UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MERCEDES-BENZ USA, LLC,
Petitioner,

V.

YECHEZKAL EVAN SPERO,
Patent Owner.

U.S. Patent No. 9,955,551
Case IPR 2023-01039
Case IPR 2023-01040

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SPERO EX. 2041

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- - -

DEPOSITION OF DR. NIKOLAOS PAPANIKOLOPOULOS

FRIDAY, FEBRUARY 23, 2024

9:55 P.M.

Washington, DC

REPORTED BY:

SHERRY L. BROOKS, CERTIFIED LIVENOTE REPORTER

JOB NO. 28642

SPERO EX. 2041

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I N D E X

DR. NIKOLAOS PAPANIKOLOPOULOS PAGE
Examination by Mr. Turner 5

E X H I B I T S

EXHIBIT NO. DESCRIPTION PAGE
Exhibit A Detection and Classification of Vehicles 19

(Exhibit attached to transcript.)

SPERO EX. 2041

1 Washington, DC, Friday, February 23, 2024
2 9:55 a.m. - 3:44 p.m.
3 P R O C E E D I N G S
4 * * * * *
5 WHEREUPON,
6 DR. NIKOLAOS PAPANIKOLOPOULOS
7 having been previously first duly sworn, was examined
8 and testified as follows:
9 EXAMINATION
10 BY MR. TURNER:
11 Q. Great. Good morning, Doctor.
12 A. Good morning.
13 Q. And could you pronounce your last name for
14 me, please?
15 A. Sure, Nikolaos Papanikolopoulos.
16 Q. Papanikolopoulos?
17 A. Yes.
18 Q. Okay. I apologize in advance if I
19 mispronounce it.
20 A. No problem.
21 Q. I probably will.
22 Do you know why you're here today?
23 A. Yes.
24 Q. Why are you here?
25 A. To opine about my declaration about the

patent '551.
Q. Okay. And do you understand you're here for a deposition today for two IPRs, IPR 2023-01039 and IPR 2023-01040?
A. Yes.
Q. Okay. Great. Have you been deposed before?
A. Yes.
Q. Approximately, how many times?
A. Five times, including an ITC case.
Q. An ITC case. Okay. Have you been deposed for an IPR before?
A. Yes.
Q. And do you remember the parties in that IPR?
A. It was Canon against an entity. It was about a video tripwire. It was Toyota against -- I think Advances Solutions or something like that.
Q. So you were offering your opinion for -- on behalf of Toyota?
A. Toyota and Canon.
Q. And was that -- were they the petitioner or the petition owner in the case?
A. They were the petitioner.
Q. Okay. And how did you prepare for your

deposition today?
A. So I try -- since, it's more than six months since I prepared my declaration, I look at some of the references. I look at the declaration. I had several phone calls with counsel and I came here.
Q. Okay. And so which counsel did you meet with to review your declaration?
A. With Scott.
Q. Okay. Anyone else?
A. Joe was in and out. Basically, Scott.
Q. Okay. Did you meet with anyone outside of the law firm, Hogan Lovells?
A. No.
Q. Okay. And which documents did you review in preparation for your deposition?
A. My declaration, two volumes, each one for the -- my bio and basically the '551 patent and some references involved like Alden, A-L-D-E-N.
Q. Did you review any documents that are not referenced in your declaration?
A. No.
Q. I'm going to give you a declaration here. Do you recognize this document?
A. Yes.

Q. Okay.
A. This is the first IPR. Am I right?
Q. Correct. I don't think there's a label on it, but that's -- let's see.
On the top page can you read which patent is challenged or which patent this is in reference to?
A. Patent 9,955,551.
Q. Okay. And does it list an IPR number on the front page?
A. No. It says case to be assigned.
Q. Okay.
A. There is a side note here.
Q. Yeah. That's -- actually, that's my Post-it note. So this one -- I'll just explain to you this is IPR 2023-01039. I guess your counsel will let us know if that's the wrong number.
A. Yep.
Q. Okay. Can you turn to the last page of the document?
A. My signature page?
Q. Your signature page. So I guess that's the second to the last page. All right.
Do you recognize your signature? Is that your signature?

A. Yes, indeed.
Q. Okay. Excellent. So this is Exhibit 1003 from the IPR proceeding. So we won't need this as an exhibit. It's already of record.
Do you remember how much time you spent preparing this Exhibit 1003?
A. It's tough to tell because I work also on three other IPRs at the same time involving the '503 patent. So I will say this particular one was around 40 hours total, give and take.
Q. Okay. And who did you work with while -- in preparing your declaration?
A. With Scott and Sally, the associate who work here, S-A-L-L-Y.
Q. So she also -- she's an attorney with the same firm, Hogan Lovells?
A. Yep.
Q. Okay. So who drafted your declaration?
A. I have full control. Some parts I drafted. Some parts were drafted under my direction. But every statement that's contained here had my final approval.
Q. And what did you rely on in preparing your declaration?
A. I rely on references listed on the back on

Appendix C and some POSITA, understanding of the technology at the time in 2002 involving cameras, headlights, lighting, optics, computer vision.

Q. So you said you relied on the documents listed in your exhibit list and also you said your understanding of a POSITA?

A. Yes.

Q. And what is your understanding of the POSITA, what is that based on?

A. Let me go to my -- let me make sure that I have -- if you go to page 15: "A person of ordinary skill in the art in the field of the '551 would have had an undergraduate degree in mechanical engineering, electrical engineering, automotive engineering, optical engineering, applied physics, computer science, or similar disciplines, along with two years of experience working with intelligent vehicle systems, automotive control systems, or lighting control systems.

"The more education one has, the less experience needed to attain an ordinary level of skill. Similarly, more experience in the field may serve as a substitute for formal education."

Q. So this is your definition of a person of ordinary skill in the art from paragraph 33 of your

declaration. That's what you were just reading?
A. That's right.
Q. Okay. So what is an intelligent vehicle system as used in your skill level?
A. At the time general -- because I have been working on intelligent vehicle systems since 1994 and there are some examples of my -- let me go back.
So if you go -- so if you go to just before paragraph 14, this is work done in the mid '90s. And I have been working on using cameras in order to control the traffic light and extend the traffic signals so the pedestrian can have enough time to cross the street.
Now, another example is basically just before paragraph 21, page 9 where in I believe 1997, winter, we use a camera in order to follow a license plate and keep a safe distance from the car ahead of us.
So to me an intelligent vehicle has gone through several iterations, but this shows that we have been working on this broader area of controlling lights, of basically having this information to autonomously and semiautonomously control the car.
So to go back to your question, an intelligent vehicle is a system that can assess its

environment, the driving intentions of the driver, and can make decisions such as following a path, avoiding obstacles, following the lanes, or interacting with other vehicles or pedestrians.

In 2002 at the same time as part of the system that was supported by many agencies, including the Minnesota Department of Transportation, we coauthored a paper with Osama Masoud, M-A-S-O-U-D, and Gupte, G-U-P-T-E, on tracking of vehicles and pedestrians where basically the system was able to detect headlights and using the headlight information in order to make inferences about the movement of cars at night.

So I don't know -- I tried to summarize.

Q. Okay. So let's -- all right. So let's go back a minute.

So you were just describing this paper you authored. Is that referenced in your declaration?

A. Yes. This is the paper. My paper, Detection and Classification of Vehicles published in the --

Q. I'm sorry. Sir, are you reading?

A. Yes. I'm reading the title. It's paragraph 16.

Q. Okay.

A. This is the paper. It's basically still the most cited paper. And this particular transaction is where I happen to be the senior editor for basically anything that has to do with imaging and sensing for intelligent transportation systems.

And I explain in paragraph 16 how we use headlights and taillights in order basically to direct traffic or basically assist police at traffic control, if there is an incident, and so on and so forth, or if you have a situation that may be dangerous like, for example, a crash or a pedestrian or vehicle incident.

Q. All right. So in your paper that's titled, Detection and Classification of Vehicles, what type of sensor did you use to detect these vehicles?

A. Cameras.

Q. Cameras?

A. Um-hum.

Q. Were they mounted on a vehicle?

A. In this particular paper they were mounted on the side of the highway.

Q. So not on the vehicle. So they were in a fixed location?

A. In a fixed location.

Q. Okay. And what type of cameras were used?
A. These were the prior versions -- these were Axis systems. I don't know if you're familiar, A-X-I-S.
Q. Please explain. What's an Axis system?
A. It's just a camera that basically has a heating element. So basically it can withstand the weather conditions and lengths (phonetic) and imaging sensor and then basically the electronics in order to get images and transfer the images to our lab in order to do the processing on the laptops, the computational resources we had at that time.
Q. So these type of cameras, you said they would transfer the images to a lab to do the computations. So this wasn't like a real time determination?
MR. HUGHES: Objection. Mischaracterizes his testimony.
A. This was -- if my recollection is correct, this was transferred to something that's called a traffic control center in the Twin Cities controlled by the Minnesota Department of Transportation.
So this was real time, and then in the analysis of these systems there were components that were done real time there and components that we did

offline basically to make sure that the algorithms work or basically try to figure out the ground truthing; in other words what can be detected, what cannot be detected, and so on and so forth.

But there was a component of this work that involved a real time system outside the Xcel Center (sic). The Xcel Center is a large sporting center -- event center in St. Paul where we have -- we have the task after an event happening at night to monitor pedestrians and vehicles.

This was a real time because we were trying actually to control actual traffic light to direct the traffic, and this continues until now. We have a system of hundreds of cameras. Of course, they are far more advanced in the state of Kansas.

We try to assess in real time the truck parking availability. Big trucks, they try to park in the rest areas. So we try to communicate to the drivers the openings. So you can see since '94 until now we are still doing this line of work.

BY MR. TURNER:

Q. Okay. And this paper you're referencing, when was this published?

A. 2002.

Q. Okay.

A. But you understand that in order to be published in 2002, the work was done.

Q. Okay. Now the sensors you used, were these stereo sensors?

MR. HUGHES: Objection. Form.

A. For this particular paper, no. For the system at Kansas, these are what we call multicamera systems. In other words, there are multiple cameras that do the 3-D construction. So think of what we call N cameras that basically have overlapping areas in order to do this reconstruction basically that is needed, end recognition.

BY MR. TURNER:

Q. All right. So you said that for this paper you were not using stereo sensors. So, again, what type of sensors were you using?

A. Stereo -- it's a stereo system. I will say we need to separate sensors because we may have different sensors. But stereo is basically when you have two or more cameras, among other implementations.

So these were plain cameras, exterior cameras, that were detecting vehicle characteristics. And, in fact, if my memory is correct, there is a figure 2 where we show how we built the background

model for the extraction of vehicles at dusk, so when the lighting is not really good.

Q. Okay. Now, did you include a copy of this paper with your declaration?

A. No. I don't believe so.

Q. Okay. Do you recognize this paper?

A. Yes.

Q. Is this the paper you were just referring to?

A. Yep.

Q. All right. Can you take a look at the bottom right portion of page 37, the paragraph starting with, "Despite."

A. "Despite the large amount"? This is where you want me?

Q. Yes.

A. Do you want me to read it loudly?

Q. Well, actually, if you could read about the bottom quarter of this, the sentence that starts with -- yeah. Please read the paragraph.

A. "Despite the large amount of literature on vehicle detection and tracking, there has been relatively little work done in the field of vehicle classification. This is because vehicle classification is an inherently hard problem.

Moreover, detection and tracking are simply preliminary steps in the task of vehicle classification."

Q. So what do you mean by "detection and tracking are simply preliminary steps in the task of vehicle classification"?

A. There is a logic flowchart that requires basically to extract features that can be used for the -- so basically you need to detect the features such as sign (phonetic) parts, headlights, taillights. And they basically construct the models that are going to help you do the classification.

And one of the things that we had to do as part of this project was basically classify bigger vehicles with respect to smaller vehicles. And in particular, if you look at the federal standards of big trucks, we are asked if we can use this information in order to classify if this is something -- six-wheeler or eight-wheeler basically, if my memory is correct.

And there is another thing we had at that time. Do you have a copy of my resume?

Q. Your CV?

A. Yeah.

Q. I think that was an exhibit to this.

A. It was an exhibit, if you can give me it.
MR. TURNER: So this is going to be -- this is Exhibit 1004 from the IPR. This was previously marked.
The paper was not previously marked so we will mark that now.
(Exhibit A was marked for identification and was attached to the deposition.)
A. If you go to the selected recent grants, this is page -- after my publications, my publication list, do you see Selected Recent Grants?
BY MR. TURNER:
Q. Let's see. I see book chapters, conference papers.
A. And then Selected Recent Grants. If you see -- do you see in the middle it says: "A Real-time Truck Parking Availability System for the state of Wisconsin; A Real-time Truck Parking Availability System for the state of Kansas"?
So if you go up, and then towards the bottom we have sensing --
Q. Can you hold on just a second? You said on this list there's real-time. Oh, I see.
A. Do you see 2016, 2019?
Q. Okay. "Real-time Truck Parking

Availability System" --
A. -- "System for the state of Wisconsin."
Q. Okay.
A. "A Real-time Truck Parking Availability System for the state of Kansas." And above that we have "Maintenance for the Truck Parking Availability System over the state of Kansas."
So if we go back to 2000, we are doing a lot of similar projects for the Minnesota Department of Transportation and the Department of Homeland Security and the working group against counterterrorism.
And basically the idea was the following -- and I mentioned this in my declaration -- over at the 30th Street Station were classified vehicles based, for example, on their movement and the possibility of a threat to the infrastructure site.
So think of a big truck parking under the Light Rail station or the rail station in Philadelphia. So depending on the project there were different needs for classification. Like, for example, classification of a vehicle that may have a threat, classification of a vehicle that may not belong to the parking area.
Classification of a vehicle that basically

stays too long. So the classification -- my point is that based on the needs of the particular funding agency the classification was tailored to their constraints, to the work scope that we had.

Q. So it wasn't classifying a car versus a truck. This was more of a threat level of the vehicle?

A. The first step it was car versus truck. Second level was actually human versus -- because there was also perimeter enforcement. So we don't want -- and the same is true here. For example, at the same time we had the project from MDOT, Minnesota Department of Transportation, monitoring work zones; in other words, monitoring workers plus trucks plus traffic next to the work zone.

So the task was actually classified workers, traffic, and big trucks as they were parking or they were moving in the work zone.

I don't know if I answered your question. And if I mention something else which I think is relevant, if you go to my resume there is a paper -- in fact, I had to look at this equipment this week.

Do you see paper -- if you go to journal publications number 74 -- if you go journal papers, look at 73 and 74.

Q. Since these aren't page numbered, can you put a star -- with the ones you're referencing, can you just put a little note on the side so then that will help later with the transcript?

A. Yep. So should I put one star or --

Q. One star or a circle just so it's a reference for us later.

A. So this is a project -- this is -- these are papers that -- basically, we tried to use a camera provided by Honeywell, Inc. in order to count the number of vehicle occupants inside the vehicle as the vehicle moves in an HOV lane.

And then you see this is work that was done in 2000. So why is this important? Because this in order to detect the vehicle occupants and count them, you know, because on an HOV lane you cannot have more -- you need to pay extra.

So we developed the system in order to enforce the usage of the HOV lane. Now, this involved sensors --

Q. I'm sorry. Which number are you on?

A. 73 and 74.

Q. Okay. And you said these are from 2000?

A. These were published 2000 -- June 2000 and April 2000.

Q. Okay. I think I'm looking at the wrong ones. Can you read just the title of these papers?

A. Yes. "A Vehicle Occupant Counting System Based on Near-Infrared Phenomenology and Fuzzy Neural Classification." And the other one was "Automatic Detection of Vehicle Occupants-The Imaging Problem and its Solution."

So why am I mentioning this? At the same time we're trying to use the techniques I mentioned earlier in order to not only detect the vehicle, classify as a vehicle violating the HOV, because official vehicles were classified as non-violating, and then do the task of penetrating the windshield and then count occupants.

So at times you say that we have all these different projects fitting: Detection, tracking, classification. Some of these characteristics been different based on the particular needs of the project and the work scope.

Q. Okay.

A. And I can go -- I don't want to take your time, but there are several other papers. For example, driver fatigue detection. So think of a camera inside the car that monitors the driver, if the driver is fit to drive, and so on and so forth.

This is 19 where lighting was very important because there were shadows, there were all sorts of stuff.

Q. Okay. Why don't we go back to your paper?

A. Sure.

Q. So this is -- I think we marked that as Exhibit A. So you were reading the paragraph on the bottom right. And I think you stopped right after your mention of the detection -- "Moreover, detection and tracking are simply preliminary steps in the task of vehicle classification."

A. Yep.

Q. So do you agree that classification is a difficult problem?

A. In general? At that time? Give me a little bit of context.

Q. In the time you wrote this paper, at that time frame.

A. Yeah, agree.

Q. Okay. All right. Can you continue reading that paragraph, please?

A. Moreover -- "Given the wide variety of shapes and sizes of vehicles within a single category alone, it is difficult to categorize vehicles using simple parameters."

You want me to continue?
Q. Yes.
A. "This task is made even more difficult when multiple categories are desired. In real-world traffic scenes, occlusions, shadows, camera noise, changes in lighting and weather conditions are a fact of life.
"In addition, stereo cameras are rarely used for traffic monitoring. This makes the recovery of vehicle parameters such as length, width, height, even more difficult given a single camera view."
You want me to continue?
Q. Yes.
A. "The inherent complexity of stereo algorithms and the need to solve the correspondence problem makes them unfeasible for real-time applications."
And it should be noted here that what I'm saying is actually in the context of what you see in figure 1, 2, 3, which is basically a highway scene that may have vehicles going very slowly or being static, stationary, or basically completely parked or when you have shadows.
What I'm trying to explain, you know, there is recovery of structure; in other words, of

depth, by using multiple views of the same scene instead of having two cameras that require maintenance and things like that.

So it should be taken into context of this particular set of applications that I mentioned and that are depicted in these particular figures.

Q. All right. And these figures -- so these are images from the camera?

A. Yeah. You can see the --

Q. So like on page -- there's a number of images on page 39. Are these the ones you're referring to?

A. 39 is just the logic used basically.

Q. Okay.

A. And the logic is highlighted by what -- the type of images we're dealing with. But if you want to see, figure 2 have some -- basically the initial background, which is the result of basically processing images as they come in in real time and then applies some of the math and the logic described here.

Q. So initial background is the -- you're referring to the image taken by the camera before it's processed?

A. No. Think of an empty highway, so -- with

no one. This is the starting point. Then this is my background model. Cars are coming in and going out. I have changes in shadows occlusions. This model is updated. This is the mask, we call it.

Q. Okay.

A. And then as new images are coming in, we have this obstruction of the camera (phonetic) images in real time from the model. And this gives us some initial features such as headlights or taillights, if we're talking at dusk, or, for example, rust or other subtle salient features that will help us say, okay, this may belong to a vehicle.

And then we use something -- if I recall correctly, it's called bipartite graph, a graph with two parts basically, in order basically to match these features to the thing that we call vehicles or pedestrians or whatever.

Q. Okay. So you're saying in the system -- you described in your paper this is a -- the camera is fixed. So you're taking a picture of the background scene without any vehicles to compare it to the vehicles when they're in the scene?

A. But if you do this you're going to have failure very quickly. Why? Because basically, this background model changes. Think of a road in the

morning and a road after it snows -- it's very common in areas -- or some rain or some shadows. So you need to continuously in real time update this background model.

And this is -- I think the reason why this paper was cited so many times -- there are two reasons. One is actually that we provided a way that people can do this in real time and also a way that we can do the classification as well by using very noisy information.

Q. I'm sorry. Very noisy?

A. Information. In other words, look at the quality of the images we are talking here. I mean, it's not -- it's not the greatest.

Q. And you're referring to the images on page 39?

A. 39, even the background adaptation that happens. Look, for example, figure 4, the top row, A and B.

Q. Figure 4, that's on page 42, correct?

A. Yep.

Q. Okay.

A. The top ones. And then going back to the classification -- if you can go at figure 9 you can see snapshots of different car, truck classification

results. Cars are shown surrounded by their bounding box. Non-cars are marked by drawing the diagonals of the bounding box.

And you can see some of the operation of the system in real time. So you can see the classification was basically -- it gives you more information about what we were trying to do for MDOT, Minnesota Department of Transportation, in this particular case.

Q. So in these images is the bounding box different or is the bounding box a function of what's in the image?

MR. HUGHES: Objection. Compound.

A. The bounding box is just a graphical -- in this case, it's a graphical illustration in order to convince our funding agency that basically we can separate these objects. That's why this is not a classical (sic) bounding box because some of them -- they have the diagonals inside.

Again, we are talking about work that was done late '90s, 2000 in order for the paper to be published in 2002.

BY MR. TURNER:

Q. All right. Can you turn back to page 38?

A. Yep.

Q. All right. Can you read III on the left side of the page under Overview?
A. I can read it, but I think I would need to mention all six stages --
Q. Okay. Please.
A. -- or at least mention stage Number 1 is the segmentation.
Q. Again, so these six stages, these are the six stages of what that you're describing here?
A. These are basically the logic, the algorithmical part, I would say, used.
Q. Okay.
A. Second is region tracking. Third is recovery of vehicle parameters.
Q. Could you read point 3, please?
A. "To enable accurate classification of the vehicles, the vehicle parameters such as length, width, and height need to be recovered from the 2-D projections of the vehicles. This stage uses information about the camera's location and makes use of the fact that in a traffic scene, all motion is along the ground plane."
The other steps are step -- states vehicle identification, vehicle tracking, and vehicle classification.

Q. All right. So if we could go back to point 3, with your system you used the fixed sensor, correct?

A. Yes.

Q. Okay. So could this be done using moving sensors like sensors mounted on a vehicle?

A. Yes, but it depends on the context. Like, for example, in my declaration I have this information of vehicle following paragraph 20.

Now, again, the constraints that we have from MDOT, the Minnesota Department of Transportation, we want less hardware because less hardware means less maintenance, less impact from weather conditions. For example, these cameras need to be heated, the removal of snow, and so on and so forth.

And also the stuff that you see here is from the most -- there used to be the point where I believe -- if my memory serves me well because this is 20 years plus -- is where 94 and 35 W merge (phonetic), Which is one of the deadliest and most prone accident areas.

So we couldn't fiddle. We were not allowed to go with the truck with a cherry picker and install cameras and stuff like that. So all told,

this is what we have. Tell us what you can do.
So what you see here is basically -- it's a paper, but I didn't think much at the beginning but became very much cited because basically it was not something out of a lab. It was not a lab experiment where we run a simulation. It was with a constraint.
We were trying to give information to MDOT basically to do this stuff. If we had the free environment like we had in Kansas, for example, the technology we had then, it would have been probably a different implementation.
Q. Okay. And the Kansas project, that's something -- what time frame was that that you were working on that one?
A. The Kansas project started -- let me make sure. Do you want me to put a star on this as well?
Q. Sure.
A. So Kansas, 2016, and I'm going to have the first one. But this was the outcome of a federal highway project. It was based on the outcome of the federal highway project that started in 2012, I believe.
Q. Okay. Now, your project 2012 to 2016 was the Kansas project?
A. No, 2016 until now and we just got renewed

for another five years. We maintained as the University of Minnesota all the cameras and the related systems and truck rest areas in Kansas, 22 sites.

Q. Okay. And now are those fixed sensors or those are moving sensors?

A. It's a mixture of the things.

Q. All right. So the project you were describing in your paper from 2002, you were using fixed sensors?

A. Yeah. In this particular -- and, in fact, it were (sic) not even our sensors. It were (sic) available infrastructure from MDOT. As I mentioned, we couldn't go. And if my memory serves me well, these were either image sensing systems sensors, the Autoscope or Axis. But I may be wrong because --

Q. And can you turn back to page 37 of your paper, please?

A. Yes.

Q. On that paragraph you were reading from before on the bottom right, the last sentence you refer to a correspondence problem.

Do you see that?

A. Yes.

Q. What do you mean by a "correspondence

problem"?
A. So correspondence is, I detect a feature. How do I know that this corresponds? It's not an artifact. And how do I know that this corresponds either to an object of interest or an object that I'm following or I'm interested in?
Q. Okay. So how did you address this -- the correspondence?
A. Well, this structure that I mentioned, bipartite graph and the algorithm, which is -- again --
Q. These were the steps that -- the stages?
A. Yeah -- I mean, if you look -- give me a minute because basically it has been quite some time.
Q. Okay. Maybe it would help if you read the whole sentence when we were talking about the correspondence problem.
A. "The inherent complexity of stereo algorithms and the need to solve the correspondence problem makes them unfeasible for real-time applications."
Q. So you're referring to a correspondence problem with stereo algorithms or stereo sensors?
A. Yes. Basically, when you try to find -- if this feature in one camera belongs to the other,

in this particular scenario that I mentioned here, highway real-time applications, it was -- we didn't have the computation or the resources to do it.

That's basically --

Q. In real time?

A. In real time at the intersection of the connection between 35W and 94.

Q. So that's a location where highways merge?

A. Yes. Basically, you have two highways. So it's not only -- so they ask us -- the project is about extracting real time information.

So, for example, I cannot have stereo. Second of all, I cannot have a box of resources to solve this.

Q. And you said you can't have stereo. That's by the constraints or that's just the technology at the time that you couldn't have stereo?

A. By the constraints of the site. I mean, if you see -- it's so tight it has been already designed. But it's so tight that basically we wouldn't even be -- they wouldn't even let us access this place. You see what I mean?

Q. The site of the highway?

A. Yes, because basically the cameras were mounted, first of all, on the side of the highway,

all on buildings, private buildings, where we didn't have access. So when we were asking can we go and install more sensors -- I don't know if I answered your question.

Q. Okay. So in this sentence you're saying that the stereo algorithms, the stereo sensor type approach makes them unfeasible for real-time implications?

MR. HUGHES: Objection. Mischaracterizes his testimony.

A. What I said is, basically, if you look at this particular paper, it describes classification of vehicles in freeway traffic in a large metropolitan area where basically we are given the sensors and we are asked what we can extract.

So what I'm saying is that as we design the logic, our choice for this real time freeway application with all these constraints was actually to work to use the existing cameras and try to see what we can accomplish.

As I mentioned, for example, the Kansas Department of Transportation problem, the parking assessment, there are multiple -- as I mentioned, multiple overlapping cameras with stereo or tri-stereo, or the project I mentioned to you,

vehicle occupant detection.

We were able to use our own cameras mostly around places and were able to triangulate; in other words, to solve this correspondence problem.

BY MR. TURNER:

Q. So in this sentence you refer to the inherent complexity of these stereo algorithms that made them unfeasible -- they were unfeasible at that time. But you're saying they became feasible when you were working on the Kansas project?

A. No. I said -- I say in this particular freeway application at that time -- let me try to -- so if you look at intelligent vehicles at that time there were a lot of efforts on basically using video streams acquired at some time and then I process them.

But I have the ability to work this in the lab, add additional sensors, and do whatever I want. Here we try to use an existing set of cameras at an actual site and see if we can do for Minnesota Department of Transportation classification.

So in this free-flowing highway system we solve -- to have stereo, first of all, it was not -- it was a constraint we were not allowed to overcome.

The second problem actually we couldn't

1 have a box next to it. So -- and the correspondence
2 problem requires this box, this logic, to be there
3 running to solve it. So we said, okay, with this
4 existing can we do classification effectively?
5 And the classification where it is doing
6 is the one that I highlight with this -- with the
7 rudimentary graphics, basic graphics in figure 9.
8 And I believe these were from another site where we
9 try similar constraints to do our method.
10 Something that I want to be accurate. If
11 you see -- go to page 42. The graph we use is called
12 the association graph, so I stand corrected. There
13 may be a bipartite graph in the background, but
14 basically this is the meat -- one of the key steps in
15 this logic we follow.
16 Q. So the association graph, is that what's
17 shown in the middle of this page with the dots with
18 arrows extending between them?
19 A. Yeah. So, basically, we tried to
20 associate -- so do you see original tracking?
21 Q. Which page is it?
22 A. It's page 40.
23 Q. Okay.
24 A. So original tracking basically says --
25 think of it -- think of two headlights, okay, at

night and maybe it will have partial view.

So these are regions which are extracted. So how do we make association of these to an entity that we call a vehicle? This is basically what it does because you may have -- in a scenario like this you may have a lot of interesting combinations.

So this is -- we think -- and as -- this is a decent way of solving this association problem. Think of how you move from basic features such as light intensities, two objects. Think of a bright spot here and another bright spot.

Q. You're referring to, again, the figures on page 40?

A. Yeah. If you look above this is a general depiction of how -- when you look at the feature figure 2b, what are the first things someone may observe? In other words, what are the first things that the camera may observe?

They're going to be the pair of headlights.

Q. Okay.

A. So how mathematically we can capture this and we can say that these two headlights based on the use of some constraints with respect to the models of cars exist and correspond to an object.

Q. So figure B shows these vehicle at night. So figure A --

A. At dusk. It's not exactly at night in particular because it shows everything in the caption, just to be accurate, background and adaptation to changes in light and conditions. The initial background provided the algorithm. This is A.

B, image of the scene at dusk. Car and background after four seconds. Car and background D, after six seconds. Car and background after eight seconds.

So you can see the system recognizes these features, it extracts them, and then it sees my model -- my background model changes slightly because it's getting darker.

But I don't -- I don't incorporate these headlights because they are temporary in my view to information that I incorporate. What does this mean? It means if I compare this map, this image, to the car and the image map that is coming in, then basically I will get the features I want.

Think of this as my model of the scene in front of me, of what I see.

Q. So these images at C, D, and E, this is

the same. It's just an image taken a few seconds later?

A. No. This is the model as it's updated every two seconds.

Q. So this is the model, not the image that's taken?

A. This is the model that is informed from the images and is used in order to compare the incoming image with the model in order to -- you say, okay, I have a new -- in order to get to this stuff -- you see there are all these steps that I mentioned earlier --

Q. Right.

A. -- in figure 9. Again, I wish I had the ability to show you this video because we have this video in front of the Xcel Center (sic). It's pitch black and we track pedestrians and vehicles based on headlights and taillights.

Of course, not -- it's like 60, 70 percent accurate. But we can get the density of how many vehicles, if there is flow, if there is no flow, if there is divergence of individuals.

Q. Okay. And this video you're referring to, this is from the project described in the paper or this is the current project like the Kansas project?

A. No. No. No. This is at that time. As I mentioned, we had the huge set of projects serving -- think of $60-, $70,000 project to do certain tasks for the Minnesota Department of Transportation.

I mean, if we go back Minnesota had one of the first with California -- Minnesota had one of the first intelligent transportation centers in the country. So we are very likely to have funding to do all these variations from highways to arterials to work zones to HOV lanes to you name it.

Q. Can you turn to page -- let's go to page 43.

A. Yes.

Q. All right. Can you read the paragraph under the section, Recovery of Vehicle Parameters?

A. Let me see. Can you point me, 46?

Q. Sorry, 43. Page 43 on the right side there's -- under the heading Roman numeral VI, Recovery Vehicle Parameters?

A. "To be able to detect and classify vehicles, the location, length, width, and velocity of the regions (which are vehicle fragments) needs to be recovered from the image. Knowledge of camera calibration parameters is necessary in estimating these attributes.

"Accurate calibration can therefore significantly impact the computation of vehicle velocities and classification."

You want me to continue?

Q. Yes, please.

A. "Calibration parameters are usually difficult to obtain from the scene as they are rarely measured when the camera is installed. Moreover, since the cameras are installed approximately 20 to 30 feet above the ground, it is usually difficult to measure certain quantities such as pan and tilt that can help in computing the calibration parameters."

You want me to continue?

Q. Yes, please.

A. "Therefore, it becomes difficult to calibrate after the camera has been installed. One way to compute the camera parameters is to use known facts about the scene. For example, we know that the road, for the most part, is restricted to a plane," which is indeed the case for this freeway.

"We also know that the lane markings are parallel and lengths of markings, as well as distances between those markings are precisely specified. Once the camera parameters are computed, any point on the image can be back-projected onto the

road.

"Therefore, we have a way of finding the distance between any two points on the road by knowing their image locations."

Q. Okay. So in this paragraph you're describing a calibration process. And your sentence here, "one way to compute the camera parameters is to use known facts about the scene."

So this is in your test you had a fixed sensor location. So would you be able to use this process if you had a dynamic scene where you didn't have known facts about the scene, like if this was mounting the camera on a moving vehicle?

A. This is -- if you can help me a little bit narrow down, because let me tell you something which is very important from this paragraph.

Q. Okay.

A. For liability reasons they wouldn't let us drive even at night. So what we suggested at that time, we said we are going to rent a University of Minnesota vehicle with a pattern and we are going to drive the highway back and forth because we didn't want someone to go on the highway in the middle of the night with a pattern.

So they told us forget it. So we said,

okay. What can we do? And this is the tool that you see here. Now, in a vehicle following we can use the information. For example, vehicles have certain dimensions. License plates generally appear to be in the center.

So we use the symmetry axis and we use the voting scheme in order to find. So the pixels from the image vote about the symmetry axis of the vehicle.

So there are a lot of different ways that you can do this. This is driven by the fact that we couldn't go -- so you give me a scene, let's say Kansas, where we have had this problem, or something -- there is wind that blows and the cameras get misaligned.

We have a way of using, for example, any metric like the height of a tree. Someone measures the tree. We can use it and then we can calibrate the space. But there we didn't have any access to this space, nor I wanted to risk the graduate students to be there in front of there.

Q. The pattern?

A. The pattern.

Q. So a pattern is one way to calibrate?

A. It's one of the many ways. But for this

1 particular application we told them, Can we drive at
2 night? I mean, I recall because I ended up driving
3 the truck at one point because I didn't want anyone
4 to have the liability. But this was not feasible.
5 Q. So this was the truck that was being
6 detected or you had sensors mounted on the truck
7 itself?
8 A. No. We had patterns on the truck. Think
9 of black dots. Sometimes they are used by NASA in
10 order to basically do the docking. So you have
11 rhombuses, so -- or triangles, black, white
12 triangles. And we're trying to calibrate. But this
13 is not feasible. You cannot have me on the rental
14 truck.
15 Q. Okay.
16 A. So some of the statements -- and I think
17 this is the interesting thing about this paper. It
18 was so heavily constrained but still we were able to
19 do something that it was interesting.
20 MR. TURNER: We've been going for a while.
21 Do you want to take a break?
22 THE WITNESS: It's up to you.
23 MR. TURNER: Five minutes?
24 MR. HUGHES: That's fine.
25 (A break was taken.)

BY MR. TURNER:
Q. I have another exhibit for you, Dr. Papanikolopoulos.
A. Can I take this out?
Q. You can just set it aside for now. We may come back to those.
All right. Are you familiar with the document I just gave you?
A. Yep.
Q. What is this document?
A. It's a patent application by Alden and the title is Segmented Distribution Headlight System, Method, and Apparatus.
Q. And this exhibit is marked Exhibit 1005. It's already in the record. Are you okay if we refer to this as the Alden reference or just Alden?
A. Yes.
Q. So what does Alden describe?
MR. HUGHES: Objection. Form.
A. Can you tell me -- it describes many things. So where do you want me to focus?
BY MR. TURNER:
Q. What would you say is the purpose of the Alden reference?
A. Let me try to look at my --

Q. Sure.
A. Just let me be sure. It's a little bit open-ended. It says many things. So I'm going to paragraph 46. And I'm going to say that Alden -- I'm just reading.
"Alden is directed to a headlight system with individually-controllable LEDs such that different areas in the field-of-view of the vehicle can be illuminated in different ways. For example, high beam and low beam areas can be created concurrently."
And if I can go because I think it's important. It says -- give me one minute because I think --
Q. And you were just reading there -- you were reading from your declaration?
A. Yes, from my declaration.
Q. Paragraph 46?
A. 46.
Q. Okay.
A. So let me -- one minute. So paragraph 2, the last sentence: "The result" -- on page 1.
"The result is an automated headlight system which enables the driver of a vehicle so equipped to see optimally while concurrently the

driver of an oncoming (or alternately a leading) vehicle also can see optimally."

And my comment here is actually by having reduced glare.

Q. Okay. Can you read starting at the beginning of that paragraph, please?

A. "The present invention provides a significant advancement in variable distribution headlights by providing a means to automatically dim some portions of the headlight distribution pattern while concurrently keeping other portions of the headlight distribution pattern illuminated on high beam."

Q. So what does Alden mean by "keeping other portions of the headlight distribution pattern illuminated on high beam"?

A. Well, we have to look at the particular aspect because this is the background and the field that he mentioned.

So he mentions different things, including -- if you go to 61 the last sentence, it says: "It will be understood that the present invention can also be used to operate a segmented light distribution system to provide illumination to independently controlled segments each operable

within a range of intensities between the high beam and the low beam state."

Q. All right. So you're just reading from paragraph 61?

A. 61, the last sentence.

Q. Okay. So back -- if we go back to paragraph 2 --

A. Yes.

Q. -- so do you agree that Alden describes a system that keeps the beam pattern at high beam but then selectively automatically dims some portions?

A. I think it's one of the objectives. But if you look at figure 11, for example, we have another usage. It's basically by using -- the reflector is 157. If you look also at the -- I believe this is 36 paragraph. It's using the system in order to have a lot of light on the curve of the road and less light in areas of no interest.

So I see multiple usages of this technology. So one is the glare and -- minimize the glare for the driver of a vehicle who might be oncoming or a vehicle who is in front of us and maximize the visibility for the driver where the headlights on the vehicle -- where the headlights are mounted on.

And also from figure 11 it has the dual problem where we try to have maximum light on the curve, maximum illumination.

Q. All right. Can you turn to Figure 1 of Alden?

A. Sure.

Q. I'm sorry -- figure 2, please.

A. Yeah.

Q. So what is shown in figure 2 of Alden?

A. I think I will go to his description. It is paragraph 11. "Figure 2 illustrates the elements of a segmented distribution illumination process."

Q. Okay. What is element 61 in figure 2?

A. It's a segmented beam headlight.

Q. Okay. Now, is figure 2 -- is this a top view or a side-view of the segmented beam headlight?

A. I think this is a top view. It can be a side-view as well, but my first thought it was a top view.

Q. And what are the lines extending from -- the lines that are marked as 65 and 63 that are extending from element 61?

A. Let's go to the -- where that is described. Give me one minute. 61 produces a high beam in the first sector, 60. So "Some methods

employed within 61" -- so paragraph 26: "Some methods employed within 61 to segment light into independently controlled sectors are discussed later.

"61 produces a high beam in a first sector 65 while concurrently producing a low beam in a second respective sector 63 (or dim beam) where the 41 is sensed."

Q. Okay. So now those other light beams that are shown below 41, would those be high beams or low beams?

A. I think with the annotation that all these are high-level schematics and since I don't see any object, I would say that I would look at this as high beams. But, again, this is a high-level schematic. It goes back to the top view, side-view.

Q. Right. So because there's no object, your understanding is those would be high beams below?

A. Yeah. My understanding is more -- I look at figure 2 in conjunction with figure 3, figure 4, and figure 5 because this describes -- I mean, I think figure 3 is very informative. Given what we discussed earlier, it gives us how the algorithm detects the vehicle 41.

And figure 4 gives us the logic and the steps. And figure 5 gives us the LED, the selectable

LED operation.

Q. Okay. So if we could turn to figure 5. So on figure 5 is this another -- is this a top view or is this a side-view of this?

A. I think this is a top view but can be viewed as a side-view. Again, it's a slice of a vehicle light that consists of several slices.

Q. By slice, do you mean a section?

A. Yeah. Think of when you have a medical -- in medical imaging, you use an analogy. You have slices. You put the slices together and you get the 3-D structure.

Q. Okay.

A. For example, you see the switch array 115. And then you see the bright light control sequence, which is basically the activation. It's calling this array matrix.

Q. Now, on figure 5 is this a right headlamp or is this a left headlamp?

A. I think it can be any one of these.

Q. So the switch array that's shown here is used to control the light source in this headlamp; is that correct?

A. The light sources, I would say, plural. Again, it's a slice because -- I think Alden

discloses basically this array matrix either for the left or the right.

Q. All right. And what type of light sources are used in this array matrix shown in figure 5?

A. So it has -- in the figure 5 it has one element 119. It says can be white LED -- this is paragraph 29.

It says "The 119 can be white LED (or alternate lighting mechanism)."

Q. All right. And what type of LEDs are these? Are those described in Alden?

A. It says a white LED.

Q. Okay. And what is the shape of these LEDs?

A. You mean of the physical structure or the shape of the light used?

Q. The physical structure.

A. It's basically a light emitted diode. They can come in many types. For example, basically, you have -- I believe, if my memory serves me well, now most of them are aluminum 60, 63, I believe. But basically you have a blue emitting dye and then you have phosphor on top, and basically you have the white it says here.

Q. Now, are these LEDs -- they're mounted on

a substrate? Is that what's shown in figure 5?
A. They are mounted on this curve that enables them to have this directionality that we mentioned earlier, but each one of these is a separate unit. You see it just basically is an individual unit fully controllable either by intensity or other methods, current.
Q. So each LED is individually controlled. That's how Alden describes it?
A. Yes. And the way I see this -- I don't know if you are familiar with something that's called -- you can find it in a lot of European cars. It's called LED matrix. I don't know if you have heard the term.
Q. Please explain.
A. So Audi 2005 demonstrated what became basically one of the standards. I don't recall exactly the name. So, basically, think of LEDs mounted on a curvy linear. In other words, the surface has a curve.
And I recall they started 42 and now the implementations by Porsche has thousands of them. So each one of them can be fired depending on the task that you want to accomplish.
Q. Okay. Is that described in Alden?

A. I think this -- this is described in Alden. A combination of two, three, four, five is basically this -- I mean, in totality this is the way as a POSITA at that time they envisioned this. At that time the LED markets were something very interesting, but there was a lot of discussion.

For example, some of the automotive engineering circles thought we keep high beam/low beam. This had problems. You see glare, so on and so forth. So there were discussions on basically having this type of -- that's at least I think -- this is what is disclosed here.

I don't recall the name of the standard. It's on top of my head.

Q. I'm sorry. What type of shape of LEDs is disclosed in Alden?

A. By shape, you mean -- it's just a white LED. At that time it was basically a compound diode. The diode was implemented with the compound and then you had the dye, either blue or ultraviolet, UV, dye.

And then you had a cover that will produce the white, which was made out, I believe, of phosphor. And some of them they have this plastic polycarbonate cover in order to protect the LED.

Q. Okay. How many LEDs are disclosed in the

headlamp that's shown in figure 5?
A. Again, I want to tell you this is a high-end schematic and we see a slice. So I can count them, but it says the plurality of LEDs that they need to cover the whole field of view.
Did I answer the question?
Q. Let's see. So my question was: How many LEDs are disclosed in the figure 5 embodiment?
A. In plurality, because basically we have to consider that this is a slice and this is a high-level schematic.
Q. So by that, are you saying there's more LEDs disclosed than what's shown in figure 5?
A. What I'm saying is actually this is a schematic. So it just shows the concept, how this thing works. I wouldn't count here because things, for example, are out of scale. I mean, look at Figure 1, for example. I think the important part is actually you have a plurality of them and the fact that you can class them based on the logic described earlier in figure 4.
Q. So in figure 5 if this is what would be a top view, are you saying we're looking at one row of multiple rows or there's just a single row of LEDs?
A. What I'm saying is -- actually, this is

one slice. Let's suppose we're looking at the top. So it's going to be a second slice, a third, and one, two, three, four end from the bottom. This is demonstrated from figure 4. If you look at 77 and 79 -- these are the control sequence --

MR. HUGHES: For the record, I think -- are you referring to figure 3, not figure 4?

THE WITNESS: Sorry -- figure 3 -- sorry.

MR. HUGHES: Yeah, just to be clear on the record.

A. I stand corrected. Figure 3, 77, and 79. If we go to the description, in paragraph 27 -- so if you see 27, it says: "Information from the 72 and 71 is sent to control the power flow from a power source via a left light control circuit 55a and a right light control circuit 55b.

"Note that the left shaded circuit area 75 indicates the areas of a segmented headlight control switch array switches which will cause portions of the left headlight to be dim while a non-shaded left circuit area 77 represents the portions of the segmented headlight which will be on high beam.

"The 75 area is significantly larger than the headlight dots that were initially received by 51a and 51b because, the CPU has made assumptions

about the space that may potentially be occupied by the driver of the sensed vehicle."

And then he says: "Likewise, a right shaded circuit area 81 indicates the areas of a segmented headlight control switch array switches which will cause portions of the right headlight to be dim while a non-shaded right circuit area 79 represents the portions of the right segmented headlight which will be on high beam."

So, in other words, to me, it's very clear we're talking about a two-dimensional structure that is map of this set of slices in figure 5.

BY MR. TURNER:

Q. So you're saying based on Alden's description in figure 27 Alden's description of the light control circuits based on that, that describes how that informs your decision on what the shape of the LED array is? Is that what you're saying?

A. No. What I'm saying is actually what -- the description of figure 3 gives you which elements of this LED matrix or array are going to be activated, which are going to be high beam, which are going to be dimmed.

Q. Okay.

A. And, again, this is -- if you go to figure

4, it shows the logic. This is figure 4. If you look at the element 89, so it says: "Is threshold light present at A1L sensor position?" And then it says: "Is threshold light present at A2L?" So still at the left sensor, but basically introduces the coordinates XY.

So, in other words, this is a two-dimensional array image and try to find the dot. And that does the same on the right sensor in elements 93 and 95. And then it says: "I compile left sensor map and I compile right sensor map," which are basically images, and then finally compare the left map to the right map based on the memory.

And I do the tabulation and the other steps that basically in the end informs the element 111, the drive -- sorry -- element 109 that requisite headlight segments to dim. Switch other segments to high beam.

Q. So in this section is there any expressed disclosure of the shape of the LED array in figure 5 of Alden?

A. Let me read it. You mean that the LED elements are placed on the curve or --

Q. Yes.

A. Give me a minute to read it. It says in

the middle of 29: "The 119 and other lighting elements are on a curve along the focal point of a headlight lens 121 such that the light from each lighting element goes into a specified portion (or portions) of the headlight distribution area."

Q. Okay. So this curve is along the focal point of the headlight lens. So where is this focal point shown in figure 5?

A. The focal point generally is associated somewhere close to the center. Okay? Again, we have to be -- the scale and things may be off, but this is the optical control element that focuses the light basically.

Q. Okay. Do you still have your pen?

A. Yeah.

Q. Do you mind? Can you identify the -- draw the focal point on there?

MR. HUGHES: Objection. Calls for speculation.

A. You see, as I mentioned, it will be speculation because this is not to scale. So I don't know anything about the focal length. I don't know anything about, so I don't have the information to do this.

BY MR. TURNER:

Q. Okay. Well, based on your understanding of Alden, can you estimate the location of the focal point?

A. It will be close to the lens. Generally in this area, in this broader area of the center. But I don't want to put down because basically these things, as I mentioned in my disclosure, are high-level schematics.

Q. Okay.

A. They try to articulate the concept basically. Like, for example, 119 is associated with this 15-degree segment and it tries to show what is on.

Q. So the -- so you're saying -- which LED is associated with the 15-degree segment?

A. You see there is a description about 119, and he uses 119 as a representative of what is happening -- uses 119 as the representative LED of this controlled operation of the system by Alden.

It says: "For example, the power to 119 is controlled by the CPU" -- this is paragraph 29 -- "is controlled by the CPU which dictates its respective switch characteristics at 115 such that the power from a power supply 113 is carried via segment wire 117 is controlled in response to the

sensed environmental conditions.

"All of the other light elements are similarly individually controlled," which I think is important. "The 119 and other" -- and then towards the end of that, it says: "In the illustration, the 125 from 119 falls across the 15-degree section of the headlight distribution area.

"Each other lighting element similarly falls within a defined area of the light distribution area. Thus, the light sent to the area of 41" -- I believe 41 is referred to in figure 2 -- "is dimmed using a headlight with segmented lighting means."

Q. Okay. So which LED illustrated in figure 5 generates the beam that's noted as the 15 degrees?

A. Do you see the one that says 119?

Q. So the one with the reference numeral pointing to what would be the lowest --

A. The lowest one. And then you can see the two rays that go through the lens and they create the 15-degree segment that you see under 125.

Q. Can you trace the rays that extend from this light element to the 15-degree segment?

A. You can connect the center. Again, this is high-level schematic. You can connect the two centers that we see here or the two points that we

see here, and basically this is creating -- so we connect the 119 with a point where we have all these lines intersecting at the bottom.

And then we have the line that goes from 119 to the other upper intersection point. And this creates this 15-degree segment.

Q. Okay. Can you mark it on the exhibit? Can you trace these beam patterns extending from 119 to the --

A. I prefer to describe it because, again, it's not -- it's not really in my -- I think I trace them in my declaration with this preface. These are pretty generic and high level.

Q. Okay.

A. So I think, for example -- let me find -- I think I have traced them in my -- so, for example, this is the -- my declaration for the 2023-01039.

If you go to paragraph 69 at the end I have these clusters. And you can see the 119 and three LED. This creates one cluster.

So 119 and the two neighbors (phonetic) create a noncontiguous cluster with the other three LEDs on top of the curve that they're creating these traces in order to illustrate, again, what is low beam/high beam.

Q. All right. So you just described these as being noncontiguous clusters. Which clusters are these that are not contiguous?
A. If you go with me in --
Q. Paragraph 69?
A. -- 69 at the end, at the top of the page 47.
MR. HUGHES: Counsel, I think we may actually be in the declaration for 01040.
MR. TURNER: I think I only gave him one declaration so far.
THE WITNESS: I have IPR 2023-01039.
MR. HUGHES: Okay. Apologies, Counsel.
MR. TURNER: No problem.
BY MR. TURNER:
Q. All right. So you're referencing, was it paragraph 69?
A. 69 at the end.
Q. So you were describing these as being noncontiguous; is that correct?
A. Yes.
Q. And by noncontiguous -- which ones are noncontiguous?
A. So do you see the three red at the bottom?
Q. Yes.

A. And look at the three pink ones at the -- so three pink at the bottom, three pink at the top of the curve. Am I right?

Q. Okay.

A. So since there's a vehicle that it has been sensed in the middle of the field of view as we examine this slice, basically the first cluster of LEDs which are the three, again, for graphical presentation are green, because basically these are dimmed by the control switch that I mentioned earlier, 79 or 77, depending if it's left or right in order to be dimmed.

Q. All right. And you're describing this group of LEDs in the center that you've annotated in green as they would be the ones that are generating this portion of the beam pattern that you have highlighted in green?

A. Yes.

Q. And now the upper grouping of LEDs that you have as red or pink, do they generate the pink portion of the light being on the bottom or the top of this image?

A. So if you look at what I say -- so if you look at -- the group on the top is representative for the pink stuff on the bottom, the second -- the --

this part of the second (inaudible) there's no object. There is no object present in this area, in this area at the bottom.

And the ones on the top -- so, again, think -- you see where 119 is and where are the 15 degrees per segment symbol is? These are produced -- the pink in this sector is produced by these LEDs where 119 is a member of. And the other group of LEDs is basically presenting the bottom part, the other pink.

Q. Okay. So just to clarify, you're saying the lower grouping of red LEDs which have reference numeral 119 next to them, they're generating the portion of the beam that you have highlighted in red that you have marked as high beam at the top that also has the 15 degrees per segment notation in the figure; is that correct?

A. Yes. Yes.

Q. Okay. So then also -- so then the top LEDs would be generating the pink beam on the lower portion of the image?

A. Yes.

Q. Okay. And what type of optic is shown in this figure -- is disclosed in figure 5?

A. Can you elaborate? Because optics is many

things.

Q. Okay. How would you describe the optic illustrated in figure 5 of --

MR. HUGHES: Objection. Form.

A. The optics -- so the optical element 121 is optics. The LEDs are optics. The interaction of the light with the 121 is optics. So which part do you want me to do?

BY MR. TURNER:

Q. Element 121. How would you describe the optic that's identified as reference Number 121?

A. It's -- according to Alden -- just to follow his disclosure, he discloses -- let me read this. The 119 -- this is paragraph 29.

"The 119 and other lighting elements are on a curve along the focal point of a headlight lens 121 such that the light from each lighting element goes into a specified portion (or portions) of the headlight distribution center."

So he calls this a lens, discloses a lens, and then talks about "Element emitted light 125 being an example of an element's light being directed into one sector of the light distribution area.

"In the illustration, the 125 from 119 falls across a 15-degree section of the headlight

distribution area. Each other lighting element similarly falls within a defined area of the light distribution area.

And then goes and says: "Thus, the light sent to the area of 41 is dimmed using a headlight with segmented lighting means."

Q. All right. So with reference to figure 5 Alden refers to element 121 as a headlight lens, which you described as an optic.

What type of optic --

MR. HUGHES: Objection to the extent it mischaracterizes testimony.

A. Can you repeat?

BY MR. TURNER:

Q. What type of optic is illustrated in figure 5 of Alden?

MR. HUGHES: Objection. Form.

A. I mean, tied in what sense? I mean, in the sense of Alden? In the sense of general optics?

BY MR. TURNER:

Q. I mean, based on your experience. For example, would you describe element 121 as a concave optic or a convex optic or another type of optic?

A. I'm describing this as something that directs the light in a certain direction as a

function.
Q. Are there technical descriptions or terms for this type of optic?
A. Lenses operate on a refraction. So here you have no change wavelength when you go through this optical medium, and you either focus or divert depending on the type of optical element you have.
The other type of refraction is when you go through a material and you change things. Like you apply current and you change the properties of the light. So if I can describe in great enough terms, this is a lens which is based on pretty simple refraction.
Q. Okay.
A. Which it focuses and directs in a certain area. We shouldn't forget that the objective is a control -- is a set of control abilities that tie to maximize the visibility for the driver and reduce the glare for drivers' vehicles which are coming towards the vehicle where the headlight is mounted or vehicles ahead of us.
Q. All right. Can you turn to figures 8 and 9 of Alden?
A. Yes.
Q. What is shown in figures 8 and 9?

A. Let's go to the document. So 17 it says: "Figure 8, the element of an individual electro-optic cell in a first state. Figure 9 is an electro-optic material in a second state of alignment."

And figure -- paragraph 32 and paragraph 33 -- 33 gives more information about figure 8 and 34 gives more information about figure 9.

Q. All right. So these are described as two different states. So on figure 8 what is this state?

A. Give me one minute. So it describes -- basically, the states are associated with a liquid crystal. The first state is actually when there is nothing applied, no current applied to the liquid crystal. The second state is when something is applied to the liquid crystal, if I read correctly.

Q. So figure 8 is like a default state where no current is applied?

A. Yes.

Q. So what happens to the light that's transmitted through that?

A. It just goes through.

Q. It just passes through?

A. Yes.

Q. And then what happens in the figure 9 state?

A. In the figure 9 state basically you have some bending depending on the anisotropic properties of the material and the current you apply, the temperature and so on, and so forth.

Q. Okay. So by bending of the light that's transmitted through the optic?

A. Yeah. Basically you have -- so liquid crystal is quartz. It's a material -- it's an element, an optical element, that is made out of material that is anisotropic.

So by applying current and with respect to the external pressure, property of materials, humidity, so on and so forth, then instead of going through you start getting this divergence basically, this bending.

I don't know if I answered your question.

Q. All right. So now can you turn to figure 10? So what is shown in figure 10 of Alden?

A. Just give me one minute. So according to paragraph 19: "Figure 10 depicts a segmented headlight with individually controlled sectors of distribution of the third embodiment."

So if we go to paragraph 35, it says: "Figure 10 depicts a segmented headlight with individually controlled sectors of distribution of

the third embodiment. A single light element 129a produces collimated light due to collimating surface 131a.

"The light then passes through an array of variable refraction elements (described in figure 9.) This headlight architecture enables light from an individual headlight distribution sector to be redirected in response to sense environmental conditions when used in conjunction with the elements and processes previously discussed herein.

"Thus, light from one section has been diverted to become diverted light 151 (in low beam where a vehicle (not shown) has been sensed) while the light from other segments are not diverted (are in high beam) where no vehicle is sensed."

Q. Okay. So you were just reading. That was paragraph 35 of Alden?

A. Yes.

Q. And this -- so figure 10, that's using the --

A. The principle.

Q. -- the principle from figures 8 and 9, those elements?

A. Yes.

Q. All right. Can you turn to figure 11,

please, of Alden?
A. Yes.
Q. So what is shown in figure 11?
A. That's where the records today I read to you. Do you want me to --
Q. To describe what's shown, yes.
A. So we see a vehicle C approaching a curve. The vehicle has two headlights. The vehicle is denoted by the Number 153. The headlight is denoted -- the right headlight is denoted by 155. There is a reflector associated with the fact that we have a curve on the road 157.
And then we have one of the sectors 159, light sectors. I can go to more detailed description. So it says: "An equipped vehicle 153 senses that the road turns by receiving light from reflectors" -- this is paragraph 36 -- "such as the reflector 157.
"The responding headlights 155 direct light into the corner to maximize the driver's ability to see there. The directing of the light can be achieved with the segmented sensing elements and segmented light distribution elements described herein."
Q. Okay. So which of the light sources

described in Alden are used to generate this beam pattern that's illustrated in figure 11?

A. Can you repeat the question just to make sure?

Q. So we just discussed a couple different headlamp embodiments, right? There's the figure 5 embodiment and then we just discussed one with reference to figure 10 as a different type of embodiment.

MR. HUGHES: Objection. Form.

BY MR. TURNER.

Q. So which of these embodiments or another embodiment, the headlamp, is used to generate the beam pattern illustrated in figure 11?

A. I need to go because I think I have an explanation of what is used -- do you have a copy of my -- of the other part of the declaration, the '551?

Q. I do.

A. If you can share with me, it would be great.

MR. TURNER: So this is the other declaration. It's the same exhibit number, but it's from the other IPR. It's Exhibit 1003, and then I think the IPR is listed on the little Post-it. So that should be IPR 2023 and it's 01040.

A. Bear with me. I have a detailed description. So in the IPR 2023-01039, if you go --

BY MR. TURNER:

Q. So that was the first declaration we're talking about?

A. The first exhibit you gave me.

Q. Okay.

A. Go to paragraph 111, page 79. What I described, basically the second usage of basically the figure -- the figures 2, 3, 4, and 5, in order to maximize to direct the light where there is a curve and how can this be done with figure 5.

So do you see where in the center of the page 79 it says claim 24g?

Q. Yes.

A. "By directing light into the corner, or curve of the road, to maximize the driver's ability to see there, the system is increasing illumination in the direction of the curve.

"For example, Alden can recognize the curve, determine which segments of the light distribution area of the headlight lie along the curve, and then switch the lighting segments that direct light to those segments to be on high beam.

"This can be considered in reference to

figures 3 and 5 of Alden. The system of Alden would detect the light from reflectors based on left and right sensors.

"The logic CPU would then determine that this light indicates the curve of a road, much in the same way that it can detect an oncoming vehicle based on its headlights, and the location and distance of the headlights from the equipped vehicle."

This is figure 4, the controlling logic. "Once this determination is made, the CPU would instruct the control circuitry to adjust illumination of the LEDs accordingly. In particular, LEDs pointed in the direction of those reflectors can be switched to high beam, while other LEDs directed towards other areas can be switched to low beam.

"Further, a POSITA would have understood from Alden that when positioning LEDs along the curved structure in the headlamp (such as shown in figure 5), LEDs could be positioned to ensure that the beam created by the headlamp is sufficiently wide to illuminate turns.

"That is, a POSITA would understand to position the LEDs on each end of the array; for example, far enough along the curve and at such an angle that their emitted light would be directed

sufficiently to the sides of the vehicle.

"This directing of light into the corner, as shown on figure 11 above, is an adaptation of the light pattern of the headlamps."

So if we go to figure 4 of -- let me try to add a -- so, again, we are in the first part of the declaration, the same document I just read.

Q. Okay.

A. Go to paragraph 85. Do you see figure 3?

Q. Yes.

A. So here what does Alden disclose, that when something -- if you look at 70 elements in figure 3, 77 and 79, do you see the black boxes inside?

Q. Yes.

A. So basically here what is happening, when there is a detection like this, Alden, by using the LEDs described in figure 5 and the corresponding paragraph, makes this dim while the other has full light in order to increase the visibility for the driver.

In figure 11, I believe, the same structural figure 5 can do the dual (phonetic). In other words, I can have dots of the reflectors -- instead of having the dots that correspond to the

headlights, I have dots that correspond to the reflectors on the side of the road.

So I want to -- as we drive, we want to be able to see this better. So it's going to send as much light as possible to this one by using the same structure.

Q. Okay.

A. So it's the dual problem. Again, one is actually high beam so I don't create glare for the oncoming driver, or if I'm on a turn the system can use these refractors (sic) by using the same logic of detecting lights -- using the same reflectors in order basically to just have direct LED light in order for the driver to make inferences about the curvature.

I don't know if this answers your question.

Q. So using the figure 5 embodiment you're saying that light reflects off these reflectors on the side of the road and the headlamp detects these and then dims those corresponding lights?

MR. HUGHES: Objection. Mischaracterizes his testimony.

A. No. What I'm saying is the following: There are two main use cases in Alden. One is

1 basically headlights maximizing visibility for the
2 driver and minimizing -- we discussed this.
3 The second one is actually using the same
4 logic, which is described in figures 3, 4, and 5. I
5 detect that, so my dots here in the figure 3 are
6 going to be the reflectors. The reflectors are going
7 to be something that corresponds -- it will have the
8 same appearance on the image like the headlights.
9 So I will have a rectangle like -- but
10 instead of having dim light I'm going to have high
11 beam, and the rest is of no interest because
12 basically I'm trying to compensate -- of course, I
13 have Alden discloses that he has information from
14 other sources such as the steering wheel sensor.
15 So I can have more information, the
16 driver, by having the light. So that's -- that's the
17 way -- to the best my understanding, this is what I
18 believe is disclosed here. And it's important to say
19 -- let me read just one minute.
20 The directing of lights -- I'm reading
21 from 36 at the end. "The directing of" the light --
22 "of light can be achieved with the segmented sensing
23 elements and segmented light distribution elements
24 described herein."
25 MR. TURNER: All right. It's 1:00. Do

you guys want to break for lunch?
MR. HUGHES: That's fine.
(Whereupon, at 1:01 p.m., a
luncheon recess was taken.)
- - -
A F T E R N O O N S E S S I O N
(1:43 p.m.)
Whereupon,
DR. NIKOLAOS PAPANIKOLOPOULOS
was called for continued examination, and having been previously duly sworn was examined and testified further as follows:
EXAMINATION (CONTINUED)
BY MR. TURNER:
Q. All right. Welcome back.
A. Thank you.
Q. All right. If you could turn to your declaration. This is your first declaration, which is for the 039 IPR?
A. Yes.
Q. Okay. Can you turn to paragraph 33?
A. Yes.
Q. Okay. We discussed this a little bit before. This was your definition of person of ordinary skill in the art. Can you read the last

sentence of your -- or the last two sentences?
A. "The more education one has, the less experience needed to attain an ordinary level of skill. Similarly, more experience in the field may serve as a substitute for formal education."
Q. What is your understanding of these sentences?
A. So the layman -- I'm not a lawyer -- so let's suppose that you have a master's. Some of these two years which I mention here may become one year or zero. So if you have, let's say, four years of experience, you may have a degree from a two-year college like a community college. So basically that's --
Q. That's the scale?
A. The scale, yes.
Q. Okay. All right.
A. For example, Dunwoody. It's a small technical college in the Twin Cities. It has automotive engineering. That's my point -- D-U-N-W-O-O-D-Y.
Q. All right. Can you turn to paragraph 50 of the same declaration?
A. Yes.
Q. All right. So this you're describing

ground 1?
A. Yep.
Q. Okay. Can you read paragraph 50 for us, please?
A. "As viewed by a POSITA, Alden anticipates and renders obvious Claim 48."
Q. So in your view what's the difference between "anticipates" and "renders obvious"?
A. To me, anticipate -- what is happening anticipate also renders obvious. It's above everything.
Q. So it's --
A. Again, I'm not a lawyer, but --
Q. So in your view if something anticipates, it also renders obvious?
A. Yes.
Q. If something renders something obvious, does it also anticipate?
A. No.
Q. So anticipates --
A. Not necessarily.
Q. So for this ground 1 you have an anticipates and an obvious analysis. So in your view what is not expressly disclosed that would require obviousness analysis?

A. In my view as we discussed this now, I believe Alden anticipates. I mean, it has either expressly or basically -- all the terms of the claims are disclosed, taught by -- and we can go claim by claim basically.

Q. So do you know which limitation you provide your obviousness analysis for?

A. Let me -- in both declarations or --

Q. Just one at a time.

A. So we can talk about ground 2.

Q. Well, first with ground 1. Can we just focus on ground 1 for now that you proposed anticipatory reference and obviousness?

A. It's "or" render obvious. It's not "and."

Q. All right. So on this ground you're analyzing claim 48; is that correct?

A. I don't think -- let me see.

MR. HUGHES: Counsel, which IPR petition should we be looking at?

A. I don't see 48 on this one.

BY MR. TURNER:

Q. Okay. All right. Well, in paragraph 50 which independent claim are you analyzing in this section?

A. You mean paragraph 50?

Q. How about at --
A. Let me understand. You want me to see -- because I'm at the Table of Contents.
Q. Well, if you can look at paragraph 50, which is page 23.
A. Should I start with independent claim 24?
Q. Okay. So for -- I'm sorry. Did you say dependent claim or independent claim?
A. Independent claim.
Q. So for independent claim 24 what are you relying on for satisfying the light source limitations of this claim?
MR. HUGHES: Objection. Vague.
A. So the way I analyzed this is actually I started with the preamble and I say basically what are the elements of the claim. So are you referring to the preamble where it says an illuminating device having automatic control? Because I go term by term.
BY MR. TURNER:
Q. Why don't we scroll down to limitation 24 B, which is at the bottom of page 26?
A. Yep.
Q. So what are you relying on for satisfying the LED limitations of this claim?
A. It's a plurality of the individual control

abilities.

Q. Okay. What are you relying on for satisfying the plurality of individually controllable LED limitation?

A. So if you go to 54, I say: "As discussed, Alden discloses that its 'segmented beam' headlights 61 are incorporated in 47. See supra paragraphs 52-53, claim 24a Also Alden figures 1 and 2.

"Each headlight can include an 'array of individual lighting elements,' with each lighting element being a 'white LED (or alternate lighting mechanism),' which is from 29 paragraph in Alden.

"That is, the plurality of LEDs are incorporated in the motor vehicle structure by being included in headlights 61, which are mounted to the vehicle."

And, in fact, dependent on 26 and 29 in figure 2, if we go to figure 2, there is the element 47 which is the vehicle itself which shows that this whole thing is mounted on the vehicle.

So "further, this LED array ('lighting elements 119') is in communication with a power source ('power supply 113') via a 'switch array 115' and 'segment wire 117,'" which is basically figure 5.

You want me to continue?

Q. No. That's fine. Can you turn to paragraph 120 of your declaration, page 87?
A. Yes.
Q. So for ground 2, are you combining Alden with Kobayashi for claims 28, 36, and 44; is that correct?
A. That's right.
Q. What are you relying on the Kobayashi reference for teaching?
A. Do you have a copy of Kobayashi with you?
Q. I don't think I have Kobayashi. But did you describe it in your declaration?
A. I describe it, but --
Q. Do you remember what you're relying on Kobayashi for teaching?
A. Give me one minute to make sure that the record is accurate. It's the GPS map. But let me -- so if you go to 121, page 89, specifically Kobayashi discloses everything -- so it's under the figure on page 89.
"Specifically, Kobayashi discloses that its controller ('irradiation control means 4') receives 'roadmap information' from 'road profile calculated means 2,' along with other sensor data, and use these inputs to automatically adjust the

1 illumination of headlamp 5.
2 "(Id.; see also 2:4-39.) The 'road
3 profile calculated means' can also be included as
4 part of a GPS sensor that outputs 'map information.'"
5 And I believe -- I don't have it in front
6 of me -- there is a figure 12 in 17, 3 to 47 where
7 basically the GPS -- so, in other words, think of the
8 following: Both Kobayashi and Alden are basically
9 trying to make the driving through the use of
10 headlights safer.
11 In addition to the information processed
12 by Alden, Kobayashi discloses the use of GPS in order
13 to have maps that are going to inform the driver
14 there is a curve.
15 So, for example, something like this may
16 be useful. Let's suppose we are in an environment
17 like New York where there's a curve, but this is what
18 we call a GPS denied environment. Then you relied on
19 these reflectors.
20 Now, you are in a rural environment where
21 you have a GPS but you don't have the reflectors. So
22 this map information along with the steering wheel
23 information can inform how these LEDs or the
24 combination will be turned on in order to focus the
25 light on the curve.

Q. And also another thing that -- I really like this figure 10 from Kobayashi, which is on page 90 because it shows, "Kobayashi further discloses that as a vehicle moves along roads in a travel route, including, for example, traveling along straight roads or bending roads, the 'irradiation control means 4' can 'conduct irradiation control of the lighting device in accordance with the road profile.

"As a result, 'when the vehicle turns to left, the left shoulder is irradiated,' and 'when the vehicle turns to right, the right shoulder is irradiated.'" And this is figure 2 (sic), 15:6-28, 17:41-67 and also figure 9."

Q. Okay.

A. I hope I answered your question.

Q. Yeah. That's fine. All right. Can you turn to paragraph 124 of your declaration?

A. Yes.

Q. All right. So for ground 3 you're combining Alden with Kondo for claim 8, 10 through 14?

A. Um-hum.

Q. What are you relying on the Kondo reference for teaching?

A. If I may ask, do you have a copy or --
Q. I don't know if I have Kondo -- I do have a copy of Kondo.
A. Thank you.
MR. TURNER: You guys want this?
MR. HUGHES: Thank you.
A. So you see paragraph 127 on page 96?
BY MR. TURNER:
Q. Yes.
A. So I'm reading the claim element: "The light fixer having movable structure for aiming the directional light sources mounted thereon in a defined direction."
So if you look at Kondo, which is titled, Automatic Optical-Axis Adjusting Device for Automatically Adjusting the Directions of Optical Axes of from Lights.
So it has -- "Kondo discloses vehicle front lights comprised of swivel lights 11L-11R and left and right headlights 10L-10R." This is described on 16, I believe. Yeah. It's paragraph 16. It has the whole description.
And I use it also -- let me see -- for 8d. I think that's -- yeah, these are there.
Q. Okay.

A. Basically, the swivel structure which corresponds to their moving.

Q. All right. So you're relying on Kondo swivel structure for satisfying the moving structural limitations?

A. Yes.

Q. So how do you combine Alden and Kondo? How would a person of ordinary skill in the art combine these references?

A. I have a pretty good description. So go to paragraph 131, page 99.

Q. Okay.

A. It says: "Further, a POSITA would have had a reasonable expectation of success in using the swivel structure (and associated actuator) taught by Kondo to mount certain LEDs to in the system of Alden.

"For example, LEDs in Alden (such as those in figure 5) could be mounted to the movable structure and controlled using the same controller (Alden's CPU 71) that is already assessing how and in what directions light should be projected - something that Kondo similarly uses a CPU to assess."

Q. So are you saying that a person of ordinary skill in the art would mount a -- use

Kondo's swivel structure to adjust the entire headlamp assembly that's shown in figure 5 of Alden?

A. Um-hum. And I have actually -- so Lexus has a swivel system along with LEDs introduced around the time -- maybe one year later. So I think it would have been something, because for someone to introduce it means they were working on this for several years at that time.

So also Audi -- I believe it had a swivel system with LEDs at the same time. So I think the POSITA would have been motivated because it increases -- don't forget, we tried to increase the visibility for the driver and decrease the glare.

Q. Okay. But your combination, you're talking about moving the entire LED array of Alden, not some subset of the LED array?

A. This is what I'm talking here as one possibility.

Q. Okay.

A. But I know, for example, the Audi system moves only certain LEDs in this matrix LED system that we discussed.

Q. Okay. But that's Audi. But we're -- in your combination are you moving the entire LED array or a portion of the LED array?

A. What I mention is the whole, basically.
Q. Okay. All right. Can you turn to paragraph 154 of the same declaration? It actually starts at 153.
A. Yeah.
Q. Okay. So this ground 4 looks like you're combining Alden with Kondo and Stam; is that correct?
A. Yes.
Q. What are you relying on the Stam reference for teaching?
A. Again -- sorry to ask it -- do you have a copy of Stam?
Q. I think I have Stam.
MR. TURNER: Again, so this would be Mercedes Exhibit 1008.
A. Give me a minute. Yeah. So, basically, if you go to paragraph 154 -- this is the one you told me -- or 153?
BY MR. TURNER:
Q. I think the ground starts at 153, but it's --
A. Yeah. I think for this particular, the dependent claim, if you look at the figure on the first page, which is System for Controlling Exterior Vehicle Lights and we go to paragraph 154: "A POSITA

1 would have been motivated to implement the teachings
2 in Stam to the Alden-Kondo system.
3 "Stam is in the same field as Alden,
4 similarly discloses vehicles with headlamps that can
5 be controlled to change brightness and beam pattern
6 so as to 'maximize the illuminated area in front of
7 the vehicle without causing excess glare in the eyes
8 of other drivers.'
9 "Like Alden, Stam also receives data from
10 sensors, and controls the headlights to 'control
11 their beam patterns in response to objects detected'
12 in the vicinity of the vehicle."
13 Stam in here is -- so Stam discusses some
14 numerical values about glare. But here in this
15 particular case: "Stam merely adds that the same
16 image sensor and optical system 'for the headlamp
17 on/off and headlamp dimmer control' could also be
18 used to detect other conditions such as fog, and
19 other exterior lights on the vehicle like fog lights
20 could be controlled based on the sense information."
21 So, in other words, if we look at this
22 figure which is actually on page 117, there is the
23 element -- there are several sensors along with an
24 image sensor, which is element 201, is the image
25 sensor.

We have element 1107 of the light sensor, we have glare lights sensor 1109, and EC mirror drive 1111, along with a microcontroller that through means (phonetic) 1142 affects and instructs the fog lamp control 1141 in order to change the fog lights 1147, 1145, and 1143.

So, again, since several vehicles have fog lights which are used for additional visibility around curves -- for example, BMW has this as a standard feature. This, again, improves the visibility around corners. Again, for a POSITA it would have been reasonable to combine these two, to combine Alden with Kondo with Stam.

Q. So, again, what limitation are you relying on Stam for teaching?

A. Basically this closure about the fog -- the fog lamp controller. So, basically -- so Stam merely adds -- this is paragraph 154.

So "Stam merely adds" -- this is paragraph 154. Stam merely adds that the same image sensor and optical system 'for the headlamp on/off and headlamp dimmer control' could also be used to detect other conditions such as fog, and other exterior lights on the vehicle like fog lights could be controlled based on the sensed information."

So, in other words, he adds to the mix the fog lights, which unfortunately in the U.S. are not regulated.

Q. All right. So you're relying on his disclosure of fog lights for teaching which claim limitations?

A. So you see it says: "The illumination device of claim 8, further comprising a controller with communication capability to other devices, where the camera in one location obtains information and the controller processes the information and communicates the camera obtained information to a second device." The second device.

Q. So you're relying on Stam for satisfying the second device or is it the structures of the camera? Are you relying on Stam for satisfying the camera limitation?

A. No. What I'm saying is actually both of them -- the three of them, Alden combined with Kondo and Stam make the whole thing obvious.

So we have illumination device of claim 8. We have a controller. So both Alden and Kondo, they have a controller. They communicate to other devices where the camera angle allocation obtains information. So I have an image sensor in Kondo. I

have an image sensor in Alden.

Where the camera in one location obtains information and the controller processes the information, microcontroller in Kondo, CPU logic in figure 4 of Alden then communicates the camera update information to a second device.

So in the case of fog, what does the camera communicate? If we have basically no visibility, the camera can capture and the processor can make inferences regarding this and it can send the obtained information to a second device.

In this case, this is the fog lamp control who -- that impacts 1143, 1145, and 1147, which are the fog lights.

Q. Okay.

A. And if you go to the patent claim 16 paragraph 165, basically -- and 155 says: "As discussed, Stam discloses the microcontroller 1105 communicates the camera-obtained information to the fog lights on the vehicle, and the illuminated area of the fog lights is a road, and it would have been obvious to apply these teachings to the Alden system for the reasons explained above."

Q. So are you proposing adding fog lights to Alden or you're using Alden's headlamp for fog light

functionality?

A. No. I don't do either of these. I'm saying what is being -- what this reference teaches is that basically we can take Alden with Kondo and we can basically use Stam teachings, especially with the operation of fog lights, and a POSITA would have found these as applying known methods -- applying basically these techniques in order to get predictable results.

Because all of them dealing with lights, automotive lights, and a fog light is just another device that can be utilized and be informed to the communication. So I'm not suggesting that this is preferable. I'm just saying how a POSITA would have looked at this prior art.

Q. So are you proposing adding additional structure with this combination?

A. No. I'm just saying how these three references -- you see, as I mentioned earlier, BMW I think is one of the few manufacturers that have fog lights that are activated on a curve on the road. It doesn't mean that everyone adopts this.

And, in fact, as I mentioned earlier, the U.S. has no directions, has no standards for fog lights. In fact, the fog lights for a big

manufacturer, as far as I know, are the rear lights on the back.

Q. All right. Why don't we turn to your other declaration. Do you have your other declaration from -- excuse me -- IPR 2023-01040? Did I give you a copy of the other declaration?

A. Yes, yeah. This one. So this is --

Q. It's also marked Exhibit 1003, but this is for the IPR 2023-01040. All right. Can you turn to page 101, paragraph 143, please?

A. Paragraph 143, sure.

Q. All right. So for this ground you have Alden alone or in combination with Stam in view of Beam for claim 49; is that correct?

A. Yes.

Q. All right. So what do you mean by Alden alone or in combination with Stam?

A. So let me read this. So let me explain to you. Let's go to paragraph 146. This is 49b claim element. So I say: "With respect to illuminance being below a 'predefined glare level,' a POSITA would have understood that for low beam to have 'minimum glare' as disclosed in Alden, the low beam's intensity would need to be below a particular threshold.

"Below" -- for example, "Below a level such that the 'driver of 41 sees only a dim or low beam light from 47.'" This is Alden 26 -- paragraph 26 to 27, figures 1 and 2.

"High beam light would be above this threshold, so that, as Alden teaches, visibility in high beam areas is maximized. (Alden 26 to 27.) Further, Alden's system can 'provide illumination to independently controlled segments each operable within a range of intensities between the high and the low beam state.'

"That is, Alden's system can operate not only at high beam and low beam but also at intensities in between medium low, medium, medium high. The 'dimmed, low beam state' is a selected intensity at the low end of this range and thus below a predefined glare level that Alden characterizes as 'minimizing glare' to other drivers."

Again, Alden wants -- now, if we want to see an example or a POSITA would have been interested to see an example of predefined glare, numerically meaning in units.

"Stam similarly" -- I'm going to paragraph 147. "Stam similarly discloses vehicles with headlamps that can be controlled to change brightness

and beam patterns based on objects, so as to maximize the illuminated area in front of the vehicle without causing excess glare in the eyes of other drivers.

"Stam further discloses that predefined threshold values can be considered in setting the illuminance of low and high beams, and that governments have laws limiting the intensity of vehicle headlamps, including to control the amount of glare experienced by drivers of other vehicles. (1:16-2:5)

"Stam gives an example of limiting headlight illuminance to below a threshold of '0.1 foot candles" -- so this is candles per square feet. It's a unit that's used to measure illuminance -- "incident or other vehicles, to avoid causing glare and to comply with regulations, and notes that when no other vehicles are present, the lights can be on high beam above this predefined threshold."

And then in 148 it says: "It would have been obvious to use such a predefined glare level, such as 0.1 foot candles, in the system of Alden. This would have required nothing more than setting a predetermined illuminance level to 'control the amount of glare experienced by drivers' as taught by Stam."

Q. Okay. So you're relying on Stam for teaching a threshold level; is that correct?
A. Just giving this particular value.
Q. Okay.
A. If my argument -- my previous argument was basically -- although I think it's rather obvious, I use Stam to provide this particular figure.
Q. Okay. So now what do you rely on Beam for teaching in this combination?
A. Give me one minute. Do you happen to have Beam? I'm sorry to ask.
Q. I brought a lot of paper that I want to get rid of.
THE WITNESS: And this is Exhibit No. 007 (sic).
MR. TURNER: So 1007?
A. Yes. Just give me one minute. Yeah. I used from Beam -- should I describe Beam or no?
BY MR. TURNER:
Q. Well, just -- sure.
A. So Beam discloses like Alden a system -- this is paragraph 152. "Like Alden, Beam discloses a system controlling headlight output patterns in particular areas to eliminate 'the blinding of a driver in an oncoming vehicle, while continuing to

provide intense forward illumination.'"

This is from Beam, Abstract and 1:5-19. "Beam describes a vehicle headlamp system that uses a 'sensor 107' to detect light from other vehicles. (Beam 4:9-59, 5:3-16, claims 1-6, figures 1-2, 4.)

"The sensor data is used by a controller 108 to adjust the output of a plurality of individually controlled light sources, or 'microbeams,' making up the headlight beam in order to attenuate beams directed to detect vehicles.

Q. Now, just that last sentence, when you say "light sources or microbeams," are you --

A. I'm referring to this individual who uses the term "microbeams."

Q. Okay. So what is a microbeam?

A. Let me go back and see. Bear with me one minute, sir. So if you go to column 2, row 56 says: "It will then control the light output of a group selected from a multiplicity of narrow angle beams (microbeams) which comprise the overall headlight beam pattern."

So it uses these microbeams as components of the overall headlight beam pattern.

Q. So the microbeam is a component of an overall beam?

A. Headlight beam, according to the disclosure here.

Q. All right. And what creates a microbeam?

A. So if you go to column 5, row 32: "Figure 7 is a block diagram of the electronics portion of a controller 108. The spatial scene data from sensor 107 is thresholded to eliminate weak signals and becomes the input to a processor.

"A clock generator produces a line clock which determines the line to be read or illuminated, and a dot clock, which determines the location of the pixel on the line to be read or illuminated. The dot clock output is connected to sensor, spatial light modulator and a dot counter 1103 via a bus 1111.

"The line clock output is connected to sensor 107, spatial light modulator 203 and a line counter 1104 via a bus. The numeric value of dot counter is transferred to processor 1105 via a bus 1113.

"The numeric value of line counter 1104 is transferred to processor 1105 via a bus 1112. Processor 1105 uses appropriate algorithms on the incoming data to determine the locations to be blanked, and stores them in memory 1106."

So, in other words, blank. So they don't

want any light there.
Q. So the microbeam is light?
A. Yeah. Produced, I believe, in this case by using basically this electronic apparatus in conjunction with the spatial light modulator. It's one of the methods used to produce light.
Q. Okay. So a microbeam would be the output from a modulator?
A. Among other things based on the description here.
Q. Okay. Does the term "microbeam" refer to any type of structure or is it the output of a lighting device?
A. Can you clarify? What do you mean structure a beam (phonetic)? I mean, polarization? You mean a phase? You mean second wavelength?
Q. Well, let me rephrase. Do you agree that a microbeam is the output of a lighting system?
A. Yeah. Um-hum -- or it's a possible output, one of the many ways that we can produce light output.
MR. HUGHES: Counsel, we've been going a little over an hour.
MR. TURNER: Yes. Let's take a break. Five, ten minutes?

MR. HUGHES: Okay.
(A break was taken.)
BY MR. TURNER:
Q. Okay. I'd like to return to the Alden reference, which was Exhibit 1005.
A. One main part of the declaration or -- I'll do both.
Q. Okay. All right. So for Alden, can you turn to figure 5 again?
A. Yep.
Q. So when we discussed this before, we discussed the 15-degree spread.
Do you recall that?
A. Yes.
Q. Okay. And that 15-degree spread, that was from one of the light elements; is that correct?
A. Yeah. Based on the spec -- let's make sure -- yeah. Paragraph 29 it says: "In the illustration, the 125 from 119" -- 119 is the LED -- "falls across a 15-degree section of the headlight distribution area."
Q. Okay. So if that's one light element that provides a 15-degree segment, what is the total spread from all of the light elements shown in figure 5?

A. Again, this is a slice, so this is a three-dimensional structure, Number 1. Number 2, it says: "Each other lighting element similarly falls within a defined area of the light distribution area." So it's just depending on the figure 3, the logic in figure 4, and how these are placed on the curve.

This is going to be different. And we're talking about, again, 3-D structure as it corresponds to the headlight.

Q. Okay. So the light elements that are shown in figure 15, what is the total beam spread?

MR. HUGHES: Objection. Form.

A. As I said, this is a high-level diagram. So it just illustrates how this whole headlight with controllable LEDs work. So it will be speculation to say that this is exact because this is a high-level concept diagram.

BY MR. TURNER:

Q. Okay. So based on your analysis in reviewing the challenge claims in view of Alden, what is your opinion on the total beam spread as described in Alden?

A. I will go with what he says, paragraph 2: "The result is an automated headlight system which

enables the driver of a vehicle so equipped to see optimally, while concurrently the driver of an oncoming (inaudible) can -- also can see optimally.

In other words, depending on the scenario and depending on what we have on figure 3 on elements, left sensor, right sensor, and through the logic and CPU, which is described in figure 4, how they select the elements, the shadowed areas, basically, you have the whole system of Alden in its totality.

Q. Okay. So does the figure 3 description affect the total beam spread of the figure 5 embodiment?

A. The figure 3 can inform. But, again, this is a concept. So if you look at the number of rows on 77 and 79, it's not clear how many. Assuming that each element controls one LED, it's not clear and I cannot count here.

Q. I'm sorry. What were you just referring to?

A. Do you see 77?

Q. In figure 3?

A. In figure 3. It's a reference as an array matrix. In other words, there are rows and columns. So here basically the disclosure is that each one of

these controls one LED. And this is what the POSITA would understand at that time.

So it doesn't give me any information how many rows, how many columns we have. It's a concept diagram. There are no dimensions, no scale.

Q. So you're saying from the figure 3 embodiment --

A. It's not really an embodiment. It doesn't mention this as an embodiment.

Q. Okay. So is this a sensor array in --

A. The sensor array is the 14 -- is the 51a, 51b.

Q. 51a and 51b. So are you saying that for each sensor there's an associated LED?

A. No. This is not what I said. If you look at figure 4, we have the information that is extracted through thresholding from figure 4 elements 89, 91, and then 93, 95.

Then we compile a left sensor map and we compile a right sensor map. We compare the left with the right. Then through the use of memory we calculate the distance of each threshold object.

I need to mention here that the figure 4 discloses something quite important and interesting, that they move from lights -- thresholding lights to

objects, and then calculate distance of each thresholding object using triangulation, calculate the headlight dim zones for each threshold object, and switch -- this is the part that goes -- that informs 77 and 79, requisite headlight segments to dim; switch other segments to high beam.

So, basically, if we go -- I had one figure highlighted -- let me find it -- figure 3. So if you go paragraph 85, page 63 on the 01039 -- so the yellow area is the high beam, which is in the broader field above and below left and right of the area where are the headlights and the driver plus this expanded box remains, and then the other area is dim.

But -- so you see we have to see all this intertwined. This is the process. This is the logic that describes the pattern recognition or the object recognition, and then the figure 5 actually shows you the LEDs.

Q. All right. So back to the figure 25 embodiment. Do these beams overlap? Do each segment overlap?

MR. HUGHES: Objection. Vague. Compound.

A. From the diagram -- I will only speculate from this diagram.

BY MR. TURNER:

Q. Okay. So, in your opinion, do the beams overlap?

A. Again, I don't want to speculate on this one because I don't have the exact distance between the LEDs, the placement of LEDs, the angle, the curvature associated with this curve that we see here.

Q. So is it your opinion that without all this additional information a person of ordinary skill in the art would not understand the shape of the beam pattern from the Alden reference?

A. No. I disagree with this. I think that is a very clear concept that goes from headlights, cameras, sensors to CPU logic, which is described in figure 4, and then having controller LEDs which are going to direct the light in areas where we need the light, or in areas where we want to reduce the glare we're going to dim them.

So I think a POSITA -- I was asked to opine how a POSITA would look at these documents and this prior art. So I think this is -- this is what Alden teaches us.

Q. So does Alden teach to a person of ordinary skill in the art what the output beam

pattern is from the figure 5 embodiment?
A. I think it teaches you that basically you have one sensor associated with the left headlight, one right sensor associated with the right headlight.
Then as soon as the system detects the logic and CPU as the cameras, these sensors, register lights through the flow which is described in figure 4, we can basically follow these steps, create these sensor maps, which are basically the images.
We can through pattern recognition calculate the object, calculate the distance of the object through triangulation, and then calculate the headlight dim zones for this thresholding object and then we can switch the requisite headlight segments dim, if this is in autonomous mode, or basically the driver can select the manual dimmer switch in the use case of headlights at minimum glare and maximum visibility for the driver.
Q. So in the scenario when there's not any vehicles present -- so this is not a dim condition -- would the beams -- the output beams in the figure 5 embodiment overlap?
A. I think my answer, again, would be speculation because the issue there is not so much -- as I mentioned earlier, there are a lot of parameters

which -- there are several parameters that come into play: How many LEDs? What is the angle, the curvature of the -- and then the existence or nonexistence of a vehicle or vehicles. Because, in particular, Alden discloses that it can detect multiple vehicles and have multiple dimming zones.

It can influence a lot of these optics or the impact of optics as we sense the environment.

Q. So what is the shape of the lens 121 in the figure 5 embodiment?

A. It's the headlight lens that focus the light basically.

Q. Okay. What is the shape of the headlight lens that focuses the light?

A. With respect to convex? concave? The way I see this is actually more like a convex. But, again, it's pure speculation because this is at a higher level.

Q. So the lens illustrated in figure 5, which is 121, that's a convex shape?

MR. HUGHES: Objection to the extent it mischaracterizes his testimony.

A. I say this is pure speculation, and I don't want to do this. So I would say with extreme caution that there is a possibility that this is a

convex lens.

BY MR. TURNER:

Q. Okay.

A. But just to give you the infinite possibilities, it may be a polycarbonate headlight cover that may have different characteristics but still act as a lens. A polycarbonate lens with different segments may follow this category. So that's why I say that this is pure speculation.

Q. All right. And how about the LED array? What is the shape of the LED array that's shown in figure 5?

A. As I mentioned, the disclosure basically is -- "The 119 and other lighting elements are on a curve along the focal point of a headlight lens 121 such that the light from each lighting element goes into a specified portion (or portions) of the legality distribution area.

Element emitted light 125 being an example of an element's light being directed into one sector of the light distribution area."

Q. Okay. So you said the light elements are on a curve. So what shape would that be?

A. This is not what I say. This is what the spec says.

Q. Okay. But you're giving us your opinion on what the spec discloses, right?
A. My opinion -- I was asked to opine if the elements of the particular claims basically were anticipated, and this is what I opined. And I can read you from my declaration.
Q. Okay. So what would be the three-dimensional shape of this array that's shown in figure 5?
A. If we take the slice, again, at the conceptual level, it's going to be something that corresponds to the figure 4 -- to the figure 3 that we have, which is an array matrix of LED elements, each one controlled by each control switch that corresponds to the particular location coordinate where the light has been detected.
Q. So figure 5 shows one row of LEDs. Are you saying there would be multiple rows stacked on top of each other?
A. Can you repeat the question?
Q. So for figure 5 it shows one group of light elements 119 that are formed along a curve; is that correct?
A. Yes.
Q. Okay. So if this is a section, what is --

what is below this section of light elements?
A. So they will be multiple -- so think of stacks of this section that are going to form the -- basically, the array of LED elements that corresponds to this control switch which is shown in figure 3, the element 77 and 79.
Q. So do these stacks follow the same curve?
A. I think they will follow. They will be on the curve in order to maximize the visibility for the driver in reducing glare. I think I read earlier a statement. I can go back. But a POSITA would have known how to place these on this curve in order to maximize visibility and non-glare for the oncoming or the drivers who are proceeding.
And we shouldn't forget the second application which is actually around the curve. So around the curve we may want to have LEDs on the sides that are going to be activated when we want to highlight the curvature up and down.
So, again, if you look at this idea that this -- I believe it's called ADB standard, adaptive, I believe, driving beam or something like that.
It was approved recently to come to the U.S. But this is a matrix of elements. It was demonstrated in Europe by Lexus years back, and

slowly we see it in cars here.

So I think that's -- that's what POSITA Alden in its -- based on the specific statements that they have included, this is what it discloses.

Q. Okay. So you referenced the ADB, I think you said, standard; is that correct?

A. Yes.

Q. So is it your opinion that the Alden design, Alden reference, is based on this ADB standard?

A. No. That's not what I said. I said if we want to see the trend -- so let's go back to the history a little bit of headlights.

As I told you, I have worked all these years with automotive system and intelligent vehicles. So we go back to the Tucker, T-U-C-K-E-R, cars. So this is one of the first ones that introduce some standards for headlights. Then there was a lot of discussion about how we can make these safer, more effective.

Then -- I may have the years wrong -- excuse me. It's getting late. So somehow at the beginning of 2000 The National Highway board started a three-phase effort -- I don't recall the name -- basically, how we can change this; how we can improve

this.

In the meantime, in Europe Audi and then BMW and I believe Volkswagen created another committee to look at the ADB standard which stands for, I believe, adaptive driving beam or something like that.

So the U.S. is so fragmented until very recently that states, for example, have power. If you look, for example, the state of California has a standard about the luminance associated with headlights which is completely different than the standard that we have in Minnesota. The Minnesota (inaudible) has a different one.

Not only this, but there are different operating environments. The beginning -- I think until COVID the matrix LED and ADB standard was not allowed because basically the -- so, if I understand correctly, the main objection of the Federal Government was actually we need to have high beams and low beams.

By the middle of COVID I believe that cars like this are allowed in the U.S., but I think -- I know of a few models and we start seeing more. But the idea is that you don't have -- you have a matrix of LEDs and basically you can do some very

interesting things.

And this is the new generation of lights. I mean, my advisor at the project at Carnegie Mellon University -- they have a project of a pickup truck with intelligent headlights where they were having special modulators and LEDs and fans. The problem is that you need to conduct the heat. You need to remove the heat for the headlight.

Q. All right. So if we can return back to the shape of LED array in figure 5, is there -- if these are multiple stacks or multiple rows of LEDs, would they be uniform in shape between one stack and an adjacent stack?

A. It can be many variations. I mean, you can have, for example -- I will give you an example. You can have an LED with a spherical cover that may give you more -- better visibility on the corner.

So depending on the task at hand -- so, for example, you can put -- let's suppose you are in a turning situation and you want to highlight the reflectors more, you can have different type of LEDs as long as all of them are controllable.

Once you consider how you are going to cool these -- I mean, the use of aluminum as part of the material is -- actually, aluminum is a very good

conductor so it can take the heat out.

So a POSITA will have had enough information in order to start designing -- I mean, if I look at the Lexus system that probably is the first one that introduced LEDs in a commercial car in 2003, 2004 roughly.

And if you look at the Audi system they're basically -- they have different operational characteristics because in Europe the height of headlights is something that is heavily regulated. It's not the same in the U.S.

So all of these constraints there will be parts of a POSITA knowledge in order to design a vehicle's headlights. And if I can mention another example, LEDs in general are 90 percent more efficient than incandescent light. The problem is they are also far better to resisting vibrations.

However, one should consider specialized buses and processors for these lights -- data buses and processors in order basically to implement these logics that we have been discussing now.

Now, when you have a bus some of the dangers you have -- you may have a cyber attack or a security issue with a processor that runs your headlights or LEDs.

Q. Okay. So you mentioned that the LED array of Alden could be a spherical shape; is that correct?
A. Among other things. Again, it's a different design -- this may be different for a car that sits low like Porsche, for example.
I have seen a Porsche take on (phonetic) that's very low versus a truck like a Dodge Ram that is high, because if we want to see over the hill a car that sits very low may have different requirements.
MR. TURNER: Okay. I'm all set. Do you guys want to break?
MR. HUGHES: We'll take just a few minutes.
(A break was taken.)
MR. HUGHES: We don't have anything.
THE REPORTER: Reading and signing?
MR. HUGHES: Reading and signing, yes.
THE REPORTER: Would you like a copy, Mr. Hughes?
MR. HUGHES: Yes, please.
THE REPORTER: eTran, hardcopy, or both?
MR. HUGHES: An eCopy is fine.
MR. TURNER: Electronic is fine.
THE REPORTER: Did you need a rough, Mr.

Hughes?

MR. HUGHES: Yes, please.

MR. TURNER: Rough, please, also.

THE REPORTER: Regular delivery?

MR. HUGHES: If we can get the rough, and regular delivery is fine.

(Signature having not been waived, the deposition of Dr. Nikolaos Papanikolopoulos was concluded at 3:44 p.m.)

CERTIFICATE OF WITNESS

I, DR. NIKOLAOS PAPANIKOLOPOULOS, do hereby declare under penalty of perjury that I have read the entire foregoing transcript of my deposition testimony, or the same has been read to me, and certify that it is a true, correct, and complete transcript of my testimony given on Monday, October 16, 2023, save and except for changes and/or corrections, if any, as indicated by me on the attached Errata Sheet, with the understanding that I offer these changes and/or corrections as if still under oath.

_____ I have made corrections to my deposition.
_____ I have NOT made any changes to my deposition.

Signed
_____
DR. NIKOLAOS PAPANIKOLOPOULOS
Dated this _____ day of _____ of 20___.

1 ERRATA SHEET

2 Deposition of: DR. NIKOLAOS PAPANIKOLOPOULOS
Date taken: February 23, 2024
3 Case: Mercedes-Benz USA, LLC v. Yechezkal Evan Spero
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ERRATA SHEET

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REPORTER CERTIFICATE

WASHINGTON, DC

I, Sherry L. Brooks, a Notary Public within and for the Jurisdiction aforesaid, do hereby certify that the foregoing deposition of DR. NIKOLAOS PAPANIKOLOPOULOS appeared before me on Friday, February 23, 2024, pursuant to notice, at the time and place indicated; that said deponent was by me duly sworn to tell the truth, the whole truth, and nothing but the truth; that the testimony of said deponent was correctly recorded by machine shorthand by me and thereafter transcribed under my supervision with computer-aided transcription; that the deposition is a true record of the testimony given by the witness; and that I am neither of counsel nor kin to any party in said action, nor interested in the outcome thereof.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal this 1st day of March 2024.

Sherry Brooks

SHERRY L. BROOKS, CLR and Notary Public

Commission Expires: November 30, 2025

Exhibits

Exhibit A 4:10 19:7 24:7

$

$60- 42:3

$70,000 42:3

'

'irradiation 87:22

'lighting 86:21

'power 86:23

0

0.1 101:12,21

007 102:14

01039 110:9

01040 65:9 75:25

039 81:19

1

1 25:20 30:6 48:22 51:4 57:18 83:1,22 84:11,12 86:8 100:4 107:2

1-2 103:5

1-6 103:5

10 72:18,20,24 73:19 75:8 89:2,21

1003 9:2,6 75:23 99:8

1004 19:3

1005 47:14 106:5

1007 102:16

1008 93:15

101 99:10

107 103:4 104:7,16

108 103:7 104:6

109 60:16

10L-10R 90:20

11 50:13 51:1,11 73:25 74:3 75:2,14 78:3,22

1103 104:14

1104 104:17,20

1105 97:18 104:18,21,22

1106 104:24

1107 95:1

1109 95:2

111 60:16 76:8

1111 95:3 104:14

1112 104:21

1113 104:19

113 62:24

113' 86:23

1141 95:5

1142 95:4

1143 95:6 97:13

1145 95:6 97:13

1147 95:5 97:13

115 53:14 62:23 86:23

117 62:25 94:22

117,'" 86:24

119 54:6,8 61:1 62:11,16,17, 18,20 63:4,6,15 64:2,5,8,19,21 67:5,8,13 68:14,15,24 106:19 114:14 115:22

119' 86:22

11L-11R 90:19

12 88:6

120 87:2

121 61:3 68:5,7,10,11,17 69:8, 22 87:18 113:9,20 114:15

124 89:18

125 63:6,20 68:21,24 106:19 114:19

127 90:7

129a 73:1

131 91:11

131a 73:3

14 11:9 89:22 109:11

143 99:10,11

146 99:19

147 100:24

148 101:19

15 10:11 63:14 67:5,16 107:12

15-degree 62:12,15 63:6,20, 22 64:6 68:25 106:12,15,20,23

151 73:12

152 102:22

153 74:9,15 93:4,18,20

154 93:3,17,25 95:18,20

155 74:10,19 97:17

157 50:15 74:12,18

159 74:13

15:6-28 89:13

16 12:24 13:6 90:21,22 97:16

165 97:17

17 71:1 88:6

17:41-67 89:14

19 24:1 72:20

1994 11:6

1997 11:15

1:00 80:25

1:01 81:3

1:16-2:5 101:10

1:43 81:7

1:5-19 103:2

2

2 16:25 25:20 26:17 48:21 50:7 51:7,9,11,13,15 52:19 63:11 76:10 84:10 86:8,18 87:4 89:13 100:4 103:17 107:2,24

2,' 87:24

2-D 30:18

20 31:9,20 43:9
2000 20:8 22:14,23,24,25 29:21 117:23
2002 10:2 12:5 15:24 16:2 29:22 33:9
2003 120:5
2004 120:6
2005 55:16
201 94:24
2012 32:21,23
2016 19:24 32:18,23,25
2019 19:24
2023 75:25
2023-01039 6:3 8:16 64:17 65:12 76:2
2023-01040 6:4 99:5,9
2024 5:1
203 104:16
21 11:15
22 33:3
23 5:1 85:5
24 85:6,10,20
24a 86:8
24g 76:14
25 110:20
26 52:1 85:21 86:17 100:3,4,7
27 58:12,13 59:15 100:4,7
28 87:5
29 54:7 61:1 62:21 68:14 86:12,17 106:18
2:4-39 88:2
2b 39:16

3

3 25:20 30:15 31:2 52:19,21 58:7,8,11 59:20 76:10 77:1 78:9,13 80:4,5 88:6 89:20 107:5 108:5,11,14,22,23 109:6 110:8 115:12 116:5
3-D 16:9 53:12 107:9
30 43:10
30th 20:15
32 71:5 104:4
33 10:25 71:6 81:21
34 71:6
35 31:20 72:23 73:17
35W 35:7
36 50:16 74:17 80:21 87:5
37 17:12 33:17
38 29:24
39 26:11,13 28:16,17
3:44 5:2 122:9

4

4 28:18,20 52:19,24 57:21 58:4,7 60:1 76:10 77:9 78:5 80:4 93:6 97:5 103:5 107:6 108:7 109:16,17,23 111:16 112:8 115:12
4' 87:22 89:7
40 9:10 38:22 39:13
41 52:7,9,23 63:10,11 69:5 100:2
42 28:20 38:11 55:21
43 42:12,17
44 87:5
46 42:16 48:4,18,19
47 65:7 86:7,19 88:6
47.'" 100:3
48 83:6 84:16,20
49 99:14
49b 99:19
4:9-59 103:5

5

5 52:20,25 53:2,3,18 54:4,5 55:1 57:1,8,13,22 59:12 60:20 61:8 63:14 67:24 68:3 69:7,16 75:6 76:10,12 77:1,19 78:18,23 79:18 80:4 86:24 88:1 91:19 92:2 104:4 106:9,25 108:12 110:18 112:1,21 113:10,19 114:12 115:9,17,21 119:10
50 82:22 83:3 84:22,25 85:4
503 9:8
51a 58:25 109:11,13
51b 58:25 109:12,13
52-53 86:8
54 86:5
551 6:1 7:18 10:12 75:17
55a 58:15
55b 58:16
56 103:17
5:3-16 103:5

6

60 41:19 51:25 54:21
61 49:21 50:4,5 51:13,22,24 52:1,2,4 86:7,15
63 51:21 52:6 54:21 110:9
65 51:21 52:5
69 64:18 65:5,6,17,18

7

7 104:5
70 41:19 78:12
71 58:13 91:21
72 58:13
73 21:25 22:22
74 21:24,25 22:22
75 58:17,23
77 58:4,11,21 66:11 78:13 108:16,21 110:5 116:6
79 58:4,11 59:7 66:11 76:8,14 78:13 108:16 110:5 116:6

8

8 70:22,25 71:2,6,9,16 73:22 89:21 96:8,21

81 59:4

85 78:9 110:9

87 87:2

89 60:2 87:18,20 109:18

8d 90:23

9

9 11:15 28:24 38:7 41:14 70:23,25 71:3,7,24 72:1 73:5, 22 89:14

9,955,551 8:8

90 89:3 120:15

90s 11:10 29:21

91 109:18

93 60:10 109:18

94 15:19 31:20 35:7

95 60:10 109:18

96 90:7

99 91:11

9:55 5:2

A

A-L-D-E-N 7:19

A-X-I-S 14:4

a.m. 5:2

A1l 60:3

A2l 60:4

abilities 70:17 86:1

ability 37:17 41:15 74:21 76:17

able 12:10 37:2,3 42:20 44:10 46:18 79:4

about 5:25 6:17 12:12 17:18 29:7,20 30:20 34:16 35:11 43:18 44:8,12 45:8 46:17 59:1, 11 61:22,23 62:16 68:21 71:6, 7 76:5 79:14 84:10 85:1 92:15 94:14 95:16 107:9 114:10 117:19 118:10

above 20:5 39:14 43:10 78:3 83:10 97:23 100:5 101:18 110:11

Abstract 103:2

access 35:21 36:2 45:19

accident 31:22

accomplish 36:20 55:24

accordance 89:8

according 68:12 72:19 104:1

accordingly 77:12

accurate 30:16 38:10 40:5 41:20 43:1 87:17

achieved 74:22 80:22

acquired 37:15

across 63:6 68:25 106:20

act 114:7

activated 59:22 98:21 116:18

activation 53:16

actual 15:12 37:20

actually 8:14 15:12 17:18 21:9,16 25:19 28:7 36:18 37:25 49:3 57:14,19,25 59:19 65:9 71:12 79:9 80:3 85:14 92:3 93:3 94:22 96:18 110:18 113:16 116:16 118:19 119:25

actuator 91:15

adaptation 28:17 40:6 78:3

adaptive 116:21 118:5

ADB 116:21 117:5,9 118:4,16

add 37:18 78:6

adding 97:24 98:16

addition 25:8 88:11

additional 37:18 95:8 98:16 111:10

address 34:7

adds 94:15 95:18,19,20 96:1

adjacent 119:13

adjust 77:11 87:25 92:1 103:7

Adjusting 90:15,16

adopts 98:22

advance 5:18

advanced 15:15

advancement 49:8

Advances 6:18

advisor 119:3

affect 108:12

affects 95:4

after 15:9 19:10 24:8 28:1 40:10,11 43:16

again 16:15 29:20 30:8 31:10 34:10 39:12 41:14 52:14 53:6, 25 57:2 59:25 61:10 63:23 64:10,24 66:8 67:4 78:6 79:8 83:13 93:11,14 95:7,10,11,14 100:19 106:9 107:1,9 108:14 111:4 112:23 113:17 115:10 116:20 121:3

against 6:16,17 20:11

agencies 12:6

agency 21:3 29:16

agree 24:13,19 50:9 105:17

ahead 11:17 70:21

aiming 90:11

alden 7:19 47:11,16,18,24 48:4,6 49:14 50:9 51:5,9 53:25 54:11 55:9,25 56:2,16 60:21 62:2,19 68:12 69:8,16,19 70:23 72:18 73:17 74:1 75:1 76:20 77:1,17 78:11,17 79:25 80:13 83:5 84:2 86:6,8,12 87:4 88:8,12 89:21 91:7,17,18 92:2, 15 93:7 94:3,9 95:13 96:19,22 97:1,5,22,25 98:4 99:13,16,23 100:3,6,7,17,19 101:21 102:21,22 106:4,8 107:21,23 108:9 111:12,23,24 113:5 117:3,8,9 121:2

alden's 59:14,15 91:21 97:25 100:8,12

Alden-kondo 94:2

algorithm 34:10 40:7 52:22

algorithmical 30:11

algorithms 15:1 25:15 34:19, 23 36:6 37:7 104:22

alignment 71:4

allocation 96:24

allowed 31:24 37:24 118:17, 22

alone 24:24 99:13,17

along 10:16 30:22 61:2,6 68:16 76:22 77:17,24 87:24 88:22 89:4,5 92:4 94:23 95:3 114:15 115:22

already 9:4 35:19 47:15 91:21

also 9:7,15 10:5 21:10 28:8 31:17 43:21 49:2,23 50:15 51:1 67:16,19 83:10,15,18 86:8 88:2,3 89:1,14 90:23 92:9 94:9,17 95:22 99:8 100:13 108:3 120:17 122:3

alternate 54:9 86:11

alternately 49:1

although 102:6

aluminum 54:21 119:24,25

am 8:2 23:8 66:3

among 16:20 105:9 121:3

amount 17:14,21 101:8,24

analogy 53:10

analysis 14:24 83:23,25 84:7 107:20

analyzed 85:14

analyzing 84:16,23

angle 77:25 96:24 103:19 111:6 113:2

anisotropic 72:2,10

annotated 66:14

annotation 52:11

another 11:14 18:21 33:1 38:8 39:11 47:2 50:14 53:3 69:23 75:12 89:1 98:11 118:3 120:14

answer 57:6 112:23

answered 21:19 36:3 72:16 89:16

answers 79:16

anticipate 83:9,10,18

anticipated 115:5

anticipates 83:5,8,14,20,23 84:2

anticipatory 84:13

any 7:20 27:21 43:25 44:3 45:16,19 52:12 53:20 60:19 105:1,12 109:3 112:19

anyone 7:10,12 46:3

anything 13:4 61:22,23 121:16

Apologies 65:13

apologize 5:18

apparatus 47:13 105:4

appear 45:4

appearance 80:8

Appendix 10:1

application 36:18 37:12 46:1 47:11 116:16

applications 25:17 26:5 34:21 35:2

applied 10:15 71:13,15,17

applies 26:20

apply 70:10 72:3 97:22

applying 72:11 98:7

approach 36:7

approaching 74:7

appropriate 104:22

approval 9:22

approved 116:23

approximately 6:9 43:9

April 22:25

architecture 73:6

area 11:21 20:24 36:14 58:17, 21,23 59:4,7 61:5 62:5 63:7,9, 10 67:2,3 68:23 69:1,2,3,5 70:16 76:22 94:6 97:20 101:2 106:21 107:4,5 110:10,12,13 114:18,21

areas 15:18 16:10 28:2 31:22 33:3 48:8,10 50:18 58:18 59:4 77:15 100:7 102:24 108:8 111:17,18

aren't 22:1

argument 102:5

around 9:9 37:3 92:4 95:9,11 116:16,17

array 53:14,17,21 54:1,4 58:19 59:5,18,21 60:8,20 73:4 77:23 86:9,21,23 92:15,16,24, 25 108:23 109:10,11 114:10, 11 115:8,13 116:4 119:10 121:1

arrows 38:18

art 10:12,25 81:25 91:8,25 98:15 111:11,22,25

arterials 42:9

articulate 62:10

artifact 34:4

aside 47:5

ask 35:10 90:1 93:11 102:11

asked 18:17 36:15 111:20 115:3

asking 36:2

aspect 49:18

assembly 92:2

assess 11:25 15:16 91:23

assessing 91:21

assessment 36:23

assigned 8:11

assist 13:8

associate 9:13 38:20

associated 61:9 62:11,15 71:11 74:11 91:15 109:14 111:7 112:3,4 118:10

association 38:12,16 39:3,8

Assuming 108:16

assumptions 58:25

attached 19:8

attack 120:23

attain 10:21 82:3

attenuate 103:10

attorney 9:15

attributes 42:25

Audi 55:16 92:9,20,23 118:2 120:7

authored 12:18

automated 48:23 107:25

automatic 23:5 85:18 90:15

automatically 49:9 50:11 87:25 90:16

automotive 10:14,18 56:7 82:20 98:11 117:15

autonomous 112:15

autonomously 11:23

Autoscope 33:16

availability 15:17 19:17,19 20:1,4,6

available 33:13

avoid 101:15

avoiding 12:3

Axes 90:17

axis 14:3,5 33:16 45:6,8

B

back 9:25 11:7,24 12:16 20:8 24:4 28:23 29:24 31:1 33:17 42:5 44:22 47:6 50:6 52:15 81:15 99:2 103:16 110:20 116:11,25 117:12,16 119:9

back-projected 43:25

background 16:25 26:18,22 27:2,21,25 28:4,17 38:13 40:5, 7,10,11,15 49:18

based 10:9 20:16 21:2 23:4,18 32:20 39:23 41:17 57:20 59:14,16 60:13 62:1 69:21 70:12 77:2,6 94:20 95:24 101:1 105:9 106:17 107:20 117:3,9

basic 38:7 39:9

basically 7:11,18 11:14,22 12:10 13:1,4,7,8 14:6,7,9 15:1, 2 16:10,11,19 18:8,9,11,14,19 20:13,25 22:9 25:20,22 26:13, 17,18 27:15,24 29:6,16 30:10 32:2,4,8 34:14,24 35:4,9,20,24 36:11,14 37:14 38:14,19,24 39:4 40:22 46:10 50:14 53:16 54:1,18,19,22,23 55:5,17,18 56:3,10,18 57:9 60:5,12,15 61:13 62:6,11 64:1 66:7,9 67:9 71:11 72:1,7,14 76:9 78:16 79:13 80:1,12 82:13 84:3,5 85:15 86:24 88:7,8 91:1 93:1, 16 95:16,17 97:8,17 98:4,5,8 102:6 105:4 108:9,25 110:7 112:2,8,9,15 113:12 114:13 115:4 116:4 117:25 118:17,25 120:8,20

beam 48:10 49:13,16 50:1,2, 10 51:14,16,25 52:4,5,6 56:9 58:22 59:9,22 60:18 63:14 64:8,25 66:16 67:14,15,20 73:12,15 75:1,14 76:24 77:14, 15,20 79:9 80:11 86:6 94:5,11 99:14,22 100:3,5,7,11,13,15 101:1,18 102:8,11,18,21,22 103:2,3,5,9,21,23,25 104:1 105:15 107:12,22 108:12 110:6,10 111:12,25 116:22 118:5

beam's 99:23

beam/high 64:25

beam/low 56:8

beams 52:8,9,10,14,17 101:6 103:10,19 110:21 111:2 112:21 118:19,20

Bear 76:1 103:16

became 32:4 37:9 55:16

because 9:7 11:5 15:11 16:18 17:24 21:9 22:14,16 23:11 24:2 27:24 29:18 31:12,19 32:4 33:16 34:14 35:24 39:5 40:4,15,18 41:15 44:15,22 46:2,3 48:12,13 49:18 52:16, 20 53:25 57:9,16 58:25 61:21 62:6 64:10 66:9 67:25 75:15 80:11 85:3,18 89:3 92:6,11 98:10 107:17 111:5 112:24 113:4,17 118:17 120:9 121:8

become 73:12 82:10

becomes 43:15 104:8

been 5:7 6:6,11 11:5,10,21 17:22 23:17 32:10 34:14 35:19 43:16 46:20 66:6 73:11,13 81:10 92:6,11 94:1 95:12 97:21 100:20 101:20 105:22 115:16 120:21 122:7

before 6:7,12 11:9,15 26:23 33:21 81:24 106:11

beginning 32:3 49:6 117:23 118:15

behalf 6:20

being 25:21 46:5 65:2,19 66:21 68:21,22 86:11,14 98:3 99:21 114:19,20

believe 11:15 17:5 31:19 32:22 38:8 50:16 54:20,21 56:22 63:11 78:22 80:18 84:2 88:5 90:21 92:9 105:3 116:21, 22 118:3,5,21

belong 20:24 27:12

belongs 34:25

below 52:9,17 99:21,24 100:1, 16 101:12 110:11 116:1

bending 72:2,5,15 89:6

best 80:17

better 79:4 119:17 120:17

between 35:7 38:18 43:23 44:3 50:1 83:8 100:10,14 111:5 119:12

big 15:17 18:17 20:18 21:17 98:25

bigger 18:14

bio 7:18

bipartite 27:14 34:10 38:13

bit 24:16 44:14 48:2 81:23 117:13

black 41:17 46:9,11 78:13

blank 104:25

blanked 104:24

blinding 102:24

block 104:5

blows 45:14

blue 54:22 56:20

BMW 95:9 98:19 118:3

board 117:23

book 19:13

both 84:8 88:8 96:18,22 106:7 121:22

bottom 17:12,19 19:21 24:8 33:21 58:3 64:3 65:24 66:2,21, 25 67:3,9 85:21

bounding 29:1,3,10,11,14,18

box 29:2,3,10,11,14,18 35:13 38:1,2 110:13

boxes 78:13

break 46:21,25 81:1 105:24 106:2 121:12,15

bright 39:10,11 53:15

brightness 94:5 100:25

broader 11:21 62:5 110:11

brought 102:12

buildings 36:1

built 16:25

bus 104:14,17,18,21 120:22

buses 120:19

C

calculate 109:22 110:1,2 112:11,12

calculated 87:24 88:3

calibrate 43:16 45:18,24 46:12

calibration 42:24 43:1,6,12 44:6

California 42:6 118:9

call 16:7,10 27:4,16 39:4 88:18

called 14:20 27:14 38:11 55:11,13 81:10 116:21

calling 53:16

calls 7:5 61:18 68:20

came 7:5

camera 11:16 14:6 22:10 23:24 25:5,11 26:8,23 27:7,19 34:25 39:18 42:23 43:8,16,17, 24 44:7,13 96:10,12,16,17,24 97:2,5,8,9

camera's 30:20

camera-obtained 97:19

cameras 10:2 11:10 13:17,18 14:1,13 15:14 16:8,10,20,22, 23 25:8 26:2 31:14,25 33:2 35:24 36:19,24 37:2,19 43:9 45:14 111:15 112:6

can 8:5,19 11:12,25 12:2 14:7 15:3,19 17:11 18:8,17 19:1,22 22:1,2 23:2,21 24:20 26:9 28:8,9,24 29:4,5,16,24 30:1,3 32:1 33:17 36:2,15,20 37:20 38:4 39:22,23 40:13 41:20 42:11,14,16 43:1,12,25 44:14 45:1,2,11,18 46:1 47:4,5,20 48:9,10,12 49:2,5,22 51:4,17 53:5,20 54:6,8,19 55:12,23 57:3,20 61:16 62:2 63:18,21, 23,24 64:7,8,19 67:25 69:13 70:11,22 72:17 73:25 74:14,21 75:3,19 76:12,20,25 77:6,13, 15 78:23,24 79:10 80:15,22 81:21,25 82:22 83:3 84:4,10, 11 85:4 86:9 87:1 88:3,23 89:7,17 93:2 94:4 97:9,10 98:4,5,12 99:9 100:8,12,25 101:5,17 105:14,20 106:8 108:3,14 112:8,10,14,16 113:5,7 115:5,20 116:11 117:19,25 118:25 119:9,14,15, 16,19,21 120:1,14 122:5

can't 35:15

candles 101:13,21

cannot 15:4 22:17 35:12,13 46:13 108:18

Canon 6:16,21

capability 96:9

caption 40:5

capture 39:22 97:9

car 11:17,23 21:5,8 23:24 28:25 40:9,10,11,21 120:5 121:4,9

Carnegie 119:3

carried 62:24

cars 12:13 27:2 29:1 39:25 55:12 117:1,17 118:21

case 6:10,11,23 8:11 29:9,15 43:20 94:15 97:7,12 105:3 112:17

cases 79:25

categories 25:4

categorize 24:24

category 24:23 114:8

cause 58:19 59:6

causing 94:7 101:3,15

caution 113:25

cell 71:3

center 14:21 15:7,8 41:16 45:5 61:10 62:5 63:23 66:14 68:19 76:13

centers 42:7 63:25

certain 42:3 43:11 45:3 69:25 70:15 91:16 92:21

challenge 107:21

challenged 8:6

change 70:5,9,10 94:5 95:5 100:25 117:25

changes 25:6 27:3,25 40:6,15

chapters 19:13

characteristics 16:23 23:17 62:23 114:6 120:9

characterizes 100:17

cherry 31:24

choice 36:17

circle 22:6

circles 56:8

circuit 58:15,16,17,21 59:4,7

circuitry 77:11

circuits 59:16

cited 13:2 28:6 32:4

Cities 14:21 82:19

claim 76:14 83:6 84:4,5,16,23 85:6,8,9,10,12,16,24 86:8 89:21 90:10 93:23 96:5,8,21 97:16 99:14,19

claims 84:3 87:5 103:5 107:21 115:4

clarify 67:11 105:14

class 57:20

classical 29:18

classification 12:20 13:14 17:24,25 18:3,6,12 20:21,22, 23,25 21:1,3 23:5,17 24:11,13 28:9,24,25 29:6 30:16,25 36:12 37:21 38:4,5 43:3

classified 20:15 21:16 23:12

classify 18:14,18 23:11 42:20

classifying 21:5

clear 58:9 59:10 108:16,17 111:14

clock 104:9,11,13,15

close 61:10 62:4

closure 95:16

cluster 64:20,22 66:7

clusters 64:19 65:2

coauthored 12:8

college 82:13,19

collimated 73:2

collimating 73:2

column 103:17 104:4

columns 108:24 109:4

combination 56:2 88:24 92:14,24 98:17 99:13,17 102:9

combinations 39:6

combine 91:7,9 95:12,13

combined 96:19

combining 87:4 89:21 93:7

come 26:19 47:6 54:19 113:1 116:23

coming 27:2,6 40:21 70:19

comment 49:3

commercial 120:5

committee 118:4

common 28:1

communicate 15:18 96:23 97:8

communicates 96:12 97:5, 19

communication 86:22 96:9 98:13

community 82:13

compare 27:21 40:20 41:8 60:12 109:20

compensate 80:12

compile 60:10,11 109:19,20

completely 25:22 118:11

complexity 25:14 34:18 37:7

comply 101:16

component 15:5 103:24

components 14:24,25 103:22

compound 29:13 56:18,19 110:23

comprise 103:20

comprised 90:19

comprising 96:8

computation 35:3 43:2

computational 14:12

computations 14:15

compute 43:17 44:7

computed 43:24

computer 10:3,16

computing 43:12

concave 69:22 113:15

concept 57:15 62:10 107:18 108:15 109:4 111:14

conceptual 115:11

concluded 122:9

concurrently 48:11,25 49:11 52:5 108:2

condition 112:20

conditions 14:8 25:6 31:14 40:6 63:1 73:9 94:18 95:23

conduct 89:7 119:7

conductor 120:1

conference 19:14

conjunction 52:19 73:9 105:5

connect 63:23,24 64:2

connected 104:13,15

connection 35:7

consider 57:10 119:23 120:18

considered 76:25 101:5

consists 53:7

constrained 46:18

constraint 32:6 37:24

constraints 21:4 31:10 35:16, 18 36:18 38:9 39:24 120:12

construct 18:11

construction 16:9

contained 9:21

Contents 85:3

context 24:16 25:19 26:4 31:7

contiguous 65:3

continue 24:20 25:1,12 43:4, 13 86:25

continued 81:10,13

continues 15:13

continuing 102:25

continuously 28:3

control 9:19 10:18,19 11:11, 23 13:9 14:21 15:12 53:15,22 58:5,14,15,16,18 59:5,16 61:12 66:10 70:17 77:11 85:18,25 87:22 89:7 94:10 95:5 97:12 101:8,23 103:18 115:14 116:5

control' 94:17 95:22

controllable 55:6 86:3 107:16 119:22

controlled 14:21 49:25 52:3

55:8 62:19,21,22,25 63:3 72:21,25 91:20 94:5,20 95:24 100:9,25 103:8 115:14

controller 87:22 91:20 95:17 96:8,11,22,23 97:3 103:6 104:6 111:16

controlling 11:21 77:9 93:24 102:23

controls 94:10 108:17 109:1

convex 69:23 113:15,16,20 114:1

convince 29:16

cool 119:24

coordinate 115:15

coordinates 60:6

copy 17:3 18:22 75:16 87:10 90:1,3 93:12 99:6 121:19

corner 74:20 76:16 78:2 119:17

corners 95:11

correct 8:3 14:19 16:24 18:20 28:20 31:3 53:23 65:20 67:17 84:16 87:6 93:7 99:14 102:2 106:16 115:23 117:6 121:2

corrected 38:12 58:11

correctly 27:14 71:15 118:18

correspond 39:25 78:25 79:1

correspondence 25:15 33:22,25 34:2,8,17,19,22 37:4 38:1

corresponding 78:18 79:21

corresponds 34:3,4 80:7 91:2 107:9 115:12,15 116:4

could 5:13 17:18 30:15 31:1,5 53:2 77:19 81:17 91:19 94:17, 20 95:22,24 121:2

couldn't 31:23 33:14 35:17 37:25 45:12

counsel 7:5,7 8:16 65:8,13 84:18 105:22

count 22:10,16 23:14 57:4,16 108:18

counter 104:14,17,18,20

counterterrorism 20:12

Counting 23:3

country 42:8

couple 75:5

course 15:14 41:19 80:12

cover 56:21,24 57:5 114:6 119:16

COVID 118:16,21

CPU 58:25 62:21,22 77:4,10 91:21,23 97:4 108:7 111:15 112:6

crash 13:11

create 63:19 64:22 79:9 112:8

created 48:10 77:20 118:3

creates 64:6,20 104:3

creating 64:1,23

cross 11:13

crystal 71:12,14,15 72:8

current 41:25 55:7 70:10 71:13,17 72:3,11

curvature 79:15 111:7 113:3 116:19

curve 50:17 51:3 55:2,20 60:23 61:2,6 64:23 66:3 68:16 74:7,12 76:11,17,19,21,23 77:5,24 88:14,17,25 98:21 107:7 111:7 114:15,23 115:22 116:7,9,12,16,17

curved 77:18

curves 95:9

curvy 55:19

CV 18:23

cyber 120:23

D

D-U-N-W-O-O-D-Y 82:21

dangerous 13:11

dangers 120:23

darker 40:16

data 87:24 94:9 103:6 104:6, 23 120:19

DC 5:1

deadliest 31:21

dealing 26:16 98:10

decent 39:8

decision 59:17

decisions 12:2

declaration 5:25 7:3,4,8,17, 21,23 9:12,18,24 11:1 12:18 17:4 20:14 31:8 48:16,17 64:12,17 65:9,11 75:17,22 76:4 78:7 81:18 82:23 87:2,12 89:18 93:3 99:4,5,6 106:6 115:6

declarations 84:8

decrease 92:13

default 71:16

defined 63:9 69:2 90:13 107:4

definition 10:24 81:24

degree 10:13 82:12

degrees 63:14 67:6,16

delivery 122:4,6

demonstrated 55:16 58:4 116:25

denied 88:18

denoted 74:9,10

density 41:20

Department 12:7 14:22 20:9, 10 21:13 29:8 31:11 36:22 37:21 42:4

dependent 85:8 86:17 93:23

depending 20:20 55:23 66:11 70:7 72:2 107:5 108:4,5 119:18

depends 31:7

depicted 26:6

depiction 39:15

depicts 72:20,24

deposed 6:6,11

deposition 6:3 7:1,16 19:8 122:8

depth 26:1

describe 47:18 64:10 68:2,10 69:22 70:11 74:6 87:12,13 102:18

described 26:20 27:19 41:24 51:24 54:11 55:25 56:1 57:20 65:1 69:9 71:8 73:5 74:23 75:1 76:9 78:18 80:4,24 90:21 107:22 108:7 111:15 112:7

describes 36:12 47:20 50:9 52:20 55:9 59:16 71:10 103:3 110:17

describing 12:17 30:9 33:9 44:6 65:19 66:13 69:24 82:25

description 51:10 58:12 59:15,20 62:16 74:15 76:2 90:22 91:10 105:10 108:11

descriptions 70:2

design 36:16 117:9 120:13 121:4

designed 35:20

designing 120:3

desired 25:4

Despite 17:13,14,21

detailed 74:14 76:1

detect 12:11 13:15 18:9 22:15 23:10 34:2 42:20 77:2,6 80:5 94:18 95:22 103:4,10 113:5

detected 15:3,4 46:6 115:16

detected' 94:11

detecting 16:23 79:12

detection 12:20 13:14 17:22 18:1,4 23:6,16,23 24:9 37:1 78:17

detects 52:23 79:20 112:5

determination 14:16 77:10

determine 76:21 77:4 104:23

determines 104:10,11

developed 22:18

device 85:17 89:8 90:15 96:8, 13,15,21 97:6,11 98:12 105:13

devices 96:9,23

diagonals 29:2,19

diagram 104:5 107:14,18 109:5 110:24,25

dictates 62:22

did 6:25 7:7,12,15,20 9:11,23 13:15 14:25 17:3 34:7 57:6 85:7 87:11 99:5 121:25

didn't 32:3 35:2 36:1 44:11,22 45:19 46:3

difference 83:7

different 16:19 20:21 23:16, 18 28:25 29:11 32:11 45:10 48:8,9 49:20 71:9 75:5,8 107:8 114:6,8 118:11,13,14 119:21 120:8 121:4,9

difficult 24:14,24 25:3,11 43:7,10,15

dim 49:9 52:6 58:20 59:7 60:17 78:19 80:10 100:2 110:3,6,14 111:19 112:13,15, 20

dimensions 45:4 109:5

dimmed 59:23 63:11 66:10,12 69:5 100:15

dimmer 94:17 95:22 112:16

dimming 113:6

dims 50:11 79:21

diode 54:18 56:18,19

direct 13:8 15:13 74:19 76:11, 24 79:13 111:17

directed 48:6 68:22 77:14,25 103:10 114:20

directing 74:21 76:16 78:2 80:20,21

direction 9:20 69:25 76:19 77:13 90:13

directional 90:12

directionality 55:3

directions 90:16 91:22 98:24

directs 69:25 70:15

disagree 111:13

disciplines 10:16

disclose 78:11

disclosed 56:12,16,25 57:8, 13 67:24 80:18 83:24 84:4 99:23

discloses 54:1 68:13,20 80:13 86:6 87:19,21 88:12 89:3 90:18 94:4 97:18 100:24 101:4 102:21,22 109:24 113:5 115:2 117:4

disclosure 60:20 62:7 68:13 96:5 104:2 108:25 114:13

discussed 52:3,22 73:10 75:5,7 80:2 81:23 84:1 86:5 92:22 97:18 106:11,12

discusses 94:13

discussing 120:21

discussion 56:6 117:19

discussions 56:10

distance 11:17 44:3 77:7 109:22 110:1 111:5 112:11

distances 43:23

distribution 47:12 49:8,10, 12,15,24 51:12 61:5 63:7,9 68:19,23 69:1,3 72:22,25 73:7 74:23 76:22 80:23 106:21 107:4 114:18,21

divergence 41:22 72:14

divert 70:6

diverted 73:12,14

docking 46:10

Doctor 5:11

document 7:24 8:20 47:8,10 71:1 78:7

documents 7:15,20 10:4 111:21

Dodge 121:7

does 8:9 39:5 40:19 47:18 49:14 60:9 78:11 83:18 97:7 105:11 108:11 111:24

doesn't 98:22 109:3,8

doing 15:20 20:8 38:5

don't 8:3 12:14 14:3 17:5 21:10,19 23:21 24:4 36:3 40:17 52:12 55:10,13,17 56:13

61:21,22,23 62:6 72:16 79:9, 16 84:17,20 85:20 87:11 88:5, 21 90:2 92:12 98:2 99:3 104:25 111:4,5 113:24 117:24 118:24 121:16

done 11:9 14:25 16:2 17:23 22:14 29:21 31:5 76:12

dot 60:8 104:11,12,14,17

dots 38:17 46:9 58:24 78:24, 25 79:1 80:5

down 44:15 62:6 85:20 116:19

Dr 5:6 47:2 81:9 122:8

drafted 9:18,20

draw 61:16

drawing 29:2

drive 23:25 44:19,22 46:1 60:16 79:3 95:2

driven 45:11

driver 12:1 23:23,24,25 48:24 49:1 50:21,23 59:2 70:18 78:21 79:10,14 80:2,16 88:13 92:13 100:2 102:25 108:1,2 110:12 112:16,18 116:10

driver's 74:20 76:17

drivers 15:19 100:18 101:3,9 116:14

drivers' 70:19 101:24

drivers.' 94:8

driving 12:1 46:2 88:9 116:22 118:5

dual 51:1 78:23 79:8

due 73:2

duly 5:7 81:11

Dunwoody 82:18

dusk 17:1 27:10 40:3,9

dye 54:22 56:20

dynamic 44:11

E

each 7:17 49:25 55:4,8,23 61:3 63:8 68:17 69:1 77:23 86:9,10 100:9 107:3 108:17,25 109:14,22 110:1,3,21 114:16 115:14,19

earlier 23:10 41:12 52:22 55:4 57:21 66:11 98:19,23 112:25 116:10

EC 95:2

ecopy 121:23

editor 13:3

education 10:20,23 82:2,5

effective 117:20

effectively 38:4

efficient 120:16

effort 117:24

efforts 37:14

eight 40:11

eight-wheeler 18:19

either 33:15 34:5 54:1 55:6 56:20 70:6 84:2 98:2

elaborate 67:25

electrical 10:14

electro-optic 71:2,3

electronic 105:4 121:24

electronics 14:9 104:5

element 14:7 51:13,22 54:6 60:2,15,16 61:4,12 63:8,22 68:5,10,17,21 69:1,8,22 70:7 71:2 72:9 73:1 86:11,18 90:10 94:23,24 95:1 99:20 106:22 107:3 108:17 114:16,19 116:6

element's 68:22 114:20

elements 51:11 59:20 60:10, 23 61:2 63:2 68:15 73:5,9,23 74:22,23 78:12 80:23 85:16 86:22 106:16,24 107:11 108:6, 8 109:17 114:14,22 115:4,13, 22 116:1,4,24

elements,' 86:10

eliminate 102:24 104:7

else 7:10 21:20

embodiment 57:8 72:22 73:1 75:7,9,13 79:18 108:13 109:7, 8,9 110:21 112:1,22 113:10

embodiments 75:6,12

emitted 54:18 68:21 77:25 114:19

emitting 54:22

employed 52:1,2

empty 26:25

enable 30:16

enables 48:24 55:3 73:6 108:1

end 16:12 58:3 60:15 63:5 64:18 65:6,18 77:23 80:21 100:16

ended 46:2

enforce 22:19

enforcement 21:10

engineering 10:14,15 56:8 82:20

enough 11:12 70:11 77:24 120:2

ensure 77:19

entire 92:1,15,24

entity 6:16 39:3

environment 12:1 32:9 88:16,18,20 113:8

environmental 63:1 73:8

environments 118:15

envisioned 56:4

equipment 21:22

equipped 48:25 74:15 77:8 108:1

especially 98:5

estimate 62:2

estimating 42:24

etran 121:22

Europe 116:25 118:2 120:9

European 55:12

even 25:3,11 28:17 33:12 35:21 44:19

event 15:8,9

every 9:21 41:4

everyone 98:22

everything 40:4 83:11 87:19

exact 107:17 111:5

exactly 40:3 55:18

examination 5:9 81:10,13

examine 66:7

examined 5:7 81:11

example 11:14 13:11 20:16, 22 21:11 23:23 27:10 28:18 31:8,14 32:9 35:12 36:21 43:18 45:3,16 48:9 50:13 53:14 54:19 56:7 57:17,18 62:11,20 64:15,16 68:22 69:22 76:20 77:24 82:18 88:15 89:5 91:18 92:20 95:9 100:1,20,21 101:11 114:19 118:8,9 119:15, 19 120:15 121:5

examples 11:7

Excellent 9:2

excess 94:7 101:3

excuse 99:5 117:22

exhibit 9:2,4,6 10:5 18:25 19:1,3,7 24:7 47:2,14 64:7 75:22,23 76:6 93:15 99:8 102:14 106:5

exist 39:25

existence 113:3

existing 36:19 37:19 38:4

expanded 110:13

expectation 91:14

experience 10:17,21,22 69:21 82:3,4,12

experienced 101:9,24

experiment 32:5

explain 8:15 13:6 14:5 25:24 55:15 99:18

explained 97:23

explanation 75:16

expressed 60:19

expressly 83:24 84:3

extend 11:11 63:21

extending 38:18 51:20,22 64:8

extent 69:11 113:21

exterior 16:22 93:24 94:19 95:23

external 72:12

extra 22:17

extract 18:8 36:15

extracted 39:2 109:17

extracting 35:11

extraction 17:1

extracts 40:14

extreme 113:24

eyes 94:7 101:3

F

fact 16:24 21:22 25:6 30:21 33:11 45:11 57:19 74:11 86:17 98:23,25

facts 43:18 44:8,12

failure 27:24

falls 63:6,9 68:25 69:2 106:20 107:3

familiar 14:3 47:7 55:11

fans 119:6

far 15:15 65:11 77:24 99:1 120:17

fatigue 23:23

feasible 37:9 46:4,13

feature 34:2,25 39:15 95:10

features 18:8,9 27:9,11,16 39:9 40:14,22

February 5:1

federal 18:16 32:19,21 118:18

feet 43:10 101:13

few 41:1 98:20 118:23 121:13

fiddle 31:23

field 10:12,22 17:23 49:18 57:5 66:6 82:4 94:3 110:11

field-of-view 48:8

figure 15:2 16:25 25:20 26:17 28:18,20,24 38:7 39:16 40:1,2 41:14 50:13 51:1,4,7,9,11,13, 15 52:19,20,21,24,25 53:2,3, 18 54:4,5 55:1 57:1,8,13,18, 21,22 58:4,7,8,11 59:12,15,20, 25 60:1,20 61:8 63:11,13 67:17,24 68:3 69:7,16 71:2,3, 5,6,7,9,16,24 72:1,17,18,20,24 73:5,19,25 74:3 75:2,6,8,14 76:10,12 77:9,19 78:3,5,9,13, 18,22,23 79:18 80:5 86:18,24 87:19 88:6 89:2,13,14 91:19 92:2 93:23 94:22 97:5 102:7 104:4 106:9,24 107:5,6,12 108:5,7,11,12,14,22,23 109:6, 16,17,23 110:8,18,20 111:16 112:1,7,21 113:10,19 114:12 115:9,12,17,21 116:5 119:10

figures 26:6,7 39:12 70:22,25 73:22 76:10 77:1 80:4 86:8 100:4 103:5

final 9:22

finally 60:12

find 34:24 45:7 55:12 60:8 64:15 110:8

finding 44:2

fine 46:24 81:2 87:1 89:17 121:23,24 122:6

fired 55:23

firm 7:13 9:16

first 5:7 8:2 21:8 32:19 35:25 37:23 39:16,17 42:6,7 51:18, 25 52:4 66:7 71:3,12 76:4,6 78:6 81:18 84:11 93:24 117:17 120:4

fit 23:25

fitting 23:16

five 6:10 33:1 46:23 56:2 105:25

fixed 13:24,25 27:20 31:2 33:5,10 44:9

fixer 90:11

flow 41:21 58:14 112:7

flowchart 18:7

focal 61:2,6,7,9,17,22 62:2 68:16 114:15

focus 47:21 70:6 84:12 88:24 113:11

focuses 61:12 70:15 113:14

fog 94:18,19 95:4,5,7,16,17, 23,24 96:2,5 97:7,12,14,20,21, 24,25 98:6,11,20,24,25

follow 11:16 38:15 68:13 112:8 114:8 116:7,8

following 12:2,3 20:13 31:9 34:6 45:2 79:24 88:8

follows 5:8 81:12

foot 101:13,21

forget 44:25 70:16 92:12 116:15

form 16:5 47:19 68:4 69:17 75:10 107:13 116:3

formal 10:23 82:5

formed 115:22

forth 13:10 15:4 23:25 31:16 44:22 56:10 72:4,13

forward 103:1

found 98:7

four 40:10 56:2 58:3 82:11

fragmented 118:7

fragments 42:22

frame 24:18 32:13

free 32:8

free-flowing 37:22

freeway 36:13,17 37:12 43:20

Friday 5:1

from 9:3 10:25 11:17 19:3 21:12 22:23 26:8 27:8 30:18 31:11,13,18 33:9,13,20 38:8 39:9 41:7,24 42:9,23 43:7 44:16 45:7 48:16,17 50:3 51:1, 20,22 58:3,4,13,14 61:3 62:24 63:6,21 64:4,8 68:17,24 73:6, 11,14,22 74:16 75:23 77:2,8, 17 80:13,21 82:12 86:12 87:23 89:2 90:17 94:9 99:5 100:3 102:18 103:2,4,19 104:6 105:8 106:16,19,24 109:6,17,25 110:24,25 111:12,14 112:1 114:16 115:6

front 8:10 40:24 41:16 45:21 50:22 88:5 90:19 94:6 101:2

full 9:19 78:19

fully 55:6

function 29:11 70:1

functionality 98:1

funding 21:2 29:16 42:8

further 77:16 81:12 86:21 89:3 91:13 96:8 100:8 101:4

Fuzzy 23:4

G

G-U-P-T-E 12:9

gave 47:8 65:10 76:6

general 11:5 24:15 39:14 69:19 120:15

generally 45:4 61:9 62:4

generate 66:20 75:1,13

generates 63:14

generating 66:15 67:13,20

generation 119:2

generator 104:9

generic 64:13

getting 40:16 72:14 117:22

give 7:23 9:10 19:1 24:15 32:7 34:13 45:12 48:13 51:24 60:25 71:10 72:19 87:16 93:16 99:6 102:10,17 109:3 114:4 119:15, 17

given 24:22 25:11 36:14 52:21

gives 27:8 29:6 52:22,24,25 59:20 71:6,7 101:11

giving 102:3 115:1

glare 49:4 50:20,21 56:9 70:19 79:9 92:13 94:7,14 95:2 99:21, 23 100:17,18,21 101:3,9,15, 20,24 111:18 112:17 116:10

go 10:10,11 11:7,8,24 12:15 19:9,20 20:8 21:21,23,24 23:21 24:4 28:24 31:1,24 33:14 36:2 38:11 42:5,11 44:23 45:12 48:12 49:21 50:6 51:10,23 58:12 59:25 63:19 64:18 65:4 70:5,9 71:1 72:23 74:14 75:15 76:2,8 78:5,9 84:4 85:18 86:5,18 87:18 91:10 93:17,25 97:16 99:19 103:16, 17 104:4 107:24 110:7,9 116:11 117:12,16

goes 52:15 61:4 64:4 68:18 69:4 71:21 110:4 111:14 114:16

going 7:23 18:12 19:2 25:21 27:2,23 28:23 32:18 39:19 44:20,21 46:20 48:3,4 58:2 59:21,22,23 72:13 79:4 80:6, 10 88:13 100:23 105:22 107:8 111:17,19 115:11 116:3,18 119:23

gone 11:19

good 5:11,12 17:2 91:10 119:25

got 32:25

Government 118:19

governments 101:7

GPS 87:17 88:4,7,12,18,21

graduate 45:20

grants 19:9,11,15

graph 27:14 34:10 38:11,12, 13,16

graphical 29:14,15 66:8

graphics 38:7

great 5:11 6:6 70:11 75:20

greatest 28:14

green 66:9,15,17

ground 15:2 30:22 43:10 83:1,22 84:10,11,12,15 87:4 89:20 93:6,20 99:12

group 20:11 66:14,24 67:8 103:18 115:21

grouping 66:19 67:12

guess 8:16,22

Gupte 12:9

guys 81:1 90:5 121:12

H

had 7:5 9:21 10:13 14:12 18:13,21 21:4,12,22 32:8,9,10 41:14 42:2,5,6 44:9,11 45:13 46:6,8 56:9,20,21 91:14 92:9 110:7 120:2

hand 119:18

happen 13:3 102:10

happening 15:9 62:18 78:16 83:9

happens 28:18 71:19,24

hard 17:25

hardcopy 121:22

hardware 31:12,13

has 10:20 11:19 13:4 14:6 17:22 34:14 35:19 43:16 51:1 54:5 55:20,22 58:25 66:5 67:16 73:11,13 74:8 78:19 80:13 82:2,19 84:2 90:18,22 92:4 95:9 98:24 115:16 118:9, 13

have 6:6,11 9:19 10:11,12 11:5,10,12,21 13:10 15:8,9,14 16:10,18,20 18:22 19:21 20:6, 22 22:17 23:15 25:21,23 26:17 27:3,7,23 29:19 31:8,10 32:1, 10,18 35:3,9,12,13,15,17 36:2 37:17,23 38:1 39:1,5,6 41:10, 15 42:8 44:2,12 45:3,13,16,19 46:4,10,13 47:2 49:17 50:13, 17 51:2 53:9,10 54:20,22,23 55:3,13 56:23 57:9,19 61:10, 14,23 64:2,4,16,19 65:12 66:16,20 67:12,14,15 70:5,7 72:1,7 74:11,13 75:15,16 76:1 77:16 78:24 79:1,13 80:7,9,10, 13,15 82:9,11,12 83:22 87:10, 11 88:5,13,21 90:1,2 91:10,13 92:3,6,11 93:11,13 94:1 95:1, 2,7,12 96:21,22,23,25 97:1,8, 21 98:6,14,20 99:4,12,22 100:20 101:7,19,22 102:10 108:5,9 109:4,16 110:15 111:5 112:3 113:6 114:6 115:13 116:11,17 117:4,14,21 118:8, 12,19,24 119:4,15,16,21 120:2,8,21,22,23 121:6,9,16

having 5:7 11:22 26:2 49:3 56:11 78:25 80:10,16 81:10 85:18 90:11 111:16 119:5 122:7

head 56:14

heading 42:18

headlamp 53:18,19,22 57:1 75:6,13 77:18,20 79:20 88:1 92:2 94:16,17 95:21 97:25 103:3

headlamps 78:4 94:4 100:25 101:8

headlight 12:11 47:12 48:6, 23 49:10,12,15 51:14,16 58:18,20,22,24 59:5,6,9 60:17 61:3,5,7 63:7,12 68:16,19,25 69:5,8 70:20 72:21,24 73:6,7 74:9,10 76:22 86:9 101:12 102:23 103:9,20,23 104:1 106:20 107:10,15,25 110:3,5 112:3,4,13,14 113:11,13 114:5,15 119:8

headlights 10:3 12:11 13:7 18:10 27:9 38:25 39:20,23 40:18 41:18 49:9 50:24 74:8, 19 77:7,8 79:1 80:1,8 86:6,15 88:10 90:20 94:10 110:12 111:14 112:17 117:13,18 118:11 119:5 120:10,14,25

heard 55:13

heat 119:7,8 120:1

heated 31:15

heating 14:7

heavily 46:18 120:10

height 25:10 30:18 45:17 120:9

help 18:12 22:4 27:11 34:15 43:12 44:14

here 5:22,24 6:2 7:6,23 8:13 9:14,21 21:11 25:18 26:21 28:13 30:9 31:17 32:2 35:1 37:19 39:11 44:7 45:2 49:3 53:21 54:24 56:12 57:16 63:25 64:1 70:4 78:11,16 80:5,18 82:10 92:17 94:13,14 104:2 105:10 108:18,25 109:23 111:8 117:1

herein 73:10 74:24 80:24

high 48:10 49:12,16 50:1,10 51:24 52:4,9,13,17 56:8 58:22 59:9,22 60:18 64:13 67:15 73:15 76:24 77:14 79:9 80:10 100:5,7,10,13,15 101:6,18 110:6,10 118:19 121:8

high-end 57:3

high-level 52:12,14 57:11 62:8 63:24 107:14,17

higher 113:18

highlight 38:6 116:19 119:20

highlighted 26:15 66:17 67:14 110:8

highway 13:22 25:20 26:25 32:20,21 35:2,23,25 37:22 44:22,23 117:23

highways 35:8,9 42:9

hill 121:8

history 117:13

Hogan 7:13 9:16

hold 19:22

Homeland 20:10

Honeywell 22:10

hope 89:16

hour 105:23

hours 9:10

HOV 22:12,16,19 23:11 42:10

how 6:9,25 9:5 13:6 16:25 34:3,4,7 39:3,9,15,22 41:20 52:22 55:9 56:25 57:7,15 59:17 68:2,10 76:12 85:1 88:23 91:7,8,21 98:14,18 107:6,15 108:7,16 109:3,4 111:21 113:2 114:10 116:12 117:19,25 119:23

However 120:18

huge 42:2

Hughes 14:17 16:5 29:13 36:9 46:24 47:19 58:6,9 61:18 65:8, 13 68:4 69:11,17 75:10 79:22 81:2 84:18 85:13 90:6 105:22 106:1 107:13 110:23 113:21 121:13,16,18,20,21,23 122:1,

2,5

human 21:9

humidity 72:13

hundreds 15:14

I

I'D 106:4

I'LL 8:15 106:7

I'M 7:23 12:22,23 22:21 23:1 25:18,24 28:11 32:18 34:5,6 36:16 48:3,4 51:7 56:15 57:14, 25 59:19 69:24 79:10,24 80:10,12,20 82:8 83:13 85:3,7 90:10 92:17 96:18 98:2,13,14, 18 100:23 102:11 103:13 108:19 121:11

id 88:2

idea 20:13 116:20 118:24

identification 19:7 30:24

identified 68:11

identify 61:16

III 30:1

illuminance 99:20 101:6,12, 14,23

illuminate 77:21

illuminated 48:9 49:12,16 94:6 97:20 101:2 104:10,12

illuminating 85:17

illumination 49:24 51:3,12 76:18 77:11 88:1 96:7,21 100:8

illumination.' 103:1

illustrate 64:24

illustrated 63:13 68:3 69:15 75:2,14 113:19

illustrates 51:11 107:15

illustration 29:15 63:5 68:24 106:19

image 26:23 29:12 33:15 40:9, 20,21 41:1,5,9 42:23 43:25 44:4 45:8 60:8 66:22 67:21 80:8 94:16,24 95:20 96:25 97:1

images 14:10,14 26:8,11,16, 19 27:6,7 28:13,15 29:10 40:25 41:8 60:12 112:9

imaging 13:4 14:8 23:6 53:10

impact 31:13 43:2 113:8

impacts 97:13

implement 94:1 120:20

implementation 32:11

implementations 16:21 55:22

implemented 56:19

implications 36:8

important 22:14 24:2 44:16 48:13 57:18 63:4 80:18 109:24

improve 117:25

improves 95:10

inaudible 67:1 108:3 118:13

Inc 22:10

incandescent 120:16

incident 13:9,12 101:15

include 17:3 86:9

included 86:15 88:3 117:4

including 6:10 12:6 49:20 89:5 101:8

incoming 41:9 104:23

incorporate 40:17,19

incorporated 86:7,14

increase 78:20 92:12

increases 92:11

increasing 76:18

indeed 9:1 43:20

independent 84:23 85:6,8,9, 10

independently 49:25 52:3 100:9

indicates 58:18 59:4 77:5

individual 55:6 71:2 73:7 85:25 86:10 103:13

individually 55:8 63:3 72:21, 25 86:3 103:8

individually-controllable 48:7

individuals 41:22

inferences 12:12 79:14 97:10

infinite 114:4

influence 113:7

inform 88:13,23 108:14

information 11:22 12:11 18:18 28:10,12 29:7 30:20 31:9 32:7 35:11 40:19 45:3 58:13 61:23 71:6,7 80:13,15 87:23 88:11,22,23 94:20 95:25 96:10,11,12,25 97:3,4,6,11,19 109:3,16 111:10 120:3

information.' 88:4

informative 52:21

informed 41:7 98:12

informs 59:17 60:15 110:5

infrastructure 20:17 33:13

inherent 25:14 34:18 37:7

inherently 17:25

initial 26:18,22 27:9 40:7

initially 58:24

input 104:8

inputs 87:25

inside 22:11 23:24 29:19 78:14

install 31:25 36:3

installed 43:8,9,16

instead 26:2 72:13 78:25 80:10

instruct 77:11

instructs 95:4

intelligent 10:17 11:3,6,19,25 13:5 37:13 42:7 117:15 119:5

intense 103:1

intensities 39:10 50:1 100:10,14

intensity 55:7 99:24 100:16

101:7

intentions 12:1

interacting 12:4

interaction 68:6

interest 34:5 50:18 80:11

interested 34:6 100:20

interesting 39:6 46:17,19 56:6 109:24 119:1

intersecting 64:3

intersection 35:6 64:5

intertwined 110:16

introduce 92:7 117:18

introduced 92:4 120:5

introduces 60:5

invention 49:7,22

involved 7:19 15:6 22:20

involving 9:8 10:2

IPR 6:3,4,12,15 8:2,9,16 9:3 19:3 65:12 75:23,24,25 76:2 81:19 84:18 99:5,9

IPRS 6:3 9:8

irradiated,' 89:11

irradiated.' 89:13

irradiation 89:6,7

issue 112:24 120:24

it's 7:2 9:4,7 12:23 13:1 14:6 16:17 22:6 26:24 27:14 28:1, 14 29:15 32:2 33:7 34:3 35:10, 19,20 38:22 40:3,15 41:1,3,16, 19 45:25 46:22 47:11,15 48:2, 12 50:12,14,16 51:14 53:6,16, 25 54:18 55:12 56:14,17 58:2 59:10 64:11 66:11 68:12 72:8 75:22,23,25 79:4,8 80:18,25 82:18 83:10,12 84:14 85:25 87:17,19 90:21 93:20 99:8 101:14 102:6 105:5,19 107:5 108:16,17,23 109:4,8 113:11, 17 115:11 116:21 117:22 120:11 121:3

ITC 6:10,11

iterations 11:20

itself 46:7 86:19

J

Joe 7:11

journal 21:23,24

June 22:24

just 8:15 11:1,8,14 12:17 14:6 17:8 19:22 22:3,6 23:2 26:13 29:14 32:25 35:16 40:5 41:1 47:5,8,16 48:2,5,15 50:3 55:5 56:17 57:15,24 58:9 65:1 67:11 68:12 71:21,22 72:19 73:16 75:3,5,7 78:7 79:13 80:19 84:9,11 98:11,14,18 102:3,17,20 103:11 107:5,15 108:19 114:4 121:13

K

Kansas 15:15 16:7 19:19 20:5,7 32:9,12,15,18,24 33:3 36:21 37:10 41:25 45:13

keep 11:17 56:8

keeping 49:11,14

keeps 50:10

key 38:14

know 5:22 8:17 12:14 14:3 21:19 22:16 25:24 34:3,4 36:3 43:18,21 55:11,13 61:22 72:16 79:16 84:6 90:2 92:20 99:1 118:23

knowing 44:4

knowledge 42:23 120:13

known 43:17 44:8,12 98:7 116:12

Kobayashi 87:5,8,10,11,15, 18,21 88:8,12 89:2,3

Kondo 89:21,24 90:2,3,14,18 91:3,7,16,23 93:7 95:13 96:19, 22,25 97:4 98:4

Kondo's 92:1

L

lab 14:10,14 32:5 37:18

label 8:3

lamp 95:4,17 97:12

lane 22:12,16,19 43:21

lanes 12:3 42:10

laptops 14:11

large 15:7 17:14,21 36:13

larger 58:23

last 5:13 8:19,23 33:21 48:22 49:21 50:5 81:25 82:1 103:11

late 29:21 117:22

later 22:4,7 41:2 52:3 92:5

law 7:13

laws 101:7

lawyer 82:8 83:13

layman 82:8

leading 49:1

least 30:6 56:11

LED 52:25 53:1 54:6,8,12 55:8,13 56:5,18,24 59:18,21 60:20,22 62:14,18 63:13 64:20 79:13 85:24 86:4,11,21 92:15, 16,21,24,25 106:19 108:17 109:1,14 114:10,11 115:13 116:4 118:16 119:10,16 121:1

LEDS 48:7 54:10,14,25 55:18 56:15,25 57:4,8,13,24 64:23 66:8,14,19 67:7,9,12,20 68:6 77:12,14,17,19,23 78:18 86:13 88:23 91:16,18 92:4,10,21 107:16 110:19 111:6,16 113:2 115:17 116:17 118:25 119:6, 11,21 120:5,15,25

left 30:1 53:19 54:2 58:15,17, 20 60:5,11,13 66:11 77:2 89:11 90:20 108:6 109:19,20 110:11 112:3

legality 114:18

length 25:10 30:17 42:21 61:22

lengths 14:8 43:22

lens 61:3,7 62:4 63:19 68:16, 20 69:8 70:12 113:9,11,14,19 114:1,7,15

Lenses 70:4

less 10:20 31:12,13 50:18 82:2

let 8:17 10:10 11:7 32:15 35:21 37:12 42:16 44:15,18 47:25 48:2,21 60:22 64:15 68:13 78:5 80:19 84:8,17 85:2 87:17 90:23 99:18 103:16 105:17 110:8

let's 8:4 12:15 19:13 42:11 45:12 51:23 57:7 58:1 71:1 82:9,11 88:16 99:19 105:24 106:17 117:12 119:19

level 10:21 11:4 21:6,9 64:13 82:3 99:21 100:1,17 101:20,23 102:2 113:18 115:11

Lexus 92:3 116:25 120:4

liability 44:18 46:4

license 11:16 45:4

lie 76:22

life 25:7

light 11:11 15:12 20:19 39:10 40:6 49:23 50:17,18 51:2 52:2,8 53:7,15,22,24 54:3,16,18 58:15,16 59:16 60:3,4 61:3,12 63:2,9,10,22 66:21 68:7,17,21,22,23 69:2,4,25 70:11 71:19 72:5 73:1,2,4,6,11,12,14 74:14,16,20,21,23,25 76:11,16,21,24 77:2,5,25 78:2,4,20 79:5,13,19 80:10,16,21,22,23 85:11 88:25 90:11,12 91:22 95:1 97:25 98:11 100:3,5 103:4,8,12,18 104:13,16 105:1,2,5,6,21 106:16,22,24 107:4,11 111:17,18 113:12,14 114:16,19,20,21,22 115:16,22 116:1 120:16

lighting 10:3,19 17:2 24:1 25:6 54:9 61:1,4 63:8,12 68:15,17 69:1,6 76:23 86:10,11 89:8 105:13,18 107:3 114:14,16

lights 11:22 79:12,21 80:20 90:17,19 93:25 94:19 95:2,5,8,23,24 96:2,5 97:14,20,21,24 98:6,10,11,21,25 99:1 101:17 109:25 112:7 119:2 120:19

like 6:18 7:19 13:11 14:15 20:21 26:3,10 31:6,7,25 32:9 39:5 41:19,25 44:12 45:17 62:11 70:9 71:16 78:17 80:8,9 82:13 88:15,17 89:2 93:6 94:9,19 95:24 102:21,22 106:4 113:16 116:22 118:6,22 121:5,7,19

likely 42:8

Likewise 59:3

limitation 84:6 85:20 86:4 95:14 96:17

limitations 85:12,24 91:5 96:6

limiting 101:7,11

line 15:20 64:4 104:9,10,12,15,16,20

linear 55:19

lines 51:20,21 64:3

liquid 71:11,13,15 72:7

list 8:9 10:5 19:11,23

listed 9:25 10:5 75:24

literature 17:21

little 17:23 22:3 24:16 44:14 48:2 75:24 81:23 105:23 117:13

location 13:24,25 30:20 35:8 42:21 44:10 62:2 77:7 96:10 97:2 104:11 115:15

locations 44:4 104:23

logic 18:7 26:13,15,20 30:10 36:17 38:2,15 52:24 57:20 60:1 77:4,9 79:11 80:4 97:4 107:6 108:7 110:16 111:15 112:6

logics 120:21

long 21:1 119:22

look 7:3,4 17:11 18:16 21:22,25 28:12,18 34:13 36:11 37:13 39:14,15 47:25 49:17 50:13,15 52:13,18 57:17 58:4 60:2 66:1,23,24 78:12 85:4 90:14 93:23 94:21 108:15 109:15 111:21 116:20 118:4,9 120:4,7

looked 98:15

looking 23:1 57:23 58:1 84:19

looks 93:6

lot 20:9 37:14 39:6 45:10 50:17 55:12 56:6 102:12 112:25 113:7 117:19

loudly 17:17

Lovells 7:13 9:16

low 48:10 50:2 52:5,9 64:24 73:12 77:15 99:22,23 100:2,11,13,14,15,16 101:6 118:20 121:5,7,9

lower 67:12,20

lowest 63:17,18

luminance 118:10

lunch 81:1

luncheon 81:4

M

M-A-S-O-U-D 12:8

made 25:3 37:8 56:22 58:25 72:9 77:10

main 79:25 106:6 118:18

maintained 33:1

maintenance 20:6 26:3 31:13

make 10:10 12:2,12 15:1 32:15 39:3 75:3 79:14 87:16 88:9 96:20 97:10 106:17 117:19

makes 25:9,16 30:20 34:20 36:7 78:19

making 103:9

manual 112:16

manufacturer 99:1

manufacturers 98:20

many 6:9 12:6 28:6 41:20 45:25 47:20 48:3 54:19 56:25 57:7 67:25 105:20 108:16 109:4 113:2 119:14

map 40:20,21 59:12 60:11,13 87:17 88:4,22 109:19,20

maps 88:13 112:9

mark 19:6 64:7
marked 19:4,5,7 24:6 29:2 47:14 51:21 67:15 99:8
markets 56:5
markings 43:21,22,23
mask 27:4
Masoud 12:8
master's 82:9
match 27:15
material 70:9 71:4 72:3,8,10 119:25
materials 72:12
math 26:20
mathematically 39:22
matrix 53:17 54:1,4 55:13 59:21 92:21 108:24 115:13 116:24 118:16,24
maximize 50:23 70:18 74:20 76:11,17 94:6 101:1 116:9,13
maximized 100:7
maximizing 80:1
maximum 51:2,3 112:17
may 10:22 13:10 16:18 20:22, 23 25:21 27:12 33:16 38:13 39:5,6,16,18 47:5 59:1 61:11 65:8 82:4,10,12 88:15 90:1 114:5,6,8 116:17 117:21 119:16 120:23 121:4,9
maybe 34:15 39:1 92:5
MDOT 21:12 29:7 31:11 32:7 33:13
mean 18:4 28:13 33:25 34:13 35:18,22 40:19 42:5 46:2 49:14 52:20 53:8 54:15 56:3, 17 57:17 60:22 69:18,21 84:2, 25 98:22 99:16 105:14,15,16 119:3,14,24 120:3
meaning 100:22
means 31:13 40:20 49:9 63:12 69:6 87:22,24 89:7 92:7 95:3
means' 88:3
meantime 118:2
measure 43:11 101:14
measured 43:8
measures 45:17
meat 38:14
mechanical 10:13
mechanism 54:9
medical 53:9,10
medium 70:6 100:14
meet 7:7,12
Mellon 119:3
member 67:8
memory 16:24 18:20 31:19 33:14 54:20 60:13 104:24 109:21
mention 21:20 24:9 30:4,6 82:10 93:1 109:9,23 120:14
mentioned 20:14 23:9 26:5 33:13 34:9 35:1 36:21,23,25 41:11 42:2 49:19 55:4 61:20 62:7 66:10 98:19,23 112:25 114:13 121:1
mentioning 23:8
mentions 49:20
Mercedes 93:15
merely 94:15 95:18,19,20
merge 31:20 35:8
method 38:9 47:13
methods 51:25 52:2 55:7 98:7 105:6
metric 45:17
metropolitan 36:13
microbeam 103:15,24 104:3 105:2,7,11,18
microbeams 103:9,12,14,20, 22
microcontroller 95:3 97:4,18
mid 11:9
middle 19:16 38:17 44:23 61:1 66:6 118:21
might 50:21
mind 61:16
minimize 50:20
minimizing 80:2 100:18
minimum 99:23 112:17
Minnesota 12:7 14:22 20:9 21:12 29:8 31:11 33:2 37:20 42:4,5,6 44:21 118:12
minute 12:16 34:14 48:13,21 51:24 60:25 71:10 72:19 80:19 87:16 93:16 102:10,17 103:17
minutes 46:23 105:25 121:14
mirror 95:2
misaligned 45:15
mischaracterizes 14:17 36:9 69:12 79:22 113:22
mispronounce 5:19
mix 96:1
mixture 33:7
mode 112:15
model 17:1 27:2,3,8,25 28:4 40:14,15,23 41:3,5,7,9
models 18:11 39:24 118:23
modulator 104:14,16 105:5,8
modulators 119:6
monitor 15:10
monitoring 21:13,14 25:9
monitors 23:24
months 7:3
more 7:2 10:20,22 15:15 16:20 21:6 22:17 25:3,11 29:6 36:3 52:18 57:12 71:6,7 74:14 80:15 82:2,4 101:22 113:16 117:20 118:23 119:17,21 120:15
Moreover 18:1 24:9,22 43:8
morning 5:11,12 28:1
most 13:2 31:18,21 43:19 54:21
mostly 37:2
motion 30:21
motivated 92:11 94:1

motor 86:14

mount 91:16,25

mounted 13:20,21 31:6 35:25 46:6 50:25 54:25 55:2,19 70:20 86:15,20 90:12 91:19

mounting 44:13

movable 90:11 91:19

move 39:9 109:25

movement 12:12 20:16

moves 22:12 89:4 92:21

moving 21:18 31:5 33:6 44:13 91:2,4 92:15,24

Mr 5:10 14:17 15:21 16:5,13 19:2,12 29:13,23 36:9 37:5 46:20,23,24 47:1,19,22 58:6,9 59:13 61:18,25 65:8,10,13,14, 15 68:4,9 69:11,14,17,20 75:10,11,21 76:3 79:22 80:25 81:2,14 84:18,21 85:13,19 90:5,6,8 93:14,19 102:16,19 105:22,24 106:1,3 107:13,19 110:23 111:1 113:21 114:2 121:11,13,16,18,19,21,23,24, 25 122:2,3,5

much 9:5 32:3,4 77:5 79:5 112:24

multicamera 16:7

multiple 16:8 25:4 26:1 36:23, 24 50:19 57:24 113:6 115:18 116:2 119:11

multiplicity 103:19

my 5:25 7:3,17,18 8:14,21 9:20,21 10:10 11:7 12:19 14:19 16:24 18:19,22 19:10 20:14 21:1,21 27:1 31:8,19 33:14 40:14,15,18,23 47:25 48:17 49:3 51:18 52:18 54:20 56:14 57:7 62:7 64:11,12,16, 17 75:17 80:5,17 82:20 84:1 102:5 112:23 115:3,6 119:3

N

name 5:13 42:10 55:18 56:13 117:24

narrow 44:15 103:19

NASA 46:9

National 117:23

Near-infrared 23:4

necessarily 83:21

necessary 42:24

need 9:3 16:18 18:9 22:17 25:15 28:3 30:3,18 31:14 34:19 57:5 75:15 99:24 109:23 111:17 118:19 119:7 121:25

needed 10:21 16:12 82:3

needs 20:21 21:2 23:18 42:22

neighbors 64:21

Neural 23:4

new 27:6 41:10 88:17 119:2

next 21:15 38:1 67:13

night 12:13 15:9 39:1 40:1,3 44:19,24 46:2

Nikolaos 5:6,15 81:9 122:8

no 5:20 7:14,22 8:11 16:6 17:5 26:25 27:1 32:25 37:11 41:3, 21 42:1 46:8 50:18 52:16 59:19 65:14 67:1,2 70:5 71:13, 17 73:15 79:24 80:11 83:19 87:1 96:18 97:8 98:2,18,24 101:17 102:14,18 109:5,15 111:13 117:11

noise 25:5

noisy 28:10,11

Non-cars 29:2

non-glare 116:13

non-shaded 58:20 59:7

non-violating 23:12

noncontiguous 64:22 65:2, 20,22,23

nonexistence 113:4

nor 45:20

notation 67:16

note 8:13,15 22:3 58:17

noted 25:18 63:14

notes 101:16

nothing 71:13 101:22

number 8:9,17 21:24 22:11,21 26:10 30:6 68:11 74:9 75:22 107:2 108:15

numbered 22:1

numeral 42:18 63:16 67:13

numeric 104:17,20

numerical 94:14

numerically 100:21

O

object 34:5 39:25 52:13,16 67:2 109:22 110:2,3,17 112:11,12,13

objection 14:17 16:5 29:13 36:9 47:19 61:18 68:4 69:11, 17 75:10 79:22 85:13 107:13 110:23 113:21 118:18

objective 70:16

objectives 50:12

objects 29:17 39:10 94:11 101:1 110:1

observe 39:17,18

obstacles 12:3

obstruction 27:7

obtain 43:7

obtained 96:12 97:11

obtains 96:10,24 97:2

obvious 83:6,8,10,15,17,23 84:14 96:20 97:22 101:20 102:6

obviousness 83:25 84:7,13

occlusions 25:5 27:3

occupant 23:3 37:1

occupants 22:11,15 23:14

Occupants-the 23:6

occupied 59:1

off 61:11 79:19

offering 6:19

official 23:12

offline 15:1

Oh 19:23

okay 5:18 6:2,6,11,25 7:7,10, 12,15 8:1,9,12,19 9:2,11,18 11:3 12:15,25 14:1 15:22,25 16:3 17:3,6 19:25 20:3 22:23 23:1,20 24:4,20 26:14 27:5,11, 18 28:22 30:5,12 31:5 32:12, 23 33:5 34:7,15 36:5 38:3,23, 25 39:21 41:10,23 44:5,17 45:1 46:15 47:15 48:20 49:5 50:6 51:13,15 52:8 53:2,13 54:13 55:25 56:25 59:24 61:6, 10,14 62:1,9 63:13 64:7,14 65:13 66:4 67:11,19,23 68:2 70:14 72:5 73:16 74:25 76:7 78:8 79:7 81:21,23 82:17 83:3 84:22 85:7 86:2 89:15 90:25 91:12 92:14,19,23 93:2,6 97:15 102:1,4,8 103:15 105:7, 11 106:1,4,8,15,22 107:11,20 108:11 109:10 111:2 113:13 114:3,22 115:1,7,25 117:5 121:1,11

on/off 94:17 95:21

Once 43:24 77:10 119:23

oncoming 49:1 50:22 77:6 79:10 102:25 108:3 116:13

one 7:17 8:15 9:9 10:20 18:13 22:5,6 23:5 27:1 28:7 31:21 32:14,19 34:25 38:6,14 42:5,6 43:16 44:7 45:24,25 46:3 48:13,21 50:12,20 51:24 53:20 54:5 55:4,17,23 57:23 58:1,2 63:15,16,18 64:20 65:10 68:23 71:10 72:19 73:11 74:13 75:7 79:5,8,25 80:3,19 82:2,10 84:9,20 87:16 92:5,17 93:17 96:10 97:2 98:20 99:7 102:10, 17 103:16 105:6,20 106:6,16, 22 108:17,25 109:1 110:7 111:5 112:3,4 114:20 115:14, 17,21 117:17 118:13 119:12 120:5,18

ones 22:2 23:2 26:11 28:23 65:22 66:1,15 67:4 117:17

only 23:10 35:10 65:10 92:21 100:2,13 110:24 118:14

onto 43:25

open-ended 48:3

openings 15:19

operable 49:25 100:9

operate 49:23 70:4 100:12

operating 118:15

operation 29:4 53:1 62:19 98:6

operational 120:8

opine 5:25 111:21 115:3

opined 115:5

opinion 6:19 107:22 111:2,9 115:1,3 117:8

optic 67:23 68:2,11 69:9,10, 15,23 70:3 72:6

optical 10:15 61:12 68:5 70:6, 7 72:9 90:16 94:16 95:21

Optical-axis 90:15

optics 10:3 67:25 68:5,6,7 69:19 113:7,8

optimally 48:25 49:2 108:2,3

order 11:11,16 12:12 13:7 14:9,11 16:1,11 18:18 22:10, 15,18 23:10 27:15 29:15,21 41:8,9,10 45:7 46:10 50:17 56:24 64:24 66:12 76:10 78:20 79:13,14 88:12,24 95:5 98:8 103:9 116:9,12 120:3,13,20

ordinary 10:11,21,25 81:25 82:3 91:8,25 111:10,25

original 38:20,24

Osama 12:8

other 9:8 12:4 15:3 16:8,20 21:14 23:5,22 25:25 27:10 28:12 30:23 34:25 37:3 39:17 49:11,14 52:8 55:7,19 59:10 60:7,14,17 61:1 63:2,4,8 64:5, 22 67:8,10 68:15 69:1 70:8 73:14 75:17,21,23 77:14 78:19,24 80:14 87:24 88:7 94:8,18,19,21 95:22,23 96:1,9, 23 99:4,6 100:18 101:3,9,15, 17 103:4 104:25 105:9 107:3 108:4,24 110:6,13 114:14 115:19 121:3

outcome 32:19,20

output 102:23 103:7,18 104:13,15 105:7,12,18,20,21 111:25 112:21

outputs 88:4

outside 7:12 15:6

over 20:7,14 105:23 121:8

overall 103:20,23,25

overcome 37:24

overlap 110:21,22 111:3 112:22

overlapping 16:10 36:24

Overview 30:2

own 37:2

owner 6:23

P

p.m. 5:2 81:3,7 122:9

page 8:5,10,19,21,22,23 10:11 11:15 17:12 19:10 22:1 26:10, 11 28:15,20 29:24 30:2 33:17 38:11,17,21,22 39:13 42:11,17 48:22 65:6 76:8,14 85:5,21 87:2,18,20 89:2 90:7 91:11 93:24 94:22 99:10 110:9

pair 39:19

pan 43:11

Papanikolopoulos 5:6,15,16 47:3 81:9 122:8

paper 12:8,17,19 13:1,2,13,21 15:22 16:6,15 17:4,6,8 19:5 21:21,23 24:4,17 27:19 28:6 29:21 32:3 33:9,18 36:12 41:24 46:17 102:12

papers 19:14 21:24 22:9 23:2, 22

paragraph 10:25 11:9,15 12:24 13:6 17:12,20 24:7,21 31:9 33:20 42:14 44:5,16 48:4, 18,21 49:6 50:4,7,16 51:11 52:1 54:7 58:12 62:21 64:18 65:5,17 68:14 71:5 72:20,23 73:17 74:17 76:8 78:9,19 81:21 82:22 83:3 84:22,25 85:4 86:12 87:2 89:18 90:7,21 91:11 93:3,17,25 95:18,19 97:17 99:10,11,19 100:3,23 102:22 106:18 107:24 110:9

paragraphs 86:7

parallel 43:22

parameters 24:25 25:10 30:14,17 42:15,19,24 43:6,12, 17,24 44:7 112:25 113:1

park 15:17

parked 25:22

parking 15:17 19:17,18,25 20:4,6,18,24 21:17 36:22

part 12:5 18:14 30:11 43:19 57:18 67:1,9 68:7 75:17 78:6 88:4 106:6 110:4 119:24

partial 39:1

particular 9:9 13:2,21 16:6 18:16 21:2 23:18 26:5,6 29:9 33:11 35:1 36:12 37:11 40:4 46:1 49:17 77:12 93:22 94:15 99:24 102:3,7,24 113:5 115:4, 15

parties 6:14

parts 9:19,20 18:10 27:15 120:13

passes 71:22 73:4

patent 6:1 7:18 8:5,6,8 9:9 47:11 97:16

path 12:2

pattern 44:21,24 45:22,23,24 49:10,12,15 50:10 66:16 75:2, 14 78:4 94:5 103:21,23 110:17 111:12 112:1,10

patterns 46:8 64:8 94:11 101:1 102:23

Paul 15:8

pay 22:17

pedestrian 11:12 13:11

pedestrians 12:4,10 15:10 27:17 41:17

pen 61:14

penetrating 23:13

people 28:8

per 67:6,16 101:13

percent 41:19 120:15

perimeter 21:10

person 10:11,24 81:24 91:8, 24 111:10,24

petition 6:23 84:18

petitioner 6:22,24

phase 105:16

Phenomenology 23:4

Philadelphia 20:20

phone 7:5

phonetic 14:8 18:10 27:7 31:21 64:21 78:23 95:4 105:15 121:6

phosphor 54:23 56:23

physical 54:15,17

physics 10:15

picker 31:24

pickup 119:4

picture 27:20

pink 66:1,2,20,25 67:7,10,20

pitch 41:16

pixel 104:12

pixels 45:7

place 35:22 116:12

placed 60:23 107:6

placement 111:6

places 37:3

plain 16:22

plane 30:22 43:19

plastic 56:23

plate 11:17

plates 45:4

play 113:2

please 5:14 14:5 17:20 24:21 30:5,15 33:18 43:5,14 49:6 51:7 55:15 74:1 83:4 99:10 121:21 122:2,3

plural 53:24

plurality 57:4,9,19 85:25 86:3, 13 103:7

plus 21:14 31:20 110:12

point 21:1 27:1 30:15 31:2,18 42:16 43:25 46:3 61:2,7,8,9,17 62:3 64:2,5 68:16 82:20 114:15

pointed 77:12

pointing 63:17

points 44:3 63:25

polarization 105:15

police 13:8

polycarbonate 56:24 114:5,7

Porsche 55:22 121:5,6

portion 17:12 61:4 66:16,21 67:14,21 68:18 92:25 104:5 114:17

portions 49:10,11,15 50:11 58:19,21 59:6,8 61:5 68:18 114:17

POSITA 10:1,6,9 56:4 77:16, 22 83:5 91:13 92:11 93:25 95:11 98:6,14 99:21 100:20 109:1 111:20,21 116:11 117:2 120:2,13

position 60:3 77:23

positioned 77:19

positioning 77:17

possibilities 114:5

possibility 20:17 92:18 113:25

possible 79:5 105:19

Post-it 8:15 75:24

potentially 59:1

power 58:14 62:20,24 86:22 118:8

preamble 85:15,17

precisely 43:23

predefined 99:21 100:17,21 101:4,18,20

predetermined 101:23

predictable 98:9

preface 64:12

prefer 64:10

preferable 98:14
preliminary 18:2,5 24:10
preparation 7:16
prepare 6:25
prepared 7:3
preparing 9:6,12,23
present 49:7,22 60:3,4 67:2 101:17 112:20
presentation 66:9
presenting 67:9
pressure 72:12
pretty 64:13 70:12 91:10
previous 102:5
previously 5:7 19:4,5 73:10 81:11
principle 73:21,22
prior 14:2 98:15 111:22
private 36:1
probably 5:21 32:10 120:4
problem 5:20 17:25 23:6 24:14 25:16 33:22 34:1,17,20, 23 36:22 37:4,25 38:2 39:8 45:13 51:2 65:14 79:8 119:6 120:16
problems 56:9
proceeding 9:3 116:14
process 37:15 44:6,11 51:12 110:16
processed 26:24 88:11
processes 73:10 96:11 97:3
processing 14:11 26:19
processor 97:9 104:8,18,21, 22 120:24
processors 120:19,20
produce 56:21 105:6,20
produced 67:6,7 105:3
produces 51:24 52:4 73:2 104:9
producing 52:5
profile 87:23 88:3 89:9
project 18:14 20:20 21:12 22:8 23:19 32:12,15,20,21,23, 24 33:8 35:10 36:25 37:10 41:24,25 42:3 119:3,4
projected 91:22
projections 30:19
projects 20:9 23:16 42:2
prone 31:22
pronounce 5:13
properties 70:10 72:2
property 72:12
proposed 84:12
proposing 97:24 98:16
protect 56:24
provide 49:24 84:7 100:8 102:7 103:1
provided 22:10 28:7 40:7
provides 49:7 106:23
providing 49:9
publication 19:10
publications 19:10 21:24
published 12:20 15:23 16:2 22:24 29:22
pure 113:17,23 114:9
purpose 47:23
put 22:2,3,5 32:16 53:11 62:6 119:19

Q

quality 28:13
quantities 43:11
quarter 17:19
quartz 72:8
question 11:24 21:19 36:4 57:6,7 72:16 75:3 79:17 89:16 115:20
quickly 27:24
quite 34:14 109:24

R

rail 20:19
rain 28:2
Ram 121:7
range 50:1 100:10,16
rarely 25:8 43:7
rather 102:6
rays 63:19,21
read 8:5 17:17,18,20 23:2 30:1,3,15 34:15 42:14 49:5 60:22,25 68:13 71:15 74:4 78:7 80:19 81:25 83:3 99:18 104:10,12 115:6 116:10
reading 11:1 12:22,23 24:7,21 33:20 48:5,15,16 50:3 73:16 80:20 90:10 121:17,18
real 14:15,23,25 15:6,11,16 26:19 27:8 28:3,8 29:5 35:5,6, 11 36:17
real-time 19:17,18,23,25 20:4 25:16 34:20 35:2 36:7
real-world 25:4
really 17:2 64:11 89:1 109:8
rear 99:1
reason 28:5
reasonable 91:14 95:12
reasons 28:7 44:18 97:23
recall 27:13 46:2 55:17,21 56:13 106:13 117:24
received 58:24
receives 87:23 94:9
receiving 74:16
recent 19:9,11,15
recently 116:23 118:8
recess 81:4
recognition 16:12 110:17,18 112:10
recognize 7:24 8:24 17:6 76:20

recognizes 40:13
recollection 14:19
reconstruction 16:11
record 9:4 47:15 58:6,10 87:17
records 74:4
recovered 30:18 42:23
recovery 25:9,25 30:14 42:15, 19
rectangle 80:9
red 65:24 66:20 67:12,14
redirected 73:8
reduce 70:18 111:18
reduced 49:4
reducing 116:10
refer 33:22 37:6 47:15 105:11
reference 8:6 22:7 47:16,24 63:16 67:12 68:11 69:7 75:8 76:25 84:13 87:9 89:25 93:9 98:3 106:5 108:23 111:12 117:9
referenced 7:21 12:18 117:5
references 7:4,19 9:25 91:9 98:19
referencing 15:22 22:2 65:16
referred 63:11
referring 17:8 26:12,23 28:15 34:22 39:12 41:23 58:7 85:16 103:13 108:19
refers 69:8
reflector 50:15 74:11,18
reflectors 74:17 77:2,13 78:24 79:2,12,19 80:6 88:19, 21 119:21
reflects 79:19
refraction 70:4,8,13 73:5
refractors 79:11
regarding 97:10
region 30:13
regions 39:2 42:22
register 112:6
regular 122:4,6
regulated 96:3 120:10
regulations 101:16
related 33:3
relatively 17:23
relevant 21:21
relied 10:4 88:18
rely 9:23,25 102:8
relying 85:11,23 86:2 87:8,14 89:24 91:3 93:9 95:14 96:4,14, 16 102:1
remains 110:13
remember 6:14 9:5 87:14
removal 31:15
remove 119:8
render 84:14
renders 83:6,8,10,15,17
renewed 32:25
rent 44:20
rental 46:13
repeat 69:13 75:3 115:20
rephrase 105:17
REPORTER 121:17,19,22,25 122:4
representative 62:17,18 66:24
represents 58:21 59:8
require 26:2 83:24
required 101:22
requirements 121:10
requires 18:7 38:2
requisite 60:16 110:5 112:14
resisting 120:17
resources 14:12 35:3,13
respect 18:15 39:24 72:11 99:20 113:15
respective 52:6 62:23
responding 74:19
response 62:25 73:8 94:11
rest 15:18 33:3 80:11
restricted 43:19
result 26:18 48:22,23 89:10 107:25
results 29:1 98:9
resume 18:22 21:21
return 106:4 119:9
review 7:8,15,20
reviewing 107:21
rhombuses 46:11
rid 102:13
right 8:2,23 11:2 12:15 13:13 16:14 17:11,12 24:8,20 26:7 29:24 30:1 31:1 33:8,21 41:13 42:14,17 47:7 50:3 51:4 52:16 53:18 54:2,3,10 58:15 59:3,6, 7,8 60:9,11,13 65:1,16 66:3, 11,13 69:7 70:22 71:8 72:17 73:25 74:10 75:6 77:3 80:25 81:15,17 82:17,22,25 84:15,22 87:7 89:12,17,20 90:20 91:3 93:2 96:4 99:3,9,12,16 104:3 106:8 108:6 109:20,21 110:11, 20 112:4 114:10 115:2 119:9
risk 45:20
road 27:25 28:1 43:19 44:1,3 50:18 74:12,16 76:17 77:5 79:2,20 87:23 88:2 89:8 97:21 98:21
roadmap 87:23
roads 89:4,6
Roman 42:18
rough 121:25 122:3,5
roughly 120:6
route 89:5
row 28:18 57:23,24 103:17 104:4 115:17
rows 57:24 108:15,24 109:4 115:18 119:11
rudimentary 38:7
run 32:6

running 38:3

runs 120:24

rural 88:20

rust 27:10

S

S-A-L-L-Y 9:14

safe 11:17

safer 88:10 117:20

said 10:4,5 14:13 16:14 19:22 22:23 35:15 36:11 37:11 38:3 44:20,25 107:14 109:15 114:22 117:6,11

salient 27:11

Sally 9:13

same 9:8,16 12:5 21:11,12 23:8 26:1 41:1 60:9 75:22 77:6 78:7,22 79:5,11,12 80:3,8 82:23 91:20 92:10 93:3 94:3, 15 95:20 116:7 120:11

satisfying 85:11,23 86:3 91:4 96:14,16

say 9:9 16:18 23:15 27:11 30:11 37:11 39:23 41:9 45:12 47:23 48:4 52:13 53:24 66:23 80:18 82:11 85:7,15 86:5 99:20 103:11 107:17 113:23, 24 114:9,24

saying 25:19 27:18 36:5,16 37:9 57:12,14,23,25 59:14,18, 19 62:14 67:11 79:19,24 91:24 96:18 98:3,14,18 109:6,13 115:18

says 8:11 19:16 38:24 48:3,13 49:21 54:6,8,12,24 57:4 58:13 59:3 60:2,4,10,25 62:20 63:5, 15 69:4 71:1 72:23 74:15 76:14 85:17 91:13 96:7 97:17 101:19 103:17 106:18 107:3, 24 114:25

scale 57:17 61:11,21 82:15,16 109:5

scenario 35:1 39:5 108:4 112:19

scene 25:20 26:1 27:21,22 30:21 40:9,23 43:7,18 44:8,11, 12 45:12 104:6

scenes 25:5

schematic 52:14 57:3,11,15 63:24

schematics 52:12 62:8

scheme 45:7

science 10:16

scope 21:4 23:19

Scott 7:9,11 9:13

scroll 85:20

second 8:23 19:22 21:9 30:13 35:13 37:25 52:6 58:2 66:25 67:1 71:4,14 76:9 80:3 96:13, 15 97:6,11 105:16 116:15

seconds 40:10,11,12 41:1,4

section 42:15 53:8 60:19 63:6 68:25 73:11 84:24 106:20 115:25 116:1,3

sector 51:25 52:4,6 67:7 68:23 73:7 114:20

sectors 52:3 72:21,25 74:13, 14

security 20:11 120:24

see 8:4 15:19 19:11,13,16,23, 24 21:23 22:13 25:19 26:9,17 28:25 29:4,5 31:17 32:2 33:23 35:19,22 36:19 37:20 38:11,20 40:13,24 41:11 42:16 45:2 48:25 49:2 50:19 52:12 53:14, 15 55:5,10 56:9 57:3,7 58:13 61:20 62:16 63:15,18,20,25 64:1,19 65:24 67:5 74:7,21 76:13,18 78:9,13 79:4 84:17, 20 85:2 86:7 88:2 90:7,23 96:7 98:19 100:20,21 103:16 108:1, 3,21 110:15 111:7 113:16 117:1,12 121:8

seeing 118:23

seen 121:6

sees 40:14 100:2

segment 52:2 62:12,15,25 63:20,22 64:6 67:6,16 86:24 106:23 110:21

segmentation 30:7

segmented 47:12 49:23 51:12,14,16 58:18,22 59:5,8 63:12 69:6 72:20,24 74:22,23 80:22,23 86:6

segments 49:25 60:17 73:14 76:21,23,24 100:9 110:5,6 112:14 114:8

select 108:8 112:16

selectable 52:25

selected 19:9,11,15 100:15 103:19

selectively 50:11

semiautonomously 11:23

send 79:4 97:10

senior 13:3

sense 69:18,19 73:8 94:20 113:8

sensed 52:7 59:2 63:1 66:6 73:13,15 95:25

senses 74:16

sensing 13:5 19:21 33:15 74:22 80:22

sensor 13:15 14:9 31:2 36:6 44:10 60:3,5,9,11 80:14 87:24 88:4 94:16,24,25 95:1,2,20 96:25 97:1 103:4,6 104:6,13, 16 108:6 109:10,11,14,19,20 112:3,4,9

sensors 16:3,4,15,16,18,19 22:20 31:6 33:5,6,10,12,15 34:23 36:3,14 37:18 46:6 77:3 94:10,23 111:15 112:6

sent 58:14 63:10 69:5

sentence 17:19 33:21 34:16 36:5 37:6 44:6 48:22 49:21 50:5 82:1 103:11

sentences 82:1,7

separate 16:18 29:17 55:5

sequence 53:15 58:5

serve 10:23 82:5

serves 31:19 33:14 54:20

serving 42:2

set 26:5 37:19 42:2 47:5 59:12 70:17 121:11

setting 101:5,22

several 7:5 11:20 23:22 53:7 92:8 94:23 95:7 113:1

shaded 58:17 59:4

shadowed 108:8

shadows 24:2 25:5,23 27:3 28:2

shape 54:13,16 56:15,17 59:17 60:20 111:11 113:9,13, 20 114:11,23 115:8 119:10,12 121:2

shapes 24:23

share 75:19

she 9:15

she's 9:15

should 22:5 25:18 26:4 75:25 84:19 85:6 91:22 102:18 120:18

shoulder 89:11,12

shouldn't 70:16 116:15

show 16:25 41:15 62:12

shown 29:1 38:17 51:9 52:9 53:21 54:4 55:1 57:1,13 61:8 67:23 70:25 72:18 73:13 74:3, 6 77:18 78:3 92:2 106:24 107:12 114:11 115:8 116:5

shows 11:20 40:1,4 57:15 60:1 86:19 89:3 110:18 115:17,21

sic 15:7 29:18 33:12 41:16 79:11 89:13 102:15

side 8:13 13:22 22:3 30:2 35:25 42:17 79:2,20

side-view 51:16,18 52:15 53:4,6

sides 78:1 116:18

sign 18:10

signals 11:12 104:7

signature 8:21,22,24,25 122:7

significant 49:8

significantly 43:2 58:23

signing 121:17,18

similar 10:16 20:9 38:9

similarly 10:22 63:3,8 69:2 82:4 91:23 94:4 100:23,24 107:3

simple 24:25 70:12

simply 18:1,5 24:10

simulation 32:6

since 7:2,3 11:6 15:19 22:1 43:9 52:12 66:5 95:7

single 24:23 25:11 57:24 73:1

sir 12:22 103:17

site 20:17 35:18,23 37:20 38:8

sites 33:4

sits 121:5,9

situation 13:10 119:20

six 7:2 30:4,8,9 40:11

six-wheeler 18:19

sizes 24:23

skill 10:12,22,25 11:4 81:25 82:4 91:8,25 111:11,25

slice 53:6,8,25 57:3,10 58:1,2 66:7 107:1 115:10

slices 53:7,11 59:12

slightly 40:15

slowly 25:21 117:1

small 82:18

smaller 18:15

snapshots 28:25

snow 31:15

snows 28:1

so 6:19 7:2,7 8:15,22 9:2,3,9, 15,18 10:4,24 11:3,8,12,19,24 12:14,15,17 13:9,13,23 14:7, 13,15,23 15:4,18,19 16:9,14, 15,22 17:1,5 18:4,9 19:2,5,20 20:8,18,20 21:1,5,10,16 22:3, 5,6,8,14,18 23:8,15,23,25 24:6,7,13 26:4,7,10,22,25 27:18,20 28:2,6 29:5,10 30:8 31:1,5,15,23,25 32:2,18 33:8 34:2,7,22 35:8,10,12,19,20 36:2,5,16 37:6,13,22 38:1,3, 12,16,19,20,24 39:2,3,7,22 40:1,2,13,25 41:5 42:8 44:5,9, 10,19,25 45:6,7,10,12,24 46:5, 10,11,16,18 47:18,21 48:3,21, 24 49:14,20 50:3,6,9,19,20 51:9,25 52:1,8,16 53:2,3,21 54:5 55:8,16,18,22 56:9,10 57:3,7,12,15,22 58:2,12 59:10, 14 60:2,4,7,19 61:6,7,21,23 62:14 63:13,16 64:1,15,16,21 65:1,11,16,19,24 66:2,5,23 67:4,11,19 68:5,7,20 69:7 70:4,11 71:1,8,9,10,16,19 72:4,5,7,11,13,17,18,19,23 73:16,19 74:3,7,15,25 75:5,12, 21,24 76:2,4,13 78:5,6,11,16 79:3,4,8,9,18 80:5,9,15,16 82:8,11,13,25 83:7,12,14,20, 22,23 84:6,10,15 85:7,10,14, 16,23 86:5,21 87:4,18,19 88:7, 15,21 89:20 90:7,10,14,18 91:3,7,10,24 92:3,5,9,10 93:6, 14,16 94:6,13,21 95:7,14,17, 19 96:1,4,7,14,21,22,25 97:7, 24 98:13,16 99:7,12,16,18,20 100:6 101:1,13 102:1,8,16,21 103:15,17,22,24 104:4,25 105:2,7 106:8,11,22 107:1,5, 11,15,16,20 108:1,11,15,25 109:3,6,10,13 110:7,8,9,15,20 111:2,9,20,22,24 112:19,20,24 113:9,19,24 114:8,22,23 115:7,17,21,25 116:2,7,16,20 117:2,5,8,12,16,17,22 118:7, 17 119:9,18 120:1,2,12 121:1

Solution 23:7

Solutions 6:18

solve 25:15 34:19 35:14 37:4, 23 38:3

solving 39:8

some 7:4,18 9:19,20 10:1 11:7 23:17 26:17,20 27:8 28:2 29:4, 18 34:14 37:15 39:24 46:16 49:10 50:11 51:25 52:1 56:7, 23 72:2 82:9 92:16 94:13 117:18 118:25 120:22

somehow 117:22

someone 39:16 44:23 45:17 92:6

something 6:18 14:20 18:18

21:20 27:13 32:5,13 38:10 44:15 45:13 46:19 55:11 56:5 69:24 71:14 78:12 80:7 83:14, 17 88:15 91:22 92:6 109:24 115:11 116:22 118:5 120:10

Sometimes 46:9

somewhere 61:10

soon 112:5

sorry 12:22 22:21 28:11 42:17 51:7 56:15 58:8 60:16 85:7 93:11 102:11 108:19

sorts 24:3

source 53:22 58:14 85:11 86:23

sources 53:24 54:3 74:25 80:14 90:12 103:8,12

space 45:19,20 59:1

spatial 104:6,13,16 105:5

spec 106:17 114:25 115:2

special 119:6

specialized 120:18

specific 117:3

specifically 87:18,21

specified 43:24 61:4 68:18 114:17

speculate 110:24 111:4

speculation 61:19,21 107:16 112:24 113:17,23 114:9

spent 9:5

spherical 119:16 121:2

sporting 15:7

spot 39:11

spread 106:12,15,24 107:12, 22 108:12

square 101:13

St 15:8

stack 119:12,13

stacked 115:18

stacks 116:3,7 119:11

stage 30:6,19

stages 30:4,8,9 34:12

Stam 93:7,9,12,13 94:2,3,9, 13,15 95:13,15,17,19,20 96:14,16,20 97:18 98:5 99:13, 17 100:23,24 101:4,11,25 102:1,7

stand 38:12 58:11

standard 56:13 95:10 116:21 117:6,10 118:4,10,12,16

standards 18:16 55:17 98:24 117:18

stands 118:4

star 22:2,5,6 32:16

start 72:14 85:6 118:23 120:3

started 32:15,21 55:21 85:15 117:23

starting 17:13 27:1 49:5

starts 17:19 93:4,20

state 15:15 19:18,19 20:2,5,7 50:2 71:3,4,9,12,14,16,25 72:1 100:15 118:9

state.' 100:11

statement 9:21 116:11

statements 46:16 117:3

states 30:23 71:9,11 118:8

static 25:22

station 20:15,19

stationary 25:22

stays 21:1

steering 80:14 88:22

step 21:8 30:23

steps 18:2,5 24:10 30:23 34:12 38:14 41:11 52:25 60:15 112:8

stereo 16:4,15,17,19 25:8,14 34:18,23 35:12,15,17 36:6,24 37:7,23

still 13:1 15:20 46:18 60:4 61:14 114:7

stopped 24:8

stores 104:24

straight 89:6

streams 37:15

street 11:13 20:15

structural 78:23 91:4

structure 25:25 34:9 53:12 54:15,17 59:11 77:18 79:6 86:14 90:11 91:1,4,15,20 92:1 98:17 105:12,15 107:2,9

structures 96:15

students 45:21

stuff 24:3 31:17,25 32:8 41:10 66:25

subset 92:16

substitute 10:23 82:5

substrate 55:1

subtle 27:11

success 91:14

such 12:2 18:10 25:10 27:9 30:17 39:9 43:11 48:7 61:3 62:23 68:17 74:17 77:18,24 80:14 91:18 94:18 95:23 100:2 101:20,21 114:16

sufficiently 77:20 78:1

suggested 44:19

suggesting 98:13

summarize 12:14

supply 62:24 86:23

supported 12:6

suppose 58:1 82:9 88:16 119:19

supra 86:7

sure 5:15 10:10 15:1 24:5 32:16,17 48:1,2 51:6 75:4 87:16 99:11 102:20 106:18

surface 55:20 73:2

surrounded 29:1

switch 53:14,21 58:19 59:5 60:17 62:23 66:10 76:23 86:23 110:4,6 112:14,16 115:14 116:5

switched 77:13,15

switches 58:19 59:5

swivel 90:19 91:1,4,15 92:1,4,9

sworn 5:7 81:11

symbol 67:6

symmetry 45:6,8

system 11:4,25 12:6,10 14:5 15:6,14 16:7,17 19:17,19 20:1,2,5,7 22:18 23:3 27:18 29:5 31:2 37:22 40:13 47:12 48:6,24 49:24 50:10,16 62:19 76:18 77:1 79:10 91:16 92:4,10,20,21 93:24 94:2,16 95:21 97:22 100:8,12 101:21 102:21,23 103:3 105:18 107:25 108:9 112:5 117:15 120:4,7

systems 10:18,19 11:6 13:5 14:3,24 16:8 33:3,15

T

T-U-C-K-E-R 117:16

Table 85:3

tabulation 60:14

taillights 13:7 18:11 27:9 41:18

tailored 21:3

take 9:10 17:11 23:21 46:21 47:4 98:4 105:24 115:10 120:1 121:6,13

taken 26:4,23 41:1,6 46:25 81:4 106:2 121:15

taking 27:20

talk 84:10

talking 27:10 28:13 29:20 34:16 59:11 76:5 92:15,17 107:9

talks 68:21

task 15:9 18:2,5 21:16 23:13 24:10 25:3 55:23 119:18

tasks 42:3

taught 84:4 91:15 101:24

teach 111:24

teaches 98:3 100:6 111:23 112:2

teaching 87:9,15 89:25 93:10 95:15 96:5 102:2,9

teachings 94:1 97:22 98:5

technical 70:2 82:19

techniques 23:9 98:8

technology 10:2 32:10 35:17 50:20

tell 9:7 32:1 44:15 47:20 57:2

temperature 72:4

temporary 40:18

ten 105:25

term 55:14 85:18 103:14 105:11

terms 70:2,12 84:3

test 44:9

testified 5:8 81:11

testimony 14:18 36:10 69:12 79:23 113:22

than 7:2 57:13 58:23 101:22 118:11 120:16

Thank 81:16 90:4,6

that 6:14,18,22 7:20 8:24 10:9,10 11:20,25 12:6,18 13:4,10 14:6,12,24,25 15:1,6 16:1,9,10,11,14,23 17:19 18:7,8,12,13,21,25 19:6 20:5,22,23,25 21:2,4 22:3,9,13 23:15,24 24:6,13,15,17,21 25:18,21 26:2,3,5,6 27:11,16 28:7,8,17 29:16,20 30:9,21 31:10,17,25 32:13,14,21 33:20,23 34:3,4,5,9,12 35:1,17,20 36:6,16 37:7,8,12,13 38:6,10,16 39:4,18,23 40:19,21 41:7,11 42:1 43:11,18,21 44:19 45:1,10,11,14 46:5,19 48:4,7 49:6,19,22 50:9,10 51:21,23 52:8,11,13 53:7,23 55:1,2,3,24,25 56:4,5,18,21 57:4,10,12,20 58:17,24 59:1,11,16,17,18 60:9,15,16,22 61:3,12 62:23 63:5,15,19,20,21,25 64:4,23 65:3,20 66:5,10,14,15,16,19 67:14,15,17 68:17 69:24 70:16,17 71:20 72:9,10 73:16 74:11,16 75:25 76:4,23 77:4,6,17,19,22,25 78:11,25 79:1,19 80:5,7,13 82:9 83:24 84:12,16 86:6,13,19 87:5,16,21 88:4,13 89:1,4 91:21,23,24 92:8,22 93:7 94:4,15 95:3,20 97:13 98:4,12,13,20,21,22 99:14,22 100:2,6,12,17,25 101:4,6,16 102:2,12 103:3,11 105:17,20 106:13,15,16,22 107:11,17 108:16,25 109:2,13,16,23,25 110:4,17 111:7,9,13,14 112:2 113:1,5,11,14,25 114:6,9,16,23 115:11,12,14,22,23 116:3,4,18,20,22 117:3,6,8,17 118:6,8,12,21,24 119:7,16 120:4,5,10,21,24 121:1,2,5,7,9

that's 8:4,14,17,22 9:21 11:1,2 13:13 14:20 28:20 29:17 32:12 35:4,8,16 41:5 46:24 53:21 55:9,11 56:11 57:1 63:14 68:11 71:19 72:5 73:19 74:4 75:2 80:16 81:2 82:14,15,20 87:1,7 89:17 90:24 92:2,23 101:14 106:22 113:20 114:9,11 115:8 117:2,11 121:7

their 20:16 21:3 29:1 44:4 77:25 91:2 94:11

them 22:16 25:16 29:18 34:20 36:7 37:8,16 38:18 40:14 46:1 54:21 55:3,22,23 56:23 57:4,19,20 64:12,16 67:13 96:19 98:10 104:24 111:19 119:22

then 14:9,23 19:15,20 22:3,13 23:13,14 26:20 27:1,6,13 28:23 32:10 37:15 40:14,21 45:18 50:11 53:15 54:22 56:19,21 59:3 60:3,10,12 63:4,18 64:4 67:19 68:21 69:4 71:24 72:13 73:4 74:13 75:7,23 76:23 77:4 79:21 88:18 97:5 101:19 103:18 109:18,19,21 110:1,13,18 111:16 112:5,12,14 113:3 117:18,21 118:2

there 8:13 11:7 13:9 14:24,25 15:5 16:8,24 17:22 18:7,21 20:20 21:10,21 23:22 24:2 25:25 28:6 31:18 36:23 37:14 38:2,12 41:11,21,22 45:10,14,19,21 48:15 56:6,10 60:19 61:17 62:16 67:2 70:2 71:12 74:10,21 76:11,18 78:17 79:25 86:18 88:6,14 90:24 94:22,23

105:1 108:24 109:5 112:24,25 113:1,25 115:18 117:18 118:14 119:10 120:12

there's 8:3 19:23 26:10 42:18 52:16 57:12,24 66:5 67:1 75:6 88:17 109:14 112:19

therefore 43:1,15 44:2

thereon 90:12

these 13:15 14:2,13,24 16:4,7, 22 22:1,8,23,24 23:2,15,17 26:6,7,11 27:16 29:10,17 30:8, 10 31:14 33:15 34:12 36:18 37:7 38:8 39:2,3,23 40:1,13, 17,25 41:11 42:9,25 52:11 53:20 54:11,13,25 55:4 58:5 62:6 64:2,8,12,19,23 65:1,3,19 66:9 67:6,7 71:8 75:12 79:11, 19,20 82:6,10 87:25 88:19,23 90:24 91:9 95:12 97:22 98:2,7, 8,18 103:22 107:6 109:1 110:21 111:21 112:6,8 113:7 116:7,12 117:14,19 119:11,24 120:12,19,20

they 6:22,24 13:20,21,23 14:13 15:15,17 18:11 21:17,18 26:19 29:19 35:10,21 37:8,9 40:18 43:7 44:18,25 46:9 54:19 55:2,21 56:4,23 57:5 62:10 63:19 66:15,20 92:7 96:22,23 104:25 108:8 109:25 116:2,8 117:4 119:4,5,12 120:8,17

they're 27:22 39:19 54:25 64:23 67:13 120:7

thing 18:21 27:16 46:17 57:16 86:20 89:1 96:20

things 18:13 26:3 33:7 39:16, 17 47:21 48:3 49:20 57:16 61:11 62:7 68:1 70:9 105:9 119:1 121:3

think 6:18 8:3 16:9 18:25 20:18 21:20 23:1,23 24:6,8 26:25 27:25 28:5 30:3 32:3 38:25 39:7,9,10 40:23 42:3 46:8,16 48:12,14 50:12 51:10, 17 52:11,21 53:5,9,20,25 55:18 56:1,11 57:18 58:6 63:3 64:11,15,16 65:8,10 67:5 75:15,24 84:17 87:11 88:7 90:24 92:5,10 93:13,20,22 98:20 102:6 111:13,20,22 112:2,23 116:2,8,10 117:2,5 118:15,22

third 30:13 58:2 72:22 73:1

this 7:24 8:2,6,15,16 9:2,3,6,9 10:24 11:9,20,21,22 12:17,19 13:1,2,21 14:15,19,20,23 15:5, 11,13,20,22,23 16:6,11,14 17:3,6,8,14,19,24 18:14,17,18, 25 19:2,3,10,23 20:14 21:6,22 22:8,13,14,15,19 23:8 24:1,6, 17 25:3,9 26:4 27:1,3,4,7,8,12, 19,23,24 28:3,5,8 29:8,15,17 30:19 31:5,8,19 32:1,8,16,19 33:11 34:3,4,7,9,25 35:1,14,22 36:5,12,17 37:4,6,11,17,22 38:2,3,6,14,15,17 39:4,5,7,8, 14,22 40:7,19,20,23,25 41:3,5, 7,10,15,23,24,25 42:1 43:20 44:5,9,10,12,14,16 45:1,11,13, 20,25 46:4,5,12,17 47:4,10,14, 16 49:18 50:16,19 51:15,17 52:13,14,20 53:3,4,5,16,18,19, 22 54:1,4,6 55:2,3,10 56:1,3,4, 9,11,12,23 57:2,10,14,15,22, 25 58:3 59:12,21,25 60:1,7,19 61:6,7,11,21,24 62:5,12,19,21 63:22,23 64:1,5,6,12,17,20 66:7,13,16,22 67:1,2,3,7,24 68:14,20 69:24 70:3,6,12 71:9 72:14,15 73:6,19 74:17 75:1, 21 76:12,25 77:5,9,10 78:2,17, 19 79:4,5,16 80:2,17 81:18,23, 24 82:25 83:22 84:1,15,20,23 85:12,14,24 86:19,21 88:15, 17,22 89:2,13 90:5,20 92:7,17, 21 93:6,14,17,22 94:14,21 95:9,10,16,18,19 97:10,12 98:3,13,15,17,22 99:7,8,12,18, 19 100:3,5,16 101:13,18,22 102:3,7,9,14,22 103:2,13 105:3,4 106:11 107:1,8,14,15, 17 108:14 109:1,9,10,15 110:4,13,15,16,25 111:4,7,10, 13,22 112:13,15,20 113:16,17, 23,24,25 114:8,9,24 115:5,8, 25 116:1,3,5,12,20,21,24 117:4,9,17,25 118:1,14,22 119:2 121:4

those 33:5,6 43:23 47:6 52:8, 9,17 54:11 73:23 76:24 77:13 79:21 91:18

thought 51:18 56:8

thousands 55:22

threat 20:17,23 21:6

three 9:8 56:2 58:3 64:20,22 65:24 66:1,2,8 96:19 98:18

three-dimensional 107:2 115:8

three-phase 117:24

threshold 60:2,4 99:25 100:6 101:5,12,18 102:2 109:22 110:3

thresholded 104:7

thresholding 109:17,25 110:2 112:13

through 11:20 63:19 70:5,9 71:20,21,22 72:6,14 73:4 88:9 89:21 95:3 108:6 109:17,21 112:7,10,12

thus 63:10 69:4 73:11 100:16

tie 70:17

tied 69:18

tight 35:19,20

tilt 43:11

time 9:5,8 10:2 11:5,13 12:5 14:12,15,23,25 15:6,11,16 18:22 21:12 23:9,22 24:15,17, 18 26:19 27:8 28:3,8 29:5 32:13 34:14 35:5,6,11,17 36:17 37:9,12,13,15 42:1 44:20 56:4,5,18 84:9 92:5,8,10 109:2

times 6:9,10 23:15 28:6

title 12:23 23:2 47:12

titled 13:14 90:14

today 5:22 6:3 7:1 74:4

together 53:11

told 31:25 44:25 46:1 93:18 117:14

tool 45:1

top 8:5 28:18,23 51:15,17,18 52:15 53:3,5 54:23 56:14 57:23 58:1 64:23 65:6 66:2,21, 24 67:4,15,19 115:19

total 9:10 106:23 107:12,22 108:12

totality 56:3 108:10

tough 9:7

towards 19:20 63:4 70:19 77:14

Toyota 6:17,20,21

trace 63:21 64:8,11

traced 64:16

traces 64:24

track 41:17

tracking 12:9 17:22 18:1,5 23:16 24:10 30:13,24 38:20,24

traffic 11:11,12 13:8 14:21 15:12,13 21:15,17 25:5,9 30:21 36:13

transaction 13:3

transcript 22:4

transfer 14:10,14

transferred 14:20 104:18,21

transmitted 71:20 72:6

transportation 12:7 13:5 14:22 20:10 21:13 29:8 31:12 36:22 37:21 42:4,7

travel 89:4

traveling 89:5

tree 45:17,18

trend 117:12

tri-stereo 36:25

triangles 46:11,12

triangulate 37:3

triangulation 110:2 112:12

tried 12:14 22:9 38:19 92:12

tries 62:12

tripwire 6:17

truck 15:16 19:17,18,25 20:4, 6,18 21:6,8 28:25 31:24 33:3 46:3,5,6,8,14 119:4 121:7

trucks 15:17 18:17 21:14,17

true 21:11

truthing 15:3

try 7:2 15:2,16,17,18 34:24 36:19 37:12,19 38:9 47:25 51:2 60:8 62:10 78:5

trying 15:12 23:9 25:24 29:7 32:7 46:12 80:12 88:9

Tucker 117:16

turn 8:19 29:24 33:17 42:11 51:4 53:2 70:22 72:17 73:25 79:10 81:17,21 82:22 87:1 89:18 93:2 99:3,9 106:9

turned 88:24

TURNER 5:10 15:21 16:13 19:2,12 29:23 37:5 46:20,23 47:1,22 59:13 61:25 65:10,14, 15 68:9 69:14,20 75:11,21 76:3 80:25 81:14 84:21 85:19 90:5,8 93:14,19 102:16,19 105:24 106:3 107:19 111:1 114:2 121:11,24 122:3

turning 119:20

turns 74:16 77:21 89:10,12

Twin 14:21 82:19

two 6:3 7:17 10:17 16:20 26:2 27:15 28:6 35:9 38:25 39:10, 23 41:4 44:3 56:2 58:3 63:19, 24,25 64:21 71:8 74:8 79:25 82:1,10 95:12

two-dimensional 59:11 60:8

two-year 82:12

type 13:15 14:1,13 16:16 26:16 36:6 54:3,10 56:11,15 67:23 69:10,15,23 70:3,7,8 75:8 105:12 119:21

types 54:19

U

U.S. 96:2 98:24 116:24 118:7, 22 120:11

ultraviolet 56:20

Um-hum 13:19 89:23 92:3 105:19

under 9:20 20:18 30:2 42:15, 18 63:20 87:19

undergraduate 10:13

understand 6:2 16:1 77:22 85:2 109:2 111:11 118:17

understanding 10:1,6,8 52:17,18 62:1 80:17 82:6

understood 49:22 77:16 99:22

unfeasible 25:16 34:20 36:7 37:8

unfortunately 96:2

uniform 119:12

unit 55:5,6 101:14

units 100:22

University 33:2 44:20 119:4

until 15:13,19 32:25 118:7,16

up 19:20 46:2,22 103:9 116:19

update 28:3 97:5

updated 27:4 41:3

upper 64:5 66:19

us 8:17 11:18 22:7 27:8,11 32:1 35:10,21 44:18,25 50:22 52:22,24,25 70:21 83:3 111:23 115:1

usage 22:19 50:14 76:9

usages 50:19

use 11:16 13:6,15 18:17 22:9 23:9 27:13 30:20 36:19 37:2, 19 38:11 39:24 43:17 44:8,10 45:2,6,18 53:10 79:11,25 87:25 88:9,12 90:23 91:25 98:5 101:20 102:7 109:21 112:16 119:24

used 11:4 14:1 16:3 18:8 25:9 26:13 30:11 31:2,18 41:8 46:9 49:23 53:22 54:4,16 73:9 75:1, 13,16 94:18 95:8,22 101:14 102:18 103:6 105:6

useful 88:16

uses 30:19 62:17,18 91:23 103:3,13,22 104:22

using 11:10 12:11 16:15,16 24:24 26:1 28:9 31:5 33:9 37:14 45:16 50:14,16 63:12 69:5 73:19 78:17 79:5,11,12, 18 80:3 91:14,20 97:25 105:4 110:2

usually 43:6,10

utilized 98:12

UV 56:20

V

Vague 85:13 110:23

value 102:3 104:17,20

values 94:14 101:5

variable 49:8 73:5

variations 42:9 119:14

variety 24:22

vehicle 10:18 11:3,6,19,25 13:12,20,23 16:23 17:22,23,24 18:2,6 20:22,23,25 21:7 22:11, 12,15 23:3,6,10,11 24:11 25:10 27:12 30:14,17,23,24 31:6,9 37:1 39:4 40:1 42:15, 19,22 43:2 44:13,21 45:2,9 48:8,24 49:2 50:21,22,24 52:23 53:7 59:2 66:5 70:20 73:13,15 74:7,8,15 77:6,8 78:1 86:14,16,19,20 89:4,10,12 90:18 93:25 94:7,12,19 95:24 97:20 101:2,8 102:25 103:3 108:1 113:4

vehicle's 120:14

vehicles 12:4,9,20 13:14,16 15:10 17:1 18:15 20:15 23:12 24:23,24 25:21 27:16,21,22 30:17,19 36:13 37:13 41:17,21 42:21 45:3 70:19,21 94:4 95:7 100:24 101:9,15,17 103:4,10 112:20 113:4,6 117:16

velocities 43:3

velocity 42:21

versions 14:2

versus 21:5,8,9 121:7

very 24:1 25:21 27:24 28:1,9, 11 32:4 42:8 44:16 52:21 56:5 59:10 111:14 118:7,25 119:25 121:7,9

VI 42:18

via 58:15 62:24 86:23 104:14, 17,18,21

vibrations 120:17

vicinity 94:12

video 6:17 37:14 41:15,16,23

view 25:11 39:1 40:18 51:16, 17,19 52:15 53:3,5 57:5,23 66:6 83:7,14,23 84:1 99:13 107:21

viewed 53:6 83:5

views 26:1

violating 23:11

visibility 50:23 70:18 78:20 80:1 92:12 95:8,11 97:9 100:6 112:18 116:9,13 119:17

vision 10:3

Volkswagen 118:3

volumes 7:17

vote 45:8

voting 45:7

W

waived 122:7

want 17:15,17 21:11 23:21 25:1,12 26:17 31:12 32:16 37:18 38:10 40:22 43:4,13 44:23 46:3,21 47:21 55:24 57:2 62:6 68:8 74:5 79:3 81:1 85:2 86:25 90:5 100:19 102:12 105:1 111:4,18 113:24 116:17, 18 117:12 119:20 121:8,12

wanted 45:20

wants 100:19

was 5:7 6:16,17,22 7:11 9:9 12:6,10 14:19,20,23 15:5,11, 23 16:2 18:14,25 19:1,3,5,7,8 20:13 21:3,6,8,9,10,16 22:13 23:5 24:1 28:6 29:6,20 32:4,5, 6,13,19,20,23 35:2 36:18 37:23,24 44:12 46:4,5,18,19, 25 51:18 56:6,18,19,22 57:7 65:16 73:16 76:4 81:4,10,11, 24 102:5 106:2,5,15 111:20 115:3 116:23,24 117:19 118:16,19 121:15 122:8

Washington 5:1

wasn't 14:15 21:5

wavelength 70:5 105:16

way 28:7,8 39:8 43:17 44:2,7 45:16,24 55:10 56:3 77:6 80:17 85:14 113:15

ways 45:10,25 48:9 105:20

We'll 121:13

we're 23:9 26:16 27:10 46:12 57:23 58:1 59:11 76:4 92:23 107:8 111:19

we've 46:20 105:22

weak 104:7

weather 14:8 25:6 31:14

week 21:22

Welcome 81:15

well 17:18 28:9 31:19 32:16 33:14 34:9 43:22 49:17 51:18 54:20 62:1 84:11,22 85:4 102:20 105:17

were 6:19,22,24 9:20 11:1 12:17 13:20,21,23 14:1,2,3,24, 25 15:11 16:3,15,16,22,23 17:8 20:15,20 21:17,18 22:24 23:12 24:2,7 29:7 31:23 32:7, 13 33:8,9,12,15,20 34:12,16 35:24 36:2 37:2,3,8,10,14,24 38:8 46:18 48:15,16 56:5,10 58:24 65:19 73:16 92:7 108:19 115:4 119:5

what 9:23 10:8,9 11:1,3 13:15 14:1 15:3 16:7,9,16 18:4 25:18,19,24 26:15 29:7 30:9 32:1,2,13 33:25 35:22 36:11, 15,16,20 39:4,16,17 40:19,24 44:19 45:1 47:10,18,23 49:14 51:9,13,20 52:21 54:3,10,13 55:16 56:12,15 57:14,22,25 59:17,18,19 62:12,17 63:17 64:24 66:23 67:23 69:10,15,18 70:25 71:9,19,24 72:18 74:3 75:16 76:8 78:11,16 79:24 80:17 82:6 83:9,24 85:10,15, 23 86:2 87:8,14 88:17 89:24 91:22 92:17 93:1,9 95:14 96:18 97:7 98:3 99:16 102:8 103:15 104:3 105:14 106:23 107:12,21,24 108:5,19 109:1, 15 111:22,25 113:2,9,13 114:11,23,24 115:2,5,7,25

116:1 117:2,4,11

what's 14:5 29:11 38:16 55:1 57:13 74:6 83:7

whatever 27:17 37:18

wheel 80:14 88:22

when 15:23 16:19 17:1 25:4, 23 27:22 34:16,24 36:2 37:9 39:15 43:8 53:9 70:5,8 71:12, 14 73:9 77:17 78:12,16 89:10, 11 101:16 103:11 106:11 112:19 116:18 120:22

where 11:15 12:10 13:3 15:8 16:25 17:14 24:1 31:18,20 32:6 35:8 36:1,14 38:5,8 44:11 45:13 47:21 50:23,24 51:2,23 52:6 61:7 64:2 67:5,8 70:20 71:16 73:13,15 74:4 76:11,13 85:17 88:6,17,20 96:9,24 97:2 110:12 111:17,18 115:16 119:5

whereupon 5:5 81:3,8

which 7:7,15 8:5,6 21:20 22:21 25:20 26:18 31:21 34:10 38:21 39:2 42:22 43:20 44:15 48:24 53:16 56:22 58:19,22 59:6,9,20,22 60:12 62:14,22 63:3,13 65:2,22 66:8 67:12 68:7 69:9 70:12,15,19 74:25 75:12 76:21 80:4 81:18 82:10 84:6,18,23 85:5,21 86:12,15, 19,24 89:2 90:14 91:1 93:24 94:22,24 95:8 96:2,5 97:13 103:20 104:10,11 106:5 107:25 108:7 110:10 111:15, 16 112:7,9 113:1,19 115:13 116:5,16 118:4,11

while 9:11 46:20 48:25 49:11 52:5 58:20 59:7 73:13 77:14 78:19 102:25 108:2

white 46:11 54:6,8,12,24 56:17,22 86:11

who 9:11,13,18 50:21,22 97:13 103:13 116:14

whole 34:16 57:5 86:20 90:22 93:1 96:20 107:15 108:9

why 5:22,24 22:14 23:8 24:4 27:24 28:5 29:17 85:20 99:3 114:9

wide 24:22 77:20

width 25:10 30:18 42:21

wind 45:14

windshield 23:13

winter 11:16

wire 62:25 86:24

Wisconsin 19:18 20:2

wish 41:14

within 24:23 50:1 52:1,2 63:9 69:2 100:10 107:4

without 27:21 94:7 101:2 111:9

withstand 14:7

WITNESS 46:22 58:8 65:12 102:14

won't 9:3

words 15:3 16:8 21:14 25:25 28:12 37:4 39:17 55:19 59:10 60:7 78:24 88:7 94:21 96:1 104:25 108:4,24

work 9:7,11,14 11:9 15:2,5,20 16:2 17:23 21:4,13,15,18 22:13 23:19 29:20 36:19 37:17 42:10 107:16

worked 117:14

workers 21:14,17

working 10:17 11:6,10,21 20:11 32:14 37:10 92:7

works 57:16

would 10:12 14:14 30:3,11 32:10 34:15 44:10 47:23 52:9, 13,17 53:24 57:22 63:17 66:15 67:20 68:2,10 69:22 75:19 77:1,4,10,16,22,25 83:24 91:8, 13,25 92:6,11 93:14 94:1 95:12 97:21 98:6,14 99:22,24 100:5,20 101:19,22 105:7 109:2 111:11,21 112:21,23 113:24 114:23 115:7,18 116:11 119:12 121:19

wouldn't 35:21 44:18 57:16

wrong 8:17 23:1 33:16 117:21

wrote 24:17

X

Xcel 15:6,7 41:16

XY 60:6

Y

yeah 8:14 17:20 18:24 24:19 26:9 33:11 34:13 38:19 39:14 51:8 52:18 53:9 58:9 61:15 72:7 89:17 90:21,24 93:5,16, 22 99:7 102:17 105:3,19 106:17,18

year 82:11 92:5

years 10:17 31:20 33:1 82:10, 11 92:8 116:25 117:15,21

yellow 110:10

Yep 8:18 9:17 17:10 22:5 24:12 28:21 29:25 47:9 83:2 85:22 106:10

yes 5:17,23 6:5,8,13 7:25 9:1 10:7 12:19,23 17:7,16 23:3 25:2,13 31:4,7 33:19,24 34:24 35:9,24 42:13 43:5,14 47:17 48:17 50:8 55:10 60:24 65:21, 25 66:18 67:18,22 70:24 71:18,23 73:18,24 74:2,6 76:15 78:10,15 81:20,22 82:16,24 83:16 87:3 89:19 90:9 91:6 93:8 99:7,15 102:17 105:24 106:14 115:24 117:7 121:18,21 122:2

York 88:17

you're 5:22 6:2 14:3 15:22 22:2 26:11,22 27:18,20,23 28:15 30:9 34:22 36:5 37:9 39:12 41:23 44:5 50:3 59:14, 18 62:14 65:16 66:13 67:11 79:18 82:25 84:15 87:14 89:20 91:3 92:14 93:6 96:4,14 97:25 102:1 109:6 115:1

you've 66:14

your 5:13 6:19,25 7:8,16,21 8:16,22,24,25 9:12,18,23 10:5, 8,24,25 11:4,24 12:18 13:13 17:4 18:23 21:19 23:21 24:4,9 27:19 31:2 32:23 33:9,17 36:4 44:6,9 48:16 52:16 59:17

61:14 62:1 69:21 72:16 79:16
81:17,18,24 82:1,6 83:7,14,23
84:7 87:2,12 89:16,18 92:14,
24 99:3,4 107:20,22 111:2,9
115:1 117:8 120:24

Z

zero 82:11

zone 21:15,18

zones 21:13 42:10 110:3
112:13 113:6