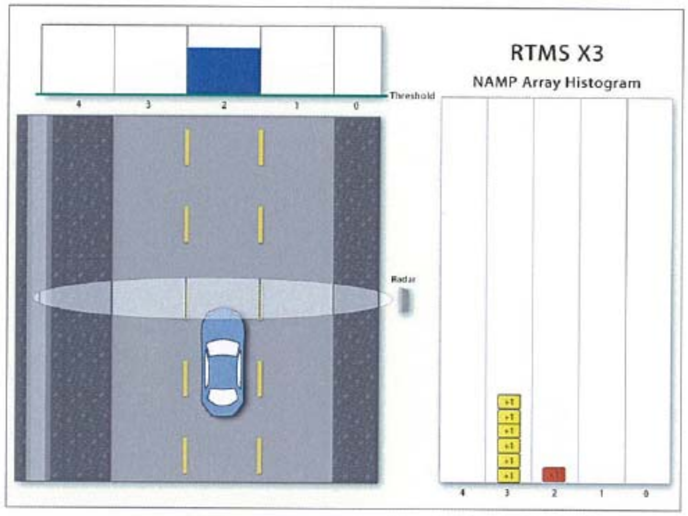

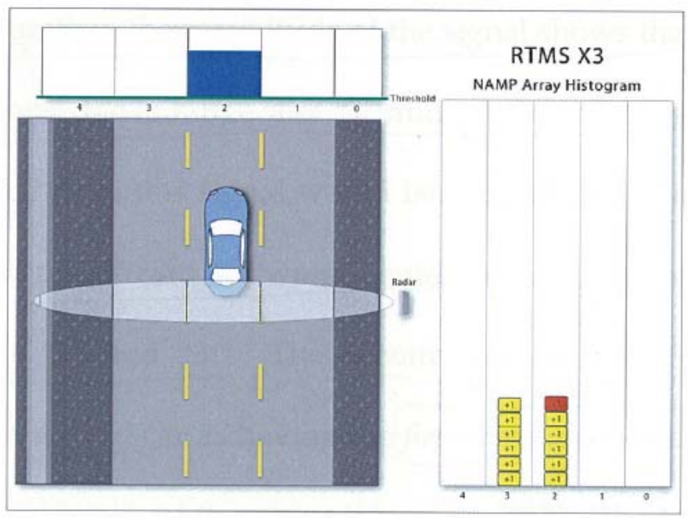

As noted, the RTMX X3's field of vision actually contains thirty-two range slices, not just five. Upon completion of the one minute period, the NAMP array contains thirty-two values corresponding to each of the thirty-two range slices. These NAMP array values are used to define lanes. Specifically, the Setup Wizard defines as a lane any range slice for which the final count in the NAMP array exceeds about one percent of the total number of Q-vectors analyzed in the laptop. Because the set-up period lasts about one minute, a given range slice must register a minimum of approximately ten counts in order for the system to determine that the range slice corresponds to a lane.

A range slice is either found to correspond to a lane or it is not. If fewer lanes are found than the human installer told the system to expect, then the one-minute detection and recording stage repeats itself. If more lanes have been found than expected, the system deletes the lanes that registered the least number of first local maxima until the expected number of lanes is reached. Upon completion of the set-up phase, the Setup Wizard has identified which of the thirty-two range slices spanning the sensor's field of vision actually correspond to traffic lanes. The system is then ready to begin the long-term monitoring of vehicle traffic within the identified lanes.

C. Relevant Procedural History

Wavetronix filed this action on January 27, 2005. On March 13, 2006, the district court granted summary judgment to Wavetronix on EIS's best mode defense, finding as a matter of law that EIS could not prevail on the defense. The district court similarly granted summary judgment to Wavetronix on EIS's inequitable conduct defense, on May 18, 2006. The court conducted some fourteen days of pre-trial hearings and, on September 21, 2007, entered an order granting summary judgment of non-infringement. At no time did the court enter a claim construction order. After entry of judgment dismissing Wavetronix's claim of infringement and EIS's counterclaims of invalidity and unenforceability, Wavetronix timely appealed and EIS timely cross-appealed. We have jurisdiction pursuant to 28 U.S.C. § 1295(a)(1).

II. DISCUSSION

The appeal and cross-appeal are taken from judgment entered by the district court following grants of summary judgment. A court may grant summary judgment only when, drawing all inferences and resolving all doubts in favor of the non-moving party, there are no genuine issues of material fact and the moving party is entitled to judgment as a matter of law. Fed. R. Civ. P. 56(c). See generally Anderson v. Liberty Lobby, Inc., 477 U.S. 242 (1986). A fact is "material" if it may affect the outcome of the proceedings, and an issue of material fact is "genuine" if the evidence is such that a reasonable jury could return a verdict for the non-moving party. Anderson, 477 U.S. at 248. The moving party bears the burden of identifying those portions of the pleadings, discovery and affidavits that demonstrate the absence of a genuine issue of material fact. Celotex Corp. v. Catrett, 477 U.S. 317, 323 (1986). Once the moving party meets its initial burden, the non-moving party must go beyond the pleadings and, by its own affidavits or discovery, set forth specific facts showing that there is a genuine issue for trial. Fed R. Civ. P. 56(e); see Anderson, 477 U.S. at 250. We review a district court's grant of summary judgment de novo. Netscape Commc'ns Corp. v. Konrad, 295 F.3d 1315, 1319 (Fed. Cir. 2002).

A. Claim Construction

The district court determined as a matter of law that the EIS system does not infringe the '916 patent. Infringement analysis involves a two-step process: the court first determines the meaning of disputed claim terms and then compares the accused device to the claims as construed. Markman v. Westview Instruments, Inc., 52 F.3d 967, 976 (Fed. Cir. 1995), aff'd, 517 U.S. 370 (1996); see also Middleton, Inc. v. Minn. Mining & Mfg. Co., 311 F.3d 1384, 1387 (Fed. Cir. 2002).

The district court did not explicitly construe claim 1's "probability density function estimation" limitation. The parties agree that this is the only claim term requiring construction. They urge this court to construe the term on appeal rather than remand for claim construction. There being only one independent claim in dispute and no material issues of fact as to how the accused system works, the construction of that term is the key issue for deciding infringement.

Although claim construction is a question of law, we generally refuse to construe claims in the first instance. See, e.g., Metro. Life Ins. Co. v. Bancorp Servs., L.L.C., 527 F.3d 1330, 1336 (Fed. Cir. 2008); Electro Scientific Indus., Inc. v. Dynamic Details, Inc., 307 F.3d 1343, 1350 (Fed. Cir. 2002); Bayer AG v. Biovail Corp., 279 F.3d 1340, 1349 (Fed. Cir. 2002). But see Frank's Casing Crew & Rental Tools, Inc. v. PMR Techs., Ltd., 292 F.3d 1363, 1373 (Fed. Cir. 2002). We have explained that this court's review, although de novo, is not to function as an independent analysis in the first instance. See Nazomi Commc'ns, Inc. v. Arm Holdings, PLC, 403 F.3d 1364, 1371 (Fed. Cir. 2005). In this case, however, we accept the parties' invitation to construe the "probability density function estimation" claim term, for three reasons. First, although the district court did not specifically construe the claim term, its opinion references the question of claim construction, and it is apparent that the district court's views on the matter have been exhausted. See id. (noting importance of taking into account views of trial judge); see also Fireman's Fund Ins. Co. v. United States, 909 F.2d 495, 499 (Fed. Cir. 1990) (addressing new argument in first instance where remand would serve no useful purpose). Second, both parties have agreed that we should construe the claim limitation. Third, we agree that the record, which includes considerable evidence and expert testimony, has been sufficiently developed to enable us to construe the claim term without prejudicing either party. See Fireman's Fund, 909 F.2d at 499; cf. Apex, Inc. v. Raritan Computer, Inc., 325 F.3d 1364, 1374-75 (Fed. Cir. 2003) (declining to construe claim terms where record had not been sufficiently developed, because prejudice could result).

A claim term is construed according to its ordinary and customary meaning as understood by a person of ordinary skill in the art at the time of the invention. Phillips v. AWH Corp., 415 F.3d 1303, 1312-13 (Fed. Cir. 2005) (en banc).[5] "[T]he court looks to those sources available to the public that show what a person of skill in the art would have understood disputed claim language to mean," including "the words of the claims themselves, the remainder of the specification, the prosecution history, and extrinsic evidence concerning relevant scientific principles, the meaning of technical terms, and the state of the art." Id. at 1314 (citations and internal quotation marks omitted). A dictionary definition may be relied upon "so long as [it] does not contradict any definition found in or ascertained by a reading of the patent documents." Id. at 1322-23 (quoting Vitronics Corp. v. Conceptronic, Inc., 90 F.3d 1576, 1584 n.6 (Fed. Cir. 1996)).

There is no dispute that a "probability density function estimation" ("PDFE") is, in some manner, an "estimation" of a "probability density function" ("PDF"). In the words of Wavetronix's expert, "probability density function is a precisely defined term in statistics which corresponds to the probabilities of the different possible outcomes of some experiment." EIS agrees that "PDF" is a well known mathematics term and offers the following dictionary definition: "a function of a continuous variable whose integral over a region gives the probability that a random variable falls within the region."[6] While the

[5] Neither party has argued that the other party's proffered experts are unqualified to opine as persons of ordinary skill in the art.

[6] Random House Webster's Unabridged Dictionary 1541 (2d ed. 2001). This definition comports with those found in other general reference and technical

parties agree upon the definition of "PDF," they dispute the definition of "PDFE." We conclude below that the salient difference between the two concepts is that a PDF is a mathematical function, whereas a PDFE is an approximation of such a function using actual finite data. We also explain below that, in light of the teachings of the specification and the recitation of the PDFE within the claim language, for the purposes of claim 1 a PDFE must estimate a PDF with sufficient precision to indicate both where vehicles are located and where they are not. In other words, as the specification teaches, a PDFE should at a minimum provide enough data to ascertain "peaks" and "valleys" approximating the centers and boundaries of traffic lanes, respectively.

In advocating for its construction of "PDFE," EIS focuses on the term "probability" and argues that a PDFE must represent some sort of probabilistic analysis. Wavetronix argues that the "E" in "PDFE" modifies the whole phrase "PDF," not just "P" or "probability." According to Wavetronix, an "estimate" of a PDF need not have all of the characteristics of an actual PDF, including estimating the actual probability that a vehicle has driven in a given lane. Rather, as we understand Wavetonix's argument, any histogram that allows for an estimation of lane boundaries is a PDFE, because any graph that accurately allows for lane detection must have some correlation with the number or probability of cars in each lane. Wavetronix argues that the definition that most aligns with the specification and includes all of the disclosed embodiments is "a tabulation of frequencies of vehicle positions."

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dictionaries. See, e.g., Webster's Third New International Dictionary 1806 (2002) ("a function of a continuous random variable whose integral over an interval gives the probability that its value will fall within the interval"); McGraw-Hill Dictionary of Scientific and Technical Terms 1674 (6th ed. 2003) ("[a] real-valued function whose integral over any set gives the probability that a random variable has values in this set").

The claim language itself provides little guidance on how to define "PDFE," and the parties have not relied upon the patent's prosecution history to define the proper scope of the claim limitations referencing a PDFE.[7] The patent's specification does provide guidance, but its references to PDFE are not entirely consistent. Nowhere does the patent set forth an explicit definition of PDFE. See Phillips, 415 F.3d at 1316 (patentee may act as own lexicographer); Johnson Worldwide Assocs., Inc. v. Zebco Corp., 175 F.3d 985, 990 (Fed. Cir. 1999) (same). The specification refers variously to: a PDF "as estimated," '916 patent col.6 l.6; using a PDF "to estimate" lane boundaries, id. col.6 ll.14-15; "PDF estimation," id. col.6 l.32; a "PDF estimator," id. col.6 l.33; and "estimated PDFs," id. col.8 l.13. In some places, the specification appears to refer to PDF and PDFE interchangeably. Id. col.4 ll.1-7, col.7 ll.30-39.

The concept of "PDF" is defined with greater clarity and consistency in the specification than is the concept of "PDFE" standing alone. Both the summary of the invention and the description of the preferred embodiments describe the concept of PDF in terms of a graph in which enough data is collected to observe peaks, which

[7] The parties look to the patent's prosecution history only for the purposes of supporting their respective positions on the question of whether claim 1 requires the counting of discrete vehicles. EIS points out that Wavetronix remained silent in the face of the patent examiner's characterization of the patent's method as "determining . . . the number of cars which pass beneath [the sensor]." According to EIS, Wavetronix conceded through its silence that the patent claimed the counting of discrete vehicles as opposed to mere vehicle detections that may or may not yield an accurate tally of individual vehicles. The parties have expended considerable effort arguing this point. Whatever the merits of the argument, see 3M Innovative Props. Co. v. Avery Dennison Corp., 350 F.3d 1365, 1373-74 (Fed. Cir. 2003) (silence does not necessarily indicate acquiescence to examiner's characterization when allowance is on grounds unrelated to characterization), it is unnecessary to decide whether the claim encompasses only detections of discrete vehicles. Even if the claim also encompasses vehicle detections, an accused system must still generate a PDFE and define lanes from said PDFE to infringe. For the same reason, it is also unnecessary to determine whether a PDFE requires "unbiased" or "normalized" data, as asserted by EIS.

represent the centers of lanes, and valleys, which represent the lane boundaries or edges. See, e.g., id. col.4 ll.2-7 (summary of invention) ("The probability density function describes the probability that a vehicle will be located at any range. The peaks of the probability function represent the center of each lane and the valleys of the probability density function represent the lane boundaries."); id. col.6 ll.15-19 (explanation of Figure 3, a diagram of the method) ("The peaks of the PDF represent the center of each lane and the low spots (or valleys) of the PDF represent the lane boundaries (or regions where cars don't drive). The lane boundaries are set to be the low spots (or valleys) between peaks."). This "peaks and valleys" arrangement allows for the definition of lanes from the PDFE as recited in step (c) of claim 1.

The understanding of PDF as a data plot showing a range of high values ("peaks") and low values ("valleys") as explicated in the specification aligns well with the standard mathematics definition of PDF. A PDF is a theoretical mathematical function that seeks to model reality. As Wavetronix's expert noted, a PDF does not represent actual data. When displayed on a histogram, a PDF is a smooth line or curve, because it is produced by a mathematical equation. When a finite set of actual data is plotted on a histogram, the resulting plot will not be a smooth curve but rather a disjointed one. See, e.g., '916 patent fig.8. Such a plot may be represented by points connected with lines or by a series of bars. The more data that is collected and plotted, the smoother the line will be; however, a plot based on data would require an infinite number of data points to duplicate the perfect smoothness of a mathematical function. In real-world situations such as traffic monitoring, it is impossible to collect infinite data, but a plot of a significant number of automobiles can estimate the mathematical curve that would describe the automobiles' distribution. A PDF and a PDFE do not, therefore, differ in the sense of allowing for a comparison of values over a range of positions. The distinction between them lies, rather, in the fact that a PDF is a perfectly smooth mathematical function, whereas a PDFE is an estimation of some hypothetical PDF. The PDFE is not perfectly smooth, but it has the advantage of being based on actual data.

The specification is hardly a paragon of clarity, but this understanding of PDF estimation comports with the various descriptions and explanations of the PDF and PDFE concepts found in the specification. There are differences between the embodiments disclosed in the specification, but each of them suggests that a number of data points is used to estimate a hypothetical mathematical model, i.e., a PDF. One embodiment (shown in the histogram at Figure 7) uses "normalized" data, i.e., data displayed as a percentage of a total rather than as raw counts, while at least one (shown in the histogram at Figure 8) does not.[8] Two embodiments apparently refer to a count of individual vehicles (Figures 6 and 8), see '916 patent col.7 l.25 ("The number of vehicles in each bin is counted . . . ."), while a third (Figure 7) could just as easily refer to vehicle detections, i.e., the number of signals bounced back to the transceiver, which may be more than one per vehicle. What is the same about all of the disclosed embodiments (Figures 6, 7 and 8) is that each of them represents, in the form of a histogram, a comparison of the number of vehicles or vehicle detections across a range.

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[8] That Figure 7 represents a normalized graph is indicated by the fact that the y-axis is scaled from zero to one. A given value is expressed as a fraction of the whole, rather than as a raw count of detections. Determining the fraction of the whole represented by a given value in Figure 8, which is not normalized, would require dividing that value by the total number of counts measured in all positions.

This ability to compare the data across a range is significant, because it provides information not only about where vehicles are but where they are not—i.e., where traffic lanes begin and end.[9] Such data is used for "defining . . . traffic lanes . . . from said [PDFE]." The record reveals no material intrinsic or extrinsic evidence indicating that the attribute of a PDF that a PDFE does not possess is the fundamental property of functioning over a range.

In summary, what makes a PDFE an estimate of a PDF in the context of the '916 patent is the fact that a PDFE is based on actual data points, rather than a perfectly smooth, if hypothetical, mathematical function or model. But a PDFE, like a PDF, has the characteristic of comparing values across a range of positions. The court therefore construes a PDFE to be "a finite data set large enough to approximate a function of a continuous variable whose integral over a region gives the probability that a random variable falls within the region." This construction applies equally to step (b) ("generating a [PDFE] . . .") and step (c) ("defining . . . traffic lanes . . . from said [PDFE]") of claim 1; however, our infringement analysis infra focuses on step (c).

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[9] The patent contains two references suggesting that some embodiments may have only one range bin per lane. See '916 patent col.7 ll.7-8 ("[A] lane may be comprised of a plurality of bins) (emphasis added); id. col.9 ll.58-61 (a limitation in claim 3 claiming a plurality of range bins in each lane, which appears redundant if claim 1 already implies this limitation). No doubt, using one bin per lane would not result in an optimal lane definition using the "peaks" and "valleys" method. Nevertheless, there is nothing plainly suggesting that, if only one bin per lane were used, the method would take advantage of some technique other than comparing values across a range of lanes to define lanes. The specification teaches that range bins of a width that results in histograms without "peaks" and "valleys" are incapable of providing useful information about where vehicle lanes begin and end. This teaching is an essential characteristic of the patented system, and is relevant to the analysis of both literal infringement and infringement under the doctrine of equivalents.

B. Literal Infringement

Aided by our construction of PDFE, we now turn to the question of literal infringement. "Literal infringement of a properly construed claim is a question of fact." Applied Med. Res. Corp. v. U.S. Surgical Corp., 448 F.3d 1324, 1332 (Fed. Cir. 2006). "We affirm a district court's grant of summary judgment of non-infringement only if, after viewing the alleged facts in the light most favorable to the non-movant, there is no genuine issue as to whether the accused device is encompassed by the claims." Combined Sys., Inc. v. Def. Tech. Corp. of Am., 350 F.3d 1207, 1210 (Fed. Cir. 2003) (citation omitted).

Wavetronix contends that the RTMS X3 Setup Wizard uses the NAMP array data to perform the step of "defining . . . traffic lanes" as set forth in step (c) of claim 1. Wavetronix characterizes the operation of the Setup Wizard software as using detections of first local maxima to conclude "it is probable" vehicles travel in certain range slices. EIS counters that the accused device performs no probability analysis, and indeed that no such probability analysis could be performed using the NAMP array. While the NAMP array collects data for a number of bins corresponding to spatial positions, these data cannot fairly be said to represent probabilities. EIS states that its device never conducts any probabilistic analysis to search for "peaks" and "valleys" in a histogram, wherein valleys would represent boundaries between the lanes. Rather, because the EIS system uses bins that are the full width of normal traffic lanes, the data collected in the NAMP array is simply too coarse to reveal any "peaks" representing lane centers or any "valleys" representing lane boundaries. EIS argues that its system actually employs a much simpler methodology that identifies traffic lanes by applying a common threshold value to the NAMP data. EIS also notes that the system requires manual intervention by a human to set the precise boundaries of traffic lanes. Because the NAMP array does not have any of the essential properties of the PDFEs described in the ’916 patent, EIS argues that its system cannot meet the “defining said traffic lanes . . . from said [PDFE]” limitation, either literally or by equivalents.

Properly construed, the PDFE claim term requires a representation of vehicle frequencies across a range of positions with sufficient detail to provide meaningful information about where traffic lanes begin and end. This detail allows for the definition of lanes claimed in step (c). In contrast, the processing of the sensor data in the NAMP array, which the parties agree is used to select lanes, does not involve comparisons among values for the range slices. As noted, the parties are in agreement as to how the accused system operates. In the words of Wavetronix’s brief, “[T]he Wizard defines a lane as any range slice for which the final count in the NAMP array exceeds about one percent of the total number of Q-vectors analyzed in the laptop.” The analysis of the NAMP array data does not involve comparisons across lanes using “peaks” and “valleys” or any similar method. The determination that any particular range slice corresponds to a lane is made independently for each range slice, without reference to the values in other range slices. In other words, the range of highs and lows in the NAMP array does not provide data from which the user could extrapolate lane boundaries. Thus, the character of the NAMP data does not comport with our previously stated construction of PDFE.

As an example, imagine a four-lane highway, and imagine further that the NAMP array values collected for the four lanes are x, x-1, x+2 and x+1, in that order. The fact that x+2 is the highest value (and could accordingly be described as a "peak") and that x-1 is the lowest value (and could be described as a "valley") is irrelevant to the definition of traffic lanes. There is only one value per lane; therefore, both the "peak" and the "valley" represent whole lanes, rather than lane centers or boundaries. This illustrates that the data set produced in the NAMP array is too coarse to be a PDFE in the sense required by the '916 patent. The RTMS X3 selects lanes by analyzing the NAMP array data, and the NAMP array cannot be a PDFE. Accordingly, we hold as a matter of law the RTMS X3 does not practice the "defining . . . traffic lanes" step of claim 1 and therefore does not literally infringe the '916 patent.

C. Doctrine of Equivalents

Wavetronix argues that the district court failed to give adequate consideration to the possibility of infringement by equivalents. EIS contends that Wavetronix waived the argument below. We assume without deciding that Wavetronix did not waive the argument.

The essential inquiry under the doctrine of equivalents is whether "the accused product or process contain[s] elements identical or equivalent to each claimed element of the patented invention." Warner-Jenkinson Co., Inc. v. Hilton Davis Chem. Co., 520 U.S. 17, 40 (1997). As with literal infringement, infringement by equivalents is a question of fact. Id. at 38. "An element in the accused product is equivalent to a claim limitation if the differences between the two are 'insubstantial' to one of ordinary skill in the art." Eagle Comtronics, Inc. v. Arrow Commc'n Labs., Inc., 305 F.3d 1303, 1315 (Fed. Cir. 2002) (citing Warner-Jenkinson, 520 U.S. at 40); see also Graver Tank & Mfg. Co. v. Linde Air Prods. Co., 339 U.S. 605, 609 (1950). A plaintiff can prove equivalence by showing on a limitation-by-limitation basis that the accused product performs substantially the same function in substantially the same way with substantially the same result as each claim limitation of the patented product. Eagle Comtronics, 305 F.3d at 1315 (quoting Graver Tank, 339 U.S. at 608); see also Warner-Jenkinson, 520 U.S. at 39-40. A court may not apply the doctrine of equivalents where so doing would effectively eliminate a claim element in its entirety. Warner-Jenkinson, 520 U.S. at 29; Carnegie Mellon Univ. v. Hoffmann-La Roche, Inc., 541 F.3d 1115, 1129 (Fed. Cir. 2008).

The Setup Wizard does not define lanes in substantially the same way as the patented method because it simply confirms whether the range slices of uniform width set in the system by the operator are aligned with actual traffic lanes on a one-to-one basis. Indeed, the Setup Wizard's determination of where lanes are located is made in relation to a specific threshold, rather than as a comparison between different range slices. The significance of this difference may be illustrated by returning to the example of the series of four hypothetical NAMP array values x, x-1, x+2 and x+1. If the threshold value were, for example, x-3, then all four of the values would be determined by the EIS system to represent lanes, regardless of any "peak" or "valley," because they all exceed the threshold. If, on the other hand, the threshold value were x+3, then none of the values would be determined to represent lanes.[10] The "peaks" and "valleys" that are so critical to the method of the '916 patent are irrelevant to the way the Setup Wizard uses data to select lanes. Claim 1 of the '916 patent requires the definition of

[10] To put it another way, the integral over a given NAMP region does not indicate the probability a vehicle has driven within that region, as is required by our construction of PDFE.

lane boundaries by analyzing vehicle traffic both among and within lanes to determine where cars are actually driving, which as a matter of probability should reveal the centers of the lanes. In contrast to the ’916 patent’s definition of traffic lanes from a PDFE, none of the operations on or by the Q-vector, REQ array or NAMP array use any meaningful information about where traffic lanes begin and end to accomplish lane selection. The system can use the data only to confirm whether a range slice that is already pre-selected to be the full width of a traffic lane is or is not within the trafficked roadway—it does not compare data across different bins to locate the boundaries between lanes. Assuming arguendo that the EIS system can be said to “define” traffic lanes, it does so in a very different way than the way taught by the ’916 patent. It cannot be said that these differences are insubstantial.

Wavetronix has focused exclusively on the NAMP array as the step in EIS’s process that purportedly generates a PDFE from which lanes are defined. Data is processed using several arrays, however. In the context of a patent in the mechanical arts, we have noted: “[T]wo physical components of an accused device may be viewed in combination to serve as an equivalent of one element of a claimed invention, as long as no claim limitation is thereby wholly vitiated.” Searfoss v. Pioneer Consol. Corp., 374 F.3d 1142, 1151 (Fed. Cir. 2004) (alteration in original) (quoting Ethicon Endo-Surgery, Inc. v. U.S. Surgical Corp., 149 F.3d 1309, 1320 (Fed. Cir. 1998)). If the data associated with some other array could be described as a PDFE, it could be argued that the combination of that array and the NAMP array infringes the “defining . . . traffic lanes” step by equivalents. As noted above, some comparisons across lanes are made in relation to the REQ array to the extent that a local maximum is defined at any array position having a higher value than do the positions to its immediate left or right. This suggests that the operations carried out with the REQ array could perhaps be expressed in terms of PDFEs. Conceivably, expert testimony on remand might establish that each of these repeated comparisons across a few range slices approximates a function of a continuous variable whose integral over that limited region gives the probability that some random variable falls within the region, as required by our construction of "PDFE."

Even so, there would be no infringement by equivalents. Even if these comparisons within the REQ array were determined to be PDFEs, the "way" in which the combination of the REQ array and the NAMP array defines lanes—assuming the EIS system "defines" lanes at all, in the sense of the '916 patent—is much different. During the one minute set-up period, a multitude of comparisons are made in the REQ array to generate the NAMP data that is used to define lanes by applying a threshold. Neither claim 1 nor the specification foresees the use of a multiplicity of PDFEs to define lanes. The claim language describes defining lanes from "said" PDFE, and every embodiment in the specification teaches the use of a method that can be described by a single PDFE. This problem notwithstanding and as noted above, the RTMS X3 does not assist in the identification of traffic lane boundaries: it can only use the data it collects to confirm whether a range slice that is already pre-selected to be the full width of a traffic lane is or is not within the trafficked roadway. Accordingly, even if the combination of the NAMP array and the REQ array could be said to "defin[e] . . . said traffic lanes . . . from said [PDFE]"—and it cannot—it would still do so in a very different way than the patented invention. For these reasons, looking beyond the NAMP array would not salvage Wavetronix's infringement case. There is as a matter of law no infringement by equivalents.

D. Cross-Appeal

The district court determined on summary judgment that EIS could not prevail on its inequitable conduct and best mode counterclaims. EIS has cross-appealed these two rulings. Having considered the cross-appeal, we affirm the district court's grant of summary judgment on the counterclaims.

III. CONCLUSION

We agree with the district court, albeit on different grounds, that as a matter of law the RTMS X3 does not infringe claim 1 of the '916 patent. We also agree that defendant-cross appellant's counterclaims should be dismissed.

AFFIRMED.

COSTS

Each party shall bear its own costs on appeal.