

1 UNITED STATES PATENT AND TRADEMARK OFFICE

2 -----
3 BEFORE THE PATENT TRIAL AND APPEAL BOARD
4 -----

5 Exotec Product France SAS, Exotec North America
6 Inc., and Exotec Product USA Inc.,

7 Petitioners

8 v.

9 Opex Corporation,

10 Patent Owner
11 -----

12 IPR2024-00850

13 U.S. Patent No. 11,472,632
14 -----

15 REMOTE DEPOSITION OF
16 WILLIAM E. SINGHOSE, Ph.D.

17 April 29, 2025
18
19

20 Reported by: Brooklyn E. Schweitzer, RPR, CRR

21 Job No.: 580482

22 Pages: 1 - 144

1 Deposition of WILLIAM E. SINGHOSE, Ph.D.,
2 conducted virtually.

3
4
5 ** ALL PARTIES ATTENDED REMOTELY. **
6
7

8 Pursuant to Notice, before Brooklyn E.
9 Schweitzer, Registered Professional Reporter,
10 Certified Realtime Reporter, and Notary Public in
11 and for the Commonwealth of Pennsylvania.
12
13
14
15
16
17
18
19
20
21
22

A P P E A R A N C E S

Attorneys for Petitioner:

DANA M. ZOTTOLA, ESQUIRE

BRIAN ELLSWORTH, ESQUIRE

ALSTON & BIRD

55 2nd Street

Suite 2100

San Francisco, CA 94105

Attorneys for Patent Owner:

GOUTAM PATNAIK, ESQUIRE

DESMARAIS LLP

1899 Pennsylvania Avenue, NW

Suite 400

Washington, D.C. 20006

Also Present: Merinda Evans, Technician

1	C O N T E N T S		
2	EXAMINATION		PAGE
3	By Ms. Zottola		6
4	By Mr. Patnaik		138
5			
6			
7			
8	E X H I B I T S		
9	EXHIBIT		PAGE
10	Exhibit 2007	Declaration of William E.	
11		Singhose, Ph.D.	19
12	Exhibit 1001	Patent No.: US 11,472,632 B2	27
13	Singhose 1	Illustration	33
14	Exhibit 1005	Pub. No.: US 2017/0158430 A1	57
15	Exhibit 1006	Application Publication	
16		No. CN 109987366 A	61
17	Exhibit 2009	Multipath Interference in	
18		Indirect Time-of-Flight Depth	
19		Sensors	98
20	Exhibit 1008	Patent No.: US 10,472,172 B2	115
21	Singhose 2	Illustration	133
22	///		

1	E X H I B I T S C O N T I N U E D		
2	EXHIBIT		PAGE
3	Exhibit 2004	Fault-Free Integrity of Urban	
4		Driverless Vehicle	
5		Navigation with Multi-Sensor	
6		Integration: A Case Study	
7		In Downtown Chicago	134
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

P R O C E E D I N G S

WILLIAM E. SINGHOSE, Ph.D.,

was called, and having been duly sworn,

testified as follows:

EXAMINATION

BY MS. ZOTTOLA:

Q Dana Zottola, Alston & Bird, on behalf of
Petitioners. Before we get started and as a
matter of housekeeping, I know the technician just
noted this, but I want to note on the record that
the parties have agreed to take this deposition
remotely over video, so all of the parties have
agreed to be in physically different locations,
including the court reporter. And today's
deposition is related to IPR 2024-00850.

Dr. Singhose, is anybody there in the room
with you?

A Yes, counsel for Opex is here.

Q Got it.

MS. ZOTTOLA: And your name, Counsel?

MR. PATNAIK: Goutam Patnaik for Desmarais
LLP.

1 THE WITNESS: Sorry. I didn't know if --

2 BY MS. ZOTTOLA:

3 Q That's okay. And, Dr. Singhose, do you
4 have any applications open on your computer?

5 A Let me see. I have Zoom for this, and
6 then I have -- I had QuickTime opened, but did my
7 Zoom just quit?

8 MR. PATNAIK: You don't get QuickTime.
9 That, you need to close.

10 THE WITNESS: I tried to, but let me see
11 if something's still working.

12 TECHNICIAN: Your screen just disappeared
13 on Zoom.

14 THE WITNESS: Yeah. So that's what I'm
15 worried, is I shut -- I think I have to reconnect
16 here. Just a second.

17 Okay. I think I'm back on Zoom, and I'm
18 just checking that everything else is shut.

19 That's all I'm seeing operating right now,
20 is Zoom.

21 BY MS. ZOTTOLA:

22 Q Thank you. Do you have any papers in

1 front of you?

2 A Yes, the attorneys provided me some of --
3 a stack of documents over here.

4 Q And what papers are those?

5 A I've got my -- I have my two declarations
6 right here, and I have the Raizer reference. I've
7 got my CV. I've got a CV of Dr. Spenko. I have a
8 couple of technical papers that were appendices, I
9 think, to one of my -- second declaration, I
10 believe. So it's those. Then I have -- looks
11 like they also gave me a copy of Dr. Spenko's
12 deposition testimony. I have, of course, the '632
13 patent that we're here to discuss. I have Raizer.
14 Looks like I have two copies of that. And they
15 also gave me -- let's see what this is. I have
16 the -- my first declaration as well.

17 So they just gave me the stuff -- I didn't
18 know it was in there.

19 MR. PATNAIK: Dana, I was concerned about
20 him reading documents on the screen, so we thought
21 we would just give him unannotated versions.

22 Q Understood. And are there any notes

1 written on any of those papers?

2 A I didn't write any notes. I just got them
3 a few minutes ago. So I don't think there is.

4 MR. PATNAIK: I'll represent there isn't
5 any notes as well.

6 MS. ZOTTOLA: Okay. Thank you.

7 BY MS. ZOTTOLA:

8 Q Dr. Singhose -- and it is Dr. Singhose,
9 right, not Dr. Singhouse? I know it's a
10 constitution decision. They referenced
11 Dr. Singhouse a couple times.

12 A Yeah. It's Dr. Singhose. It was
13 Dr. Singhouse in 1795, so we're going back in time
14 to that spelling, it looks like.

15 Q Okay. All right. Dr. Singhose, have you
16 had your deposition taken before?

17 A Yes, I have.

18 Q Roughly how many times?

19 A Probably about 40 times.

20 Q How many of those were patent cases? If
21 any.

22 A I'd say probably half of those. Maybe 20

1 have been intellectual property cases, involving
2 patents normally.

3 Q And how many -- were any of those IPRs or
4 PDR proceedings before the PTAB?

5 A Yes, they were.

6 Q What was the most recent case you were
7 deposited in?

8 A I'd have to check my records on that. I
9 don't have them in front of me. I think recently
10 I did do an IPR. I'm trying to think of -- of the
11 subject matter, but I think the most recent one I
12 did was an IPR, maybe last month.

13 Q And who did you represent in that case?

14 A You mean, like, the company name, or the
15 patent owner, or the petitioner?

16 Q We'll start with -- yeah, were you on the
17 patent owner's side or the petitioner's side?

18 A I think in that case, I was on the
19 petitioner.

20 Q And who was the petitioner in that case?

21 A That's what I'm trying to remember. I'm
22 drawing a blank on that proceeding.

1 I can pull it up for you if you really
2 want to know. I'm sure I have it somewhere on my
3 computer here.

4 Q Has there -- has there been an outcome
5 associated with that case yet?

6 A No, not that I'm aware of.

7 Q Prior to being engaged by -- by Opex, were
8 you aware of Opex?

9 A I kind of want to clarify your question.
10 You mean prior to being engaged for this matter?

11 Q Right.

12 A Yes, I was aware of Opex for several
13 years. Not many years.

14 Q In what capacity were you aware of them?

15 A Well, I was aware that Opex makes
16 machinery for warehouse automation. There's
17 actually a big warehouse automation or machine
18 automation conference that's held in Atlanta from
19 time to time, and I went there several years ago
20 and visited and inspected many machines, and Opex
21 was there, and they had a couple of their machines
22 there. So that may have been four years ago, four

1 or five years ago I did that.

2 Q Do you have any ongoing interest in Opex?

3 MR. PATNAIK: Object to form.

4 A No. I mean, I don't own any shares or
5 have any investment in it or anything like that.

6 Q Have you received any research or grant
7 money from Opex?

8 A No.

9 Q Outside of this IPR proceeding, have you
10 ever done any work for Opex?

11 A Yes.

12 Q In what capacity?

13 A I served as a technical expert for them on
14 two ITC cases.

15 Q Okay. Well, it sounds like you're
16 experienced in the deposition process, but just to
17 remind you of some ground rules, I'm going to be
18 asking you questions today, and you're under oath
19 to answer them truthfully and to the best of your
20 ability.

21 Do you understand that?

22 A Yes, I do.

1 Q We have a court reporter today, although
2 the reporter's not physically in the room with any
3 of us, but please be sure you respond verbally --
4 no head shakes or uh-huhs -- so the court reporter
5 can accurately transcribe your answers. Okay?

6 A Yes.

7 Q Also for the sake of the court reporter,
8 let's try not to talk at the same time. I know
9 that's going to be hard over video, but I'll do my
10 best to make sure you're completely finished
11 talking before I start talking, and I ask that you
12 wait until I'm completely finished asking my
13 questions before you start answering.

14 Is that okay?

15 A Yes.

16 Q And if you don't understand one of my
17 questions, please let me know, but if you give me
18 an answer, I'll assume that you understood the
19 question.

20 Is that fair?

21 A Yes.

22 Q You are free to reference your

1 declaration, either one of them, throughout the
2 deposition, but please indicate which declaration,
3 what page, and what paragraph you're looking at
4 when you do. It will be helpful for me to
5 understand, and it will be helpful for the record.

6 A Okay.

7 Q And then -- and then, finally, we'll take
8 breaks about every hour, but at any point, feel
9 free to request a break. I only ask that if
10 there's a question pending that you answer that
11 question before we take the break.

12 Fair enough?

13 A Yes.

14 Q Okay. Dr. Singhose, do you understand why
15 you're here today?

16 A Yes.

17 Q Why is that?

18 A I'm here to let you ask me questions about
19 my opinions on this matter.

20 Q For the purposes of the record, can you
21 please describe your preparation for today?

22 A Sure. I think you mean preparing just for

1 this deposition today. I started working on the
2 case last summer, but I'm -- I don't think you
3 want me to review all that.

4 Q We'll get to -- yeah, we can get to that.

5 A Yeah. In recent history, I reviewed all
6 of the materials -- kind of what we went through
7 that I just showed you, my declarations and the
8 patent at issue, the '632 patent, the prior art.
9 I reviewed all those materials, and then I met
10 with counsel as well.

11 Q How long did you spend preparing for this
12 deposition?

13 A Probably about 20 to 25 hours on those
14 activities I just mentioned to you.

15 Q And you said you met with counsel. Was
16 anybody who's not counsel present when you
17 prepared?

18 A No.

19 Q When were you engaged for this particular
20 matter?

21 A It'd be last summer last time. I'm going
22 to guess in May or June I started working on this.

1 Q And by whom?

2 A Desmarais, the law firm for Opex.

3 Q Can you describe the circumstances under
4 which you were approached by Desmarais for this
5 case?

6 A I don't recall the details of that. I
7 mean, in all likelihood, I received an email from
8 an attorney, and they said something like we have
9 this matter on automation; here's the patent at
10 issue. Can you take a look at it? And respond to
11 us if you want to work on this. That's almost
12 always how I'm approached, but I don't remember
13 the details of this particular case.

14 Q Can you please describe the work that went
15 into the preparation of your declarations?

16 A Sure. As you know, I did two
17 declarations. So starting last summer, I reviewed
18 the '632 patent. That's probably the first step I
19 did. And then I reviewed the prior art that's
20 being asserted in this case. I reviewed the --
21 what I'll call the petition where Exotec is asking
22 for the patent to be reviewed.

1 And then I also looked through the company
2 expert declaration that goes along with that, and
3 then I started performing my independent analysis
4 of those materials in assessing the arguments put
5 forth by Exotec and its expert.

6 And then that led to a report last August
7 where I submitted some opinions, and then -- so
8 that's how I got to the first one. Then there was
9 a break for me, and there was work done that I
10 don't know about, and then there was an
11 institution decision.

12 And so following the institution decision
13 and other materials that were relevant to that,
14 and I did independent research in terms looking up
15 what a person of ordinary skill in the art would
16 think about these terms and these issues, these
17 processes, and then that led me to develop my
18 second declaration in this matter.

19 Q Did you write the first draft of each of
20 your declarations?

21 A Yes, I did.

22 Q When I say the '632 patent, do you

1 understand that I am referring to U.S. Patent
2 11,472,632?

3 A Yes, I do.

4 Q And do you understand that the '632 patent
5 has been marked as Exhibit 1001 in IPR 2024-00850?

6 A That sounds correct to me.

7 Q This is all for purposes of the record.

8 A Sure. I don't -- I don't have that
9 exhibit number here, but I'm assuming that's what
10 we probably did.

11 MR. PATNAIK: Dana, we printed him the
12 patent out for the record. So he has the patent,
13 but it's not been marked.

14 MS. ZOTTOLA: Okay. And when I move it --
15 when I move it into -- move it and mark it as an
16 exhibit, I'll note that exhibit number from the
17 IPR.

18 BY MS. ZOTTOLA:

19 Q Okay. Then when I reference your original
20 declaration, I'll be referring to your declaration
21 that was submitted with the patent owner's
22 preliminary response, so your first declaration,

1 which was marked as Exhibit 2001.

2 A Exhibit 2000 -- okay. I'll try to
3 remember that.

4 Q And then -- which I will -- which I will,
5 of course, refer back to when I -- when I bring it
6 up.

7 A Okay.

8 Q And then when I refer to your response
9 declaration, I'll be referring to your declaration
10 that was submitted with the patent owner's
11 response to the petition. So that will be your
12 second declaration that was marked as
13 Exhibit 2007.

14 A Okay.

15 Q So we will turn to your second
16 declaration, Exhibit 2007, that I will move into
17 the chat.

18 (Exhibit 2007 was marked for
19 identification and is attached to the transcript.)

20 Q So I just want to turn briefly to your
21 response declaration right now, so Exhibit 2007.

22 In Paragraph 23, which is on Pages 14 and

1 15 --

2 A Okay.

3 Q You indicate here materials considered,
4 correct?

5 A Yes.

6 Q Is this a complete list of the materials
7 that you considered in preparing this declaration?

8 A This is a fairly complete list. At the
9 top, I also mentioned that I reviewed documents
10 cited herein. So there may be a couple of other
11 documents that I cited here that I didn't actually
12 put in this list, but I tried to make a complete
13 list.

14 Q Okay. So it says you reviewed the
15 petition, the '632 patent, the Derby declaration,
16 Raizer, and Hangzhou.

17 Did you review the exhibits cited in the
18 Derby declaration?

19 A I believe I did, yes. I didn't break
20 those out. I was kind of lumping that all
21 together.

22 Q Okay. So, then, I'd like to ask you some

1 questions about your background, which is
2 Appendix A to Exhibit 2007, which starts at
3 Page 86, which is your CV which you had referenced
4 earlier.

5 So it looks like you have quite a bit of
6 experience with respect to robots and crane
7 systems. Can you tell me a little bit about the
8 work you did for InVekTek, if I'm saying that
9 correctly? InVekTek, Inc.?

10 A That's a good pronunciation. So InVekTek
11 is a company that I started some years ago to
12 commercialize technology developed in my
13 laboratory at Georgia Tech, and that technology is
14 directed at material handling.

15 Largely, it's technology that makes
16 machines that move materials, move more quickly
17 with less uncertainty, less vibration, and move
18 safer. So we have built actual physical products
19 that we then sell to facilities that are moving
20 around materials to help improve their material
21 handling.

22 Q When you say move around materials, where

1 are they -- where are they moving to and from?

2 A The machines that we work on are normally
3 in, like, warehouses like we're talking about
4 here, or in manufacturing facilities. And so in
5 those kind of facilities, there's a need to pick
6 up perhaps a heavy component of a machine that
7 you're making and move it around to another part
8 of the assembly line and set it down there so it
9 can be attached, or you may need to just be moving
10 around supplies, like steel rolls.

11 So they just basically go all over these
12 facilities.

13 Q And so the technology that you are -- that
14 you were developing -- or that you do develop at
15 InVekTek, does that involve the technology that is
16 actually moving the materials, or does that
17 involve the entire infrastructure so -- including,
18 you know, where the materials would be located at
19 any given moment in the process?

20 A Well, it's a technology that's used to
21 move the machines. So it's a component within the
22 entire structure. So these machines get a command

1 either from a person, or there's automaters,
2 automated versions of this technology. It gets a
3 command asking the machine to move.

4 And our technology operates right there.
5 It decides how to move the machine, and it moves
6 it in such a way that it's fast yet safe and under
7 control. So it's part of the moving the machine
8 around technology.

9 Q Okay. So it's moving the machine. It's
10 not necessarily moving of an item? Like taking
11 the machine to move an item?

12 A Sometimes the machines have items, and
13 sometimes they don't.

14 Q Okay.

15 A So it's both of those cases.

16 Q Okay. So when you're -- when the machines
17 are moving items from, I guess, Point A to
18 Point B, as part of your work at InVekTek, are you
19 involved with the design of the systems, the
20 shelving systems where the items might be located?

21 A Generally not. Generally this is -- for
22 the most part, what we do is retro fits. So we go

1 into warehouses or facilities and we utilize their
2 existing storage bins, and we add our technology
3 on to the machine that's moving stuff around
4 between those storage areas.

5 Q Okay. Are the machines autonomous? Would
6 you characterize them as autonomous?

7 A The machines that we work with for
8 InVekTek right now are not fully autonomous. They
9 are usually human operated to some extent. So I
10 think a fair characterization is that they're
11 semiautonomous.

12 But if you look further down in the
13 resume, CAMotion Cranes, that was a company I
14 started much earlier than InVekTek, and some of
15 our products, they were fully autonomous. But the
16 InVekTek ones are what I'll characterize as
17 semiautonomous.

18 Q Okay. Did you or your team ever write --
19 well, I guess, as part of your work at InVekTek or
20 CAMotion Cranes, did your team ever write or
21 develop software?

22 A Yes.

1 Q And was the software specific to the
2 particular customer?

3 A Yes.

4 Q So -- so does that mean you developed
5 software for multiple different customers?

6 A Yes. Hundreds of different customers.

7 Q Okay. And then in each of those
8 situations, was the software owned by those
9 customers, or was it owned by InVekTek?

10 A Well, the way it works is that we have
11 technology that nobody else has. So we have
12 developed a proprietary package that's essentially
13 locked it down, and we sell it into that product,
14 and it's specially for that implementation, but
15 the customer cannot change it because then they
16 can discover what we're doing in there, and they
17 can also perhaps make the machine very dangerous
18 by changing it.

19 So we develop it specially for them, and
20 then we upload it on to the computer that's there,
21 and we essentially lock it in this proprietary
22 state.

1 Q So did the customers provide the
2 functional requirements for that software?

3 A To a small degree. I mean, they buy our
4 product because we have functional requirements
5 built into our product that they like, but they,
6 for example, have to tell us the size of their
7 machine, and that's sort of what we customize.

8 Given the size of their machine and what
9 the machine needs to do, we make a few tweaks or
10 modifications to our software, and then like I
11 said, once we've integrated in a few parameters on
12 their machine, we then upload that and lock it
13 down into our product and sell that product to
14 them.

15 Q Okay. So once you got a sense for the
16 operational parameters for the customer and the
17 specific use case that the customer was looking
18 for, you write the code specific to serve those
19 operational parameters?

20 A That's correct. I mean, the code is
21 already written, but we've written it in a way
22 that we can upload some parameters into that code,

1 and the code says, oh, thank you for those
2 parameters; I now know how to move these machines
3 around.

4 So I don't think it's rewriting the code
5 but rather giving the code some information for
6 that particular application.

7 Q All right. Let's turn to the '632 patent,
8 which I'll put into the chat. Exhibit 1001.

9 (Exhibit 1001 was marked for
10 identification and is attached to the transcript.)

11 TECHNICIAN: This is the tech. I'd like
12 to confirm that you'd like them marked as 2007 and
13 10016789.

14 MS. ZOTTOLA: Exhibit 2007 for the first
15 one is fine with me, and then this one that I'm
16 about to upload, Exhibit 1001, and fine as well.

17 TECHNICIAN: Okay. So that would be
18 Exhibit 1001.

19 MS. ZOTTOLA: Correct.

20 TECHNICIAN: Thank you.

21 MS. ZOTTOLA: Thanks.

22 THE WITNESS: I now have that.

1 BY MS. ZOTTOLA:

2 Q Dr. Singhose, can you describe the
3 warehouse layout detailed in the '632 patent?

4 MR. PATNAIK: Object to form.

5 A Sure. On one of the embodiments that's
6 visually represented in Figure 1, and it shows a
7 warehouse as a number of storage areas. It has a
8 number of what I'll call mobile robots driving
9 around, and those robots are described as driving,
10 for example, over to a storage area, picking an
11 item up or items up, and driving back, and
12 depositing them at some other location.

13 And this figure actually shows that there
14 can be people working in this warehouse; that is,
15 receiving those items from the robot. The people
16 might also be transferring items to the robot so
17 they can go and store them in the storage rack.

18 So it's a pretty typical semiautomated or
19 automated warehouse structure in that regard.

20 Q All right. So we're going to -- I'm going
21 to have you draw using the whiteboard. And
22 hopefully we can get this to work.

1 So, Dr. Singhose, can you please draw on
2 this whiteboard a storage rack, an aisle, and
3 another storage rack as you understand the
4 arrangement according to the '632 patent?

5 A I'm going to try.

6 Q I know.

7 A So -- I mean, I think I should start with,
8 like, a plan view or a side view instead of an
9 isometric view. Do you have a certain view that
10 you'd like to see?

11 Q Just a top --

12 A A plan view means an overhead view.

13 Q Yep.

14 A Okay.

15 Q Yeah.

16 A So I've never used this tool before, so
17 I'm going to see if they have a rectangle tool.

18 Did that show up? I don't know if you're
19 seeing anything. I just drew, like, a -- a row of
20 storage bins.

21 Q No.

22 A Okay. Do I have to submit?

1 MR. PATNAIK: I've never used this.

2 THE WITNESS: Okay. Let me see if there's
3 a submit.

4 MR. PATNAIK: Anyway, keep going, and
5 we'll figure it out.

6 Okay. Well, on my screen, I've just
7 basically put two big rectangles, and that would
8 represent the storage racks, and then I put a
9 space between them to indicate an aisle. I'm not
10 sure if you're seeing it or not.

11 BY MS. ZOTTOLA:

12 Q Yep, I can see it.

13 A Okay. So that's -- that's part of a
14 simple view of essentially two storage racks and
15 an aisle down the middle. That is sort of the
16 general layout there, and then these robots are
17 allowed to drive around them, under them, go up
18 into them. Of course you can't see that view
19 because it's a top-down view.

20 Q Can we label the -- the storage racks S1
21 and S2, and then label the aisle A1?

22 A (Witness complies.)

1 Okay. So in the two storage racks, I put
2 S1 and S2, and then I put A1 down the middle of
3 the aisle.

4 Q And can you please draw the legs or
5 vertical posts of the storage racks?

6 A Sure. I mean, this is just an example. I
7 guess they could be various places, but.

8 So on the left one, the left storage rack,
9 S1, I put -- again, this is an overhead view, so I
10 put rectangles representing where vertical columns
11 would be. You only see them from the overhead
12 view, so just rectangles.

13 And then that's kind of the minimum that
14 you would need, sort of four. You would probably
15 have a few intermediate ones to support these
16 racks, depending how long they are. And S2, I'm
17 not going to do it, but it would have vertical
18 posts as well.

19 Q Yeah. Why don't we go ahead and add them
20 onto S2.

21 A Okay. I've now added four vertical posts
22 to S2 as well.

1 Q So could the -- could the storage racks
2 have more vertical posts and still fall under the
3 '632 patent?

4 MR. PATNAIK: Object to form.

5 A Yeah. This is just one example of how
6 this would work. If the span got very long, you
7 would need more vertical supports or the structure
8 would sag.

9 Q And does the '632 patent require legs in
10 identical locations between storage racks like you
11 have shown here?

12 A I don't think so as far as the vertical
13 storage posts. I don't recall a requirement on
14 that being, like -- you mean symmetrical about the
15 aisle. I don't think there's a requirement on the
16 vertical post columns for that.

17 Q So does the '632 patent have a minimum
18 number of legs for a storage rack?

19 A I don't think it speaks to that. I mean,
20 a person of ordinary skill in the art would know
21 you need four or it would tip over, but it might
22 need more than that depending on the stand.

1 Q And then would the '632 have a maximum
2 number of legs?

3 A No. I mean, warehouses can get very long,
4 and so these racks can be longer and longer and
5 you can add more to the end. So I don't think
6 there's an end to it. You can just add as many as
7 you needed to keep the structure from sagging and
8 to make it stable.

9 Q All right. I'm going to save this.

10 A I'm sorry. I didn't hear that.

11 Q I'm -- I'm going to save this -- figure
12 out how to save this.

13 A It's not my best work, but go ahead and
14 save it.

15 Q Okay. How does PDF -- sorry. Suffering
16 through the technology.

17 MS. ZOTTOLA: Can we go off the record for
18 a second?

19 (A recess was taken.)

20 (Singhose 1 was marked for identification
21 and is attached to the transcript.)

22 BY MS. ZOTTOLA:

1 Q Dr. Singhose, did you discuss with counsel
2 over the break?

3 A We had a few words, yeah.

4 Q What did you --

5 A I mean, nothing of substance. If your
6 question is anything about my system, no, nothing
7 of substance about my testimony. We just went out
8 and chatted in the hall.

9 Q And did you review anything during the
10 break?

11 A No, I did not.

12 Q Okay. Continuing with the '632 patent,
13 looking at claim 1, claim 1 covers the
14 circumstance where a robot moves under one or more
15 storage racks.

16 Is that right?

17 A Yes.

18 Q So then the claims cover a robot moving
19 under a single storage rack; is that right?

20 A Yeah. It's a method claim, so part of
21 that method is you have to drive under what I've
22 characterized as a lease lot to practice that

1 method.

2 Q And the '632 patent discusses the robots
3 traveling underneath storage racks, correct?

4 A Yes.

5 Q And does the '632 patent discuss the
6 dimensions of the paths under the racks?

7 A Well, it discusses what I'll call a
8 relative dimension in that -- the patent discusses
9 that the racks would be wide enough to accommodate
10 two of the mobile robots passing side by side, but
11 it doesn't give a specific unit, like feet or
12 meters in terms of how wide these racks are.

13 Q So in column 17, line 62, the '632 patent
14 says, similarly, preferably path 860 has a
15 centerline that is spaced apart from the posts at
16 the rearward edge of the column remote from the
17 aisle 815 by a distance that is greater than half
18 the length of the vehicle.

19 Is that right?

20 A Yes.

21 Q So the '632 patent doesn't appear, in that
22 sentence, to have specific dimensions, right?

1 A That's correct.

2 Q And then turning to column 18, lines 13 to
3 16, can you read that sentence, please, starting
4 with the record "specifically"?

5 A Do you want me to read it out loud into
6 the record or just read it to myself.

7 Q Into the record is fine. Thank you.

8 A Specifically, each of path 860 and 860
9 prime is preferably spaced apart from the posts
10 815 a greater distance (sic) than the distance
11 from the axis of the rotation to each of the
12 corners of the vehicle.

13 Q So, again, consistent with your earlier
14 statement, the '632 patent appears to have
15 relative descriptions but not exact dimensions; is
16 that right?

17 A Yes, that -- that part that we just read
18 is in relative description. That is the relative
19 size of the racks compared to the vehicles.

20 Q The '632 patent also discusses columns of
21 the storage racks, correct?

22 A Yes.

1 Q And does the '632 patent discuss
2 dimensions of those columns?

3 A Yes, it does.

4 Q Where?

5 A I don't want to waste my time by
6 searching, but, for example, if you look at
7 Figure 7, it shows that those columns are wide
8 enough to accommodate three of these boxes that is
9 moving around labeled 55.

10 So, again, it's a relative description
11 of -- of how large these are; in this case,
12 compared to those containers 55 or those boxes 55.

13 Q Okay. And then if we look at column 16,
14 line 67, through column 17, line 6.

15 Would you like to read that into the
16 record starting with the word "specifically"?

17 A Sure. Specifically, the width of each
18 column is similar to the width of vehicle, and the
19 depth of the column is substantially greater than
20 the length of the vehicle.

21 Optionally, the column has a depth that is
22 more than twice the width of the vehicle as shown

1 in figures 7 and 10. Additionally, the depth of
2 the column may optionally be greater than the
3 length of the vehicle.

4 Q So the -- we've already established the
5 '632 patent doesn't discuss -- doesn't provide
6 dimensions for the paths under the racks. Does
7 the '632 patent provide dimensions for the aisles?

8 A I kind of can't answer the question
9 because I don't agree with your setup, because we
10 just discussed that it does discuss dimensions.
11 They're just relative dimensions, like the size of
12 the racks and columns and aisles are discussed
13 relative to how big your robot is.

14 Q Okay. Understood.

15 So does the '632 patent provide exact
16 dimensions for the aisles, what the aisles must
17 be?

18 A I think it provides fairly exact relative
19 dimensions. For example, we just read that
20 passage that was related to Figure 10. If you
21 look at Figure 10, it's actually describing how
22 the aisle width has to be very similar to the

1 width of the robots so the robot can drive
2 vertically, but there's no units on those
3 dimensions. Again, there's no inches or meters.

4 Q So the undershelf paths in the columns,
5 they just mean a minimum distance based on the
6 width of the robots and/or the robot's turn
7 radius; is that right?

8 A I'm sorry. I missed the first part of the
9 question.

10 Q The under -- per the '632 patent, the
11 undershelf paths in the columns, they just need a
12 minimum distance based on the width of the robots
13 and/or the robot's turn radius; is that right?

14 MR. PATNAIK: Object to form.

15 A Yes. I think -- as I understood your
16 question, the under -- under-column width is --
17 does have a requirement, that it has to be bigger
18 than the robot so the robots could drive under it.

19 So the -- the passage we were just talking
20 about is trying to clarify that, at least has to
21 be wide enough the robot can go under there,
22 possibly a few robots can go under there, and also

1 turn.

2 Q The '632 patents, the robots in the '632
3 patents, they move horizontally both in the aisles
4 and under the storage racks, correct?

5 A Yes.

6 Q In most cases, that means they move along
7 the floor, along the aisle, and then again under
8 the storage racks, right?

9 MR. PATNAIK: Object to form.

10 A I'm not sure I understand "most cases."
11 It does that. It does what you just said, but I
12 don't know if in most cases it does that. It's
13 not describing all the different activities these
14 robots do.

15 Q In all cases, then, if the robots move
16 along the floor -- move horizontally both in the
17 aisles and under the storage racks, then that
18 means they move along the floor along the aisle
19 and under the storage racks, right?

20 MR. PATNAIK: Object to form.

21 A I think they move along the floor in both
22 the aisles and under the storage racks.

1 Q Got it. So the floor extends under the
2 racks in the '632 patent?

3 A Yes.

4 Q Got it. Does the '632 patent give any
5 exact dimensions for the robots?

6 A Well, there's no requirement in the claims
7 on exact dimensions, but whether or not the
8 specification somewhere in there says, for
9 example, the robots could be 2 feet by 3 feet, I
10 didn't search for that. But certainly it's not
11 claiming any specific dimensions of the robot.

12 Q In column 16, line 62 to 64, which also
13 references Figure 5, the '632 patent says, as
14 described above, the vehicle has a length and a
15 width. As shown in Figure 5, optionally the
16 vehicle has a length, L, that is sufficiently
17 greater than its width W2.

18 Do you see that?

19 A Yes, I do.

20 Q So here, it would appear the '632 patent
21 provides some relative dimensions but not
22 necessarily exact dimensions, right?

1 A That's correct. In that section, it's
2 relative dimension -- again, not to the rack in
3 this case, just to the different ratio -- aspect
4 ratios of the robot.

5 Q Does the '632 patent foreclose robots that
6 are configured to telescope in some way to satisfy
7 those relative dimensions?

8 A I did not examine the patent for that --
9 for that question.

10 Q Would a person of ordinary skill in the
11 art be reviewing the '632 patent think that it
12 foreclosed robots that are configured to telescope
13 in some way to satisfy those dimensions, reviewing
14 it today?

15 A I mean, that's not a situation I get.
16 It'd take a while to do that. I'd need to read
17 the whole thing and see if there's some
18 prohibition against that in there. In the
19 physical structure, it looks like it can't
20 telescope, like, sideways. Like, it can't expand
21 its width, but I don't know if there's a
22 prohibition against that or I don't know if

1 there's a caveat that that's a possibility. I
2 just didn't do that investigation.

3 Q You can go ahead and take time to review
4 it right now.

5 A Just to be clear, I can't do that in a
6 reasonable amount of time today. It would require
7 reading the whole patent from front to back
8 because you're asking me to testify about
9 essentially exclusion, and that means I have to
10 read every -- I'd have to read every sentence.

11 Q Did you not already read every sentence of
12 the '632 patent?

13 A Yes, I've read every sentence of the '632
14 patent multiple times, but when I was reading it,
15 I didn't have that question in mind, and I wasn't
16 looking for that particular issue.

17 Q In the multiple times that you reviewed
18 the '632 patent, did you ever see foreclosure of a
19 telescoping robot?

20 A Just to make sure I understand the
21 question, the type of telescoping that you're
22 talking about is a telescoping -- I think the -- I

1 just want to clarify. I think what you're asking
2 is is there a telescoping of the width of
3 Figure 5? So it seems like you're asking about is
4 there an option to telescope the width from Omega,
5 from W2 to W3 or something, or telescope the
6 length L to some other value of L.

7 Is that the telescoping that you're
8 talking -- or asking about?

9 Q Either one, correct. So telescoping to
10 satisfy one of the dimensions such that these
11 relative dimensions would be satisfied.

12 A I didn't do that investigation, but I do
13 not recall seeing a telescoping version described,
14 and similarly I don't recall it saying it could
15 not telescope up. I just didn't review the patent
16 for this question.

17 Q And so you didn't see foreclosure of the
18 telescoping robot in any of the claims?

19 A Again, that's not an investigation I did,
20 but I can't peruse the claims in a reasonable
21 amount of time, and I have -- I've reviewed them
22 recently, and I don't recall the telescoping issue

1 being addressed in there. If you would point me
2 to some citation, I'm happy to analyze it now.

3 Q If you want to take a look at the claims
4 right now, we have time. If you want to take a
5 look at the claims, how about the independent
6 claims? There's only three of them. So
7 independent claim 1, 11, and 17.

8 A 1, 11, and 17? Okay. So --

9 Q 1, 11, and 23. 1, 11, and 23.

10 A 1, 11, and 23. Okay. Just so I
11 understand the question so I have it correctly in
12 my mind, you're using this term "foreclosed." I
13 just kind of want a clarification of what you mean
14 by that. Are you saying that the claims --
15 similar in here to the claim limitation that says
16 you cannot telescope? Is that the question you're
17 asking me?

18 Q The question is the -- if a robot
19 telescoped to satisfy -- so if a robot had
20 dimensions that did not initially satisfy the
21 relative dimensions that are described in the '632
22 patent but telescoped to then satisfy those

1 relative dimensions, would --

2 A I understand.

3 Q Okay.

4 A I understand the question now. But at the
5 same time, is there some limitation that you're
6 asking about? Because off the top of my head, I'm
7 not seeing limitation on this subject matter.

8 Q I'm just wondering if a person of ordinary
9 skill in the art reviewing the claims in the '632
10 patent would think that the '632 patent foreclosed
11 a telescoping robot.

12 A Okay. I think I understand the question
13 better. I'll review the claims for that issue.

14 Okay. I just reviewed claim 1. I think I
15 can answer your question just based on that
16 without going into any of the other claims. I
17 believe a person of ordinary skill in the art
18 reviewing claim 1 would believe that a telescoping
19 robot would or could practice this claim.

20 Q And then what about claim 5?

21 A Yes. A telescoping robot could practice
22 claim 5.

1 Q Okay.

2 MR. PATNAIK: Counsel, just for the
3 record, has this issue been raised in either your
4 petition or our response?

5 MS. ZOTTOLA: The issue relates to the
6 relative dimensions of claim 5, so the analysis is
7 associated with the limitations in claim 5. So,
8 yes.

9 BY MS. ZOTTOLA:

10 Q So, Dr. Singhose, since we discussed the
11 relative dimensions discussed in the '632 patent
12 where it's not -- they're not necessarily exact
13 dimensions, but generally relative dimensions, how
14 would a POSITA determine dimensions of the system
15 of the '632 patent?

16 MR. PATNAIK: Object to form.

17 A I guess I'm not understanding the
18 question. To determine dimensions, you would have
19 to build something first because that's what's
20 coming to mind. Like, they have to build
21 something and they could the measure it and they
22 can see if it -- if it read on these claims.

1 So I think just measuring it with the
2 measuring tape or whatever you want to measure it
3 with is how a person of ordinary skill in the art
4 would determine the dimensions.

5 Q So let's start with the aisles. How would
6 a person of ordinary skill in the art determine
7 the dimensions of an aisle for the '632 patent?

8 A When you say for it, you mean to practice
9 it?

10 Q Correct. According to --

11 A Okay.

12 Q -- the '632 patent, for the system
13 described in the '632 patent covered by the '632
14 patent.

15 A Okay. Well, again, I think they'd have to
16 start with some part of this, like the robot. So
17 those that have a robot that is able to drive
18 around horizontally and vertically, they would
19 measure that.

20 And then to practice this claim, they have
21 to make that aisle a little bit wider so the robot
22 can drive down it. So that's how they would

1 establish the width of the aisle. It would,
2 again, be relative to the robot, but they would
3 have an actual physical robot that they can then
4 measure.

5 And based on that is how you get the
6 actual dimension of the aisle width.

7 Q And then how would the person of ordinary
8 skill in the art determine dimensions of the
9 storage racks?

10 A Well, they have a little more freedom.
11 The storage racks could -- could just be bigger
12 than that. Right? They have to be big enough to
13 accommodate the items that you can store, and they
14 have to be big enough for the robot to go up to it
15 and essentially push a box into it or retract a
16 box.

17 So, again, they would have to be a little
18 bit bigger than those widths.

19 Q And then how would a person of ordinary
20 skill in the art determine the shelf height?

21 A Again, there would be a lot of freedom
22 there. They would set the shelf height up to the

1 height they would need to easily store the
2 largest box that they anticipate this warehouse
3 needing to store.

4 And then also, they would have to take
5 into account the height between the floor and the
6 first shelf. Right? So you would probably take
7 that into account. That's the tallest thing I can
8 drive through there, so then my storage racks can
9 also be determined relative to that.

10 But there's a whole bunch of freedom
11 basically on the height of the storage areas.

12 Q Is the height of the largest item that's
13 going to be stored, is that the primary
14 consideration a POSITA would have in setting the
15 shelf height?

16 MR. PATNAIK: Object to form.

17 A I'm not sure I can characterize as the
18 primary. That's certainly an important one, but
19 you would definitely want the height of each
20 storage area to be larger -- that is, taller --
21 than what you anticipate being stored in this
22 warehouse.

1 But you could certainly take into account
2 other issues in setting the height of your storage
3 areas.

4 Q Do you have to consider the robot plus the
5 tote height?

6 A Yes. To go under the storage racks, that
7 combined height of the robot and what I'll call
8 the box or the item that's going to be on there,
9 that combined height has to be less than the first
10 storage level of the rack.

11 Q Is there a particular amount of clearings
12 that would be required or desirable between the
13 top of that stack and the shelf?

14 A I don't think so. I mean, I think --
15 these robots aren't hopping up and down or
16 anything. So once you know the height of what
17 it's carrying, it can go under that first rack
18 shelf if that is higher than -- I think it's also
19 a possibility that if you have a really tall box,
20 that a robot could choose not to go under the
21 shelves for that particular box and just drive
22 around through the aisle and go up. I think

1 that's a possibility as well. It doesn't have to
2 go under the storage rack for all boxes that it
3 carries.

4 Q Are there any other significant
5 considerations for shelf height that you can think
6 of that we haven't discussed?

7 A Yes.

8 Q Like what?

9 A There's a lot. So you would normally put
10 this in a building that has a certain height to
11 its ceiling. So that is, again, what I'll call a
12 very important factor. You can't have your
13 shelves go up higher than that.

14 And then you would also normally be given
15 a directive on how many storage bays that you
16 would want, so that would be the other factor that
17 you would take into account in setting the height.

18 You also might set it up to where one
19 storage rack had a certain height in its storage
20 racks, and then you have a different rack for
21 extra-large-size boxes. So if you have that need,
22 you could actually set up different size --

1 different height storage racks.

2 So it's just a lot of things that could
3 come into play when you're setting the height of
4 those storage racks.

5 Q Would the robots in the '632 patent work
6 only with a new warehouse?

7 MR. PATNAIK: Object to form.

8 A I don't remember that issue being in there
9 where it says you have to build a whole new
10 warehouse for there or whether or not you go into
11 an existing warehouse and make some modifications.
12 I didn't review the patent for that particular
13 issue.

14 On its face, it -- if I was going to
15 practice it, I'd probably just want to start with
16 a new warehouse and set up the warehouse in the
17 way that this is described.

18 Q How many robots are used in the '632
19 patent?

20 A I don't know if it's a specific number
21 required. You need one, but this is really set up
22 for having a lot of robots running around, and so

1 numerous robots would be the expectation of a
2 person of ordinary skill.

3 Q How many are -- how many robots are
4 required in the claims?

5 A Some of the claims might just require one
6 where it refers to first vehicle, but there are
7 other claims in here that discuss the ability for
8 one robot to pass another robot. So that one, you
9 would need two, I would think.

10 So --

11 Q Okay.

12 A -- I think some speak to one; some speak
13 to more than one.

14 Q So one or two robots?

15 A One or two or more. And really the system
16 is set up to have many robots running around.

17 Q Is there a maximum number of robots that
18 would be used in '632?

19 A I don't think so. I mean, it would be
20 relative to the size of your warehouse. So the
21 larger your warehouse is, the more these robots
22 could be running around. Especially for the

1 physical space of it to be driving around. So for
2 any given warehouse, there's a limit. They
3 wouldn't be able to go anywhere. It would just
4 be, like, gridlock. But that number just scales
5 to the size of your warehouse.

6 Q Dr. Singhose, how do the '632 robots turn
7 while they're under the rack?

8 A Well, they're on something like wheels.
9 There's a couple variations of this, but you have
10 wheels. And so to turn, fundamentally, you would
11 have to have some of those wheels turn faster than
12 the others. So, essentially, it would be some
13 sort of differential driving the wheels which
14 cause you to turn.

15 Q If we turn to column eight, line 37. Can
16 you read that paragraph about the zero-turn
17 mechanism? Read it into the record, please.

18 A The entirety of that paragraph starting at
19 line 37?

20 Q Yes, please.

21 A As noted above, the vehicle 100 may have a
22 variety of steering mechanisms for controlling the

1 direction of travel of the vehicle. For example,
2 an optional steering mechanism is a zero-turn
3 mechanism that can turn the vehicle without
4 substantially moving forward. Optionally, the
5 zero-turn mechanism provides a means for turning
6 the vehicle about a vertical axis extending
7 through the vehicle.

8 Q Let's turn to Raizer -- sorry. One quick
9 thing to clarify about the zero-turn mechanism.
10 Is it fair to say that the robots of the '632
11 patent turn by fully rotating their bodies while
12 under the rack?

13 MR. PATNAIK: Object to form.

14 A Fully rotating only makes sense to me if
15 you tell me, like, fully rotating through 90
16 degrees or 180 degrees. "Fully" needs to have
17 some basis. But, yes, they turn fully through
18 whatever angle they are required to rotate
19 through.

20 Q Okay. Thank you.

21 So turn to Raizer, which is Exhibit 1005,
22 and I will move this into the chat to mark as

1 Exhibit 1005.

2 (Exhibit 1005 was marked for
3 identification and is attached to the transcript.)

4 A Okay. I have that.

5 Q You have it up? I'd like to turn to
6 Paragraph 0103. And looks like the third to
7 last -- third to last sentence in that paragraph.
8 It reads, no shown in the figure are a set of
9 on-board sensors that are located at various
10 locations on the robot to aid the robot in
11 navigation and to identify obstacles. The sensors
12 are of various types, e.g. optical, RFID,
13 magnetic, and indoor triangulation system that
14 form a virtual "bubble" around the robot as it
15 travels.

16 What would the term "optical" mean to a
17 POSITA in the context of this description?

18 A An optical sensor in this context means
19 that you have a sensor that emits out from it a
20 light source. Could be laser, but it could be
21 just a light source. And then right next to that
22 emitter is a receiver, and that receiver depicts

1 photons that are reflected back on various
2 surfaces. So it's essentially an
3 emitter/detector/sensor using optical system; that
4 is, light.

5 Q Would that include or exclude barcode
6 sensors?

7 A That would definitely include barcode
8 sensors. Well, I mean, so -- yeah. There's a
9 barcode out there. So the barcode is not the
10 sensor, but whatever sensor you have to read the
11 barcodes would be termed an optical sensor.

12 Q And then what would the term RFID mean to
13 a POSITA in the context of this description?

14 A Radio frequency identification.

15 Q And what would that mean in the context of
16 Raizer's sensors?

17 MR. PATNAIK: Object to form.

18 A I think in this application -- I'm trying
19 to read it as that term is used here -- it could
20 mean one of two things. It could mean that on
21 this robot is a device that emits radio signals,
22 and then somewhere around this warehouse are

1 receivers that are set up to receive that radio
2 signal.

3 And if that radio signal is received by
4 three, hopefully four, you could essentially do a
5 triangulation and find out where that signal came
6 from. So that would be what we call active RFID.

7 You could also have something like an ID
8 card on there that's a passive RFID signal, and
9 it's set up to sort of do the angulars, where
10 there is emitters of radio waves out in the
11 warehouse, and those waves hit the robot, and then
12 they passively induce a response, and that
13 response is measured, and you can also measure the
14 location of the robot in that way as well.

15 Those are, I think, the two ways a person
16 of ordinary skill in the art would understand
17 RFID.

18 Q And then what about Raizer's reference to
19 indoor triangulation systems? How would a POSITA
20 understand that in the context of this
21 description?

22 A Well, I think they would understand it to

1 probably also include RFID, which we just talked
2 about, but there would be other ways of doing
3 triangulation. Triangulation generally means that
4 you get signals received at three different
5 locations. That's where the triangle comes from.

6 And then use of those received signals,
7 that is what time you received them, and possibly
8 also what angle you received them from, you could
9 do geometry, and you can calculate back to the
10 source of that signal.

11 Q Could these sensors be used by a POSITA in
12 a dead reckoning process as you understand that
13 term in this context?

14 MR. PATNAIK: Object to form.

15 A Well, as I understand the dead reckoning
16 form in this process, that would mean that you're
17 using sensors on board the robot to record and
18 measure its motion, such as how much the wheels
19 turn, and you're kind of not using these external
20 sensors.

21 So could these be used along with dead
22 reckoning, I think yes.

1 MS. ZOTTOLA: All right. Let's go off the
2 record.

3 (A recess was taken.)

4 BY MS. ZOTTOLA:

5 Q Dr. Singhose, did you discuss your
6 testimony with counsel during the break?

7 A No.

8 Q I would like to turn to Hangzhou, which is
9 Exhibit 1006, which I will move into the chat to
10 be marked.

11 (Exhibit 1006 was marked for
12 identification and is attached to the transcript.)

13 A Okay. I have that.

14 Q Turning your attention to Paragraph 4 of
15 Hangzhou, which is on Page 10.

16 A Okay.

17 Q In Paragraph 4, Hangzhou discusses
18 single-type mobile robot solutions, correct?

19 A Yes.

20 Q What does single-type robot solutions
21 mean?

22 A That means that you set up an automated

1 warehouse just using one kind of robot rather than
2 two or three different types of robots.

3 Q And then in Paragraph 5 -- sorry. Really
4 quickly. So just to clarify, when you say
5 single -- about a single-type robots, there could
6 be multiple robots, just one type of robot; is
7 that right? Is that what you mean?

8 A Yes. I think that's what this means.

9 Q Okay. Thank you.

10 And then in Paragraph 5, Hangzhou
11 discusses multi-type robot solutions, correct?

12 A Yes.

13 Q And what does multi-type robot solutions
14 mean?

15 A Well, the term it actually uses is
16 multi-type robot collaboration solutions, and what
17 that means is that you have two robots that look
18 differently and would generally do two different
19 functions, but if you have them collaborate, they
20 achieve the overall function that you want; in
21 this case, you know, storing or reaching items
22 from these shelves.

1 Q And isn't it true that in Paragraph 4,
2 Hangzhou discusses drawbacks specific to two
3 different single-type robot solutions?

4 A Yes.

5 Q And isn't it also true that Hangzhou
6 describes drawbacks specific to three different
7 multi-type robot collaboration solutions in
8 Paragraph 5?

9 A Yes.

10 Q Is it fair to say that Hangzhou, in
11 Paragraphs 4 and 5, describes drawbacks of five
12 prior art example robot systems with two being
13 single-type and three being multi-type?

14 A Yes.

15 Q Do you see any disclosure in Paragraph 4
16 where Hangzhou criticizes the general class of all
17 single-type robots?

18 A Not in Paragraph 4.

19 Q Do you see any disclosure in Paragraph 5
20 where Hangzhou criticizes the general class of all
21 multi-type robot collaboration solutions?

22 A No, I do not.

1 Q Dr. Singhose, would you agree that there
2 are five total embodiments described in Hangzhou?

3 A Yeah. I didn't do that investigation, but
4 I tried to sort of flip through the figures, and I
5 would say it's probably more than -- more than
6 five, depending on what you mean by embodiment.
7 But there are certainly several embodiments.

8 Q All right. Let's turn back to your
9 response declaration. So Exhibit 2007.

10 A Okay.

11 Q In your response declaration, you
12 mentioned issues with modifications to proprietary
13 software.

14 A Yes.

15 Q And specifically, you state that a POSITA
16 would not know how to modify the proprietary
17 component to achieve a proposed accommodation
18 because the operating principles of the
19 proprietary components would not be known to a
20 POSITA; is that right?

21 A If you were reading through my report, I
22 probably could have read along with you more

1 accurately, but I definitely agree with the
2 substance of what you just said.

3 Q So -- so what does proprietary software
4 entail to you?

5 A Well, proprietary software would be
6 software that a company develops essentially in
7 secret and puts in some useful or unusual
8 operations that nobody else has, and so they
9 can -- normally in this industry it's so you can
10 sell it for money because you've done something
11 that nobody else has done.

12 Q Is the use of proprietary components such
13 as software typical in the automated warehouse
14 industry?

15 A Yes. The use of some proprietary elements
16 would be occurring from time to time.

17 Q And so is all software that is not open
18 sourced proprietary software?

19 MR. PATNAIK: Object to form.

20 A I don't think I'd considered that question
21 until now, but my initial response would be no.
22 There could be another class of software, but

1 certainly proprietary software and open sourced
2 software are kind of two sides of the story, where
3 open source, you can get it, you can look at it,
4 you can change it, and proprietary would have many
5 of the opposite characteristics where you couldn't
6 look exactly what was going on there and you
7 wouldn't be able to change what was going on
8 inside there.

9 Q Is it your experience that source code is
10 disclosed by software developers?

11 A It's my experience that you have software
12 that the source code is disclosed that is open
13 source, and many, many cases where it's not
14 disclosed.

15 Q And so when the source code is not
16 disclosed, is that proprietary?

17 A Again, I don't think I did this
18 investigation of where that line lies, but I can
19 see a third class where there's not a disclosure
20 of the code, but it's not so secret as you
21 couldn't pay more money and get it opened up.
22 There's all sorts of different -- there's a whole

1 spectrum of how software comes. So I didn't do
2 that investigation, all different classes of
3 software.

4 But I do know that proprietary software
5 indicates a degree of secrecy and an
6 unchangeability of that by the person or that
7 company that got the proprietary software from
8 some other company.

9 Q Could you estimate what percentage of
10 software in this automated warehouse context is
11 disclosed?

12 A I don't have any basis for that.

13 Q In your businesses that we discussed
14 earlier, did you disclose your source code to your
15 customers?

16 A No.

17 Q And then you mentioned a level of secrecy
18 and then a level of changeability or the ability
19 to change something. So if a piece of software is
20 secret but can be changed, does that make it
21 proprietary or not?

22 A I don't -- in this investigation, I didn't

1 do this thought exercise. But if there's a bunch
2 of secret stuff in there, the company is owning
3 this, who's purchased it, doesn't know where it
4 is, even if they can change certain parts of it --
5 actually, I don't know. I don't know how to
6 classify that. I'd have to think it through. But
7 I think proprietary means secret and not
8 changeable.

9 Q So -- so a piece of software has to be
10 both secret and not changeable to be proprietary?

11 A Yeah. I mean, it's not changeable. So
12 I'm trying to understand how it can be secret and
13 changeable. Like, I am just not understanding
14 that setup, and I did not do this investigation,
15 so you'd have to give me an example of how it
16 could be secret and also changeable. That seems
17 odd to me.

18 Q Right. I'm trying to get an understanding
19 of the analysis that went into your declaration
20 where you described proprietary software and what
21 a POSITA would and would not be able to do with
22 it.

1 So we're trying to get an understanding of
2 your definition of proprietary software.

3 A Yes.

4 Q Right. So if a piece of software is not
5 secret, so let's say it's public, like, it's not
6 changeable, so the POSITA would not be able to
7 change it, it's completely immutable, would that
8 be considered proprietary?

9 A Yeah. I'm not quite understanding how
10 that's set up, so let me repeat it. Let me make
11 sure I understand you.

12 So I've got code that I can open up and I
13 can see it, and I can see four I equals 1
14 through 10, something like that. Right? I can
15 see the -- I can see the line, but I can't change
16 it. I'm not sure I did that exercise because that
17 doesn't seem to be relevant to this case.

18 But I would think it wouldn't be
19 proprietary because I can just copy and paste what
20 I'm looking at and then change it. So I don't
21 understand how I'm getting both of those things,
22 being able to look at it, but not being able to

1 change it. Because if I can look at it, I can
2 copy and paste it into some kind of, you know,
3 compiler, and I can make a change there.

4 So I'm not sure how it's set up, to be
5 honest.

6 Q Could a POSITA viewing the operation of a
7 robot executing proprietary software to perform
8 operations write their own code for their own
9 robots to execute the same operations?

10 A It seems unlikely. You're basically
11 describing a concept which is normally referred to
12 as reverse engineering. So do -- can I reverse
13 engineer robot code? Generally the code is too
14 complicated to reverse engineer and know all the
15 things that are going on there.

16 For perhaps some very simple motions with
17 some very simple structures, you could reverse
18 engineer a large percentage of it, but because
19 you're not seeing what's in there, you don't know
20 what's in there. Right? So you can't possibly
21 reproduce the whole thing just by looking at the
22 output because the function of software doesn't

1 always show up in the output or the motion of the
2 robot. It's doing other stuff in there that you
3 just cannot see. So that part you certainly could
4 not reverse engineer.

5 Q When you say that the reverse engineering
6 could be done for a large percentage of the
7 operations but not all of the operations, what
8 could be part of that large percentage of the
9 operations?

10 A Well, if you had a very simple
11 structure -- as an example, a very simple
12 structure, it's a robot arm and it rotates
13 90 degrees, you could certainly write your own
14 code that it would rotate at 90 degrees. But what
15 you don't know is there there's air checking in
16 there, whether there was safety checking in there.
17 It would also be very difficult for you to pull
18 out the acceleration limits and the velocity
19 limits and the current limits and all that stuff.

20 So there could be a whole bunch of stuff
21 going on that was very important, but you just
22 simply wouldn't know what was going on and have no

1 way to measure what was going on there and then
2 try to reverse engineer it.

3 Q The '632 patent claims a number of
4 software-enabled steps, right?

5 A I'm just opening up the claims here.

6 Do you have anything in particular in mind
7 you want me to look at? I mean, a lot of them are
8 not software related. So if there's any
9 software-related ones, limitations that come to
10 mind that you want me to discuss that you can
11 point me to.

12 Q Any of the driving and turning steps of
13 zero robots?

14 A Okay. Yeah, the driving and turning, you
15 could do it without programming. It just wouldn't
16 work very well. So they would be programmed to
17 get these to drive safely.

18 So, yeah. The kind of limitations that
19 you just mentioned, driving and turning, those
20 would normally be at least partially enabled by
21 software.

22 Q And is it your view that an alleged

1 infringer would need access to Opex's source code
2 in order to infringe these claims?

3 MR. PATNAIK: Object to form; outside the
4 scope.

5 A There's nothing in claim 1 that would
6 require an infringer to have Opex's specific code.
7 That's all stuff that could be reproduced and
8 practiced without having Opex's source code.

9 Q And why is that?

10 A Well, there's nothing in here that is so
11 specific as could not be figured out by someone
12 reading the specification. If you read the
13 specification, it provides a fair number of
14 details about how the system works. So by the
15 time you got to these claims and you start
16 marching through here, given the teachings in the
17 specification, you're certainly going to be able
18 to generate a system that practices this method
19 that -- that has some limitations.

20 Q They can presumably write their own code
21 to drive and turn a robot, right?

22 A Yes.

1 Q Okay. All right. Back to your response
2 declaration, Exhibit 2007.

3 A Okay.

4 Q You mentioned that LiDAR has issues with
5 traveling under the rack associated with
6 multi-path effects. You mentioned that it works
7 well in open spaces but has difficulty under
8 shelves, correct?

9 A Yes. That's one of the challenges
10 associated with LiDAR sensors.

11 Q By open spaces, do you mean in places
12 where overhead shelves are not present like in
13 aisles and other parts to the warehouse?

14 A What I meant by open space is -- is that
15 when you use this LiDAR and you emit pulses of
16 laser, they only get bounced back from basically
17 one surface or predominantly one surface. So
18 that's my understanding of what I'm getting at as
19 an open space, is that it goes out, and the LiDAR
20 doesn't come back from multiple different places.
21 It just comes back from one, and that's the object
22 that the LiDAR is able to detect.

1 So it's an open space with an optic in it
2 that you're trying to detect, but if you've got a
3 bunch of trees and walls and stuff, glass
4 surfaces, overhead surfaces, the laser pulses will
5 get bounced back in various ways, and that
6 confuses the detector. It doesn't -- it can't
7 figure out which of those is the obstacle it's
8 really trying to see or detect.

9 Q How about in a warehouse environment?
10 Where would the open spaces be?

11 A The open spaces would be the areas where
12 there wasn't good reflection paths except for the
13 one thing you're trying to look at, like a wall.

14 So, again, it has to be some element of
15 openness, but in a warehouse you're going to have
16 walls all around you and stuff like that, but
17 they're far enough away where you don't get enough
18 reflected laser energy to confuse your sensor, or
19 the reflection path is so much longer in time that
20 the sensor is like, yeah, that's -- that's not a
21 primary reflection. That is bouncing around the
22 warehouse and coming back to me much later in

1 time.

2 So it kind of is not a simple answer,
3 warehouses, but basically you need to be somewhere
4 where there's not reflective surfaces that bounce
5 back signals in about the same time and energy as
6 the primary object you're trying to detect.

7 Q Are you suggesting that LiDAR only works
8 in a lab and can't work anywhere in a warehouse?

9 A No.

10 Q You mention in your declaration that
11 multipath effects are caused by reflected signals
12 that bounce off of the overhead shelves, the
13 support legs of the shelves, and more distant
14 objects beyond the shelves, correct?

15 A That sounds about right.

16 Q I'm looking at Paragraph 151.

17 You say, for example, LiDAR sensors emit
18 laser pulses and measure reflected signals. While
19 this can, and often does, work well in open
20 spaces, such a system being used under shelves
21 would be subject to an array of noisy reflected
22 signals that bounce off of the overhead shelves,

1 the support legs, and more distant objects beyond
2 the shelves.

3 Do you see that?

4 A Yes, I do.

5 Q Aren't at least two of these same noisy
6 reflective signals, so the bounced signals off of
7 the support legs and off of the more distant
8 objects, present in open spaces such as the
9 aisles?

10 A Yeah. Some of them would be, but, for
11 example, take the leg that's nearby. If the laser
12 bounces off that leg, it's not going to bounce
13 straight back. It's going to go up or down. So
14 let's suppose it gets bounced upwards. It then
15 hits the ceiling and then bounces back. That's
16 another -- that's another path.

17 And so this poor sensor detector that's
18 emitting this laser and passing three or four
19 different places, which means it arrives at three
20 or four different times with three or four
21 different intensities, it then has to try to
22 figure out, like, what's the real object and

1 how -- where are these signals coming from
2 reflected paths?

3 Q I'm -- so we need to say the signal
4 bounces off the support leg and then off of the
5 ceiling. Do you mean the ceiling of the
6 warehouse?

7 A I thought we were talking about under
8 racks. So because the rack is relatively low and
9 it bounces off the ceiling, it's going to bounce
10 back up a measurable or a lot of the laser signal.

11 If it has to go all the way to the
12 ceiling, it's going to diffuse, get wider and
13 wider and wider, and it's going to bounce off the
14 ceiling in all sorts of different directions, and
15 only a small fraction of that laser energy gets
16 back to the detector, and the detector is like,
17 no, that's way below the threshold of an actual
18 object, so I'm not going to take that into
19 account.

20 But in the close environment, under a
21 shelf, it's going to get a lot of energy
22 bounceback, and that's going to confuse it.

1 Q Is there a particular height of the
2 ceiling of the warehouse that might change that
3 analysis?

4 A I don't think so. I think the heights in
5 warehouses are very high compared to the distance
6 to an obstacle that a LiDAR detector on one of
7 these mobile robots would be trying to detect. So
8 if you're in an open space, I think the portion of
9 this laser that gets bounced to the ceiling is
10 probably never going to come back to the detector
11 in any meaningful amount.

12 Q If the legs are vertical and the laser
13 from the LiDAR is being transmitted horizontally,
14 why would it bounce up?

15 A Well, in that one specific case, which
16 doesn't really happen in practice, theoretically
17 you would get a very good signal. But the LiDAR
18 beam doesn't go out horizontal and the legs aren't
19 perfectly flat and reflective, and they have to
20 have undulations and textures to them.

21 So if you actually shine a laser at a
22 certain part of these legs, you're going to see

1 the laser go all over the place. There's a
2 complex reflective pattern, and that's just well
3 known.

4 And also there's going to be a general
5 driving the robot while all this is happening. So
6 to set up one particular perfect case is possible,
7 but that's not going to -- that's not going to
8 occur in the practical situations that we're
9 talking about here.

10 Q So there could be few multipath effects in
11 circumstances where the legs are vertical, right?

12 A If the legs were really close to vertical,
13 really smooth, and your LiDAR was directed very
14 much horizontally and very accurately without much
15 diffusion, then you would do a pretty good
16 measurement of LiDAR in that one particular
17 instance. But that's not the situation that
18 you're going to run into in these warehouses. So
19 you couldn't trust this in general to give you
20 good information.

21 Q In a warehouse environment -- we talked
22 earlier about what a POSITA would consider when

1 designing the dimensions of the -- the warehouse
2 environment.

3 So wouldn't a POSITA just simply address
4 that a shelf-height-related obstacles by
5 establishing a floor of the shelf height that's
6 higher than the tallest robot in the tote's path?

7 A They would do that. That's one of the --
8 we talked about. You need it to be higher if
9 you're going to drive your box or your tote to the
10 shelf. So you need to go around the shelves and
11 not under, that's an option if your box is too
12 tall, or if you're short enough, you could then
13 try to go under the shelves.

14 Q All right. And isn't it quite common to
15 use -- simply use time of arrival and signal
16 intensity to filter out what is your reflection in
17 LiDAR even if signals are bouncing off of the
18 legs?

19 A You could certainly try to do that, and
20 you'd fail in these cases that we're talking
21 about. Yes, that's the basic strategy, and it
22 does work well in open environments without a lot

1 of obstacles and reflective surfaces, but it's
2 well known not to work in close environments when
3 you have multipath possibilities, bouncing off
4 walls and ceilings. The ceiling being the bottom
5 of the shelf in this case, not the ceiling of the
6 warehouse.

7 Q Keep the roof height -- so ceiling of the
8 warehouse. If a roof height of 30 feet, let's
9 say, is not a problem, how low does a shelf -- so
10 the ceiling of the shelf, lowest shelf -- have to
11 be to cause a problem? Four feet?

12 A I didn't do that calculation, but it
13 actually is again a situation of relatives. If
14 you're emitting a laser and you're trying to
15 measure where this pole that's laying 3 feet away
16 from you, ideally you emit a laser pulse that
17 would bounce back in a certain period of time
18 using the speed of light and the distance of wave,
19 and you'd get this one nice bounceback signal.

20 But if you're doing it 3 feet away and the
21 ceiling height is 3 feet, then you're going to get
22 another reflective path with probably a fair

1 amount of energy, and the sensor is going to say,
2 well, I've got another big chunk of energy as
3 well. That could be the obstacle as well. How do
4 I choose between those two, or how do I choose
5 between the three or four or five that got bounced
6 back?

7 That's where it gets really tough for
8 these LiDAR sensors to figure out the actual
9 obstacle and distinguish it from the multiple
10 reflections that the sensor detector receives.

11 Q Is there a well-defined shelf height that
12 a POSITA would be aware of that causes attenuable
13 multipath effects?

14 A No, I don't think so. I think they'd have
15 to run experiments and try to figure out a new
16 algorithm that deals with whatever height and
17 reflectivity in these cases. Basically they'd
18 have to do a lot of experimentation to try to
19 figure that out.

20 Q How about just setting up a warehouse
21 environment to minimize multipath interference?

22 MR. PATNAIK: Object to the form.

1 A Is that a question?

2 Q Would a POSITA -- would a POSITA simply
3 set up a warehouse environment to minimize
4 multipath interference? Perhaps by reducing known
5 reflectors?

6 A Would they -- well, I mean, I guess they
7 would have to do that if they were going to use
8 this particular approach. I mean, not using this
9 approach would be a good way to go. But if you're
10 going to try to use this particular sense in your
11 approach, then I guess you would try to do that.
12 I just don't know how to do it.

13 I don't think a person of ordinary skill
14 in the art knows to do that. It's not simple.
15 It's not a simple thing to do. I'm not sure
16 anyone really knows how to do that, because it's
17 not a question of yes or no, you get a reflective
18 path. It's always a question of how much
19 multipath reflections you get.

20 Q Paragraph 154 of your response declaration
21 attempts to support your conclusion that a POSITA
22 would be unable to reliably traverse in that

1 undershelf environment by pointing to issues of
2 larger robotic companies such as iRobot and
3 SharkNinja; is that right?

4 A That's close to right. I think you said
5 attempted to show it, and I would say it does show
6 it.

7 Q iRobot is the company that produces the
8 Roomba home vacuum robot; is that right?

9 A Yes. That's one of its products. It has
10 a whole bunch of products. It has mops as well
11 and wet dry and stuff like that, but it
12 certainly -- that is one of its products.

13 Q Okay. And these are the -- so the Roomba
14 robots are the types of robots you're referring to
15 in Paragraph 154?

16 A Well, again, I'm pointing to that plus the
17 other product -- again, that is mopping devices.
18 Same as SharkNinja. SharkNinja has vacuum
19 cleaners and mopping and combinations of vacuums
20 and mops.

21 Q Aren't the home environments dramatically
22 more dynamic and less predictable than the

1 controlled environments of secure warehouse
2 facilities?

3 A I don't think so. There are differences,
4 certainly, but these warehouses have a lot of
5 robots walking around, and they certainly can have
6 people walking around as well. They could have
7 trailers driving around.

8 So there's a lot of moving objects in
9 these warehouses that would need to be sensed and
10 detected and avoided, and you would compare that
11 to a house where you have people walking around.
12 Maybe a dog, some babies.

13 So I understand that there's different
14 kinds of objects moving around, and that's a
15 difference, but the fact is there's objects moving
16 around and some that are fixed, and all those need
17 to be -- the fixed ones need to be mapped, and all
18 of them need to be avoided. So there is a lot of
19 similarity between these mobile home robots and
20 the mobile robots operating in warehouses.

21 Q In home environments, do chairs not get
22 pulled out from tables?

1 A No. They get moved around.

2 Q And do children's book bags not get
3 dropped on the floor?

4 A They're definitely on the floor sometimes.

5 Q So the robots have to deal with those
6 unexpected obstacles?

7 A Yes. And with that, they actually do
8 pretty well. They avoid obstacles. I'm pointing
9 here that when you set these robots up, there are
10 essentially survey modes that the robots go into,
11 and you push a button on and they drive around
12 your house and try to locate all the permanent
13 obstacles, such as walls and chairs and beds, and
14 they also try to detect carpets so that they know
15 where not to mop when you ask them to go out and
16 mop.

17 So these survey beams are going out there
18 and they're trying to find obstacle that are very
19 similar to the obstacles that are in warehouses,
20 and I did numerous, numerous testing of these
21 robots. And they work okay. They work fine in
22 some open spaces, but both of these companies, and

1 many of their products, have difficulty when they
2 get next to an obstacle, and especially when they
3 try to go under an obstacle like a low-lying table
4 or under a bed. The map just breaks down. They
5 can't find the wall in the obstacle, and what you
6 get when it comes back is a really crappy looking
7 map of part of your house, and both of these
8 companies realize that, so they'll allow you to
9 manually go in and change the map where the robot
10 fails, and often that failure is associated with
11 low-lying obstacles.

12 Q In warehouse settings, do vertical posts
13 and storage racks move around?

14 A I would hope not. I mean, not very often.

15 Q So once the robots -- once they've been
16 mapped or once the robots have mapped them, isn't
17 it reasonable to think that they would remain
18 stable in contrast to home environment where table
19 legs, chair legs, backpacks move frequently?

20 A I think there is an issue of frequency of
21 change of obstacles in the home environment, but
22 the mapping of the walls and the structures

1 doesn't change that often. But certainly with
2 these automated warehouses, they would -- they
3 would bring in a huge palette of supplies that
4 would just be put down on the floor, sit there for
5 a week until it's stored. They might be bringing
6 in new shelving systems.

7 So these warehouses would have changes to
8 the map of the -- what I'll call permanent
9 structures, and some of the products the companies
10 sell allow companies to update their map.

11 If they've got a huge palette of supplies,
12 they can take one of these RFID tags that we
13 talked about before, and they could push a button
14 and have a person walk around this area, and that
15 information was uploaded to our map saying don't
16 go into this area anymore because we have a
17 semipermanent obstruction here.

18 So that's going to happen. You're going
19 to need to update your map from time to time if
20 those kinds of operations or effects are happening
21 inside your warehouse.

22 Q So you secure the storage area from people

1 walking around, fenced it off. Wouldn't that be
2 much simpler than a home environment that's not so
3 secured?

4 A It's simpler for the obstacle detection
5 part of this, but the mapping part, which is what
6 I'm speaking to here, that's about the same.
7 We're talking about initial step where the robot
8 goes out and automatically locates obstacles and
9 paths and intersections and routes that -- it's
10 not affected by what you just, you know, talked
11 about.

12 Q But if the environment -- so if the
13 storage area doesn't change, so the vertical posts
14 don't move and the storage area is fenced off such
15 that your temporary palettes are not placed in the
16 storage area, and only robots are allowed to move
17 around the storage area, then isn't that a much
18 simpler environment and a not-changing environment
19 compared to the home environment that you
20 described?

21 A Yes. That environment does not change as
22 much, but the initial mapping challenge is the

1 same. Like, we may be talking past each other.
2 There's two different aspects here. One is the
3 initial mapping that these robots do to find out
4 where the walls are, where the posts are, where my
5 intersections are, where my routes are. That's
6 the same --

7 Q Mm-hmm.

8 A -- in a warehouse or a home, but I'll
9 admit to you that probably in a home, there's more
10 obstacles that need to be detected during the
11 operation of these robots.

12 Q So if we updated the map manually and then
13 ran the robot through the warehouse, would
14 multipath effects still be a problem?

15 A Okay. Let me see if I understand your
16 question. So I ran the robot in survey mode, and
17 it has this multipath effect, and then I take that
18 map and I manually override it, would I have the
19 multipath effect problem; is that your question?

20 Q So in operating -- after we have the map,
21 when the robot is in operating mode, is the -- are
22 multipath effects a problem?

1 A No. The multipath effect I'm talking
2 about is the multipath effect during mapping. So
3 their question is I'm done with mapping; is there
4 multipath effects? Not the ones I'm talking
5 about.

6 There are -- if you used an emitted
7 detector sensor to operate during the obstacle
8 detection, you would get -- you would have those
9 kind of multipath effects still, but that would be
10 for the application of detecting obstacles, not
11 for the application of mapping.

12 Q If a Roomba encounters a chair leg in an
13 unexpected spot, what happens?

14 A If the Roomba has this map, it uses it as
15 a general guideline of where it can go or it needs
16 to go to clean your house. But as it's driving
17 around, all the time it's looking for obstacles.
18 So it's hopefully not going to run into the leg,
19 or if it runs into it, it runs into it in low
20 velocity because it saw it coming, it slowed it
21 down.

22 It typically has bumpers, manual bumpers

1 on the front, so they try to evict obstacles, but
2 they know they're going to run into some from time
3 to time, so they also have a physical bumper that
4 creates a low-impact force.

5 Q Is that -- so is the bump sensor, is that
6 how a new chair/leg location is mapped?

7 A Well, the new chair location is not
8 mapped. Right? The map -- it's like, this is the
9 area you need to cover; do the best job you can,
10 and it drives around in some random motions. And
11 all the time, it's looking for obstacles. It's
12 always looking for people walking in front of it,
13 kids walking in front of it, the backpack on the
14 ground.

15 So that's a different set of obstacle
16 detection and it's always running those and trying
17 to detect the obstacles and slowing down or
18 turning before it gets to them. So the map just
19 generally provides essentially an outer boundary
20 of where its tasked space is, and so the -- that's
21 all the map is doing after it's initially
22 established.

1 Q So despite the dynamic and unpredictable
2 home environment, Roomba's POSITAs have figured
3 out how to traverse unexpected obstacles despite
4 multipath effects, right?

5 MR. PATNAIK: Object to form.

6 A The -- either the POSITAs of Roomba that
7 the team of Ph.D.s they have there, they figure
8 that out to a reasonable degree. They are pretty
9 good about avoiding obstacles or really not
10 hitting obstacles very hard. That's their goal
11 there, so they have achieved that fairly well.
12 You don't hear Roombas running down babies very
13 often.

14 Q And Roomba didn't -- iRobot didn't close
15 up shop as a result of these mapping issues or
16 multipath effects, right?

17 MR. PATNAIK: Object to form.

18 A No, they did not close up shop. I'd have
19 to check the news reports. They're doing
20 relatively poorly, and part of it, I think,
21 results from really, really bad reviews that this
22 product line received.

1 Q Would it surprise you if I represented to
2 you that iRobot sold 40 million robots in 2021?

3 A No, I'm not surprised. I would be
4 surprised if you told me they were doing very well
5 financially.

6 MS. ZOTTOLA: All right. Let's go off the
7 record.

8 (A recess was taken.)

9 BY MS. ZOTTOLA:

10 Q Dr. Singhose, did you discuss any part of
11 your testimony with counsel during the break?

12 A No. No substantive discussions.

13 Q So turning to your response declaration,
14 Exhibit 2007 --

15 A Okay.

16 Q -- Page 81. You offered some diagrams to
17 demonstrate -- as examples to demonstrate the
18 difficulty of multipath reflections for a POSITA;
19 is that right?

20 A Yes. This is -- yes, that's a fair
21 assessment.

22 Q Can you walk us through each of these

1 diagrams?

2 A Sure. So they're kind of labeled A, B, C,
3 D, E, and F, and the first one in A is sort of an
4 ideal case. This is how the sensor is supposed to
5 work. So on the right side of A, you have that
6 red symbol, which is representing a laser
7 technician -- emission. It's sending out a laser
8 signal, and then it travels out, hits an obstacle
9 represented by the wall, and it comes back to the
10 image sensor, generally through a lens.

11 So if that's how it works and you can
12 measure the time of flight, how long did that
13 take, and you know the speed of light, then you
14 can determine the distance of where the obstacle
15 was.

16 And then the other ones are showing cases
17 where there's multiple path effects. So let's go
18 to B. You have the same primary path that you are
19 trying to achieve, but in this case the laser is
20 shown as not reflecting perfectly back directly to
21 the sensor, but taking another path and bouncing
22 off, let's say, a mirror over on the left side,

1 and then it bounces off that mirror and goes back
2 to the receptor.

3 The receptor will now get two readings
4 about how far obstacles are away, and it will have
5 to choose which of those two. And that stuff's
6 kind of the simplest multipath effect.

7 And then C, D -- for other ones -- for
8 example, in C, there might be a translucent layer
9 of material before the obstacle you want to
10 detect. This translucent layer -- I mean, it
11 could be a translucent layer, or it could be,
12 like, Rayleigh, for example, outside that bounces
13 some of the laser back -- or fog that bounces some
14 of the laser back before it gets to the obstacle.

15 So here you would have two possible paths.
16 In this case, the untrue path is shorter than it
17 was in B. So you can't just pick the shortest
18 one. Like, that's not the easy way out here.
19 Just, like, pick the first signal I got back,
20 because it could be bouncing off a surface closer
21 to the obstacle you're trying to detect.

22 And then D is showing a case where there's

1 basically various different surfaces that it's
2 bouncing off in different ways, and then E is also
3 showing the sort of different translucent
4 materials or reflective layers, and F is showing
5 hitting particulates, like snow or rain could
6 cause the laser to bounce back, and basically you
7 cause your sensor to receive multiple reflection
8 signals.

9 Q All right. So let's pull up the source
10 exhibit for those drawings, which is Exhibit 2009.
11 I just moved it into the chat so that we can mark
12 it as Exhibit 2009.

13 (Exhibit 2009 was marked for
14 identification and is attached to the transcript.)

15 A Okay. I have it.

16 Q So can you read the description of each of
17 the cases at the bottom of Page 2 where it starts
18 with case A? Read it aloud -- out loud.

19 A Yeah. So A -- I'll read it. A, the ideal
20 case of low MPI, multipath interference, they
21 might be calling it, or something like that. So
22 that's what I said. That was the ideal case.

1 And then B --

2 Q I'm sorry, I'm sorry. I mean at the
3 bottom of Page 2, which is above the diagrams,
4 where it reads, Case A is the ideal scenario, a
5 single path --

6 A Okay.

7 Q Start there, please. Thank you. Sorry to
8 interrupt you.

9 A No worries. Do you want me to read it or
10 read it into the record?

11 Q Read it into the record, please.

12 A Okay. Sure. Case A is the ideal
13 scenario, a single path from the laser to the
14 pixel.

15 Case B is where there is a specular
16 interreflections in the scene between objects.
17 This could be due to objects like a disco ball in
18 the scene.

19 Case C is where there is a translucent
20 objects, there is a return from the translucent
21 object, and what is behind it.

22 Case D is diffuse interreflections in a

1 corner. There are many paths back to the same
2 pixel.

3 Case E is caused by lens flare ghosting,
4 whereby scattering inside the lens, both between
5 elements of the lenses and between the image
6 sensor and the last optical element, normally a
7 notch filter.

8 Case F is from bulk diffuse scattering,
9 such as fog caused by Rayleigh Scattering.

10 Q Isn't it true that several of the physical
11 circumstances shown in Cases A through F are not
12 relevant to or could easily be excluded from a
13 secured warehouse environment?

14 A I wouldn't say several; I would say a
15 couple. For example, F is being used to indicate
16 fog and rain and snow, in my opinion. That could
17 show up in a warehouse if you have smoke or dust
18 or something like that, but I would say for the
19 most part that's not going to happen that often.

20 And then E is the other one that don't
21 happen that often just out in the general
22 environment. It'd be more, like, what's happening

1 back on your receiver and how they've decided to
2 put lenses and surfaces in front of the detector
3 to protect it.

4 So you could have one of these protectors
5 for your robot, but you've decided how to protect
6 it, so you put, like, a headlight lamp cover over
7 it, and you messed up the sensor. So that's kind
8 of what that's representing. Again, that could
9 exist because you've not installed it that well in
10 your robot.

11 And then the other ones, A, B, and C are
12 certainly going to happen -- I mean, A, B, and D
13 are certainly going to happen. The C one, again,
14 maybe one that would show rarely in the types of
15 environments that we're talking about.

16 Q So A is an ideal scenario, which means --

17 A Yeah.

18 Q -- no locating multipath effects, right?

19 A Yeah, that's what I said. That's the one
20 case that theoretically it happens that way, and
21 that could happen from time to time in your
22 warehouse. Everything works properly.

1 Q So --

2 A But the other ones, B and D are going to
3 be happening a fair amount of time.

4 Q So B says could be due to objects like a
5 disco ball in the scene. Are disco balls common
6 in these types of warehouses?

7 A No, not at all, but that's just using
8 disco -- disco ball as an example. They're really
9 talking about a reflective surface. So they're
10 just trying to teach a reader what this might be,
11 and a disco ball has a lot of reflective surfaces.

12 But, for example, the bottom of this lower
13 shelf is going to be a reflective surface,
14 especially if it's made of metal. So instead of a
15 disco ball, you could just think of it as the
16 bottom of the shelf.

17 Q So is it common to have a mirror under a
18 shelf in a warehouse?

19 A Well, no, not a mirror, but the metallic
20 surface has reflective properties much like a
21 mirror. It bounces a lot of the stuff back. So
22 metallic surfaces is a -- is a mirroring surface

1 in the sense that it bounces a lot of light
2 signals back off it than normal.

3 Q Could you use a nonreflective surface for
4 the bottom of the shelf?

5 A Well, there is no such thing as a
6 nonreflective surface, you know, totally, but
7 certainly you could apply coatings or paints or --
8 you could try all sorts of stuff to reduce the
9 reflection path, but there's no way to get rid of
10 it.

11 Q Okay. So a non-mirrored surface could be
12 used for the bottom of the shelf, right?

13 A You could use a less reflective surface
14 for the bottom of the shelf.

15 Q Okay. And when you said Case C with the
16 translucent material, that would rarely have been,
17 right?

18 A It would rarely happen. Again, it could
19 happen if you installed your sensor in your robot
20 and you've decided that in front of your robot you
21 need a bumper, and that bumper's a translucent
22 material, and you designed or emitted it to go out

1 through the translucent material of the bumper and
2 back through. It's going to work to some extent,
3 but you are going to get this reflective pattern
4 from the inner surface of whatever laser.

5 Q But -- and what if you didn't do that?

6 A Yeah. If you didn't do that, you've got a
7 clear path with nontranslucent material, then you
8 would be back up to Cases A, and rarely because
9 that's the ideal cases, but Cases B and D would be
10 the more likely problems that you would have.

11 Q And in Case D, couldn't you solve for this
12 by placing the shelves more centrally in the
13 middle of the warehouse and putting distribution
14 centers or other workstations or open space travel
15 paths around the perimeter the way Hangzhou
16 teaches?

17 A No.

18 Q Why not?

19 A Well, because as these robots travel
20 around the warehouse, they have to, by definition,
21 go close to obstacles. They have to go to
22 containers. They have to go to boxes. They have

1 to go by poles. They have to go by the storage
2 racks.

3 So this D is going to happen a lot when
4 you're operating in these environments.

5 MR. PATNAIK: Dana, can I interrupt for a
6 second? I'm just looking at the real time, and a
7 couple questions back, I think the court reporter
8 got it -- the testimony was rarely because that's
9 the ideal cases, but Cases A and B would be more
10 likely.

11 I'm pretty sure he said B and D would be
12 more likely problems than the -- A was the ideal
13 case, and B and D was the -- it's line 19-1.

14 (A discussion was held off the record with
15 the court reporter.

16 Q Okay. So I understood -- sorry. Back to
17 Case D where we're talking about the multipath
18 effects. So I understood your opinion here
19 focused on the multipath effects occurring under
20 shelves.

21 So we are concerned with reducing multi --
22 the issue of multipath effects under the shelves?

1 A Yes. That's how I'm answering your
2 question. I thought that was the setup for this,
3 and then you said what if we were driving out in a
4 more open area?

5 Q So couldn't -- couldn't the -- couldn't
6 the scenario depicted in Case D be avoided by
7 placing the -- placing the shelves more centrally
8 in the middle of the warehouse so that we're not
9 near corners?

10 A Okay. I understand the question now. So
11 this is not representing a corner of a warehouse.
12 This is representing a corner of any obstacle. So
13 under these shelves would have vertical legs, and
14 then coming off of the right angle would be the
15 bottom of the shelf.

16 So that's a corner that this robot is
17 driving by and is sending this signal out. It's
18 going to sometimes go up there and be like this
19 pool shot, right, where you bounce off multiple
20 walls and it comes back to you.

21 So the orange in the figures aren't
22 representing walls. They're representing any

1 parts of obstacles that you're going by.

2 Q So how does -- if we are -- if we're
3 looking at these cases in the context of multipath
4 effects under introduced under the shelf, how does
5 this, I guess, orange corner, how does that
6 represent the under surface of a shelf?

7 A Well, it -- that's not exactly what this
8 is representing. These are just example
9 configurations to illustrate multipath effect.

10 So this isn't -- I didn't go on the
11 line -- I didn't go online and find an example
12 that this is the underside of a shelf. I went
13 online and just found representative cases.

14 So those -- in Case D, we have two orange
15 lines representing a corner, and they're shown at
16 90 degrees. They don't have to be at 90 degrees.
17 They could be other angles. They don't have to be
18 perfectly upside down like that. But it does
19 represent the fact that any time there's a corner
20 or multiple reflective surfaces close to each
21 other, you can have the beam bounce off one, some
22 of that beam goes back to the detector, while the

1 rest of the beam bounces over to the second
2 surface, and that second surface bounces it back
3 to the receiver.

4 That's what this is representing. So this
5 is not supposed to match under the shelf exactly,
6 but if you're under the shelf and you look around
7 you, you're going to see all sorts of different
8 reflective surfaces, some of which are at
9 90 degrees and some of which are at different
10 ones.

11 But the point is there's multiple
12 reflective surfaces under there including the
13 bottom of the shelf, which is going to bounce
14 energy back to this receiver and confuse it
15 because that's an additional path of reflection.

16 Q Don't the time-intensity profiles --
17 time-intensity profiles described at Page 5
18 demonstrate the POSITA could readily handle five
19 or six of these cases?

20 A No. It represents just some possibilities
21 of coming out of these, and what it actually shows
22 is it wouldn't be easier to handle these because

1 you have to have some sophisticated algorithms to
2 try to weigh the signals coming back and determine
3 what a real obstacle is.

4 And if you've got two signals coming back
5 with about the same peak amplitude, we really have
6 no way of knowing where the obstacle is. Is there
7 whole bunch of people working on this? Is there
8 hundreds of Ph.D.s working on this? Yeah, they'
9 are trying to solve this. They're trying to get
10 information on this. The solutions that work
11 reliably in closed environments are still not
12 available today and would be well beyond the skill
13 set of a person of ordinary skill in the art.

14 Q So if we start with Case A, there are no
15 noisy reflections. So we're good there, right?

16 A Yeah. That's the ideal case that you
17 would -- you would know. If everything worked
18 perfectly and the world was a perfect place, I
19 would get a response like that.

20 Q Okay. And then continuing at the --
21 looking at these time-intensity maps at the top of
22 Page 5, Scenario B, we've got the second return

1 arriving after the first, right?

2 A Yes.

3 Q So -- so we've got the highest intensity
4 for the first in time?

5 A Yes. For this particular case, the -- the
6 real distance, the actual distance we're trying to
7 measure returns first as a -- in this case, it
8 looks somewhat slightly higher. Doesn't always
9 have to have the same value. Again, this is a
10 representation of one possible situation that
11 occurs with B.

12 Q Right. So would a robot equipped with a
13 LiDAR system configured to select signals of
14 highest intensity and first in time identify the
15 correct signal?

16 A No, and that's shown by C. If you go to
17 C, you've got the false signal coming back first
18 and with a higher amplitude. So just compared --
19 just focusing on B and C shows this fundamental
20 problem. You just don't know where the actual
21 object is located.

22 Q Right. But focused on B, would a robot

1 equipped with a LiDAR system configured to select
2 return signals of highest intensity and first in
3 time identify the correct signal?

4 A Just that one measurement in time and
5 that's what that algorithm was? Yeah, it would
6 get that right for that one specific case.

7 Q Okay. And then D, would a robot equipped
8 with a LiDAR system configured to select return
9 signals of high intensity -- highest intensity and
10 first in time identify the correct signal here?

11 A Again, if they were exact shapes and it
12 was a very simple algorithm like that, it would
13 likely get the correct value. I mean, those peaks
14 are pretty close to the same. So if we -- go up a
15 little bit, it messes up with that result. But
16 given that one specific diagram, I would say your
17 algorithm would work okay there, too.

18 Q And then E, similarly, would a robot
19 equipped with a LiDAR system configured to select
20 the signal of highest intensity and first in time
21 identify the correct signal?

22 A It would identify the correct distance,

1 yes.

2 Q Now, C, we understand, is a little bit
3 tricky, but that could also be addressed by not
4 having translucent materials in a warehouse; is
5 that right?

6 A Well, again, this is one specific example
7 where they're using translucent materials, but
8 that reflection path could come from a variety of
9 other surfaces. Again, these are just five simple
10 examples to demonstrate the problem. They're not
11 meant to represent the full scope of a problem in
12 a warehouse. So you don't get rid of the problem,
13 C, just by not having translucent materials.

14 Q But if we're talking about multipath
15 effects in -- under shelves in a warehouse, and in
16 case C here, we could avoid Case C by not having
17 translucent materials under the shelves; is that
18 right?

19 A Are you talking about C as in this very,
20 very specific example, are you talking about C the
21 problem that it represents in general? Because
22 you can't get rid of the problem in general of

1 getting a return path back earlier.

2 If you're agreeing that it's literally
3 only in the case of a translucent sheet, then
4 yeah, just get rid of your translucent sheets, but
5 that's not really what this pictorial is about.
6 It's answering a problem with an example. It's
7 not saying this is the full scope of this early
8 return problem.

9 Q Doesn't this article teach that the first
10 method of resolving multipath interference is to
11 set up the scene to minimize the amount of
12 multipath interference being caused?

13 A I don't know, but that would be a good
14 place to start.

15 Q On Page 8 of the article, right in the
16 middle, right under where it says minimize
17 multipath interference, can you read that sentence
18 out loud, please?

19 A Above it or below it?

20 Q Below it.

21 A When positioning the camera in the scene,
22 do the following.

1 Q The sentence above that, please.

2 A Sorry. The first method of resolving
3 multipath interference is to set up the scene to
4 minimize the amount of multipath interference
5 being caused.

6 Q And so if we're setting up a warehouse
7 where we're concerned about multipath effects
8 under the shelves and we want to avoid the
9 possibility of multipath interference associated
10 with Case C from this article, then wouldn't this
11 article suggest that we just avoid using
12 translucent materials under the shelves?

13 A Can you repeat your question? Because I
14 think I didn't agree with part of the setup,
15 because I don't think it can be avoided, if that
16 was part of your question. I don't agree with the
17 setup. It can't be avoided.

18 Q If we're trying to minimize the effects of
19 multipath -- if we're trying to minimize multipath
20 effects in a scenario where we're concerned with
21 it under warehouse shelvings, so underneath the
22 warehouse shelves, and we're faced with the

1 possibility of scenario C in the article, wouldn't
2 we just avoid having translucent material under
3 the shelves?

4 A No. That's not just what we do. If we
5 wanted to minimize it, we would remove the shelf
6 because that's where reflection patterns are going
7 to come from. So that's how you minimize it, is
8 getting rid of the reflective surfaces that can
9 bounce back the signal in different paths than
10 from the object you are trying to detect.

11 Q Can you have shelves that don't have glass
12 underneath them?

13 A Yes.

14 Q Okay. Do you recall reading the U.S.
15 Patent 10,472,172, which was referred to in
16 Dr. Derby's declaration as the Goren reference,
17 Exhibit 1008?

18 A I don't recognize the number. That name
19 does sound familiar. What was the subject matter?

20 Q I will move it into the chat.

21 A Okay.

22 (Exhibit 1008 was marked for

1 identification and is attached to the transcript.)

2 Q So I've moved Exhibit 1008 into the chat
3 to be marked.

4 A This does seem familiar to me, but I'm not
5 exactly sure that I got it from where you said.
6 But it does -- it does seem like a document I
7 reviewed before.

8 Q Do you recall that Goren describes that it
9 was known at least as early as 2016 to route
10 robots under elevated shelves to allow for
11 flexible route planning?

12 A I don't recall that, but if you point it
13 to me, I would -- I would probably agree with
14 that.

15 Q Okay. So column 6, line 40. Lines 40 to
16 43.

17 A I read it. Do you have a -- do you want
18 to repeat the question?

19 Q Yeah. So would you agree that Goren
20 describes that it was known at the time to route
21 robots under elevated shelves to allow for
22 flexible route planning?

1 A I mean, you could have -- I think that's a
2 fairly good summary of this paragraph. I mean,
3 he's basically saying sometimes certain
4 embodiments, this would work, depending on the
5 robot and how it works and what you're trying to
6 do with it. There's no question. You could -- if
7 the space is big enough, you could drive a robot
8 under a shelf.

9 Q And then do you see in claim 3, so at
10 column 14, claim 3 regarding robots traveling
11 beneath shelving units. Do you see that?

12 A Yes, I do.

13 Q Do you recall Goren discussing or
14 mentioning at all the problem of multipath
15 effects?

16 A I just searched for it, and Goren doesn't
17 seem to be concerned with mapping. So I don't
18 think it would have the multipath effect problem
19 that we're talking about. It doesn't try to
20 create maps under the shelves, then there's no
21 reason why it would discuss multipath interference
22 or multipath problems in the way that we've been

1 discussing it.

2 Q So is it possible that multipath effects
3 are not explained in Goren because one of ordinary
4 skill in the art could figure out how to run
5 Goren's robots under elevated shelves without
6 undue experimentation?

7 MR. PATNAIK: Object to form.

8 A Can you repeat the question again?

9 Q Is it possible that multipath effects are
10 not explained in Goren because one of ordinary
11 skill in the art could figure out how to run
12 robots under elevated shelves without undue
13 experimentation?

14 MR. PATNAIK: Same objection.

15 A I did not do investigation on why
16 multipath effects are not in Goren, but I would
17 think that they're probably not in Goren because
18 he's not talking about the problem that's related
19 to what we're talking about, which is
20 automatically mapping under shelves. So this
21 isn't even the same subject matter.

22 Q Let's turn back to the drawing provided

1 earlier of the aisle and shelving units of the
2 '632 patent. And let me see if I'm -- good.

3 Can you please draw three robots into this
4 drawing? One traveling in the aisle. And label
5 that R1.

6 A Okay. I've represented it sort of
7 generically as not a rectangle so you can tell
8 it's something different, and that's R1. That's
9 Robot 1 going down the aisle.

10 Q And then a second robot traveling under S1
11 in a direction away from S2, and label that R2.

12 A Okay. Sorry.

13 Okay. Something like that?

14 Q Great. Can you move R2 up a little bit?

15 A Like up this way?

16 Q Yeah.

17 A Tell me when you want me to stop.

18 Q That's great.

19 A Okay.

20 Q And then a third robot traveling under S2
21 at the same level as R2 but in a direction
22 downward in the drawing.

1 A Okay.

2 Q Okay. So let's say R2 has a LiDAR, and R2
3 is mapping and then operating. The LiDAR scans in
4 front of the robot. How many legs would the robot
5 see?

6 A You know, it would see however many were
7 in front of it. First of all, LiDARs have a
8 certain scan angle. You can change that. So I
9 actually have four of these operating in my
10 laboratory right now, and we currently have them
11 set up for a 60-degree scan arc. So it would
12 detect some signal from all of the legs that are
13 within that 60-degree scanning arc.

14 You're talking about just what the
15 reflection from the legs are, the legs of the
16 shelves?

17 Q Right. And so this is --

18 A Okay.

19 Q -- in mapping?

20 A Yeah. So if it's driving around mapping,
21 it's going to have this LiDAR scanning back and
22 forth looking for stuff, and it's going to get

1 reflective signals from whatever the laser hits
2 and bounces back. And I don't know what the scan
3 window is going to be set up for. I'm just using
4 what's going on at this very moment is a
5 60-degree, but it could be 90-degree or 180.

6 So whatever obstacles are within that scan
7 path of the LiDAR, there's going to be some amount
8 of reflection from those obstacles.

9 Q Could you draw in a 60-degree arc for R2?

10 A Sure. I mean, we have to decide
11 whether -- is it going to be 60 degrees pointing
12 forward or 60 degrees pointing sideways or
13 backways? Because --

14 Q Forward.

15 A Okay. So something like that. Oops.
16 It's grabbing stuff.

17 Okay. There we go. So just eyeballing
18 it, that would look about 60 degrees. In that
19 case, it would see those two legs that are in
20 front of it like that.

21 Q Did we add in legs?

22 A Well, yeah. Remember, I told you there

1 would be any number of legs on here that you would
2 need to support the structure. I mean, four would
3 be the minimum, but you're -- I've never seen
4 that. Structure needs four. There's going to be
5 more than that.

6 Q All right. Now let's shift to the robot
7 running in the aisle. R1.

8 A Okay. What do you want to happen there?

9 Q Similar -- similar situation. How many
10 legs would R1 see?

11 I'm sorry. R1 is intending to be
12 traveling away from R2 and R3.

13 A It is? Okay.

14 And you want the same 60-degree or a wider
15 path?

16 Q 60 -- 60 degrees is fine.

17 A Okay.

18 Okay. So that would be about 60 degrees,
19 so it would -- it would see -- you know, the way I
20 sketched it there, it's going to see bits of
21 probably at least five, maybe six of those legs.

22 Q Okay.

1 A If you want me to speak to the legs, not
2 the -- not the shelf that's above it that it's
3 getting reflections from, right?

4 Q We'll get to that.

5 A Okay.

6 Q And then Robot R3 operating under -- under
7 the shelf, what sort of -- how many legs would R3
8 see?

9 A Is it headed north towards the top of the
10 figure?

11 Q It's traveling south.

12 A The same direction as R1?

13 Q Correct.

14 A Okay.

15 Okay. Probably something like that. So
16 it's going to see -- you know, it's going to see a
17 lot more legs because it's got more legs in front
18 of it than the other ones.

19 Q So you had mentioned earlier and in your
20 declaration that LiDAR does well in open spaces
21 like in aisles and faces more challenges under the
22 shelves.

1 So is it somehow easier for Robot R1 to
2 navigate when it is, you know, in view of the
3 legs, and then you also mentioned near the -- near
4 the shelving surfaces as opposed to R2/R3?

5 A The question was easier to navigate. I
6 just want to make sure -- that question doesn't
7 make sense in our discussion. Is it easier to map
8 or is it easier to recognize the obstacles?
9 Because I don't see how navigate is tied to our
10 previous discussion.

11 Q How is -- how are -- how is it easier for
12 Robot R1 to avoid multipath effects during mapping
13 and operation?

14 A That's -- that question makes sense.
15 Okay. Because it's not getting reflective
16 patterns off of as many corners or the overhead
17 surface, because there is an overhead surface.

18 So R2 and R3 have a surface above them
19 that we have represented, and it's getting
20 multipath effects bouncing off that, and then the
21 corners formed by that and each of these legs that
22 we see. And R1 doesn't have that surface above it

1 reflecting energy back to its sensors.

2 Q How many corners are available to R1
3 versus R2 in this drawing?

4 MR. PATNAIK: Object to form.

5 A Those corners are formed by a variety of
6 things. I'm going to have to -- to answer the
7 question, I'll have to state which corners it's
8 looking for, but there's going to be other corners
9 I'm not discussing.

10 So those vertical support legs that we're
11 seeing represented from the overhead view, they
12 form corners with the ground, the side wall, and
13 the ceiling, at least those three.

14 So whenever you see a robot under -- that
15 is, the S1, the R2, or the R3 robot -- they're
16 going to have those three types of corners
17 associated with each leg that it sees, and the
18 reflection times are going to be different and the
19 amplitudes are going to be different.

20 And then the R1 robot, it's essentially
21 not going to have that corner associated with the
22 overhead and the legs. So it will have a

1 corresponding -- less amount of reflection
2 patterns, and that's why it's going to be somewhat
3 easier for that robot to detect the actual objects
4 instead of the -- get confused by the ghosts or
5 the fake obstacles.

6 Q Are there more corners on the five legs
7 for R1 versus the two legs of R2?

8 A Well, again, the specific sketch that we
9 have, if R2 is only seeing two legs and it's six
10 corners that we've been talking about, the sort of
11 six simplistic corners, that would be -- I'm
12 sorry, the three, essentially. That's six.

13 And R1 -- again, this simplistic
14 representation, is seeing perhaps five, and that's
15 times two, so it would be ten. So it's possibly
16 seeing more corners than R2 in this -- in this
17 particular specific case that we've sketched out
18 here.

19 But in general, the robots under the
20 shelves are going to have a lot more reflective
21 paths than those operating with no overhead shelf.

22 Q Does your analysis change if the ceiling

1 height is eight feet and the shelf height is four
2 feet?

3 A Which ceiling height are you talking about
4 there?

5 Q Of the warehouse.

6 A I would think that I would have to know
7 more details to answer that question, what kind of
8 laser is being emitted, what sort of detector is
9 being used, those sort of algorithms.

10 But in general, the further away the
11 reflective surface is above a robot, the less
12 problematic it will be.

13 Q Would the -- looking at your diagram,
14 would the multipath effects for all three robots
15 during mapping and operation be reduced if only
16 the original four legs remained under each of the
17 racks?

18 A That's a compound question. I'm not sure
19 I can dice it all.

20 So you're saying -- let's start with the
21 last part first. You're saying I should erase all
22 the support legs and assume that there's only four

1 legs on each rack in this warehouse?

2 Q Right. We can go over --

3 A Okay.

4 Q -- it by robot.

5 A Okay.

6 Q So Robot 2, if we started with the -- your
7 original drawing and you added Robot 2 and you
8 didn't add the additional legs. So shelf two or
9 storage rack one just had the four original legs,
10 would the multipath effects for Robot 2 be reduced
11 as compared to this current version of the
12 drawing?

13 A Yes, because we're moving way far away as
14 a realistic drawing. That was just the start of
15 our drawing.

16 But as you see in these patents, the
17 spacing between the support legs are roughly the
18 size of the robot. So you would be representing a
19 very unrealistic case by having R2 robot with its
20 relative size there, only four legs. That would
21 be a huge span. They're going to have a lot more
22 support legs spaced along the side. That's why I

1 put them in there.

2 Q Okay. And same question for Robot R1.

3 Would --

4 A Yeah. I can --

5 Q Go ahead.

6 A I think I remember your question good
7 enough to answer it. Yeah. If we remove legs,
8 we're going to have less multipath effects.

9 MR. PATNAIK: Let her ask the question.

10 THE WITNESS: Okay.

11 Q Does the '632 require shelves to have much
12 more than four legs?

13 A Yeah. I mean, again, I don't think
14 there's a specified number, but the way it's
15 pictorially represented and described, for
16 example, in all of the figures, like 6, 7, 8, 9,
17 and 10, they're all showing the separation between
18 the legs being approximately the width or the
19 length of the robot.

20 So the scale that we're using here is
21 vastly out of whack if we don't have those
22 additional legs.

1 Q Looking at Robot 1 in this drawing, would
2 this robot of the '632 patent be unable to perform
3 mapping due to multipath effects?

4 A Okay. Let me -- can you ask the question
5 again? I almost thought it --

6 Q Would R1 -- would Robot R1 in the context
7 of the '632 patent, so would R1 of the '632 patent
8 be unable to perform mapping due to multipath
9 effects?

10 MR. PATNAIK: Object to the form.

11 A So I don't think that this question fits
12 in the context of the '632 patent because I'm not
13 finding where the '632 patent is talking about a
14 robot going out and mapping and creating a map
15 while driving around. So I'm not sure I can put
16 this question in the context of '632 patent.

17 Q Would R1 be unable to operate due to
18 multipath effects?

19 MR. PATNAIK: Object to form. You're
20 asking in the '632 still?

21 MS. ZOTTOLA: Correct.

22 MR. PATNAIK: Object to form.

1 A So I'm trying to place this in the context
2 of the '632. I think in that context the robot
3 can operate, but the question of whether or not
4 from time to time it will run into something comes
5 into play because there might be multipath effects
6 depending just on how its sensors are locating its
7 position in the warehouse and the position of
8 obstacles.

9 But it certainly can operate. It's a
10 question of can it operate safely?

11 Q Can Robot R2 of the '632 patent operate in
12 view of multipath effects?

13 MR. PATNAIK: Object to form.

14 A Yeah. Taking the teachings of the '632
15 patent and also integrating knowledge, the person
16 of ordinary skill in the arts knowledge of
17 multipath effects, yes, I think they can operate.

18 Q And what does the knowledge of the person
19 of ordinary skill in the art provide as part of
20 that?

21 A Well, a person of ordinary skill in the
22 art would understand multipath effects, and they

1 would understand if they were going under the
2 shelf, they would not rely on a sensor that could
3 suffer from multipath effects that could cause it
4 to stop operating.

5 Q And so the Robot R3, similar question:
6 For R3 for the '632 patent, could it operate in
7 view of multipath effects?

8 A Yes. There's no real functional
9 difference between R3 and R2.

10 Q You said that a person of ordinary skill
11 in the art could not rely on a sensor that could
12 suffer from multipath effects that could cause it
13 to stop operating. What would the person of
14 ordinary skill in the art rely on?

15 A Well, there's any number of ways that they
16 could run those robots under the shelves without
17 having multipath effects. They could turn off any
18 sensors that they have on board that might be
19 creating multipath effect. They could use dead
20 reckoning. They could use any number of sensors
21 on the wheels that would tell it where it was at.
22 It could, for example, read a barcode and say

1 based on the size and shape of this barcode, I
2 know where I'm at.

3 There's any number of ways to get a robot
4 under that shelf.

5 MS. ZOTTOLA: Let's go off the record.

6 (A recess was taken.)

7 (Singhose 2 was marked for identification
8 and is attached to the transcript.)

9 BY MS. ZOTTOLA:

10 Q Dr. Singhose, where in the '632 patent
11 does it inform a POSITA how to deal with problems
12 of multipath effects?

13 MR. PATNAIK: Object to form.

14 A I didn't do that investigation because I
15 don't think that the issue of multipath effects is
16 a problem for the technology in the '632 patent.

17 Q Is the '632 inventing multipath effects?

18 A Not that I recall.

19 Q Does the '632 patent tell you how to
20 differentiate between signals returning from
21 shelves versus roofs?

22 A No, I don't think it has that problem, so

1 it doesn't discuss it.

2 Q How about differentiating between signals
3 returning from table legs or distant walls?

4 A Again, I don't think it has those
5 problems, so it doesn't discuss them.

6 Q Does the '632 patent tell you what height
7 of shelf would produce multipath effects or what
8 other shelf height would not?

9 A No. Again, that's not a problem that
10 occurs with the technology in the '632 patent.

11 Q Dr. Singhose, in your declaration, you
12 stated that Dr. Spenko misunderstands the
13 technology at issue referencing excerpts of his
14 deposition where he's testifying about an article
15 that you also indicated you had reviewed that I
16 will put into the chat, Exhibit 2004.

17 (Exhibit 2004 was marked for
18 identification and is attached to the transcript.)

19 Q So I pasted Exhibit 2004 into the chat to
20 be marked.

21 A Okay. I have 2004. Just let me make sure
22 I have what you wanted. This is a document called

1 Fault-Free Integrity of Urban Driverless Vehicle
2 Navigation With Multi-Sensor Integration?

3 Q Correct. And you reviewed this article in
4 preparation of your declaration; is that right?

5 A Yes, I did.

6 Q And would you agree that this article is
7 about global navigation systems and driverless
8 vehicles employing such global navigation systems?

9 A Not really. I would characterize this as
10 a paper about global navigation satellite systems.

11 Q Are you familiar with global navigation
12 satellite systems?

13 A Yes.

14 Q Can you please describe how global
15 navigation satellite systems work?

16 A Sure. I mean, I'll do it at a high level
17 because there's many different variations of it.
18 But essentially you use satellites that are
19 stationed above wherever you're at, and you
20 interact with them getting signals, and if you can
21 interact with multiple of those satellites, you
22 can do something very much like triangulation that

1 we discussed before where you can calculate the
2 position of the car using the interactions with
3 those satellites.

4 Q Where does the emitter signal used in a
5 global navigation satellite system originate?

6 A You mean from -- you mean the signals
7 coming from the satellites?

8 Q Correct.

9 A Yeah. They're coming from satellites.

10 Q And where does a signal used in LiDAR
11 originate?

12 A That would generally originate from
13 somewhere on the LiDAR sensor.

14 Q Do you have any personal experience with
15 global navigation satellite systems on autonomous
16 vehicles?

17 A Yes.

18 Q Can you point in your CV where that
19 experience is set forth so we can review it?

20 A Yeah. It's under -- anything you see in
21 there called CanSat or Rescue Robot, those would
22 be projects I worked on where we launched robots

1 up to, let's say, 12,000 feet, and we used GPS to
2 measure where that vehicle is and then have that
3 vehicle adjust its flight pattern and/or driving
4 pattern when it gets back onto the ground to
5 navigate through a desert to try to get to a
6 target location.

7 Q Do you have any personal experience with
8 the relative multipath errors that would be
9 attributable to LiDAR versus global navigation
10 satellite systems?

11 A Yes.

12 Q And is that associated with the same
13 experience you just described or something else?

14 A No, certainly that experience, but also
15 I've used LiDAR to -- I've done projects where
16 I've tried to use LiDAR to measure various
17 systems, such as cars while they're driving
18 around.

19 Q Did your experience ever focus on using
20 global navigation satellite systems in urban
21 canyons?

22 A No.

1 Q Would a POSITA ever use a global
2 navigation satellite system in an automated
3 warehouse?

4 A Probably not. It's usually hard to get
5 the satellite systems in through the roof and
6 walls to -- to get good signals inside the
7 buildings.

8 Q So -- so a POSITA would not necessarily
9 consider using a global navigation satellite
10 system for robot navigation in a system like the
11 one claimed in the '632 patent?

12 A I think that would be a strange choice. I
13 don't know how they would get that to work well.

14 Q Did you study multipath effects in urban
15 canyons in your experience?

16 A No, not urban canyons.

17 MS. ZOTTOLA: I pass the witness.

18 MR. PATNAIK: Okay. I do have a couple
19 questions, Doctor.

20 EXAMINATION

21 BY MR. PATNAIK:

22 Q Same rules apply to me. If my questions

1 are unclear, please let me know, and I'll try to
2 recast it.

3 You just went through some testimony, a
4 line of questioning about what was marked as
5 Exhibit 2, the annotated drawing. Do you know
6 what I'm talking about? If you want to pull it
7 up --

8 A The drawing that I was asked to make?

9 Q The last one where counsel asked you some
10 questions and you drew it.

11 A Okay. Yeah, I'll pull it up. I'll just
12 go ahead and pull it up because I think it's
13 sitting here.

14 Okay. I have that.

15 Q I was a little confused by counsel's
16 questions with respect to the robots with respect
17 to the '632 patent and multipath effects. Why did
18 you address multipath effects, or why are they
19 relevant to your opinions contained in your second
20 declaration?

21 A Well, this whole issue came up because
22 they're important not for the '632 by for the

1 Raizer prior art.

2 Q Can you explain that?

3 A Well, the Raizer prior art needs to do the
4 survey mode where it goes around and creates a
5 map, and this is the kind of technology it would
6 use so Raizer could do its autonomous mapping
7 somewhat successfully in sort of relatively open
8 spaces.

9 But as it got close to obstacles and
10 certainly going under obstacles, that's when
11 Raizer would self-determine its multipath effects
12 and just wouldn't work very well.

13 Q Why did you testify earlier that the issue
14 of multipath effects is not a problem for the
15 technology in the '632 patent?

16 A Because the '632 patent does not operate
17 like Raizer.

18 Q Why do you say that?

19 A It -- well, there's a lot of differences.
20 I could spend all day here, but most germane at
21 this point, it doesn't do that survey mode to
22 automatically map and set up its navigation system

1 the way Raizer does. It just doesn't do that.

2 Q How does the '632 patent do that? Does it
3 provide any examples?

4 A I'd have to go back and see if it actually
5 says how to do that. I don't -- off the top of my
6 head, I'm not sure that it provides examples on --
7 on how it does its map. But it doesn't do it in
8 the same way as Raizer.

9 Q Well, let me ask -- let me direct you to
10 the '632 patent, column 12.

11 A Okay.

12 Q And 13. And you don't need to read it out
13 loud, but could you just tell me, does that shed
14 any light?

15 A So I'm pretty familiar with 12 and 13
16 because I read them in detail. What we have here
17 in 12 and 13 is a lot of details on how it
18 navigates, not -- it's not specifically directed
19 to how it sets a map up in the beginning.

20 So there's lots of details on how this is
21 how we navigate around and how we get to different
22 targets. So that's what the focus here details

1 on, how to navigate.

2 Q And does that shed any light on the
3 relevance of multipath effects of the '632 patent?

4 A Yes, I think it does. When it describes
5 how it's navigating, it's not relying on this
6 auto-mapping feature that would suffer from the
7 multipath effects. That's why I don't think it's
8 relevant to the '632.

9 Q What's it relying on?

10 A Well, it's relying on a lot of the stuff
11 that's listed in these columns. So it's relying
12 on some sensors. It's relying on anchor point
13 markers. I mean, there's just a bunch of stuff in
14 here.

15 But the point is it's relying on different
16 kind of technology to navigate rather than the
17 anchor point navigation system that is discussed
18 in Raizer.

19 MR. PATNAIK: No further questions.

20 MS. ZOTTOLA: No questions from us.

21 (Off the record at 2:38 p.m.)

22

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

ACKNOWLEDGMENT OF DEPONENT

I, WILLIAM E. SINGHOSE, Ph.D., do hereby
acknowledge that I have read and examined the
foregoing testimony, and the same is a true,
correct and complete transcription of the
testimony given by me and any corrections appear
on the attached errata sheet signed by me.

(DATE)

(SIGNATURE)

1 CERTIFICATE OF SHORTHAND REPORTER-NOTARY PUBLIC

2 I, Brooklyn E. Schweitzer, Certified Reporter
and Notary Public do hereby certify:

3 That WILLIAM E. SINGHOSE, Ph.D., the witness
4 whose deposition is hereinbefore set forth, was
duly sworn by me before the commencement of such
5 deposition and that such deposition was taken
before me and is a true record of the testimony
6 given by such witness.

7 I further certify that the adverse party,
EXOTEC, was represented by counsel at the
deposition.

8 I further certify that the deposition of
WILLIAM E. SINGHOSE, Ph.D., occurred virtually on
9 Tuesday, April 29, 2025, commencing at 9:04 a.m.
to 2:38 p.m.

10 I further certify that I am not related to
any of the parties to this action by blood or
marriage, I am not employed by or an attorney to
11 any of the parties to this action, and that I am
in no way interested, financially or otherwise, in
12 the outcome of this matter.

13 IN WITNESS WHEREOF, I have hereunto set my
hand and affixed my notarial seal this 9th day of
14 May, 2025. My commission expires: May 20th,
2026.

15
16
17 

18 _____
19 Brooklyn E. Schweitzer, RPR, CRR
20
21
22

A			
a1	above	62:15, 68:5,	134:9
30:21, 31:2	41:14, 55:21,	79:21, 82:13,	against
ability	99:3, 113:19,	87:7, 108:21,	42:18, 42:22
12:20, 54:7,	114:1, 123:2,	120:9, 141:4	ago
67:18	124:18, 124:22,	add	9:3, 11:19,
able	127:11, 135:19	24:2, 31:19,	11:22, 12:1,
48:17, 55:3,	acceleration	33:5, 33:6,	21:11
66:7, 68:21,	71:18	121:21, 128:8	agree
69:6, 69:22,	access	added	38:9, 64:1,
73:17, 74:22	73:1	31:21, 128:7	65:1, 114:14,
about	accommodate	additional	114:16, 116:13,
8:19, 9:19,	35:9, 37:8,	108:15, 128:8,	116:19, 135:6
14:8, 14:18,	49:13	129:22	agreed
15:13, 17:10,	accommodation	additionally	6:11, 6:13
17:16, 21:1,	64:17	38:1	agreeing
21:7, 22:3,	according	address	113:2
27:16, 32:14,	29:4, 48:10	81:3, 139:18	ahead
34:6, 34:7,	account	addressed	31:19, 33:13,
39:20, 43:8,	50:5, 50:7,	45:1, 112:3	43:3, 129:5,
43:22, 44:3,	51:1, 52:17,	adjust	139:12
44:8, 45:5,	78:19	137:3	aid
46:6, 46:20,	accurately	admit	57:10
55:16, 56:6,	13:5, 65:1,	91:9	air
56:9, 59:18,	80:14	adverse	71:15
60:2, 62:5,	achieve	144:10	aisle
73:14, 75:9,	62:20, 64:17,	affected	29:2, 30:9,
76:5, 76:15,	96:19	90:10	30:15, 30:21,
78:7, 80:9,	achieved	affixed	31:3, 32:15,
80:22, 81:8,	94:11	144:24	35:17, 38:22,
81:21, 83:20,	acknowledge	after	40:7, 40:18,
89:13, 90:6,	143:4	91:20, 93:21,	48:7, 48:21,
90:7, 90:11,	acknowledgment	110:1	49:1, 49:6,
92:2, 92:5,	143:1	again	51:22, 119:1,
94:9, 97:4,	action	31:9, 36:13,	119:4, 119:9,
101:15, 102:9,	144:18, 144:20	37:10, 39:3,	122:7
105:17, 109:5,	active	40:7, 42:2,	aisles
112:14, 112:19,	59:6	44:19, 48:15,	38:7, 38:12,
112:20, 113:5,	activities	49:2, 49:17,	38:16, 40:3,
114:7, 117:19,	15:14, 40:13	49:21, 52:11,	40:17, 40:22,
118:18, 118:19,	actual	66:17, 75:14,	48:5, 74:13,
120:14, 121:18,	21:18, 49:3,	82:13, 85:16,	77:9, 123:21
122:18, 126:10,	49:6, 78:17,	85:17, 101:8,	al
127:3, 130:13,	83:8, 110:6,	101:13, 103:18,	4:14
134:2, 134:14,	110:20, 126:3	110:9, 111:11,	algorithm
135:7, 135:10,	actually	112:6, 112:9,	83:16, 111:5,
139:4, 139:6	11:17, 20:11,	118:8, 126:8,	111:12, 111:17
	22:16, 28:13,	126:13, 129:13,	algorithms
	38:21, 52:22,	130:5, 134:4,	109:1, 127:9

all 2:5, 6:12, 7:19, 9:15, 15:3, 15:5, 15:9, 16:7, 18:7, 20:20, 22:11, 27:7, 28:20, 33:9, 40:13, 40:15, 52:2, 61:1, 63:16, 63:20, 64:8, 65:17, 66:22, 67:2, 70:14, 71:7, 71:19, 73:7, 74:1, 75:16, 78:11, 78:14, 80:1, 80:5, 81:14, 86:16, 86:17, 87:12, 92:17, 93:11, 93:21, 95:6, 98:9, 102:7, 103:8, 108:7, 117:14, 120:7, 120:12, 122:6, 127:14, 127:19, 127:21, 129:16, 129:17, 140:20 alleged 72:22 allow 88:8, 89:10, 116:10, 116:21 allowed 30:17, 90:16 almost 16:11, 130:5 along 17:2, 40:6, 40:7, 40:16, 40:18, 40:21, 60:21, 64:22, 128:22 aloud 98:18 already 26:21, 38:4,	43:11 also 3:18, 8:11, 8:15, 13:7, 17:1, 20:9, 25:17, 28:16, 36:20, 39:22, 41:12, 50:4, 50:9, 51:18, 52:14, 52:18, 59:7, 59:13, 60:1, 60:8, 63:5, 68:16, 71:17, 80:4, 87:14, 93:3, 98:2, 112:3, 124:3, 131:15, 134:15, 137:14 alston 3:6, 6:7 although 13:1 always 16:12, 71:1, 84:18, 93:12, 93:16, 110:8 america 1:5 amount 43:6, 44:21, 51:11, 79:11, 83:1, 102:3, 113:11, 114:4, 121:7, 126:1 amplitude 109:5, 110:18 amplitudes 125:19 analysis 17:3, 47:6, 68:19, 79:3, 126:22 analyze 45:2 anchor 142:12, 142:17 angle 56:18, 60:8,	106:14, 120:8 angles 107:17 angulares 59:9 annotated 139:5 another 22:7, 29:3, 54:8, 65:22, 77:16, 82:22, 83:2, 96:21 answer 12:19, 13:18, 14:10, 38:8, 46:15, 76:2, 125:6, 127:7, 129:7 answering 13:13, 106:1, 113:6 answers 13:5 anticipate 50:2, 50:21 any 7:4, 7:22, 8:22, 9:1, 9:2, 9:5, 9:21, 10:3, 12:2, 12:4, 12:5, 12:6, 12:10, 13:2, 14:8, 22:19, 41:4, 41:11, 44:18, 46:16, 52:4, 55:2, 63:15, 63:19, 67:12, 72:8, 72:12, 79:11, 95:10, 106:12, 106:22, 107:19, 122:1, 132:15, 132:17, 132:20, 133:3, 136:14, 137:7, 141:3, 141:14, 142:2, 143:7, 144:18, 144:20	anybody 6:16, 15:16 anymore 89:16 anyone 84:16 anything 12:5, 29:19, 34:6, 34:9, 51:16, 72:6, 136:20 anyway 30:4 anywhere 55:3, 76:8 apart 35:15, 36:9 appeal 1:3 appear 35:21, 41:20, 143:7 appears 36:14 appendices 8:8 appendix 21:2 application 4:15, 27:6, 58:18, 92:10, 92:11 applications 7:4 apply 103:7, 138:22 approach 84:8, 84:9, 84:11 approached 16:4, 16:12 approximately 129:18 april 1:17, 144:15 arc 120:11, 120:13, 121:9
--	---	--	---

area 28:10, 50:20, 89:14, 89:16, 89:22, 90:13, 90:14, 90:16, 90:17, 93:9, 106:4 areas 24:4, 28:7, 50:11, 51:3, 75:11 aren't 51:15, 77:5, 79:18, 85:21, 106:21 arguments 17:4 arm 71:12 around 21:20, 21:22, 22:7, 22:10, 23:8, 24:3, 27:3, 28:9, 30:17, 37:9, 48:18, 51:22, 53:22, 54:16, 54:22, 55:1, 57:14, 58:22, 75:16, 75:21, 81:10, 86:5, 86:6, 86:7, 86:11, 86:14, 86:16, 87:1, 87:11, 88:13, 89:14, 90:1, 90:17, 92:17, 93:10, 104:15, 104:20, 108:6, 120:20, 130:15, 137:18, 140:4, 141:21 arrangement 29:4 array 76:21 arrival 81:15	arrives 77:19 arriving 110:1 art 15:8, 16:19, 17:15, 32:20, 42:11, 46:9, 46:17, 48:3, 48:6, 49:8, 49:20, 59:16, 63:12, 84:14, 109:13, 118:4, 118:11, 131:19, 131:22, 132:11, 132:14, 140:1, 140:3 article 113:9, 113:15, 114:10, 114:11, 115:1, 134:14, 135:3, 135:6 arts 131:16 asked 139:8, 139:9 asking 12:18, 13:12, 16:21, 23:3, 43:8, 44:1, 44:3, 44:8, 45:17, 46:6, 130:20 aspect 42:3 aspects 91:2 assembly 22:8 asserted 16:20 assessing 17:4 assessment 95:21 associated 11:5, 47:7, 74:5, 74:10, 88:10, 114:9, 125:17, 125:21, 137:12 assume 13:18, 127:22 assuming 18:9 atlanta 11:18 attached 19:19, 22:9, 27:10, 33:21, 57:3, 61:12, 98:14, 116:1, 133:8, 134:18, 143:8 attempted 85:5 attempts 84:21 attenable 83:12 attended 2:5 attention 61:14 attorney 16:8, 144:19 attorneys 3:3, 3:11, 8:2 attributable 137:9 august 17:6 auto-mapping 142:6 automated 23:2, 28:19, 61:22, 65:13, 67:10, 89:2, 138:2 automaters 23:1 automatically 90:8, 118:20, 140:22 automation 11:16, 11:17, 11:18, 16:9 autonomous 24:5, 24:6, 24:8, 24:15, 136:15, 140:6 available 109:12, 125:2 avenue 3:14 avoid 87:8, 112:16, 114:8, 114:11, 115:2, 124:12 avoided 86:10, 86:18, 106:6, 114:15, 114:17 avoiding 94:9 aware 11:6, 11:8, 11:12, 11:14, 11:15, 83:12 away 75:17, 82:15, 82:20, 97:4, 119:11, 122:12, 127:10, 128:13 axis 36:11, 56:6	B b2 4:12, 4:20 babies 86:12, 94:12 back 7:17, 9:13, 19:5, 28:11, 43:7, 58:1, 60:9, 64:8, 74:1, 74:16, 74:20, 74:21, 75:5, 75:22, 76:5, 77:13, 77:15, 78:10, 78:16, 79:10, 82:17, 83:6,
--	---	--

88:6, 96:9, 96:20, 97:1, 97:13, 97:14, 97:19, 98:6, 100:1, 101:1, 102:21, 103:2, 104:2, 104:8, 105:7, 105:16, 106:20, 107:22, 108:2, 108:14, 109:2, 109:4, 110:17, 113:1, 115:9, 118:22, 120:21, 121:2, 125:1, 137:4, 141:4 background 21:1 backpack 93:13 backpacks 88:19 backways 121:13 bad 94:21 bags 87:2 ball 99:17, 102:5, 102:8, 102:11, 102:15 balls 102:5 barcode 58:5, 58:7, 58:9, 132:22, 133:1 barcodes 58:11 based 39:5, 39:12, 46:15, 49:5, 133:1 basic 81:21 basically 22:11, 30:7,	50:11, 70:10, 74:16, 76:3, 83:17, 98:1, 98:6, 117:3 basis 56:17, 67:12 bays 52:15 beam 79:18, 107:21, 107:22, 108:1 beams 87:17 because 25:15, 26:4, 30:19, 38:9, 43:8, 46:6, 47:19, 64:18, 65:10, 69:16, 69:19, 70:1, 70:18, 70:22, 78:8, 84:16, 89:16, 92:20, 97:20, 101:9, 104:8, 104:19, 105:8, 108:15, 108:22, 112:21, 114:13, 114:15, 115:6, 118:3, 118:10, 118:17, 121:13, 123:17, 124:9, 124:15, 124:17, 128:13, 130:12, 131:5, 133:14, 135:17, 139:12, 139:21, 140:16, 141:16 bed 88:4 beds 87:13 been 6:3, 10:1, 11:4, 11:22, 18:5, 18:13, 47:3, 88:15, 103:16, 117:22, 126:10	before 1:3, 2:8, 6:8, 9:16, 10:4, 13:11, 13:13, 14:11, 29:16, 89:13, 93:18, 97:9, 97:14, 116:7, 136:1, 144:6, 144:8 beginning 141:19 behalf 6:7 behind 99:21 being 11:7, 11:10, 16:20, 32:14, 45:1, 50:21, 53:8, 63:12, 63:13, 69:22, 76:20, 79:13, 82:4, 100:15, 113:12, 114:5, 127:8, 127:9, 129:18 believe 8:10, 20:19, 46:17, 46:18 below 78:17, 113:19, 113:20 beneath 117:11 best 12:19, 13:10, 33:13, 93:9 better 46:13 between 24:4, 30:9, 32:10, 50:5, 51:12, 83:4, 83:5, 86:19, 99:16, 100:4, 100:5, 128:17, 129:17, 132:9, 133:20, 134:2	beyond 76:14, 77:1, 109:12 big 11:17, 30:7, 38:13, 49:12, 49:14, 83:2, 117:7 bigger 39:17, 49:11, 49:18 bins 24:2, 29:20 bird 3:6, 6:7 bit 21:5, 21:7, 48:21, 49:18, 111:15, 112:2, 119:14 bits 122:20 blank 10:22 blood 144:18 board 1:3, 60:17, 132:18 bodies 56:11 book 87:2 both 23:15, 40:3, 40:16, 40:21, 68:10, 69:21, 87:22, 88:7, 100:4 bottom 82:4, 98:17, 99:3, 102:12, 102:16, 103:4, 103:12, 103:14, 106:15, 108:13 bounce 76:4, 76:12, 76:22, 77:12,
---	---	---	--

78:9, 78:13, 79:14, 82:17, 98:6, 106:19, 107:21, 108:13, 115:9 bounceback 78:22, 82:19 bounced 74:16, 75:5, 77:6, 77:14, 79:9, 83:5 bounces 77:12, 77:15, 78:4, 78:9, 97:1, 97:12, 97:13, 102:21, 103:1, 108:1, 108:2, 121:2 bouncing 75:21, 81:17, 82:3, 96:21, 97:20, 98:2, 124:20 boundary 93:19 box 49:15, 49:16, 50:2, 51:8, 51:19, 51:21, 81:9, 81:11 boxes 37:8, 37:12, 52:2, 52:21, 104:22 break 14:9, 14:11, 17:9, 20:19, 34:2, 34:10, 61:6, 95:11 breaks 14:8, 88:4 brian 3:5 briefly 19:20 bring 19:5, 89:3 bringing 89:5	brooklyn 1:20, 2:8, 144:2, 144:31 bubble 57:14 build 47:19, 47:20, 53:9 building 52:10 buildings 138:7 built 21:18, 26:5 bulk 100:8 bump 93:5 bumper 93:3, 103:21, 104:1 bumper's 103:21 bumpers 92:22 bunch 50:10, 68:1, 71:20, 75:3, 85:10, 109:7, 142:13 businesses 67:13 button 87:11, 89:13 buy 26:3 C ca 3:9 calculate 60:9, 136:1 calculation 82:12 call 16:21, 28:8, 35:7, 51:7, 52:11, 59:6,	89:8 called 6:3, 134:22, 136:21 calling 98:21 came 59:5, 139:21 camera 113:21 camotion 24:13, 24:20 can't 30:18, 38:8, 42:19, 42:20, 43:5, 44:20, 52:12, 69:15, 70:20, 75:6, 76:8, 88:5, 97:17, 112:22, 114:17 cannot 25:15, 45:16, 71:3 cansat 136:21 canyons 137:21, 138:15, 138:16 capacity 11:14, 12:12 car 136:2 card 59:8 carpets 87:14 carries 52:3 carrying 51:17 cars 137:17 case 5:6, 10:6, 10:13, 10:18, 10:20, 11:5, 15:2, 16:5,	16:13, 16:20, 26:17, 37:11, 42:3, 62:21, 69:17, 79:15, 80:6, 82:5, 96:4, 96:19, 97:16, 97:22, 98:18, 98:20, 98:22, 99:4, 99:12, 99:15, 99:19, 99:22, 100:3, 100:8, 101:20, 103:15, 104:11, 105:13, 105:17, 106:6, 107:14, 109:14, 109:16, 110:5, 110:7, 111:6, 112:16, 113:3, 114:10, 121:19, 126:17, 128:19 cases 9:20, 10:1, 12:14, 23:15, 40:6, 40:10, 40:12, 40:15, 66:13, 81:20, 83:17, 96:16, 98:17, 100:11, 104:8, 104:9, 105:9, 107:3, 107:13, 108:19 cause 55:14, 82:11, 98:6, 98:7, 132:3, 132:12 caused 76:11, 100:3, 100:9, 113:12, 114:5 causes 83:12 caveat 43:1 ceiling 52:11, 77:15, 78:5, 78:9, 78:12, 78:14,
---	--	--	---

79:2, 79:9, 82:4, 82:5, 82:7, 82:10, 82:21, 125:13, 126:22, 127:3 ceilings 82:4 centerline 35:15 centers 104:14 centrally 104:12, 106:7 certain 29:9, 52:10, 52:19, 68:4, 79:22, 82:17, 117:3, 120:8 certainly 41:10, 50:18, 51:1, 64:7, 66:1, 71:3, 71:13, 73:17, 81:19, 85:12, 86:4, 86:5, 89:1, 101:12, 101:13, 103:7, 131:9, 137:14, 140:10 certificate 144:1 certified 2:10, 144:2 certify 144:3, 144:10, 144:13, 144:17 chair 88:19, 92:12, 93:6, 93:7 chairs 86:21, 87:13 challenge 90:22 challenges 74:9, 123:21 change 25:15, 66:4, 66:7, 67:19,	68:4, 69:7, 69:15, 69:20, 70:1, 70:3, 79:2, 88:9, 88:21, 89:1, 90:13, 90:21, 120:8, 126:22 changeability 67:18 changeable 68:8, 68:10, 68:11, 68:13, 68:16, 69:6 changed 67:20 changes 89:7 changing 25:18 characteristics 66:5 characterization 24:10 characterize 24:6, 24:16, 50:17, 135:9 characterized 34:22 chat 19:17, 27:8, 56:22, 61:9, 98:11, 115:20, 116:2, 134:16, 134:19 chatted 34:8 check 10:8, 94:19 checking 7:18, 71:15, 71:16 chicago 5:7 children's 87:2 choice 138:12 choose 51:20, 83:4,	97:5 chunk 83:2 circumstance 34:14 circumstances 16:3, 80:11, 100:11 citation 45:2 cited 20:10, 20:11, 20:17 claim 34:13, 34:20, 45:7, 45:15, 46:14, 46:18, 46:19, 46:20, 46:22, 47:6, 47:7, 48:20, 73:5, 117:9, 117:10 claimed 138:11 claiming 41:11 claims 34:18, 41:6, 44:18, 44:20, 45:3, 45:5, 45:6, 45:14, 46:9, 46:13, 46:16, 47:22, 54:4, 54:5, 54:7, 72:3, 72:5, 73:2, 73:15 clarification 45:13 clarify 11:9, 39:20, 44:1, 56:9, 62:4 class 63:16, 63:20, 65:22, 66:19 classes 67:2 classify 68:6	clean 92:16 cleaners 85:19 clear 43:5, 104:7 clearings 51:11 close 7:9, 78:20, 80:12, 82:2, 85:4, 94:14, 94:18, 104:21, 107:20, 111:14, 140:9 closed 109:11 closer 97:20 cn 4:16 coatings 103:7 code 26:18, 26:20, 26:22, 27:1, 27:4, 27:5, 66:9, 66:12, 66:15, 66:20, 67:14, 69:12, 70:8, 70:13, 71:14, 73:1, 73:6, 73:8, 73:20 collaborate 62:19 collaboration 62:16, 63:7, 63:21 column 35:13, 35:16, 36:2, 37:13, 37:14, 37:18, 37:19, 37:21, 38:2, 41:12, 55:15, 116:15, 117:10, 141:10 columns 31:10, 32:16,
--	---	---	--

36:20, 37:2, 37:7, 38:12, 39:4, 39:11, 142:11 combinations 85:19 combined 51:7, 51:9 come 53:3, 72:9, 74:20, 79:10, 112:8, 115:7 comes 60:5, 67:1, 74:21, 88:6, 96:9, 106:20, 131:4 coming 47:20, 75:22, 78:1, 92:20, 106:14, 108:21, 109:2, 109:4, 110:17, 136:7, 136:9 command 22:22, 23:3 commencement 144:6 commencing 144:15 commercialize 21:12 commission 144:25 common 81:14, 102:5, 102:17 commonwealth 2:11 companies 85:2, 87:22, 88:8, 89:9, 89:10 company 10:14, 17:1, 21:11, 24:13, 65:6, 67:7, 67:8, 68:2, 85:7	compare 86:10 compared 36:19, 37:12, 79:5, 90:19, 110:18, 128:11 compiler 70:3 complete 20:6, 20:8, 20:12, 143:6 completely 13:10, 13:12, 69:7 complex 80:2 complicated 70:14 complies 30:22 component 22:6, 22:21, 64:17 components 64:19, 65:12 compound 127:18 computer 7:4, 11:3, 25:20 concept 70:11 concerned 8:19, 105:21, 114:7, 114:20, 117:17 conclusion 84:21 conducted 2:2 conference 11:18 configurations 107:9 configured 42:6, 42:12, 110:13, 111:1, 111:8, 111:19	confirm 27:12 confuse 75:18, 78:22, 108:14 confused 126:4, 139:15 confuses 75:6 consider 51:4, 80:22, 138:9 consideration 50:14 considerations 52:5 considered 20:3, 20:7, 65:20, 69:8 consistent 36:13 constitution 9:10 contained 139:19 containers 37:12, 104:22 context 57:17, 57:18, 58:13, 58:15, 59:20, 60:13, 67:10, 107:3, 130:6, 130:12, 130:16, 131:1, 131:2 continuing 34:12, 109:20 contrast 88:18 control 23:7 controlled 86:1 controlling 55:22 copies 8:14 copy 8:11, 69:19,	70:2 corner 100:1, 106:11, 106:12, 106:16, 107:5, 107:15, 107:19, 125:21 corners 36:12, 106:9, 124:16, 124:21, 125:2, 125:5, 125:7, 125:8, 125:12, 125:16, 126:6, 126:10, 126:11, 126:16 corporation 1:9 correct 18:6, 20:4, 26:20, 27:19, 35:3, 36:1, 36:21, 40:4, 42:1, 44:9, 48:10, 61:18, 62:11, 74:8, 76:14, 110:15, 111:3, 111:10, 111:13, 111:21, 111:22, 123:13, 130:21, 135:3, 136:8, 143:6 corrections 143:7 correctly 21:9, 45:11 corresponding 126:1 could 31:7, 32:1, 39:18, 41:9, 44:14, 46:19, 46:21, 47:21, 49:11, 51:1, 51:20, 52:22, 53:2, 54:22, 57:20, 58:19, 58:20, 59:4, 59:7, 60:8, 60:11, 60:21,
---	---	---	---

62:5, 64:22, 65:22, 67:9, 68:16, 70:6, 70:17, 71:3, 71:6, 71:8, 71:13, 71:20, 72:15, 73:7, 73:11, 80:10, 81:12, 81:19, 83:3, 86:6, 89:13, 97:11, 97:20, 98:5, 99:17, 100:12, 100:16, 101:4, 101:8, 101:21, 102:4, 102:15, 103:3, 103:7, 103:8, 103:11, 103:13, 103:18, 107:17, 108:18, 112:3, 112:8, 112:16, 117:1, 117:6, 117:7, 118:4, 118:11, 121:5, 121:9, 132:2, 132:3, 132:6, 132:11, 132:12, 132:16, 132:17, 132:19, 132:20, 132:22, 140:6, 140:20, 141:13 couldn't 66:5, 66:21, 80:19, 104:11, 106:5 counsel 6:18, 6:20, 15:10, 15:15, 15:16, 34:1, 47:2, 61:6, 95:11, 139:9, 144:11 counsel's 139:15 couple 8:8, 9:11, 11:21, 20:10,	55:9, 100:15, 105:7, 138:18 course 8:12, 19:5, 30:18 court 6:14, 13:1, 13:4, 13:7, 105:7, 105:15 cover 34:18, 93:9, 101:6 covered 48:13 covers 34:13 crane 21:6 cranes 24:13, 24:20 crappy 88:6 create 117:20 creates 93:4, 140:4 creating 130:14, 132:19 criticizes 63:16, 63:20 crr 1:20, 144:31 current 71:19, 128:11 currently 120:10 customer 25:2, 25:15, 26:16, 26:17 customers 25:5, 25:6, 25:9, 26:1, 67:15 customize 26:7 cv 8:7, 21:3, 136:18	D dana 3:4, 6:7, 8:19, 18:11, 105:5 dangerous 25:17 date 143:13 day 140:20, 144:24 dead 60:12, 60:15, 60:21, 132:19 deal 87:5, 133:11 deals 83:16 decide 121:10 decided 101:1, 101:5, 103:20 decides 23:5 decision 9:10, 17:11, 17:12 declaration 4:10, 8:9, 8:16, 14:1, 14:2, 17:2, 17:18, 18:20, 18:22, 19:9, 19:12, 19:16, 19:21, 20:7, 20:15, 20:18, 64:9, 64:11, 68:19, 74:2, 76:10, 84:20, 95:13, 115:16, 123:20, 134:11, 135:4, 139:20 declarations 8:5, 15:7, 16:15, 16:17, 17:20 definitely 50:19, 58:7,	65:1, 87:4 definition 69:2, 104:20 degree 26:3, 67:5, 94:8, 120:11, 120:13, 121:5, 121:9, 122:14 degrees 56:16, 71:13, 71:14, 107:16, 108:9, 121:11, 121:12, 121:18, 122:16, 122:18 demonstrate 95:17, 108:18, 112:10 depending 31:16, 32:22, 64:6, 117:4, 131:6 depicted 106:6 depicts 57:22 deponent 143:1 deposed 10:7 depositing 28:12 deposition 1:15, 2:1, 6:11, 6:15, 8:12, 9:16, 12:16, 14:2, 15:1, 15:12, 134:14, 144:5, 144:7, 144:12, 144:13 depth 4:18, 37:19, 37:21, 38:1 derby 20:15, 20:18 derby's 115:16 describe 14:21, 16:3,
--	--	---	---

16:14, 28:2, 135:14 described 28:9, 41:14, 44:13, 45:21, 48:13, 53:17, 64:2, 68:20, 90:20, 108:17, 129:15, 137:13 describes 63:6, 63:11, 116:8, 116:20, 142:4 describing 38:21, 40:13, 70:11 description 36:18, 37:10, 57:17, 58:13, 59:21, 98:16 descriptions 36:15 desert 137:5 design 23:19 designed 103:22 designing 81:1 desirable 51:12 desmarais 3:13, 6:21, 16:2, 16:4 despite 94:1, 94:3 detail 141:16 detailed 28:3 details 16:6, 16:13, 73:14, 127:7, 141:17, 141:20, 141:22 detect 74:22, 75:2,	75:8, 76:6, 79:7, 87:14, 93:17, 97:10, 97:21, 115:10, 120:12, 126:3 detected 86:10, 91:10 detecting 92:10 detection 90:4, 92:8, 93:16 detector 58:3, 75:6, 77:17, 78:16, 79:6, 79:10, 83:10, 92:7, 101:2, 107:22, 127:8 determine 47:14, 47:18, 48:4, 48:6, 49:8, 49:20, 96:14, 109:2 determined 50:9 develop 17:17, 22:14, 24:21, 25:19 developed 21:12, 25:4, 25:12 developers 66:10 developing 22:14 develops 65:6 device 58:21 devices 85:17 diagram 111:16, 127:13 diagrams 95:16, 96:1, 99:3 dice 127:19	difference 86:15, 132:9 differences 86:3, 140:19 different 6:13, 25:5, 25:6, 40:13, 42:3, 52:20, 52:22, 53:1, 60:4, 62:2, 62:18, 63:3, 63:6, 66:22, 67:2, 74:20, 77:19, 77:20, 77:21, 78:14, 86:13, 91:2, 93:15, 98:1, 98:2, 98:3, 108:7, 108:9, 115:9, 119:8, 125:18, 125:19, 135:17, 141:21, 142:15 differential 55:13 differentiate 133:20 differentiating 134:2 differently 62:18 difficult 71:17 difficulty 74:7, 88:1, 95:18 diffuse 78:12, 99:22, 100:8 diffusion 80:15 dimension 35:8, 42:2, 49:6 dimensions 35:6, 35:22, 36:15, 37:2, 38:6, 38:7,	38:10, 38:11, 38:16, 38:19, 39:3, 41:5, 41:7, 41:11, 41:21, 41:22, 42:7, 42:13, 44:10, 44:11, 45:20, 45:21, 46:1, 47:6, 47:11, 47:13, 47:14, 47:18, 48:4, 48:7, 49:8, 81:1 direct 141:9 directed 21:14, 80:13, 141:18 direction 56:1, 119:11, 119:21, 123:12 directions 78:14 directive 52:15 directly 96:20 disappeared 7:12 disclose 67:14 disclosed 66:10, 66:12, 66:14, 66:16, 67:11 disclosure 63:15, 63:19, 66:19 disco 99:17, 102:5, 102:8, 102:11, 102:15 discover 25:16 discuss 8:13, 34:1, 35:5, 37:1, 38:5, 38:10,
--	--	--	---

54:7, 61:5, 72:10, 95:10, 117:21, 134:1, 134:5 discussed 38:10, 38:12, 47:10, 47:11, 52:6, 67:13, 136:1, 142:17 discusses 35:2, 35:7, 35:8, 36:20, 61:17, 62:11, 63:2 discussing 117:13, 118:1, 125:9 discussion 105:14, 124:7, 124:10 discussions 95:12 distance 35:17, 36:10, 39:5, 39:12, 79:5, 82:18, 96:14, 110:6, 111:22 distant 76:13, 77:1, 77:7, 134:3 distinguish 83:9 distribution 104:13 doctor 138:19 document 116:6, 134:22 documents 8:3, 8:20, 20:9, 20:11 dog 86:12 doing 25:16, 60:2, 71:2, 82:20, 93:21, 94:19,	95:4 done 12:10, 17:9, 65:10, 65:11, 71:6, 92:3, 137:15 down 22:8, 24:12, 25:13, 26:13, 30:15, 31:2, 48:22, 51:15, 77:13, 88:4, 89:4, 92:21, 93:17, 94:12, 107:18, 119:9 downtown 5:7 downward 119:22 dr 6:16, 7:3, 8:7, 8:11, 9:8, 9:9, 9:11, 9:12, 9:13, 9:15, 14:14, 28:2, 29:1, 34:1, 47:10, 55:6, 61:5, 64:1, 95:10, 115:16, 133:10, 134:11, 134:12 draft 17:19 dramatically 85:21 draw 28:21, 29:1, 31:4, 119:3, 121:9 drawbacks 63:2, 63:6, 63:11 drawing 10:22, 118:22, 119:4, 119:22, 125:3, 128:7, 128:12, 128:14, 128:15, 130:1,	139:5, 139:8 drawings 98:10 drew 29:19, 139:10 drive 30:17, 34:21, 39:1, 39:18, 48:17, 48:22, 50:8, 51:21, 72:17, 73:21, 81:9, 87:11, 117:7 driverless 5:4, 135:1, 135:7 drives 93:10 driving 28:8, 28:9, 28:11, 55:1, 55:13, 72:12, 72:14, 72:19, 80:5, 86:7, 92:16, 106:3, 106:17, 120:20, 130:15, 137:3, 137:17 dropped 87:3 dry 85:11 due 99:17, 102:4, 130:3, 130:8, 130:17 duly 6:3, 144:6 during 34:9, 61:6, 91:10, 92:2, 92:7, 95:11, 124:12, 127:15 dust 100:17 dynamic 85:22, 94:1 E each 17:19, 25:7,	36:8, 36:11, 37:17, 50:19, 91:1, 95:22, 98:16, 107:20, 124:21, 125:17, 127:16, 128:1 earlier 21:4, 24:14, 36:13, 67:14, 80:22, 113:1, 119:1, 123:19, 140:13 early 113:7, 116:9 easier 108:22, 124:1, 124:5, 124:7, 124:8, 124:11, 126:3 easily 50:1, 100:12 easy 97:18 edge 35:16 effect 91:17, 91:19, 92:1, 92:2, 97:6, 107:9, 117:18, 132:19 effects 74:6, 76:11, 80:10, 83:13, 89:20, 91:14, 91:22, 92:4, 92:9, 94:4, 94:16, 96:17, 101:18, 105:18, 105:19, 105:22, 107:4, 112:15, 114:7, 114:18, 114:20, 117:15, 118:2, 118:9, 118:16, 124:12, 124:20, 127:14, 128:10, 129:8, 130:3, 130:9, 130:18, 131:5,
---	--	--	---

131:12, 131:17, 131:22, 132:3, 132:7, 132:12, 132:17, 133:12, 133:15, 133:17, 134:7, 138:14, 139:17, 139:18, 140:11, 140:14, 142:3, 142:7 eight 55:15, 127:1 either 14:1, 23:1, 44:9, 47:3, 94:6 element 75:14, 100:6 elements 65:15, 100:5 elevated 116:10, 116:21, 118:5, 118:12 ellsworth 3:5 else 7:18, 25:11, 65:8, 65:11, 137:13 email 16:7 embodiment 64:6 embodiments 28:5, 64:2, 64:7, 117:4 emission 96:7 emit 74:15, 76:17, 82:16 emits 57:19, 58:21 emitted 92:6, 103:22, 127:8 emitter 57:22, 58:3, 136:4 emitters 59:10	emitting 77:18, 82:14 employed 144:19 employing 135:8 enabled 72:20 encounters 92:12 end 33:5, 33:6 energy 75:18, 76:5, 78:15, 78:21, 83:1, 83:2, 108:14, 125:1 engaged 11:7, 11:10, 15:19 engineer 70:13, 70:14, 70:18, 71:4, 72:2 engineering 70:12, 71:5 enough 14:12, 35:9, 37:8, 39:21, 49:12, 49:14, 75:17, 81:12, 117:7, 129:7 entail 65:4 entire 22:17, 22:22 entirety 55:18 environment 75:9, 78:20, 80:21, 81:2, 83:21, 84:3, 85:1, 88:18, 88:21, 90:2, 90:12, 90:18, 90:19, 90:21, 94:2, 100:13, 100:22	environments 81:22, 82:2, 85:21, 86:1, 86:21, 101:15, 105:4, 109:11 equals 69:13 equipped 110:12, 111:1, 111:7, 111:19 erase 127:21 errata 143:8 errors 137:8 especially 54:22, 88:2, 102:14 esquire 3:4, 3:5, 3:12 essentially 25:12, 25:21, 30:14, 43:9, 49:15, 55:12, 58:2, 59:4, 65:6, 87:10, 93:19, 125:20, 126:12, 135:18 establish 49:1 established 38:4, 93:22 establishing 81:5 estimate 67:9 evans 3:18 even 68:4, 81:17, 118:21 ever 12:10, 24:18, 24:20, 43:18, 137:19, 138:1 every 14:8, 43:10,	43:11, 43:13 everything 7:18, 101:22, 109:17 evict 93:1 exact 36:15, 38:15, 38:18, 41:5, 41:7, 41:22, 47:12, 111:11 exactly 66:6, 107:7, 108:5, 116:5 examination 4:2, 6:5, 138:20 examine 42:8 examined 143:4 example 26:6, 28:10, 31:6, 32:5, 37:6, 38:19, 41:9, 56:1, 63:12, 68:15, 71:11, 76:17, 77:11, 97:8, 97:12, 100:15, 102:8, 102:12, 107:8, 107:11, 112:6, 112:20, 113:6, 129:16, 132:22 examples 95:17, 112:10, 141:3, 141:6 except 75:12 excerpts 134:13 exclude 58:5 excluded 100:12 exclusion 43:9
---	--	--	--

execute 70:9 executing 70:7 exercise 68:1, 69:16 exhibit 4:9, 4:10, 4:12, 4:14, 4:15, 4:17, 4:20, 5:2, 5:3, 18:5, 18:9, 18:16, 19:1, 19:2, 19:13, 19:16, 19:18, 19:21, 21:2, 27:8, 27:9, 27:14, 27:16, 27:18, 56:21, 57:1, 57:2, 61:9, 61:11, 64:9, 74:2, 95:14, 98:10, 98:12, 98:13, 115:17, 115:22, 116:2, 134:16, 134:17, 134:19, 139:5 exhibits 20:17 exist 101:9 existing 24:2, 53:11 exotec 1:5, 1:6, 16:21, 17:5, 144:11 expand 42:20 expectation 54:1 experience 21:6, 66:9, 66:11, 136:14, 136:19, 137:7, 137:13, 137:14, 137:19, 138:15	experienced 12:16 experimentation 83:18, 118:6, 118:13 experiments 83:15 expert 12:13, 17:2, 17:5 expires 144:25 explain 140:2 explained 118:3, 118:10 extending 56:6 extends 41:1 extent 24:9, 104:2 external 60:19 extra-large-size 52:21 eyeballing 121:17 F face 53:14 faced 114:22 faces 123:21 facilities 21:19, 22:4, 22:5, 22:12, 24:1, 86:2 fact 86:15, 107:19 factor 52:12, 52:16 fail 81:20 fails 88:10	failure 88:10 fair 13:20, 14:12, 24:10, 56:10, 63:10, 73:13, 82:22, 95:20, 102:3 fairly 20:8, 38:18, 94:11, 117:2 fake 126:5 fall 32:2 false 110:17 familiar 115:19, 116:4, 135:11, 141:15 far 32:12, 75:17, 97:4, 128:13 fast 23:6 faster 55:11 fault-free 5:3, 135:1 feature 142:6 feel 14:8 feet 35:11, 41:9, 82:8, 82:11, 82:15, 82:20, 82:21, 127:1, 127:2, 137:1 fenced 90:1, 90:14 few 9:3, 26:9, 26:11, 31:15, 34:3, 39:22, 80:10 figure 28:6, 28:13, 30:5, 33:11, 37:7, 38:20, 38:21, 41:13, 41:15, 44:3, 57:8, 75:7, 77:22, 83:8, 83:15, 83:19, 94:7, 118:4, 118:11, 123:10 figured 73:11, 94:2 figures 38:1, 64:4, 106:21, 129:16 filter 81:16, 100:7 finally 14:7 financially 95:5, 144:21 find 59:5, 87:18, 88:5, 91:3, 107:11 finding 130:13 fine 27:15, 27:16, 36:7, 87:21, 122:16 finished 13:10, 13:12 firm 16:2 first 8:16, 16:18, 17:8, 17:19, 18:22, 27:14, 39:8, 47:19, 50:6, 51:9, 51:17, 54:6, 96:3, 97:19, 110:1, 110:4, 110:7, 110:14, 110:17, 111:2, 111:10, 111:20, 113:9, 114:2, 120:7, 127:21
---	--	---

fits 23:22, 130:11 five 12:1, 63:11, 64:2, 64:6, 83:5, 108:18, 112:9, 122:21, 126:6, 126:14 fixed 86:16, 86:17 flare 100:3 flat 79:19 flexible 116:11, 116:22 flight 96:12, 137:3 flip 64:4 floor 40:7, 40:16, 40:18, 40:21, 41:1, 50:5, 81:5, 87:3, 87:4, 89:4 focus 137:19, 141:22 focused 105:19, 110:22 focusing 110:19 fog 97:13, 100:9, 100:16 following 17:12, 113:22 follows 6:4 force 93:4 foreclose 42:5 foreclosed 42:12, 45:12, 46:10 foreclosure 43:18, 44:17	foregoing 143:5 form 12:3, 28:4, 32:4, 39:14, 40:9, 40:20, 47:16, 50:16, 53:7, 56:13, 57:14, 58:17, 60:14, 60:16, 65:19, 73:3, 83:22, 94:5, 94:17, 118:7, 125:4, 125:12, 130:10, 130:19, 130:22, 131:13, 133:13 formed 124:21, 125:5 forth 17:5, 120:22, 136:19, 144:5 forward 56:4, 121:12, 121:14 found 107:13 four 11:22, 31:14, 31:21, 32:21, 59:4, 69:13, 77:18, 77:20, 82:11, 83:5, 120:9, 122:2, 122:4, 127:1, 127:16, 127:22, 128:9, 128:20, 129:12 fraction 78:15 france 1:5 francisco 3:9 free 13:22, 14:9 freedom 49:10, 49:21,	50:10 frequency 58:14, 88:20 frequently 88:19 front 8:1, 10:9, 43:7, 93:1, 93:12, 93:13, 101:2, 103:20, 120:4, 120:7, 121:20, 123:17 full 112:11, 113:7 fully 24:8, 24:15, 56:11, 56:14, 56:15, 56:16, 56:17 function 62:20, 70:22 functional 26:2, 26:4, 132:8 functions 62:19 fundamental 110:19 fundamentally 55:10 further 24:12, 127:10, 142:19, 144:10, 144:13, 144:17 G gave 8:11, 8:15, 8:17 general 30:16, 63:16, 63:20, 80:4, 80:19, 92:15, 100:21, 112:21, 112:22, 126:19, 127:10 generally 23:21, 47:13,	60:3, 62:18, 70:13, 93:19, 96:10, 136:12 generate 73:18 generically 119:7 geometry 60:9 georgia 21:13 germane 140:20 getting 69:21, 74:18, 113:1, 115:8, 123:3, 124:15, 124:19, 135:20 ghosting 100:3 ghosts 126:4 give 8:21, 13:17, 35:11, 41:4, 68:15, 80:19 given 22:19, 26:8, 52:14, 55:2, 73:16, 111:16, 143:7, 144:9 giving 27:5 glass 75:3, 115:11 global 135:7, 135:8, 135:10, 135:11, 135:14, 136:5, 136:15, 137:9, 137:20, 138:1, 138:9 go 22:11, 23:22, 28:17, 30:17, 31:19, 33:13, 33:17, 39:21, 39:22, 43:3,
--	---	---	--

49:14, 51:6, 51:17, 51:20, 51:22, 52:2, 52:13, 53:10, 55:3, 61:1, 77:13, 78:11, 79:18, 80:1, 81:10, 81:13, 84:9, 87:10, 87:15, 88:3, 88:9, 89:16, 92:15, 92:16, 95:6, 96:17, 103:22, 104:21, 104:22, 105:1, 106:18, 107:10, 107:11, 110:16, 111:14, 121:17, 128:2, 129:5, 133:5, 139:12, 141:4 goal 94:10 goes 17:2, 74:19, 90:8, 97:1, 107:22, 140:4 going 9:13, 12:17, 13:9, 15:21, 28:20, 29:5, 29:17, 30:4, 31:17, 33:9, 33:11, 46:16, 50:13, 51:8, 53:14, 66:6, 66:7, 70:15, 71:21, 71:22, 72:1, 73:17, 75:15, 77:12, 77:13, 78:9, 78:12, 78:13, 78:18, 78:21, 78:22, 79:10, 79:22, 80:4, 80:7, 80:18, 81:9, 82:21, 83:1, 84:7,	84:10, 87:17, 89:18, 92:18, 93:2, 100:19, 101:12, 101:13, 102:2, 102:13, 104:2, 104:3, 105:3, 106:18, 107:1, 108:7, 108:13, 115:6, 119:9, 120:21, 120:22, 121:3, 121:4, 121:7, 121:11, 122:4, 122:20, 123:16, 125:6, 125:8, 125:16, 125:18, 125:19, 125:21, 126:2, 126:20, 128:21, 129:8, 130:14, 132:1, 140:10 good 21:10, 75:12, 79:17, 80:15, 80:20, 84:9, 94:9, 109:15, 113:13, 117:2, 119:2, 129:6, 138:6 goren 115:16, 116:8, 116:19, 117:13, 117:16, 118:3, 118:10, 118:16, 118:17 goren's 118:5 goutam 3:12, 6:21 gps 137:1 grabbing 121:16 grant 12:6 great 119:14, 119:18 greater 35:17, 36:10,	37:19, 38:2, 41:17 gridlock 55:4 ground 12:17, 93:14, 125:12, 137:4 guess 15:22, 23:17, 24:19, 31:7, 47:17, 84:6, 84:11, 107:5 guideline 92:15 H half 9:22, 35:17 hall 34:8 hand 144:24 handle 108:18, 108:22 handling 21:14, 21:21 hangzhou 20:16, 61:8, 61:15, 61:17, 62:10, 63:2, 63:5, 63:10, 63:16, 63:20, 64:2, 104:15 happen 79:16, 89:18, 100:19, 100:21, 101:12, 101:13, 101:21, 103:18, 103:19, 105:3, 122:8 happening 80:5, 89:20, 100:22, 102:3 happens 92:13, 101:20 happy 45:2 hard 13:9, 94:10,	138:4 head 13:4, 46:6, 141:6 headed 123:9 headlight 101:6 hear 33:10, 94:12 heavy 22:6 height 49:20, 49:22, 50:5, 50:11, 50:12, 50:15, 50:19, 51:2, 51:5, 51:7, 51:9, 51:16, 52:5, 52:10, 52:17, 52:19, 53:1, 53:3, 79:1, 81:5, 82:7, 82:8, 82:21, 83:11, 83:16, 127:1, 127:3, 134:6, 134:8 heighth 50:1 heights 79:4 held 11:18, 105:14 help 21:20 helpful 14:4, 14:5 here 6:18, 7:16, 8:3, 8:6, 8:13, 11:3, 14:15, 14:18, 18:9, 20:3, 20:11, 22:4, 32:11, 41:20, 45:15, 54:7, 58:19, 72:5, 73:10,
--	---	--	--

73:16, 80:9, 87:9, 89:17, 90:6, 91:2, 97:15, 97:18, 105:18, 111:10, 112:16, 122:1, 126:18, 129:20, 139:13, 140:20, 141:16, 141:22, 142:14 here's 16:9 hereby 143:3, 144:3 herein 20:10 hereinbefore 144:5 hereunto 144:23 high 79:5, 111:9, 135:16 higher 51:18, 52:13, 81:6, 81:8, 110:8, 110:18 highest 110:3, 110:14, 111:2, 111:9, 111:20 history 15:5 hit 59:11 hits 77:15, 96:8, 121:1 hitting 94:10, 98:5 home 85:8, 85:21, 86:19, 86:21, 88:18, 88:21, 90:2, 90:19, 91:8, 91:9, 94:2 honest 70:5	hope 88:14 hopefully 28:22, 59:4, 92:18 hopping 51:15 horizontal 79:18 horizontally 40:3, 40:16, 48:18, 79:13, 80:14 hour 14:8 hours 15:13 house 86:11, 87:12, 88:7, 92:16 housekeeping 6:9 however 120:6 huge 89:3, 89:11, 128:21 human 24:9 hundreds 25:6, 109:8 I id 59:7 ideal 96:4, 98:19, 98:22, 99:4, 99:12, 101:16, 104:9, 105:9, 105:12, 109:16 ideally 82:16 identical 32:10 identification 19:19, 27:10, 33:20, 57:3,	58:14, 61:12, 98:14, 116:1, 133:7, 134:18 identify 57:11, 110:14, 111:3, 111:10, 111:21, 111:22 illustrate 107:9 illustration 4:13, 4:21 image 96:10, 100:5 immutable 69:7 implementation 25:14 important 50:18, 52:12, 71:21, 139:22 improve 21:20 inc 1:6, 21:9 inches 39:3 include 58:5, 58:7, 60:1 including 6:14, 22:17, 108:12 independent 17:3, 17:14, 45:5, 45:7 indicate 14:2, 20:3, 30:9, 100:15 indicated 134:15 indicates 67:5 indirect 4:18 indoor 57:13, 59:19 induce 59:12	industry 65:9, 65:14 inform 133:11 information 27:5, 80:20, 89:15, 109:10 infrastructure 22:17 infringe 73:2 infringer 73:1, 73:6 initial 65:21, 90:7, 90:22, 91:3 initially 45:20, 93:21 inner 104:4 inside 66:8, 89:21, 100:4, 138:6 inspected 11:20 installed 101:9, 103:19 instance 80:17 instead 29:8, 102:14, 126:4 institution 17:11, 17:12 integrated 26:11 integrating 131:15 integration 5:6, 135:2 integrity 5:3, 135:1 intellectual 10:1 intending 122:11 intensities 77:21
---	--	---	--

intensity 81:16, 110:3, 110:14, 111:2, 111:9, 111:20 interact 135:20, 135:21 interactions 136:2 interest 12:2 interested 144:21 interference 4:17, 83:21, 84:4, 98:20, 113:10, 113:12, 113:17, 114:3, 114:4, 114:9, 117:21 intermediate 31:15 interreflections 99:16, 99:22 interrupt 99:8, 105:5 intersections 90:9, 91:5 introduced 107:4 invetek 21:8, 21:9, 21:10, 22:15, 23:18, 24:8, 24:14, 24:16, 24:19, 25:9 inventing 133:17 investigation 43:2, 44:12, 44:19, 64:3, 66:18, 67:2, 67:22, 68:14, 118:15, 133:14 investment 12:5 involve 22:15, 22:17 involved 23:19	involving 10:1 ipr 1:12, 6:15, 10:10, 10:12, 12:9, 18:5, 18:17 iprs 10:3 irobot 85:2, 85:7, 94:14, 95:2 isometric 29:9 issue 15:8, 16:10, 43:16, 44:22, 46:13, 47:3, 47:5, 53:8, 53:13, 88:20, 105:22, 133:15, 134:13, 139:21, 140:13 issues 17:16, 51:2, 64:12, 74:4, 85:1, 94:15 it'd 15:21, 42:16, 100:22 itc 12:14 item 23:10, 23:11, 28:11, 50:12, 51:8 items 23:12, 23:17, 23:20, 28:11, 28:15, 28:16, 49:13, 62:21 J job 1:21, 93:9 june 15:22 K keep 30:4, 33:7,	82:7 kids 93:13 kind 11:9, 15:6, 20:20, 22:5, 31:13, 38:8, 45:13, 60:19, 62:1, 66:2, 70:2, 72:18, 76:2, 92:9, 96:2, 97:6, 101:7, 127:7, 140:5, 142:16 kinds 86:14, 89:20 know 6:9, 7:1, 8:18, 9:9, 11:2, 13:8, 13:17, 16:16, 17:10, 22:18, 27:2, 29:6, 29:18, 32:20, 40:12, 42:21, 42:22, 51:16, 53:20, 62:21, 64:16, 67:4, 68:3, 68:5, 70:2, 70:14, 70:19, 71:15, 71:22, 84:12, 87:14, 90:10, 93:2, 96:13, 103:6, 109:17, 110:20, 113:13, 120:6, 121:2, 122:19, 123:16, 124:2, 127:6, 133:2, 138:13, 139:1, 139:5 knowing 109:6 knowledge 131:15, 131:16, 131:18 known 64:19, 80:3, 82:2, 84:4,	116:9, 116:20 knows 84:14, 84:16 L lab 76:8 label 30:20, 30:21, 119:4, 119:11 labeled 37:9, 96:2 laboratory 21:13, 120:10 lamp 101:6 large 37:11, 70:18, 71:6, 71:8 largely 21:15 larger 50:20, 54:21, 85:2 largest 50:2, 50:12 laser 57:20, 74:16, 75:4, 75:18, 76:18, 77:11, 77:18, 78:10, 78:15, 79:9, 79:12, 79:21, 80:1, 82:14, 82:16, 96:6, 96:7, 96:19, 97:13, 97:14, 98:6, 99:13, 104:4, 121:1, 127:8 last 10:12, 15:2, 15:21, 16:17, 17:6, 57:7, 100:6, 127:21, 139:9 later 75:22
--	--	--	--

launched 136:22 law 16:2 layer 97:8, 97:10, 97:11 layers 98:4 laying 82:15 layout 28:3, 30:16 lease 34:22 least 39:20, 72:20, 77:5, 116:9, 122:21, 125:13 led 17:6, 17:17 left 31:8, 96:22 leg 77:11, 77:12, 78:4, 92:12, 92:18, 93:6, 125:17 legs 31:4, 32:9, 32:18, 33:2, 76:13, 77:1, 77:7, 79:12, 79:18, 79:22, 80:11, 80:12, 81:18, 88:19, 106:13, 120:4, 120:12, 120:15, 121:19, 121:21, 122:1, 122:10, 122:21, 123:1, 123:7, 123:17, 124:3, 124:21, 125:10, 125:22, 126:6, 126:7, 126:9, 127:16, 127:22, 128:1, 128:8, 128:9,	128:17, 128:20, 128:22, 129:7, 129:12, 129:18, 129:22, 134:3 length 35:18, 37:20, 38:3, 41:14, 41:16, 44:6, 129:19 lens 96:10, 100:3, 100:4 lenses 100:5, 101:2 less 21:17, 51:9, 85:22, 103:13, 126:1, 127:11, 129:8 let's 8:15, 13:8, 27:7, 48:5, 56:8, 61:1, 64:8, 69:5, 77:14, 82:8, 95:6, 96:17, 96:22, 98:9, 118:22, 120:2, 122:6, 127:20, 133:5, 137:1 level 51:10, 67:17, 67:18, 119:21, 135:16 lidar 74:4, 74:10, 74:15, 74:19, 74:22, 76:7, 76:17, 79:6, 79:13, 79:17, 80:13, 80:16, 81:17, 83:8, 110:13, 111:1, 111:8, 111:19, 120:2, 120:3, 120:21, 121:7, 123:20, 136:10, 136:13, 137:9,	137:15, 137:16 lidars 120:7 lies 66:18 light 57:20, 57:21, 58:4, 82:18, 96:13, 103:1, 141:14, 142:2 likelihood 16:7 likely 104:10, 105:10, 105:12, 111:13 limit 55:2 limitation 45:15, 46:5, 46:7 limitations 47:7, 72:9, 72:18, 73:19 limits 71:18, 71:19 line 22:8, 35:13, 37:14, 41:12, 55:15, 55:19, 66:18, 69:15, 94:22, 105:13, 107:11, 116:15, 139:4 lines 36:2, 107:15, 116:15 list 20:6, 20:8, 20:12, 20:13 listed 142:11 literally 113:2 little 21:7, 48:21, 49:10, 49:17, 111:15, 112:2, 119:14, 139:15	llp 3:13, 6:22 locate 87:12 located 22:18, 23:20, 57:9, 110:21 locates 90:8 locating 101:18, 131:6 location 28:12, 59:14, 93:6, 93:7, 137:6 locations 6:13, 32:10, 57:10, 60:5 lock 25:21, 26:12 locked 25:13 long 15:11, 31:16, 32:6, 33:3, 96:12 longer 33:4, 75:19 look 16:10, 24:12, 37:6, 37:13, 38:21, 45:3, 45:5, 62:17, 66:3, 66:6, 69:22, 70:1, 72:7, 75:13, 108:6, 121:18 looked 17:1 looking 14:3, 17:14, 26:17, 34:13, 43:16, 69:20, 70:21, 76:16, 88:6, 92:17, 93:11, 93:12, 105:6, 107:3, 109:21, 120:22,
---	---	--	--

125:8, 127:13, 130:1 looks 8:10, 8:14, 9:14, 21:5, 42:19, 57:6, 110:8 lot 34:22, 49:21, 52:9, 53:2, 53:22, 72:7, 78:10, 78:21, 81:22, 83:18, 86:4, 86:8, 86:18, 102:11, 102:21, 103:1, 105:3, 123:17, 126:20, 128:21, 140:19, 141:17, 142:10 lots 141:20 loud 36:5, 98:18, 113:18, 141:13 low 78:8, 82:9, 92:19, 98:20 low-impact 93:4 low-lying 88:3, 88:11 lower 102:12 lowest 82:10 lumping 20:20	machinery 11:16 machines 11:20, 11:21, 21:16, 22:2, 22:21, 22:22, 23:12, 23:16, 24:5, 24:7, 27:2 made 102:14 magnetic 57:13 make 13:10, 20:12, 25:17, 26:9, 33:8, 43:20, 48:21, 53:11, 67:20, 69:10, 70:3, 124:6, 124:7, 134:21, 139:8 makes 11:15, 21:15, 56:14, 124:14 making 22:7 manual 92:22 manually 88:9, 91:12, 91:18 manufacturing 22:4 many 9:18, 9:20, 10:3, 11:13, 11:20, 33:6, 52:15, 53:18, 54:3, 54:16, 66:4, 66:13, 88:1, 100:1, 120:4, 120:6, 122:9, 123:7, 124:16, 125:2, 135:17 map 88:4, 88:7, 88:9, 89:8,	89:10, 89:15, 89:19, 91:12, 91:18, 91:20, 92:14, 93:8, 93:18, 93:21, 124:7, 130:14, 140:5, 140:22, 141:7, 141:19 mapped 86:17, 88:16, 93:6, 93:8 mapping 88:22, 90:5, 90:22, 91:3, 92:2, 92:3, 92:11, 94:15, 117:17, 118:20, 120:3, 120:19, 120:20, 124:12, 127:15, 130:3, 130:8, 130:14, 140:6 maps 109:21, 117:20 marching 73:16 mark 18:15, 56:22, 98:11 marked 18:5, 18:13, 19:1, 19:12, 19:18, 27:9, 27:12, 33:20, 57:2, 61:10, 61:11, 98:13, 115:22, 116:3, 133:7, 134:17, 134:20, 139:4 markers 142:13 marriage 144:19 match 108:5 material 21:14, 21:20, 97:9, 103:16,	103:22, 104:1, 104:7, 115:2 materials 15:6, 15:9, 17:4, 17:13, 20:3, 20:6, 21:16, 21:20, 21:22, 22:16, 22:18, 98:4, 112:4, 112:7, 112:13, 112:17, 114:12 matter 6:9, 10:11, 11:10, 14:19, 15:20, 16:9, 17:18, 46:7, 115:19, 118:21, 144:22 maximum 33:1, 54:17 maybe 9:22, 10:12, 86:12, 101:14, 122:21 mean 10:14, 11:10, 12:4, 14:22, 16:7, 25:4, 26:3, 26:20, 29:7, 31:6, 32:14, 32:19, 33:3, 34:5, 39:5, 42:15, 45:13, 48:8, 51:14, 54:19, 57:16, 58:8, 58:12, 58:15, 58:20, 60:16, 61:21, 62:7, 62:14, 64:6, 68:11, 72:7, 74:11, 78:5, 84:6, 84:8, 88:14, 97:10, 99:2, 101:12, 111:13, 117:1, 117:2, 121:10,
M			
machine 11:17, 22:6, 23:3, 23:5, 23:7, 23:9, 23:11, 24:3, 25:17, 26:7, 26:8, 26:9, 26:12			

122:2, 129:13, 135:16, 136:6, 142:13 meaningful 79:11 means 29:12, 40:6, 40:18, 43:9, 56:5, 57:18, 60:3, 61:22, 62:8, 62:17, 68:7, 77:19, 101:16 meant 74:14, 112:11 measurable 78:10 measure 47:21, 48:2, 48:19, 49:4, 59:13, 60:18, 72:1, 76:18, 82:15, 96:12, 110:7, 137:2, 137:16 measured 59:13 measurement 80:16, 111:4 measuring 48:1, 48:2 mechanism 55:17, 56:2, 56:3, 56:5, 56:9 mechanisms 55:22 mention 76:10 mentioned 15:14, 20:9, 64:12, 67:17, 72:19, 74:4, 74:6, 123:19, 124:3 mentioning 117:14 merinda 3:18	messed 101:7 messes 111:15 met 15:9, 15:15 metal 102:14 metallic 102:19, 102:22 meters 35:12, 39:3 method 34:20, 34:21, 35:1, 73:18, 113:10, 114:2 middle 30:15, 31:2, 104:13, 106:8, 113:16 might 23:20, 28:16, 32:21, 52:18, 54:5, 79:2, 89:5, 97:8, 98:21, 102:10, 131:5, 132:18 million 95:2 mind 43:15, 45:12, 47:20, 72:6, 72:10 minimize 83:21, 84:3, 113:11, 113:16, 114:4, 114:18, 114:19, 115:5, 115:7 minimum 31:13, 32:17, 39:5, 39:12, 122:3 minutes 9:3 mirror 96:22, 97:1, 102:17, 102:19,	102:21 mirroring 102:22 missed 39:8 misunderstands 134:12 mm-hmm 91:7 mobile 28:8, 35:10, 61:18, 79:7, 86:19, 86:20 mode 91:16, 91:21, 140:4, 140:21 modes 87:10 modifications 26:10, 53:11, 64:12 modify 64:16 moment 22:19, 121:4 money 12:7, 65:10, 66:21 month 10:12 mop 87:15, 87:16 mopping 85:17, 85:19 mops 85:10, 85:20 more 21:16, 32:2, 32:7, 32:22, 33:5, 34:14, 37:22, 49:10, 54:13, 54:15, 54:21, 64:5, 64:22, 66:21, 76:13, 77:1, 77:7, 85:22, 91:9, 100:22, 104:10, 104:12,	105:9, 105:12, 106:4, 106:7, 122:5, 123:17, 123:21, 126:6, 126:16, 126:20, 127:7, 128:21, 129:12 most 10:6, 10:11, 23:22, 40:6, 40:10, 40:12, 100:19, 140:20 motion 60:18, 71:1 motions 70:16, 93:10 move 18:14, 18:15, 19:16, 21:16, 21:17, 21:22, 22:7, 22:21, 23:3, 23:5, 23:11, 27:2, 40:3, 40:6, 40:15, 40:16, 40:18, 40:21, 56:22, 61:9, 88:13, 88:19, 90:14, 90:16, 115:20, 119:14 moved 87:1, 98:11, 116:2 moves 23:5, 34:14 moving 21:19, 22:1, 22:9, 22:16, 23:7, 23:9, 23:10, 23:17, 24:3, 34:18, 37:9, 56:4, 86:8, 86:14, 86:15, 128:13 mpi 98:20 much 24:14, 60:18,
---	---	--	--

75:19, 75:22, 80:14, 84:18, 90:2, 90:17, 90:22, 102:20, 129:11, 135:22 multi 105:21 multi-path 74:6 multi-sensor 5:5, 135:2 multi-type 62:11, 62:13, 62:16, 63:7, 63:13, 63:21 multipath 4:17, 76:11, 80:10, 82:3, 83:13, 83:21, 84:4, 84:19, 91:14, 91:17, 91:19, 91:22, 92:1, 92:2, 92:4, 92:9, 94:4, 94:16, 95:18, 97:6, 98:20, 101:18, 105:17, 105:19, 105:22, 107:3, 107:9, 112:14, 113:10, 113:12, 113:17, 114:3, 114:4, 114:7, 114:9, 114:19, 117:14, 117:18, 117:21, 117:22, 118:2, 118:9, 118:16, 124:12, 124:20, 127:14, 128:10, 129:8, 130:3, 130:8, 130:18, 131:5, 131:12, 131:17, 131:22, 132:3, 132:7, 132:12, 132:17, 132:19, 133:12, 133:15, 133:17, 134:7,	137:8, 138:14, 139:17, 139:18, 140:11, 140:14, 142:3, 142:7 multiple 25:5, 43:14, 43:17, 62:6, 74:20, 83:9, 96:17, 98:7, 106:19, 107:20, 108:11, 135:21 must 38:16 myself 36:6 N name 6:20, 10:14, 115:18 navigate 124:2, 124:5, 124:9, 137:5, 141:21, 142:1, 142:16 navigates 141:18 navigating 142:5 navigation 5:5, 57:11, 135:2, 135:7, 135:8, 135:10, 135:11, 135:15, 136:5, 136:15, 137:9, 137:20, 138:2, 138:9, 138:10, 140:22, 142:17 near 106:9, 124:3 nearby 77:11 necessarily 23:10, 41:22, 47:12, 138:8 need 7:9, 22:5,	22:9, 31:14, 32:7, 32:21, 32:22, 39:11, 42:16, 50:1, 52:21, 53:21, 54:9, 73:1, 76:3, 78:3, 81:8, 81:10, 86:9, 86:16, 86:17, 86:18, 89:19, 91:10, 93:9, 103:21, 122:2, 141:12 needed 33:7 needing 50:3 needs 26:9, 56:16, 92:15, 122:4, 140:3 never 29:16, 30:1, 79:10, 122:3 new 53:6, 53:9, 53:16, 83:15, 89:6, 93:6, 93:7 news 94:19 next 57:21, 88:2 nice 82:19 nobody 25:11, 65:8, 65:11 noisy 76:21, 77:5, 109:15 non-mirrored 103:11 nonreflective 103:3, 103:6 nontranslucent 104:7 normal 103:2	normally 10:2, 22:2, 52:9, 52:14, 65:9, 70:11, 72:20, 100:6 north 1:5, 123:9 not-changing 90:18 notarial 144:24 notary 2:10, 144:3 notch 100:7 note 6:10, 18:16 noted 6:10, 55:21 notes 8:22, 9:2, 9:5 nothing 34:5, 34:6, 73:5, 73:10 notice 2:8 number 18:9, 18:16, 28:7, 28:8, 32:18, 33:2, 53:20, 54:17, 55:4, 72:3, 73:13, 115:18, 122:1, 129:14, 132:15, 132:20, 133:3 numerous 54:1, 87:20 nw 3:14 O oath 12:18 object 12:3, 28:4, 32:4, 39:14, 40:9, 40:20,
---	--	--	--

47:16, 50:16, 53:7, 56:13, 58:17, 60:14, 65:19, 73:3, 74:21, 76:6, 77:22, 78:18, 83:22, 94:5, 94:17, 99:21, 110:21, 115:10, 118:7, 125:4, 130:10, 130:19, 130:22, 131:13, 133:13 objection 118:14 objects 76:14, 77:1, 77:8, 86:8, 86:14, 86:15, 99:16, 99:17, 99:20, 102:4, 126:3 obstacle 75:7, 79:6, 83:3, 83:9, 87:18, 88:2, 88:3, 88:5, 90:4, 92:7, 93:15, 96:8, 96:14, 97:9, 97:14, 97:21, 106:12, 109:3, 109:6 obstacles 57:11, 81:4, 82:1, 87:6, 87:8, 87:13, 87:19, 88:11, 88:21, 90:8, 91:10, 92:10, 92:17, 93:1, 93:11, 93:17, 94:3, 94:9, 94:10, 97:4, 104:21, 107:1, 121:6, 121:8, 124:8, 126:5, 131:8, 140:9,	140:10 obstruction 89:17 occur 80:8 occurred 144:14 occurring 65:16, 105:19 occurs 110:11, 134:10 odd 68:17 offered 95:16 office 1:1 often 76:19, 88:10, 88:14, 89:1, 94:13, 100:19, 100:21 oh 27:1 okay 7:3, 7:17, 9:6, 9:15, 12:15, 13:5, 13:14, 14:6, 14:14, 18:14, 18:19, 19:2, 19:7, 19:14, 20:2, 20:14, 20:22, 23:9, 23:14, 23:16, 24:5, 24:18, 25:7, 26:15, 27:17, 29:14, 29:22, 30:2, 30:6, 30:13, 31:1, 31:21, 33:15, 34:12, 37:13, 38:14, 45:8, 45:10, 46:3, 46:12, 46:14, 47:1, 48:11, 48:15, 54:11, 56:20, 57:4,	61:13, 61:16, 62:9, 64:10, 72:14, 74:1, 74:3, 85:13, 87:21, 91:15, 95:15, 98:15, 99:6, 99:12, 103:11, 103:15, 105:16, 106:10, 109:20, 111:7, 111:17, 115:14, 115:21, 116:15, 119:6, 119:12, 119:13, 119:19, 120:1, 120:2, 120:18, 121:15, 121:17, 122:8, 122:13, 122:17, 122:18, 122:22, 123:5, 123:14, 123:15, 124:15, 128:3, 128:5, 129:2, 129:10, 130:4, 134:21, 138:18, 139:11, 139:14, 141:11 omega 44:4 on-board 57:9 once 26:11, 26:15, 51:16, 88:15, 88:16 one 8:9, 10:11, 13:16, 14:1, 17:8, 27:15, 28:5, 31:8, 32:5, 34:14, 44:9, 44:10, 50:18, 52:18, 53:21, 54:5, 54:8, 54:12, 54:13, 54:14, 54:15, 56:8, 58:20, 62:1, 62:6, 74:9,	74:17, 74:21, 75:13, 79:6, 79:15, 80:6, 80:16, 81:7, 82:19, 85:9, 85:12, 89:12, 91:2, 96:3, 97:18, 100:20, 101:4, 101:13, 101:14, 101:19, 107:21, 110:10, 111:4, 111:6, 111:16, 112:6, 118:3, 118:10, 119:4, 128:9, 138:11, 139:9 ones 24:16, 31:15, 72:9, 86:17, 92:4, 96:16, 97:7, 101:11, 102:2, 108:10, 123:18 ongoing 12:2 online 107:11, 107:13 only 14:9, 31:11, 45:6, 53:6, 56:14, 74:16, 76:7, 78:15, 90:16, 113:3, 126:9, 127:15, 127:22, 128:20 oops 121:15 open 7:4, 65:17, 66:1, 66:3, 66:12, 69:12, 74:7, 74:11, 74:14, 74:19, 75:1, 75:10, 75:11, 76:19, 77:8, 79:8, 81:22, 87:22, 104:14, 106:4,
--	--	---	---

123:20, 140:7 opened 7:6, 66:21 opening 72:5 openness 75:15 operate 92:7, 130:17, 131:3, 131:9, 131:10, 131:11, 131:17, 132:6, 140:16 operated 24:9 operates 23:4 operating 7:19, 64:18, 86:20, 91:20, 91:21, 105:4, 120:3, 120:9, 123:6, 126:21, 132:4, 132:13 operation 70:6, 91:11, 124:13, 127:15 operational 26:16, 26:19 operations 65:8, 70:8, 70:9, 71:7, 71:9, 89:20 opex 1:9, 6:18, 11:7, 11:8, 11:12, 11:15, 11:20, 12:2, 12:7, 12:10, 16:2 opex's 73:1, 73:6, 73:8 opinion 100:16, 105:18 opinions 14:19, 17:7, 139:19	opposed 124:4 opposite 66:5 optic 75:1 optical 57:12, 57:16, 57:18, 58:3, 58:11, 100:6 option 44:4, 81:11 optional 56:2 optionally 37:21, 38:2, 41:15, 56:4 orange 106:21, 107:5, 107:14 order 73:2 ordinary 17:15, 32:20, 42:10, 46:8, 46:17, 48:3, 48:6, 49:7, 49:19, 54:2, 59:16, 84:13, 109:13, 118:3, 118:10, 131:16, 131:19, 131:21, 132:10, 132:14 original 18:19, 127:16, 128:7, 128:9 originate 136:5, 136:11, 136:12 other 17:13, 20:10, 28:12, 44:6, 46:16, 51:2, 52:4, 52:16, 54:7, 60:2, 67:8, 71:2, 74:13, 85:17, 91:1, 96:16,	97:7, 100:20, 101:11, 102:2, 104:14, 107:17, 107:21, 112:9, 123:18, 125:8, 134:8 others 55:12 otherwise 144:21 out 18:12, 20:20, 30:5, 33:12, 34:7, 36:5, 57:19, 58:9, 59:5, 59:10, 71:18, 73:11, 74:19, 75:7, 77:22, 79:18, 81:16, 83:8, 83:15, 83:19, 86:22, 87:15, 87:17, 90:8, 91:3, 94:3, 94:8, 96:7, 96:8, 97:18, 98:18, 100:21, 103:22, 106:3, 106:17, 108:21, 113:18, 118:4, 118:11, 126:17, 129:21, 130:14, 141:12 outcome 11:4, 144:22 outer 93:19 output 70:22, 71:1 outside 12:9, 73:3, 97:12 over 6:12, 8:3, 13:9, 22:11, 28:10, 32:21, 34:2, 80:1, 96:22, 101:6,	108:1, 128:2 overall 62:20 overhead 29:12, 31:9, 31:11, 74:12, 75:4, 76:12, 76:22, 124:16, 124:17, 125:11, 125:22, 126:21 override 91:18 own 12:4, 70:8, 71:13, 73:20 owned 25:8, 25:9 owner 1:10, 3:11, 10:15 owner's 10:17, 18:21, 19:10 owning 68:2 P package 25:12 page 4:2, 4:9, 5:2, 14:3, 21:3, 61:15, 95:16, 98:17, 99:3, 108:17, 109:22, 113:15 pages 1:22, 19:22 paints 103:7 palette 89:3, 89:11 palettes 90:15 paper 135:10 papers 7:22, 8:4, 8:8,
---	--	---	--

9:1 paragraph 14:3, 19:22, 55:16, 55:18, 57:6, 57:7, 61:14, 61:17, 62:3, 62:10, 63:1, 63:8, 63:15, 63:18, 63:19, 76:16, 84:20, 85:15, 117:2 paragraphs 63:11 parameters 26:11, 26:16, 26:19, 26:22, 27:2 part 22:7, 23:7, 23:18, 23:22, 24:19, 30:13, 34:20, 36:17, 39:8, 48:16, 71:3, 71:8, 79:22, 88:7, 90:5, 94:20, 95:10, 100:19, 114:14, 114:16, 127:21, 131:19 partially 72:20 particular 15:19, 16:13, 25:2, 27:6, 43:16, 51:11, 51:21, 53:12, 72:6, 79:1, 80:6, 80:16, 84:8, 84:10, 110:5, 126:17 particulates 98:5 parties 2:5, 6:11, 6:12, 144:18, 144:20 parts 68:4, 74:13,	107:1 party 144:10 pass 54:8, 138:17 passage 38:20, 39:19 passing 35:10, 77:18 passive 59:8 passively 59:12 past 91:1 paste 69:19, 70:2 pasted 134:19 patent 1:1, 1:3, 1:10, 1:13, 3:11, 4:12, 4:20, 8:13, 9:20, 10:15, 10:17, 15:8, 16:9, 16:18, 16:22, 17:22, 18:1, 18:4, 18:12, 18:21, 19:10, 20:15, 27:7, 28:3, 29:4, 32:3, 32:9, 32:17, 34:12, 35:2, 35:5, 35:8, 35:13, 35:21, 36:14, 36:20, 37:1, 38:5, 38:7, 38:15, 39:10, 41:2, 41:4, 41:13, 41:20, 42:5, 42:8, 42:11, 43:7, 43:12, 43:14, 43:18, 44:15, 45:22, 46:10, 47:11, 47:15,	48:7, 48:12, 48:13, 48:14, 53:5, 53:12, 53:19, 56:11, 72:3, 115:15, 119:2, 130:2, 130:7, 130:12, 130:13, 130:16, 131:11, 131:15, 132:6, 133:10, 133:16, 133:19, 134:6, 134:10, 138:11, 139:17, 140:15, 140:16, 141:2, 141:10, 142:3 patents 10:2, 40:2, 40:3, 128:16 path 35:14, 36:8, 75:19, 77:16, 81:6, 82:22, 84:18, 96:17, 96:18, 96:21, 97:16, 99:5, 99:13, 103:9, 104:7, 108:15, 112:8, 113:1, 121:7, 122:15 paths 35:6, 38:6, 39:4, 39:11, 75:12, 78:2, 90:9, 97:15, 100:1, 104:15, 115:9, 126:21 patnaik 3:12, 4:4, 6:21, 7:8, 8:19, 9:4, 12:3, 18:11, 28:4, 30:1, 30:4, 32:4, 39:14, 40:9, 40:20, 47:2, 47:16, 50:16, 53:7, 56:13, 58:17,	60:14, 65:19, 73:3, 83:22, 94:5, 94:17, 105:5, 118:7, 118:14, 125:4, 129:9, 130:10, 130:19, 130:22, 131:13, 133:13, 138:18, 138:21, 142:19 pattern 80:2, 104:3, 137:3, 137:4 patterns 115:6, 124:16, 126:2 pay 66:21 pdf 33:15 pdr 10:4 peak 109:5 peaks 111:13 pending 14:10 pennsylvania 2:11, 3:14 people 28:14, 28:15, 86:6, 86:11, 89:22, 93:12, 109:7 percentage 67:9, 70:18, 71:6, 71:8 perfect 80:6, 109:18 perfectly 79:19, 96:20, 107:18, 109:18 perform 70:7, 130:2, 130:8 performing 17:3
--	---	--	---

perhaps 22:6, 25:17, 70:16, 84:4, 126:14 perimeter 104:15 period 82:17 permanent 87:12, 89:8 person 17:15, 23:1, 32:20, 42:10, 46:8, 46:17, 48:3, 48:6, 49:7, 49:19, 54:2, 59:15, 67:6, 84:13, 89:14, 109:13, 131:15, 131:18, 131:21, 132:10, 132:13 personal 136:14, 137:7 peruse 44:20 petition 16:21, 19:11, 20:15, 47:4 petitioner 3:3, 10:15, 10:19, 10:20 petitioner's 10:17 petitioners 1:7, 6:8 ph 1:16, 2:1, 4:11, 6:2, 94:7, 109:8, 143:3, 144:4, 144:14 photons 58:1 physical 21:18, 42:19, 49:3, 55:1, 93:3, 100:10 physically 6:13, 13:2	pick 22:5, 97:17, 97:19 picking 28:10 pictorial 113:5 pictorially 129:15 piece 67:19, 68:9, 69:4 pixel 99:14, 100:2 place 80:1, 109:18, 113:14, 131:1 placed 90:15 places 31:7, 74:11, 74:20, 77:19 placing 104:12, 106:7 plan 29:8, 29:12 planning 116:11, 116:22 play 53:3, 131:5 please 13:3, 13:17, 14:2, 14:21, 16:14, 29:1, 31:4, 36:3, 55:17, 55:20, 99:7, 99:11, 113:18, 114:1, 119:3, 135:14, 139:1 plus 51:4, 85:16 point 14:8, 23:17, 23:18, 45:1, 72:11, 108:11, 116:12, 136:18, 140:21, 142:12,	142:15, 142:17 pointing 85:1, 85:16, 87:8, 121:11, 121:12 pole 82:15 poles 105:1 pool 106:19 poor 77:17 poorly 94:20 portion 79:8 posita 47:14, 50:14, 57:17, 58:13, 59:19, 60:11, 64:15, 64:20, 68:21, 69:6, 70:6, 80:22, 81:3, 83:12, 84:2, 84:21, 95:18, 108:18, 133:11, 138:1, 138:8 positas 94:2, 94:6 position 131:7, 136:2 positioning 113:21 possibilities 82:3, 108:20 possibility 43:1, 51:19, 52:1, 114:9, 115:1 possible 80:6, 97:15, 110:10, 118:2, 118:9 possibly 39:22, 60:7, 70:20, 126:15	post 32:16 posts 31:5, 31:18, 31:21, 32:2, 32:13, 35:15, 36:9, 88:12, 90:13, 91:4 practical 80:8 practice 34:22, 46:19, 46:21, 48:8, 48:20, 53:15, 79:16 practiced 73:8 practices 73:18 predictable 85:22 predominantly 74:17 preferably 35:14, 36:9 preliminary 18:22 preparation 14:21, 16:15, 135:4 prepared 15:17 preparing 14:22, 15:11, 20:7 present 3:18, 15:16, 74:12, 77:8 presumably 73:20 pretty 28:18, 80:15, 87:8, 94:8, 105:11, 111:14, 141:15 previous 124:10 primary 50:13, 50:18,
---	---	--	---

75:21, 76:6, 96:18 prime 36:9 principles 64:18 printed 18:11 prior 11:7, 11:10, 15:8, 16:19, 63:12, 140:1, 140:3 probably 9:19, 9:22, 15:13, 16:18, 18:10, 31:14, 50:6, 53:15, 60:1, 64:5, 64:22, 79:10, 82:22, 91:9, 116:13, 118:17, 122:21, 123:15, 138:4 problem 82:9, 82:11, 91:14, 91:19, 91:22, 110:20, 112:10, 112:11, 112:12, 112:21, 112:22, 113:6, 113:8, 117:14, 117:18, 118:18, 133:16, 133:22, 134:9, 140:14 problematic 127:12 problems 104:10, 105:12, 117:22, 133:11, 134:5 proceeding 10:22, 12:9 proceedings 10:4 process 12:16, 22:19, 60:12, 60:16	processes 17:17 produce 134:7 produces 85:7 product 1:5, 1:6, 25:13, 26:4, 26:5, 26:13, 85:17, 94:22 products 21:18, 24:15, 85:9, 85:10, 85:12, 88:1, 89:9 professional 2:9 profiles 108:16, 108:17 programmed 72:16 programming 72:15 prohibition 42:18, 42:22 projects 136:22, 137:15 pronunciation 21:10 properly 101:22 properties 102:20 property 10:1 proposed 64:17 proprietary 25:12, 25:21, 64:12, 64:16, 64:19, 65:3, 65:5, 65:12, 65:15, 65:18, 66:1, 66:4, 66:16, 67:4, 67:7, 67:21, 68:7, 68:10,	68:20, 69:2, 69:8, 69:19, 70:7 protect 101:3, 101:5 protectors 101:4 provide 26:1, 38:5, 38:7, 38:15, 131:19, 141:3 provided 8:2, 118:22 provides 38:18, 41:21, 56:5, 73:13, 93:19, 141:6 ptab 10:4 pub 4:14 public 2:10, 69:5, 144:1, 144:3 publication 4:15 pull 11:1, 71:17, 98:9, 139:6, 139:11, 139:12 pulled 86:22 pulse 82:16 pulses 74:15, 75:4, 76:18 purchased 68:3 purposes 14:20, 18:7 pursuant 2:8 push 49:15, 87:11, 89:13 put 17:4, 20:12,	27:8, 30:7, 30:8, 31:1, 31:2, 31:9, 31:10, 52:9, 89:4, 101:2, 101:6, 129:1, 130:15, 134:16 puts 65:7 putting 104:13 Q question 11:9, 13:19, 14:10, 14:11, 34:6, 38:8, 39:9, 39:16, 42:9, 43:15, 43:21, 44:16, 45:11, 45:16, 45:18, 46:4, 46:12, 46:15, 47:18, 65:20, 84:1, 84:17, 84:18, 91:16, 91:19, 92:3, 106:2, 106:10, 114:13, 114:16, 116:18, 117:6, 118:8, 124:5, 124:6, 124:14, 125:7, 127:7, 127:18, 129:2, 129:6, 129:9, 130:4, 130:11, 130:16, 131:3, 131:10, 132:5 questioning 139:4 questions 12:18, 13:13, 13:17, 14:18, 21:1, 105:7, 138:19, 138:22, 139:10, 139:16, 142:19, 142:20 quick 56:8
--	---	--	--

quickly 21:16, 62:4 quicktime 7:6, 7:8 quit 7:7 quite 21:5, 69:9, 81:14 R r1 119:5, 119:8, 122:7, 122:10, 122:11, 123:12, 124:1, 124:12, 124:22, 125:2, 125:20, 126:7, 126:13, 129:2, 130:6, 130:7, 130:17 r2 119:11, 119:14, 119:21, 120:2, 121:9, 122:12, 124:4, 124:18, 125:3, 125:15, 126:7, 126:9, 126:16, 128:19, 131:11, 132:9 r3 122:12, 123:6, 123:7, 124:4, 124:18, 125:15, 132:5, 132:6, 132:9 rack 28:17, 29:2, 29:3, 31:8, 32:18, 34:19, 42:2, 51:10, 51:17, 52:2, 52:19, 52:20, 55:7, 56:12, 74:5, 78:8, 128:1, 128:9 racks 30:8, 30:14, 	30:20, 31:1, 31:5, 31:16, 32:1, 32:10, 33:4, 34:15, 35:3, 35:6, 35:9, 35:12, 36:19, 36:21, 38:6, 38:12, 40:4, 40:8, 40:17, 40:19, 40:22, 41:2, 49:9, 49:11, 50:8, 51:6, 52:20, 53:1, 53:4, 78:8, 88:13, 105:2, 127:17 radio 58:14, 58:21, 59:1, 59:3, 59:10 radius 39:7, 39:13 rain 98:5, 100:16 raised 47:3 raizer 8:6, 8:13, 20:16, 56:8, 56:21, 140:1, 140:3, 140:6, 140:11, 140:17, 141:1, 141:8, 142:18 raizer's 58:16, 59:18 ran 91:13, 91:16 random 93:10 rarely 101:14, 103:16, 103:18, 104:8, 105:8 rather 27:5, 62:1, 142:16 	ratio 42:3 ratios 42:4 rayleigh 97:12, 100:9 reaching 62:21 read 36:3, 36:5, 36:6, 36:17, 37:15, 38:19, 42:16, 43:10, 43:11, 43:13, 47:22, 55:16, 55:17, 58:10, 58:19, 64:22, 73:12, 98:16, 98:18, 98:19, 99:9, 99:10, 99:11, 113:17, 116:17, 132:22, 141:12, 141:16, 143:4 reader 102:10 readily 108:18 reading 8:20, 43:7, 43:14, 64:21, 73:12, 115:14 readings 97:3 reads 57:8, 99:4 real 77:22, 105:6, 109:3, 110:6, 132:8 realistic 128:14 realize 88:8 really 11:1, 51:19, 53:21, 54:15, 62:3, 75:8, 	79:16, 80:12, 80:13, 83:7, 84:16, 88:6, 94:9, 94:21, 102:8, 109:5, 113:5, 135:9 realtime 2:10 rearward 35:16 reason 117:21 reasonable 43:6, 44:20, 88:17, 94:8 recall 16:6, 32:13, 44:13, 44:14, 44:22, 115:14, 116:8, 116:12, 117:13, 133:18 recast 139:2 receive 59:1, 98:7 received 12:6, 16:7, 59:3, 60:4, 60:6, 60:7, 60:8, 94:22 receiver 57:22, 101:1, 108:3, 108:14 receivers 59:1 receives 83:10 receiving 28:15 recent 10:6, 10:11, 15:5 recently 10:9, 44:22 receptor 97:2, 97:3 recess 33:19, 61:3,
--	---	---	--

95:8, 133:6 reckoning 60:12, 60:15, 60:22, 132:20 recognize 115:18, 124:8 reconnect 7:15 record 6:10, 14:5, 14:20, 18:7, 18:12, 33:17, 36:4, 36:6, 36:7, 37:16, 47:3, 55:17, 60:17, 61:2, 95:7, 99:10, 99:11, 105:14, 133:5, 142:21, 144:8 records 10:8 rectangle 29:17, 119:7 rectangles 30:7, 31:10, 31:12 red 96:6 reduce 103:8 reduced 127:15, 128:10 reducing 84:4, 105:21 refer 19:5, 19:8 reference 8:6, 13:22, 18:19, 59:18, 115:16 referenced 9:10, 21:3 references 41:13 referencing 134:13 referred 70:11, 115:15	referring 18:1, 18:20, 19:9, 85:14 refers 54:6 reflected 58:1, 75:18, 76:11, 76:18, 76:21, 78:2 reflecting 96:20, 125:1 reflection 75:12, 75:19, 75:21, 81:16, 98:7, 103:9, 108:15, 112:8, 115:6, 120:15, 121:8, 125:18, 126:1 reflections 83:10, 84:19, 95:18, 109:15, 123:3 reflective 76:4, 77:6, 79:19, 80:2, 82:1, 82:22, 84:17, 98:4, 102:9, 102:11, 102:13, 102:20, 103:13, 104:3, 107:20, 108:8, 108:12, 115:8, 121:1, 124:15, 126:20, 127:11 reflectivity 83:17 reflectors 84:5 regard 28:19 regarding 117:10 registered 2:9 related 6:15, 38:20, 72:8, 118:18,	144:17 relates 47:5 relative 35:8, 36:15, 36:18, 37:10, 38:11, 38:13, 38:18, 41:21, 42:2, 42:7, 44:11, 45:21, 46:1, 47:6, 47:11, 47:13, 49:2, 50:9, 54:20, 128:20, 137:8 relatively 78:8, 94:20, 140:7 relatives 82:13 relevance 142:3 relevant 17:13, 69:17, 100:12, 139:19, 142:8 reliably 84:22, 109:11 rely 132:2, 132:11, 132:14 relying 142:5, 142:9, 142:10, 142:11, 142:12, 142:15 remain 88:17 remained 127:16 remember 10:21, 16:12, 19:3, 53:8, 121:22, 129:6 remind 12:17 remote 1:15, 35:16 remotely 2:5, 6:12	remove 115:5, 129:7 repeat 69:10, 114:13, 116:18, 118:8 report 17:6, 64:21 reported 1:20 reporter 2:9, 2:10, 6:14, 13:1, 13:4, 13:7, 105:7, 105:15, 144:2 reporter's 13:2 reporter-notary 144:1 reports 94:19 represent 9:4, 10:13, 30:8, 107:6, 107:19, 112:11 representation 110:10, 126:14 representative 107:13 represented 28:6, 95:1, 96:9, 119:6, 124:19, 125:11, 129:15, 144:11 representing 31:10, 96:6, 101:8, 106:11, 106:12, 106:22, 107:8, 107:15, 108:4, 128:18 represents 108:20, 112:21 reproduce 70:21 reproduced 73:7 request 14:9
--	---	---	---

require 32:9, 43:6, 54:5, 73:6, 129:11 required 51:12, 53:21, 54:4, 56:18 requirement 32:13, 32:15, 39:17, 41:6 requirements 26:2, 26:4 rescue 136:21 research 12:6, 17:14 resolving 113:10, 114:2 respect 21:6, 139:16 respond 13:3, 16:10 response 18:22, 19:8, 19:11, 19:21, 47:4, 59:12, 59:13, 64:9, 64:11, 65:21, 74:1, 84:20, 95:13, 109:19 rest 108:1 result 94:15, 111:15 results 94:21 resume 24:13 retract 49:15 retro 23:22 return 99:20, 109:22, 111:2, 111:8, 113:1, 113:8 returning 133:20, 134:3	returns 110:7 reverse 70:12, 70:14, 70:17, 71:4, 71:5, 72:2 review 15:3, 20:17, 34:9, 43:3, 44:15, 46:13, 53:12, 136:19 reviewed 15:5, 15:9, 16:17, 16:19, 16:20, 16:22, 20:9, 20:14, 43:17, 44:21, 46:14, 116:7, 134:15, 135:3 reviewing 42:11, 42:13, 46:9, 46:18 reviews 94:21 rewriting 27:4 rfid 57:12, 58:12, 59:6, 59:8, 59:17, 60:1, 89:12 rid 103:9, 112:12, 112:22, 113:4, 115:8 right 7:19, 8:6, 9:9, 9:15, 11:11, 19:21, 23:4, 24:8, 27:7, 28:20, 33:9, 34:16, 34:19, 35:19, 35:22, 36:16, 39:7, 39:13, 40:8, 40:19, 41:22, 43:4, 45:4, 49:12, 50:6,	57:21, 61:1, 62:7, 64:8, 64:20, 68:18, 69:4, 69:14, 70:20, 72:4, 73:21, 74:1, 76:15, 80:11, 81:14, 85:3, 85:4, 85:8, 93:8, 94:4, 94:16, 95:6, 95:19, 96:5, 98:9, 101:18, 103:12, 103:17, 106:14, 106:19, 109:15, 110:1, 110:12, 110:22, 111:6, 112:5, 112:18, 113:15, 113:16, 120:10, 120:17, 122:6, 123:3, 128:2, 135:4 robot 28:15, 28:16, 34:14, 34:18, 38:13, 39:1, 39:18, 39:21, 41:11, 42:4, 43:19, 44:18, 45:18, 45:19, 46:11, 46:19, 46:21, 48:16, 48:17, 48:21, 49:2, 49:3, 49:14, 51:4, 51:7, 51:20, 54:8, 57:10, 57:14, 58:21, 59:11, 59:14, 60:17, 61:18, 61:20, 62:1, 62:6, 62:11, 62:13, 62:16, 63:3, 63:7, 63:12, 63:21, 70:7, 70:13, 71:2, 71:12,	73:21, 80:5, 81:6, 85:8, 88:9, 90:7, 91:13, 91:16, 91:21, 101:5, 101:10, 103:19, 103:20, 106:16, 110:12, 110:22, 111:7, 111:18, 117:5, 117:7, 119:9, 119:10, 119:20, 120:4, 122:6, 123:6, 124:1, 124:12, 125:14, 125:15, 125:20, 126:3, 127:11, 128:4, 128:6, 128:7, 128:10, 128:18, 128:19, 129:2, 129:19, 130:1, 130:2, 130:6, 130:14, 131:2, 131:11, 132:5, 133:3, 136:21, 138:10 robot's 39:6, 39:13 robotic 85:2 robots 21:6, 28:8, 28:9, 30:16, 35:2, 35:10, 39:1, 39:6, 39:12, 39:18, 39:22, 40:2, 40:14, 40:15, 41:5, 41:9, 42:5, 42:12, 51:15, 53:5, 53:18, 53:22, 54:1, 54:3, 54:14, 54:16, 54:17, 54:21, 55:6, 56:10, 62:2, 62:5, 62:6, 62:17,
---	---	---	---

63:17, 70:9, 72:13, 79:7, 85:14, 86:5, 86:19, 86:20, 87:5, 87:9, 87:10, 87:21, 88:15, 88:16, 90:16, 91:3, 91:11, 95:2, 104:19, 116:10, 116:21, 117:10, 118:5, 118:12, 119:3, 126:19, 127:14, 132:16, 136:22, 139:16 rolls 22:10 roof 82:7, 82:8, 138:5 roofs 133:21 room 6:16, 13:2 roomba 85:8, 85:13, 92:12, 92:14, 94:6, 94:14 roomba's 94:2 roombas 94:12 rotate 56:18, 71:14 rotates 71:12 rotating 56:11, 56:14, 56:15 rotation 36:11 roughly 9:18, 128:17 route 116:9, 116:11, 116:20, 116:22 routes 90:9, 91:5	row 29:19 rpr 1:20, 144:31 rules 12:17, 138:22 run 80:18, 83:15, 92:18, 93:2, 118:4, 118:11, 131:4, 132:16 running 53:22, 54:16, 54:22, 93:16, 94:12, 122:7 runs 92:19 S s1 30:20, 31:2, 31:9, 119:10, 125:15 s2 30:21, 31:2, 31:16, 31:20, 31:22, 119:11, 119:20 safe 23:6 safely 72:17, 131:10 safer 21:18 safety 71:16 sag 32:8 sagging 33:7 said 15:15, 16:8, 26:11, 40:11, 65:2, 85:4, 98:22, 101:19, 103:15, 105:11, 106:3, 116:5, 132:10	sake 13:7 same 13:8, 46:5, 70:9, 76:5, 77:5, 85:18, 90:6, 91:1, 91:6, 96:18, 100:1, 109:5, 110:9, 111:14, 118:14, 118:21, 119:21, 122:14, 123:12, 129:2, 137:12, 138:22, 141:8, 143:5 san 3:9 sas 1:5 satellite 135:10, 135:12, 135:15, 136:5, 136:15, 137:10, 137:20, 138:2, 138:5, 138:9 satellites 135:18, 135:21, 136:3, 136:7, 136:9 satisfied 44:11 satisfy 42:6, 42:13, 44:10, 45:19, 45:20, 45:22 save 33:9, 33:11, 33:12, 33:14 saw 92:20 say 9:22, 17:22, 21:22, 48:8, 56:10, 62:4, 63:10, 64:5, 69:5, 71:5, 76:17, 78:3, 82:9, 83:1,	85:5, 96:22, 100:14, 100:18, 111:16, 120:2, 132:22, 137:1, 140:18 saying 21:8, 44:14, 45:14, 89:15, 113:7, 117:3, 127:20, 127:21 says 20:14, 27:1, 35:14, 41:8, 41:13, 45:15, 53:9, 102:4, 113:16, 141:5 scale 129:20 scales 55:4 scan 120:8, 120:11, 121:2, 121:6 scanning 120:13, 120:21 scans 120:3 scattering 100:4, 100:8, 100:9 scenario 99:4, 99:13, 101:16, 106:6, 109:22, 114:20, 115:1 scene 99:16, 99:18, 102:5, 113:11, 113:21, 114:3 schweitzer 1:20, 2:9, 144:2, 144:31 scope 73:4, 112:11, 113:7 screen 7:12, 8:20, 30:6
---	--	---	---

seal 144:24 search 41:10 searched 117:16 searching 37:6 second 7:16, 8:9, 17:18, 19:12, 19:15, 33:18, 105:6, 108:1, 108:2, 109:22, 119:10, 139:19 secrecy 67:5, 67:17 secret 65:7, 66:20, 67:20, 68:2, 68:7, 68:10, 68:12, 68:16, 69:5 section 42:1 secure 86:1, 89:22 secured 90:3, 100:13 see 7:5, 7:10, 8:15, 29:10, 29:17, 30:2, 30:12, 30:18, 31:11, 41:18, 42:17, 43:18, 44:17, 47:22, 63:15, 63:19, 66:19, 69:13, 69:15, 71:3, 75:8, 77:3, 79:22, 91:15, 108:7, 117:9, 117:11, 119:2, 120:5, 120:6, 121:19, 122:10, 122:19, 122:20, 123:8, 123:16,	124:9, 124:22, 125:14, 128:16, 136:20, 141:4 seeing 7:19, 29:19, 30:10, 44:13, 46:7, 70:19, 125:11, 126:9, 126:14, 126:16 seem 69:17, 116:4, 116:6, 117:17 seems 44:3, 68:16, 70:10 seen 122:3 sees 125:17 select 110:13, 111:1, 111:8, 111:19 self-determine 140:11 sell 21:19, 25:13, 26:13, 65:10, 89:10 semiautomated 28:18 semiautonomous 24:11, 24:17 semipermanent 89:17 sending 96:7, 106:17 sense 26:15, 56:14, 84:10, 103:1, 124:7, 124:14 sensed 86:9 sensor 57:18, 57:19, 58:3, 58:10, 58:11, 75:18, 75:20, 77:17, 83:1, 83:10,	92:7, 93:5, 96:4, 96:10, 96:21, 98:7, 100:6, 101:7, 103:19, 132:2, 132:11, 136:13 sensors 4:19, 57:9, 57:11, 58:6, 58:8, 58:16, 60:11, 60:17, 60:20, 74:10, 76:17, 83:8, 125:1, 131:6, 132:18, 132:20, 142:12 sentence 35:22, 36:3, 43:10, 43:11, 43:13, 57:7, 113:17, 114:1 separation 129:17 serve 26:18 served 12:13 set 22:8, 49:22, 52:18, 52:22, 53:16, 53:21, 54:16, 57:8, 59:1, 59:9, 61:22, 69:10, 70:4, 80:6, 84:3, 87:9, 93:15, 109:13, 113:11, 114:3, 120:11, 121:3, 136:19, 140:22, 144:5, 144:23 sets 141:19 setting 50:14, 51:2, 52:17, 53:3, 83:20, 114:6 settings 88:12	setup 38:9, 68:14, 106:2, 114:14, 114:17 several 11:12, 11:19, 64:7, 100:10, 100:14 shakes 13:4 shape 133:1 shapes 111:11 shares 12:4 sharkninja 85:3, 85:18 shed 141:13, 142:2 sheet 113:3, 143:8 sheets 113:4 shelf 49:20, 49:22, 50:6, 50:15, 51:13, 51:18, 52:5, 78:21, 81:5, 81:10, 82:5, 82:9, 82:10, 83:11, 102:13, 102:16, 102:18, 103:4, 103:12, 103:14, 106:15, 107:4, 107:6, 107:12, 108:5, 108:6, 108:13, 115:5, 117:8, 123:2, 123:7, 126:21, 127:1, 128:8, 132:2, 133:4, 134:7, 134:8 shelf-height-rel- ated 81:4 shelves 51:21, 52:13,
---	---	---	--

62:22, 74:8, 74:12, 76:12, 76:13, 76:14, 76:20, 76:22, 77:2, 81:10, 81:13, 104:12, 105:20, 105:22, 106:7, 106:13, 112:15, 112:17, 114:8, 114:12, 114:22, 115:3, 115:11, 116:10, 116:21, 117:20, 118:5, 118:12, 118:20, 120:16, 123:22, 126:20, 129:11, 132:16, 133:21 shelving 23:20, 89:6, 117:11, 119:1, 124:4 shelvings 114:21 shift 122:6 shine 79:21 shop 94:15, 94:18 short 81:12 shorter 97:16 shortest 97:17 shorthand 144:1 shot 106:19 should 29:7, 127:21 show 29:18, 71:1, 85:5, 100:17, 101:14 showed 15:7	showing 96:16, 97:22, 98:3, 98:4, 129:17 shown 32:11, 37:22, 41:15, 57:8, 96:20, 100:11, 107:15, 110:16 shows 28:6, 28:13, 37:7, 108:21, 110:19 shut 7:15, 7:18 sic 36:10 side 10:17, 29:8, 35:10, 96:5, 96:22, 125:12, 128:22 sides 66:2 sideways 42:20, 121:12 signal 59:2, 59:3, 59:5, 59:8, 60:10, 78:3, 78:10, 79:17, 81:15, 82:19, 96:8, 97:19, 106:17, 110:15, 110:17, 111:3, 111:10, 111:20, 111:21, 115:9, 120:12, 136:4, 136:10 signals 58:21, 60:4, 60:6, 76:5, 76:11, 76:18, 76:22, 77:6, 78:1, 81:17, 98:8, 103:2, 109:2, 109:4, 110:13, 111:2,	111:9, 121:1, 133:20, 134:2, 135:20, 136:6, 138:6 signature 143:13 signature-plkal 144:29 signed 143:8 significant 52:4 similar 37:18, 38:22, 45:15, 87:19, 122:9, 132:5 similarity 86:19 similarly 35:14, 44:14, 111:18 simple 30:14, 70:16, 70:17, 71:10, 71:11, 76:2, 84:14, 84:15, 111:12, 112:9 simpler 90:2, 90:4, 90:18 simplest 97:6 simplistic 126:11, 126:13 simply 71:22, 81:3, 81:15, 84:2 since 47:10 singhose 1:16, 2:1, 4:11, 4:13, 4:21, 6:2, 6:16, 7:3, 9:8, 9:12, 9:15, 14:14, 28:2, 29:1, 33:20, 34:1, 47:10, 55:6,	61:5, 64:1, 95:10, 133:7, 133:10, 134:11, 143:3, 144:4, 144:14 singhouse 9:9, 9:11, 9:13 single 34:19, 62:5, 99:5, 99:13 single-type 61:18, 61:20, 62:5, 63:3, 63:13, 63:17 sit 89:4 sitting 139:13 situation 42:15, 80:17, 82:13, 110:10, 122:9 situations 25:8, 80:8 six 108:19, 122:21, 126:9, 126:11, 126:12 size 26:6, 26:8, 36:19, 38:11, 52:22, 54:20, 55:5, 128:18, 128:20, 133:1 sketch 126:8 sketched 122:20, 126:17 skill 17:15, 32:20, 42:10, 46:9, 46:17, 48:3, 48:6, 49:8, 49:20, 54:2, 59:16, 84:13, 109:12, 109:13, 118:4, 118:11, 131:16, 131:19,
---	---	---	---

131:21, 132:10, 132:14 slightly 110:8 slowed 92:20 slowing 93:17 small 26:3, 78:15 smoke 100:17 smooth 80:13 snow 98:5, 100:16 software 24:21, 25:1, 25:5, 25:8, 26:2, 26:10, 64:13, 65:3, 65:5, 65:6, 65:13, 65:17, 65:18, 65:22, 66:1, 66:2, 66:10, 66:11, 67:1, 67:3, 67:4, 67:7, 67:10, 67:19, 68:9, 68:20, 69:2, 69:4, 70:7, 70:22, 72:8, 72:21 software-enabled 72:4 software-related 72:9 sold 95:2 solutions 61:18, 61:20, 62:11, 62:13, 62:16, 63:3, 63:7, 63:21, 109:10 solve 104:11, 109:9 some 8:2, 12:17,	17:7, 20:22, 21:11, 24:9, 24:14, 26:22, 27:5, 28:12, 41:21, 42:6, 42:13, 42:17, 44:6, 45:2, 46:5, 48:16, 53:11, 54:5, 54:12, 55:11, 55:12, 56:17, 65:7, 65:15, 67:8, 70:2, 70:16, 70:17, 73:19, 75:14, 77:10, 86:12, 86:16, 87:22, 89:9, 93:2, 93:10, 95:16, 97:13, 104:2, 107:21, 108:8, 108:9, 108:20, 109:1, 120:12, 121:7, 139:3, 139:9, 142:12 somehow 124:1 someone 73:11 something 16:8, 44:5, 47:19, 47:21, 55:8, 59:7, 65:10, 67:19, 69:14, 98:21, 100:18, 119:8, 119:13, 121:15, 123:15, 131:4, 135:22, 137:13 something's 7:11 sometimes 23:12, 23:13, 87:4, 106:18, 117:3 somewhat 110:8, 126:2, 140:7	somewhere 11:2, 41:8, 58:22, 76:3, 136:13 sophisticated 109:1 sorry 7:1, 33:10, 33:15, 39:8, 56:8, 62:3, 99:2, 99:7, 105:16, 114:2, 119:12, 122:11, 126:12 sort 26:7, 30:15, 31:14, 55:13, 59:9, 64:4, 96:3, 98:3, 119:6, 123:7, 126:10, 127:8, 127:9, 140:7 sorts 66:22, 78:14, 103:8, 108:7 sound 115:19 sounds 12:15, 18:6, 76:15 source 57:20, 57:21, 60:10, 66:3, 66:9, 66:12, 66:13, 66:15, 67:14, 73:1, 73:8, 98:9 sourced 65:18, 66:1 south 123:11 space 30:9, 55:1, 74:14, 74:19, 75:1, 79:8, 93:20, 104:14, 117:7 spaced 35:15, 36:9,	128:22 spaces 74:7, 74:11, 75:10, 75:11, 76:20, 77:8, 87:22, 123:20, 140:8 spacing 128:17 span 32:6, 128:21 speak 54:12, 123:1 speaking 90:6 speaks 32:19 specially 25:14, 25:19 specific 25:1, 26:17, 26:18, 35:11, 35:22, 41:11, 53:20, 63:2, 63:6, 73:6, 73:11, 79:15, 111:6, 111:16, 112:6, 112:20, 126:8, 126:17 specifically 36:4, 36:8, 37:16, 37:17, 64:15, 141:18 specification 41:8, 73:12, 73:13, 73:17 specified 129:14 spectrum 67:1 specular 99:15 speed 82:18, 96:13 spelling 9:14 spend 15:11, 140:20
--	---	---	--

spenko 8:7, 134:12 spenko's 8:11 spot 92:13 stable 33:8, 88:18 stack 8:3, 51:13 stand 32:22 start 10:16, 13:11, 13:13, 29:7, 48:5, 48:16, 53:15, 73:15, 99:7, 109:14, 113:14, 127:20, 128:14 started 6:8, 15:1, 15:22, 17:3, 21:11, 24:14, 128:6 starting 16:17, 36:3, 37:16, 55:18 starts 21:2, 98:17 state 25:22, 64:15, 125:7 stated 134:12 statement 36:14 states 1:1 stationed 135:19 steel 22:10 steering 55:22, 56:2 step 16:18, 90:7 steps 72:4, 72:12	still 7:11, 32:2, 91:14, 92:9, 109:11, 130:20 stop 119:17, 132:4, 132:13 storage 24:2, 24:4, 28:7, 28:10, 28:17, 29:2, 29:3, 29:20, 30:8, 30:14, 30:20, 31:1, 31:5, 31:8, 32:1, 32:10, 32:13, 32:18, 34:15, 34:19, 35:3, 36:21, 40:4, 40:8, 40:17, 40:19, 40:22, 49:9, 49:11, 50:8, 50:11, 50:20, 51:2, 51:6, 51:10, 52:2, 52:15, 52:19, 53:1, 53:4, 88:13, 89:22, 90:13, 90:14, 90:16, 90:17, 105:1, 128:9 store 28:17, 49:13, 50:1, 50:3 stored 50:13, 50:21, 89:5 storing 62:21 story 66:2 straight 77:13 strange 138:12 strategy 81:21	street 3:7 structure 22:22, 28:19, 32:7, 33:7, 42:19, 71:11, 71:12, 122:2, 122:4 structures 70:17, 88:22, 89:9 study 5:6, 138:14 stuff 8:17, 24:3, 68:2, 71:2, 71:19, 71:20, 73:7, 75:3, 75:16, 85:11, 102:21, 103:8, 120:22, 121:16, 142:10, 142:13 stuff's 97:5 subject 10:11, 46:7, 76:21, 115:19, 118:21 submit 29:22, 30:3 submitted 17:7, 18:21, 19:10 substance 34:5, 34:7, 65:2 substantially 37:19, 56:4 substantive 95:12 successfully 140:7 suffer 132:3, 132:12, 142:6 suffering 33:15 sufficiently 41:16	suggest 114:11 suggesting 76:7 suite 3:8, 3:15 summary 117:2 summer 15:2, 15:21, 16:17 supplies 22:10, 89:3, 89:11 support 31:15, 76:13, 77:1, 77:7, 78:4, 84:21, 122:2, 125:10, 127:22, 128:17, 128:22 supports 32:7 suppose 77:14 supposed 96:4, 108:5 sure 11:2, 13:3, 13:10, 14:22, 16:16, 18:8, 28:5, 30:10, 31:6, 37:17, 40:10, 43:20, 50:17, 69:11, 69:16, 70:4, 84:15, 96:2, 99:12, 105:11, 116:5, 121:10, 124:6, 127:18, 130:15, 134:21, 135:16, 141:6 surface 74:17, 97:20, 102:9, 102:13, 102:20, 102:22, 103:3, 103:6, 103:11, 103:13,
---	---	---	---

104:4, 107:6, 108:2, 124:17, 124:18, 124:22, 127:11 surfaces 58:2, 75:4, 76:4, 82:1, 98:1, 101:2, 102:11, 102:22, 107:20, 108:8, 108:12, 112:9, 115:8, 124:4 surprise 95:1 surprised 95:3, 95:4 survey 87:10, 87:17, 91:16, 140:4, 140:21 sworn 6:3, 144:6 symbol 96:6 symmetrical 32:14 system 34:6, 47:14, 48:12, 54:15, 57:13, 58:3, 73:14, 73:18, 76:20, 110:13, 111:1, 111:8, 111:19, 136:5, 138:2, 138:10, 140:22, 142:17 systems 21:7, 23:19, 23:20, 59:19, 63:12, 89:6, 135:7, 135:8, 135:10, 135:12, 135:15, 136:15, 137:10, 137:17, 137:20, 138:5	134:3 tables 86:22 tags 89:12 take 6:11, 14:7, 14:11, 16:10, 42:16, 43:3, 45:3, 45:4, 50:4, 50:6, 51:1, 52:17, 77:11, 78:18, 89:12, 91:17, 96:13 taken 9:16, 33:19, 61:3, 95:8, 133:6, 144:7 taking 23:10, 96:21, 131:14 talk 13:8 talked 60:1, 80:21, 81:8, 89:13, 90:10 talking 13:11, 22:3, 39:19, 43:22, 44:8, 78:7, 80:9, 81:20, 90:7, 91:1, 92:1, 92:4, 101:15, 102:9, 105:17, 112:14, 112:19, 112:20, 117:19, 118:18, 118:19, 120:14, 126:10, 127:3, 130:13, 139:6 tall 51:19, 81:12 taller 50:20 tallest 50:7, 81:6	tape 48:2 target 137:6 targets 141:22 tasked 93:20 teach 102:10, 113:9 teaches 104:16 teachings 73:16, 131:14 team 24:18, 24:20, 94:7 tech 21:13, 27:11 technical 8:8, 12:13 technician 3:18, 6:9, 7:12, 27:11, 27:17, 27:20, 96:7 technology 21:12, 21:13, 21:15, 22:13, 22:15, 22:20, 23:2, 23:4, 23:8, 24:2, 25:11, 33:16, 133:16, 134:10, 134:13, 140:5, 140:15, 142:16 telescope 42:6, 42:12, 42:20, 44:4, 44:5, 44:15, 45:16 telescoped 45:19, 45:22 telescoping 43:19, 43:21, 43:22, 44:2, 44:7, 44:9, 44:13, 44:18,	44:22, 46:11, 46:18, 46:21 tell 21:7, 26:6, 56:15, 119:7, 119:17, 132:21, 133:19, 134:6, 141:13 temporary 90:15 ten 126:15 term 45:12, 57:16, 58:12, 58:19, 60:13, 62:15 termed 58:11 terms 17:14, 17:16, 35:12 testified 6:4 testify 43:8, 140:13 testifying 134:14 testimony 8:12, 34:7, 61:6, 95:11, 105:8, 139:3, 143:5, 143:7, 144:8 testing 87:20 textures 79:20 th 144:25 thank 7:22, 9:6, 27:1, 27:20, 36:7, 56:20, 62:9, 99:7 thanks 27:21 theoretically 79:16, 101:20
T			
table 88:3, 88:18,			

they'd 48:15, 83:14, 83:17 thing 42:17, 50:7, 56:9, 70:21, 75:13, 84:15, 103:5 things 53:2, 58:20, 69:21, 70:15, 125:6 think 7:15, 7:17, 8:9, 9:3, 10:9, 10:10, 10:11, 10:18, 14:22, 15:2, 17:16, 24:10, 27:4, 29:7, 32:12, 32:15, 32:19, 33:5, 38:18, 39:15, 40:21, 42:11, 43:22, 44:1, 46:10, 46:12, 46:14, 48:1, 48:15, 51:14, 51:18, 51:22, 52:5, 54:9, 54:12, 54:19, 58:18, 59:15, 59:22, 60:22, 62:8, 65:20, 66:17, 68:6, 68:7, 69:18, 79:4, 79:8, 83:14, 84:13, 85:4, 86:3, 88:17, 88:20, 94:20, 102:15, 105:7, 114:14, 114:15, 117:1, 117:18, 118:17, 127:6, 129:6, 129:13, 130:11, 131:2, 131:17, 133:15, 133:22, 134:4,	138:12, 139:12, 142:4, 142:7 third 57:6, 57:7, 66:19, 119:20 thought 8:20, 68:1, 78:7, 106:2, 130:5 three 37:8, 45:6, 59:4, 60:4, 62:2, 63:6, 63:13, 77:18, 77:19, 77:20, 83:5, 119:3, 125:13, 125:16, 126:12, 127:14 threshold 78:17 through 15:6, 17:1, 33:16, 37:14, 50:8, 51:22, 56:7, 56:15, 56:17, 56:19, 64:4, 64:21, 68:6, 69:14, 73:16, 91:13, 95:22, 96:10, 100:11, 104:1, 104:2, 137:5, 138:5, 139:3 throughout 14:1 tied 124:9 time 9:13, 11:19, 13:8, 15:21, 37:5, 43:3, 43:6, 44:21, 45:4, 46:5, 60:7, 65:16, 73:15, 75:19, 76:1, 76:5, 81:15, 82:17, 89:19, 92:17,	93:2, 93:3, 93:11, 96:12, 101:21, 102:3, 105:6, 107:19, 110:4, 110:14, 111:3, 111:4, 111:10, 111:20, 116:20, 131:4 time-intensity 108:16, 108:17, 109:21 time-of-flight 4:18 times 9:11, 9:18, 9:19, 43:14, 43:17, 77:20, 125:18, 126:15 tip 32:21 today 12:18, 13:1, 14:15, 14:21, 15:1, 42:14, 43:6, 109:12 today's 6:14 together 20:21 told 95:4, 121:22 tool 29:16, 29:17 top 20:9, 29:11, 46:6, 51:13, 109:21, 123:9, 141:5 top-down 30:19 total 64:2 totally 103:6 tote 51:5, 81:9 tote's 81:6	tough 83:7 towards 123:9 trademark 1:1 trailers 86:7 transcribe 13:5 transcript 19:19, 27:10, 33:21, 57:3, 61:12, 98:14, 116:1, 133:8, 134:18 transcription 143:6 transferring 28:16 translucent 97:8, 97:10, 97:11, 98:3, 99:19, 99:20, 103:16, 103:21, 104:1, 112:4, 112:7, 112:13, 112:17, 113:3, 113:4, 114:12, 115:2 transmitted 79:13 travel 56:1, 104:14, 104:19 traveling 35:3, 74:5, 117:10, 119:4, 119:10, 119:20, 122:12, 123:11 travels 57:15, 96:8 traverse 84:22, 94:3 trees 75:3 trial 1:3
--	--	--	--

triangle 60:5 triangulation 57:13, 59:5, 59:19, 60:3, 135:22 tricky 112:3 tried 7:10, 20:12, 64:4, 137:16 true 63:1, 63:5, 100:10, 143:5, 144:8 trust 80:19 truthfully 12:19 try 13:8, 19:2, 29:5, 72:2, 77:21, 81:13, 81:19, 83:15, 83:18, 84:10, 84:11, 87:12, 87:14, 88:3, 93:1, 103:8, 109:2, 117:19, 137:5, 139:1 trying 10:10, 10:21, 39:20, 58:18, 68:12, 68:18, 69:1, 75:2, 75:8, 75:13, 76:6, 79:7, 82:14, 87:18, 93:16, 96:19, 97:21, 102:10, 109:9, 110:6, 114:18, 114:19, 115:10, 117:5, 131:1 tuesday 144:15 turn 19:15, 19:20,	27:7, 39:6, 39:13, 40:1, 55:6, 55:10, 55:11, 55:14, 55:15, 56:3, 56:8, 56:11, 56:17, 56:21, 57:5, 60:19, 61:8, 64:8, 73:21, 118:22, 132:17 turning 36:2, 56:5, 61:14, 72:12, 72:14, 72:19, 93:18, 95:13 tweaks 26:9 twice 37:22 two 8:5, 8:14, 12:14, 16:16, 30:7, 30:14, 31:1, 35:10, 54:9, 54:14, 54:15, 58:20, 59:15, 62:2, 62:17, 62:18, 63:2, 63:12, 66:2, 77:5, 83:4, 91:2, 97:3, 97:5, 97:15, 107:14, 109:4, 121:19, 126:7, 126:9, 126:15, 128:8 type 43:21, 62:6 types 57:12, 62:2, 85:14, 101:14, 102:6, 125:16 typical 28:18, 65:13 typically 92:22 U uh-huhs 13:4	unable 84:22, 130:2, 130:8, 130:17 unannotated 8:21 uncertainty 21:17 unchangeability 67:6 unclear 139:1 under 12:18, 16:3, 23:6, 30:17, 32:2, 34:14, 34:19, 34:21, 35:6, 38:6, 39:10, 39:16, 39:18, 39:21, 39:22, 40:4, 40:7, 40:17, 40:19, 40:22, 41:1, 51:6, 51:17, 51:20, 52:2, 55:7, 56:12, 74:5, 74:7, 76:20, 78:7, 78:20, 81:11, 81:13, 88:3, 88:4, 102:17, 105:19, 105:22, 106:13, 107:4, 107:6, 108:5, 108:6, 108:12, 112:15, 112:17, 113:16, 114:8, 114:12, 114:21, 115:2, 116:10, 116:21, 117:8, 117:20, 118:5, 118:12, 118:20, 119:10, 119:20, 123:6, 123:21, 125:14, 126:19, 127:16, 132:1, 132:16, 133:4, 136:20, 140:10	under-column 39:16 underneath 35:3, 114:21, 115:12 undershelf 39:4, 39:11, 85:1 underside 107:12 understand 12:21, 13:16, 14:5, 14:14, 18:1, 18:4, 29:3, 40:10, 43:20, 45:11, 46:2, 46:4, 46:12, 59:16, 59:20, 59:22, 60:12, 60:15, 68:12, 69:11, 69:21, 86:13, 91:15, 106:10, 112:2, 131:22, 132:1 understanding 47:17, 68:13, 68:18, 69:1, 69:9, 74:18 understood 8:22, 13:18, 38:14, 39:15, 105:16, 105:18 undue 118:6, 118:12 undulations 79:20 unexpected 87:6, 92:13, 94:3 unit 35:11 united 1:1 units 39:2, 117:11, 119:1 unlikely 70:10
--	---	---	---

unpredictable 94:1 unrealistic 128:19 until 13:12, 65:21, 89:5 untrue 97:16 unusual 65:7 update 89:10, 89:19 updated 91:12 upload 25:20, 26:12, 26:22, 27:16 uploaded 89:15 upside 107:18 upwards 77:14 urban 5:3, 135:1, 137:20, 138:14, 138:16 usa 1:6 use 26:17, 60:6, 65:12, 65:15, 74:15, 81:15, 84:7, 84:10, 103:3, 103:13, 132:19, 132:20, 135:18, 137:16, 138:1, 140:6 useful 65:7 uses 62:15, 92:14 using 28:21, 45:12, 58:3, 60:17, 60:19, 62:1, 82:18, 84:8,	102:7, 112:7, 114:11, 121:3, 129:20, 136:2, 137:19, 138:9 usually 24:9, 138:4 utilize 24:1 V vacuum 85:8, 85:18 vacuums 85:19 value 44:6, 110:9, 111:13 variations 55:9, 135:17 variety 55:22, 112:8, 125:5 various 31:7, 57:9, 57:12, 58:1, 75:5, 98:1, 137:16 vastly 129:21 vehicle 5:4, 35:18, 36:12, 37:18, 37:20, 37:22, 38:3, 41:14, 41:16, 54:6, 55:21, 56:1, 56:3, 56:6, 56:7, 135:1, 137:2, 137:3 vehicles 36:19, 135:8, 136:16 velocity 71:18, 92:20 verbally 13:3 version 44:13, 128:11	versions 8:21, 23:2 versus 125:3, 126:7, 133:21, 137:9 vertical 31:5, 31:10, 31:17, 31:21, 32:2, 32:7, 32:12, 32:16, 56:6, 79:12, 80:11, 80:12, 88:12, 90:13, 106:13, 125:10 vertically 39:2, 48:18 vibration 21:17 video 6:12, 13:9 view 29:8, 29:9, 29:12, 30:14, 30:18, 30:19, 31:9, 31:12, 72:22, 124:2, 125:11, 131:12, 132:7 viewing 70:6 virtual 57:14 virtually 2:2, 144:14 visited 11:20 visually 28:6 W w2 41:17, 44:5 w3 44:5 wait 13:12 walk 89:14, 95:22	walking 86:5, 86:6, 86:11, 90:1, 93:12, 93:13 wall 75:13, 88:5, 96:9, 125:12 walls 75:3, 75:16, 82:4, 87:13, 88:22, 91:4, 106:20, 106:22, 134:3, 138:6 want 6:10, 11:2, 11:9, 15:3, 16:11, 19:20, 36:5, 37:5, 44:1, 45:3, 45:4, 45:13, 48:2, 50:19, 52:16, 53:15, 62:20, 72:7, 72:10, 97:9, 99:9, 114:8, 116:17, 119:17, 122:8, 122:14, 123:1, 124:6, 139:6 wanted 115:5, 134:22 warehouse 11:16, 11:17, 28:3, 28:7, 28:14, 28:19, 50:2, 50:22, 53:6, 53:10, 53:11, 53:16, 54:20, 54:21, 55:2, 55:5, 58:22, 59:11, 62:1, 65:13, 67:10, 74:13, 75:9, 75:15, 75:22, 76:8, 78:6, 79:2, 80:21, 81:1, 82:6, 82:8,
---	--	---	---

83:20, 84:3, 86:1, 88:12, 89:21, 91:8, 91:13, 100:13, 100:17, 101:22, 102:18, 104:13, 104:20, 106:8, 106:11, 112:4, 112:12, 112:15, 114:6, 114:21, 114:22, 127:5, 128:1, 131:7, 138:3 warehouses 22:3, 24:1, 33:3, 76:3, 79:5, 80:18, 86:4, 86:9, 86:20, 87:19, 89:2, 89:7, 102:6 washington 3:16 waste 37:5 wave 82:18 waves 59:10, 59:11 way 23:6, 25:10, 26:21, 42:6, 42:13, 53:17, 59:14, 72:1, 78:11, 78:17, 84:9, 97:18, 101:20, 103:9, 104:15, 109:6, 117:22, 119:15, 122:19, 128:13, 129:14, 141:1, 141:8, 144:21 ways 59:15, 60:2, 75:5, 98:2, 132:15, 133:3 we'll 10:16, 14:7,	15:4, 30:5, 123:4 we're 8:13, 9:13, 22:3, 25:16, 28:20, 69:1, 80:8, 81:20, 90:7, 101:15, 105:17, 106:8, 107:2, 109:15, 110:6, 112:14, 114:6, 114:7, 114:18, 114:19, 114:20, 114:22, 117:19, 118:19, 125:10, 128:13, 129:8, 129:20 we've 26:11, 26:21, 38:4, 109:22, 110:3, 117:22, 126:10, 126:17 week 89:5 weigh 109:2 well-defined 83:11 went 11:19, 15:6, 16:14, 34:7, 68:19, 107:12, 139:3 wet 85:11 whack 129:21 whatever 48:2, 56:18, 58:10, 83:16, 104:4, 121:1, 121:6 wheels 55:8, 55:10, 55:11, 55:13, 60:18, 132:21 whenever 125:14	whereby 100:4 whereof 144:23 wherever 135:19 whether 41:7, 53:10, 71:16, 121:11, 131:3 whiteboard 28:21, 29:2 whole 42:17, 43:7, 50:10, 53:9, 66:22, 70:21, 71:20, 85:10, 109:7, 139:21 wide 35:9, 35:12, 37:7, 39:21 wider 48:21, 78:12, 78:13, 122:14 width 37:17, 37:18, 37:22, 38:22, 39:1, 39:6, 39:12, 39:16, 41:15, 41:17, 42:21, 44:2, 44:4, 49:1, 49:6, 129:18 widths 49:18 william 1:16, 2:1, 4:10, 6:2, 143:3, 144:4, 144:14 window 121:3 within 22:21, 120:13, 121:6 without 46:16, 56:3, 72:15, 73:8,	80:14, 81:22, 118:5, 118:12, 132:16 witness 7:1, 7:10, 7:14, 27:22, 30:2, 30:22, 129:10, 138:17, 144:4, 144:9, 144:23 wondering 46:8 word 37:16 words 34:3 work 12:10, 16:11, 16:14, 17:9, 21:8, 22:2, 23:18, 24:7, 24:19, 28:22, 32:6, 33:13, 53:5, 72:16, 76:8, 76:19, 81:22, 82:2, 87:21, 96:5, 104:2, 109:10, 111:17, 117:4, 135:15, 138:13, 140:12 worked 109:17, 136:22 working 7:11, 15:1, 15:22, 28:14, 109:7, 109:8 works 25:10, 73:14, 74:6, 76:7, 96:11, 101:22, 117:5 workstations 104:14 world 109:18 worried 7:15
---	---	---	---

worries 99:9 wouldn't 55:3, 66:7, 69:18, 71:22, 72:15, 81:3, 90:1, 100:14, 108:22, 114:10, 115:1, 140:12 write 9:2, 17:19, 24:18, 24:20, 26:18, 70:8, 71:13, 73:20 written 9:1, 26:21 Y yeah 7:14, 9:12, 10:16, 15:4, 15:5, 29:15, 31:19, 32:5, 34:3, 34:20, 58:8, 64:3, 68:11, 69:9, 72:14, 72:18, 75:20, 77:10, 98:19, 101:17, 101:19, 104:6, 109:8, 109:16, 111:5, 113:4, 116:19, 119:16, 120:20, 121:22, 129:4, 129:7, 129:13, 131:14, 136:9, 136:20, 139:11 years 11:13, 11:19, 11:22, 12:1, 21:11 yep 29:13, 30:12 Z zero 72:13	zero-turn 55:16, 56:2, 56:5, 56:9 zoom 7:5, 7:7, 7:13, 7:17, 7:20 zottola 3:4, 4:3, 6:6, 6:7, 6:20, 7:2, 7:21, 9:6, 9:7, 18:14, 18:18, 27:14, 27:19, 27:21, 28:1, 30:11, 33:17, 33:22, 47:5, 47:9, 61:1, 61:4, 95:6, 95:9, 130:21, 133:5, 133:9, 138:17, 142:20 0 00850 1:12, 6:15, 18:5 0103 57:6 0158430 4:14 04 144:15 1 1 105:13 10 38:1, 38:20, 38:21, 61:15, 69:14, 129:17 10,472,172 4:20, 115:15 100 55:21 1001 4:12, 18:5, 27:8, 27:9, 27:16, 27:18 10016789 27:13	1005 4:14, 56:21, 57:1, 57:2 1006 4:15, 61:9, 61:11 1008 4:20, 115:17, 115:22, 116:2 109987366 4:16 11 45:7, 45:8, 45:9, 45:10 11,472,632 1:13, 4:12, 18:2 115 4:20 12 141:10, 141:15, 141:17 12,000 137:1 13 36:2, 141:12, 141:15, 141:17 133 4:21 134 5:7 138 4:4 14 19:22, 117:10 144 1:22 15 20:1 151 76:16 154 84:20, 85:15 16 36:3, 37:13, 41:12 17 35:13, 37:14,	45:7, 45:8 1795 9:13 18 36:2 180 56:16, 121:5 1899 3:14 19 4:11, 105:13 2 2 142:21, 144:16 20 9:22, 15:13, 144:25 2000 19:2 20006 3:16 2001 19:1 2004 5:3, 134:16, 134:17, 134:19, 134:21 2007 4:10, 19:13, 19:16, 19:18, 19:21, 21:2, 27:12, 27:14, 64:9, 74:2, 95:14 2009 4:17, 98:10, 98:12, 98:13 2016 116:9 2017 4:14 2021 95:2 2024 1:12, 6:15, 18:5 2025 1:17, 144:15,
--	---	--	---

Transcript of William E. Singhose, Ph.D.
Conducted on April 29, 2025

184

144:25 2026 144:26 2100 3:8 23 19:22, 45:9, 45:10 25 15:13 27 4:12 29 1:17, 144:15 2nd 3:7 3 30 82:8 33 4:13 37 55:15, 55:19 38 142:21, 144:16 4 40 9:19, 95:2, 116:15 400 3:15 43 116:16 5 55 3:7, 37:9, 37:12 57 4:14 580482 1:21 6 60 120:11, 120:13,	121:5, 121:9, 121:11, 121:12, 121:18, 122:14, 122:16, 122:18 61 4:16 62 35:13, 41:12 632 8:12, 15:8, 16:18, 17:22, 18:4, 20:15, 27:7, 28:3, 29:4, 32:3, 32:9, 32:17, 33:1, 34:12, 35:2, 35:5, 35:13, 35:21, 36:14, 36:20, 37:1, 38:5, 38:7, 38:15, 39:10, 40:2, 41:2, 41:4, 41:13, 41:20, 42:5, 42:11, 43:12, 43:13, 43:18, 45:21, 46:9, 46:10, 47:11, 47:15, 48:7, 48:12, 48:13, 53:5, 53:18, 54:18, 55:6, 56:10, 72:3, 119:2, 129:11, 130:2, 130:7, 130:12, 130:13, 130:16, 130:20, 131:2, 131:11, 131:14, 132:6, 133:10, 133:16, 133:17, 133:19, 134:6, 134:10, 138:11, 139:17, 139:22, 140:15, 140:16, 141:2, 141:10, 142:3, 142:8 64 41:12	67 37:14 8 81 95:16 815 35:17, 36:10 86 21:3 860 35:14, 36:8 9 9 144:15 90 56:15, 71:13, 71:14, 107:16, 108:9, 121:5 94105 3:9 98 4:19 9th 144:24	
---	---	--	--