Transcript of James F. Shanley, Ph.D.

Date: June 6, 2024
Case: Hesai Technology Co., Ltd. -v- Ouster, Inc. (PTAB)

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UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD
- - - - - - - - - - - - - - -x
HESAI TECHNOLOGY CO., LTD, : U.S. Patent No.
Petitioner, : 11,175,405
v. :
OUSTER, INC., : IPR No. 2023-01421
Patent Owner. :
- - - - - - - - - - - - - - -x

Deposition of James F. Shanley, Ph.D.
Boston, Massachusetts
June 6, 2024
9:14 a.m.

Job No.: 539411
Pages: 1 - 83
Reported By: Alan H. Brock, RDR, CRR

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A P P E A R A N C E S

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C O N T E N T S

EXAMINATION OF JAMES F. SHANLEY, PH.D. PAGE
BY Mr. LAUPPE 5
BY Mr. HAGIZ 80

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1 June 6, 2024 9:14 a.m.
2 P R O C E E D I N G S
3 JAMES F. SHANLEY, PH.D.,
4 being first duly sworn or affirmed to testify to the
5 truth, the whole truth, and nothing but the truth, was
6 examined and testified as follows:
7 EXAMINATION
8 BY MR. LAUPPE:
9 Q. Good morning, Dr. Shanley.
10 **A. Good morning.**
11 Q. Thanks for being here today, Dr. Shanley.
12 Have you been deposed before?
13 **A. Yes.**
14 Q. How many times?
15 **A. Let's see. Three; I think this is the**
16 **fourth.**
17 Q. Have you testified at trial before?
18 **A. No.**
19 Q. Have you been an expert in an IPR proceeding
20 before?
21 **A. I've done a bunch of things on -- I'm trying**
22 **to think. You know, it's been a span of years. So**

6

1 **probably, I guess. I'd have to look at my resume.**
2 Q. How did you prepare for today's deposition?
3 **A. I read over my declaration, the patents, and**
4 **I talked with counsel.**
5 Q. How many hours did you spend talking with
6 counsel?
7 **A. A few. Do you want me to quantify it?**
8 Q. Ballpark is fine.
9 **A. Probably three or something like that.**
10 Q. When were you first engaged by Hesai?
11 **A. Oh, God. It's going back, I think, to about**
12 **this time last year. My declaration was done in**
13 **September, the end of September or so. I think it was**
14 **early summer or about this time frame.**
15 Q. And since you mentioned your declaration,
16 let's go ahead and introduce Exhibit 1003, which is
17 your declaration in this proceeding.
18 Did you draft Exhibit 1003, Dr. Shanley?
19 **A. Yes.**
20 MR. HAGIZ: Objection, form.
21 **A. I went back with the legal team and**
22 **consulting, and I wrote up parts of it and gave my**

7

1 **opinion. And so it was a give-and-take.**
2 Q. Do you have any corrections or changes to
3 Exhibit 1003?
4 **A. One I can think of was the typo on my**
5 **bachelor's degree. I think it's listed as 1996, and**
6 **that was after my doctorate. So that's kind of**
7 **incongruous.**
8 Q. And so when did you receive your bachelor's
9 degree from Clarkson University?
10 **A. 1966.**
11 Q. Do you have any other corrections or changes
12 to your declaration in this case?
13 **A. Not that I know of.**
14 Q. Does your declaration, Exhibit 1003, state
15 all of the opinions you intend to provide in this IPR?
16 **A. Yes.**
17 Q. Where did you get the alleged prior art
18 referenced in Exhibit 1003?
19 MR. HAGIZ: Object to the form.
20 **A. Through legal counsel, and also through**
21 **literature search that I did.**
22 Q. Did you choose the alleged prior art

8

1 referenced in Exhibit 1003?
2 MR. HAGIZ: Objection, form.
3 **A. Well, back and forth. We actually went**
4 **through and looked at the literature and looked at the**
5 **claims and actually selected the patents that we**
6 **thought were relevant for this.**
7 Q. Which of the prior-art references discussed
8 in your declaration were you aware of before being
9 engaged in this case?
10 **A. Well, having worked in the field, I was aware**
11 **of a lot of background information and a lot of**
12 **literature. And specifically, you know, I probably**
13 **glanced at those in the past. But, you know, I just**
14 **pulled a lot of stuff from my reference base and**
15 **provided it.**
16 **So I don't know, you know. It's that type**
17 **of thing. You know, you see so many references and so**
18 **many things that you know where to go to get the**
19 **pertinent information that you want.**
20 Q. And what is your hourly rate?
21 **A. It's listed in the -- I go through an agency,**
22 **and so the agency charges the fee. So I believe if we**

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1 **look through this we can see what they charge.**
2 Q. So if you go to Page 1, Paragraph 2, do you
3 see where you say, "I am being compensated at my
4 standard consulting rate for my time providing my
5 independent analysis, plus reasonable out-of-pocket
6 expenses"? Do you see that?
7 **A. Yes.**
8 Q. What is your standard consulting rate?
9 **A. My standard rate is not what the agency**
10 **charges. So I charge the agency that employs me $250**
11 **an hour.**
12 Q. I'm sorry, you said that's not your standard
13 consulting rate, that $250 an hour?
14 **A. So, my standard rate is $250 an hour, but the**
15 **agency doesn't charge that, they charge something**
16 **else.**
17 Q. Understood.
18 **A. So I'm employed through the agency, and the**
19 **agency contracts with Quinn Emanuel.**
20 Q. How many hours have you worked on this IPR
21 proceeding to date?
22 **A. Oh, my God. I would have to look that up. I**

10

1 **don't know that number.**
2 Q. And when I refer to "this IPR proceeding,"
3 you understand that means IPR Proceeding
4 No. 2023-1421? Is that correct?
5 **A. If that's, yes, what the declaration says,**
6 **yes.**
7 Q. Did you review the patent owner preliminary
8 response in this proceeding?
9 **A. We provided a list of items that I looked at,**
10 **and if it's in there, I did. I don't remember,**
11 **because I worked on several different things, and**
12 **going back, I'm not sure. I probably did, but I**
13 **really can't comment on that.**
14 Q. Do you know if you reviewed the institution
15 decision in this proceeding?
16 **A. What date is that on?**
17 Q. So the institution decision was issued on
18 March 19th of 2024.
19 **A. I would have to look back. It doesn't ring a**
20 **bell.**
21 Q. So let's go to Paragraph 9 of your
22 declaration. That's on Page 3 of Exhibit 1003. Do

11

1 you see where you say, "I was personally involved
2 designing and building a number of LiDAR systems"?
3 **A. Yes.**
4 Q. Did these systems use photodetectors?
5 **A. Some of them.**
6 Q. What kinds of photodetectors?
7 **A. It depended on the system. In the early days**
8 **it was photoconductors and photodiodes, and then**
9 **getting further out, we were experienced with**
10 **avalanche photodiodes. We were looking at resonant**
11 **cavity-type devices.**
12 **So there's a whole slurry of devices that**
13 **we actually looked at and evaluated to pick the best**
14 **one for our particular systems.**
15 Q. When were you first aware of single-photon
16 avalanche diodes, or what I'll refer to as SPADs?
17 **A. Oh, my goodness. Thinking back, with the**
18 **photodiodes -- so photodiodes and photoconductors are**
19 **the first devices that I worked with. But we were**
20 **always keeping an eye out for different devices, and I**
21 **was lucky enough to work with people at Lincoln Labs,**
22 **also, and consulting a lot on what they were doing.**

12

1 **And there was a lot of early research in avalanche**
2 **photodiodes. God, this goes back to the late '70s,**
3 **early '80s time frame.**
4 **I might interject that basically -- I**
5 **started my life as a device physicist. And so I was**
6 **always aware of device structures and what was going**
7 **on in the various device research and development.**
8 **And so via conferences and things like**
9 **that, I became aware of alternatives to what we could**
10 **use in LiDAR systems.**
11 Q. And so in your answer just now you referred
12 to avalanche photodiodes; correct?
13 **A. Uh-huh.**
14 Q. Those are -- strike that.
15 Avalanche photodiodes are otherwise known
16 as APDs; correct?
17 **A. Yes.**
18 Q. So my question was about SPADs or single-
19 photon avalanche diodes. Do you recall when you were
20 first aware of those?
21 **A. That was in the McDonnell Douglas days in the**
22 **early '90s and the research that was going on. I had**

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1 **groups working with semiconductor diode lasers and**
2 **receivers, and that seemed a natural way of increasing**
3 **sensitivity of these devices.**
4 Q. And were these LiDAR devices?
5 **A. Not at that particular point.**
6 Q. What kind of --
7 **A. I'm sorry. We considered, you know, as I**
8 **said earlier, all types of given devices. And so when**
9 **we sat down to design a system, one of the system**
10 **considerations was what type of device are we going to**
11 **use, what's the sensitivity, what are the ranges that**
12 **we have to work with, what are the distances, what are**
13 **the velocities, how strong is the laser power, are we**
14 **doing a satellite-to-satellite thing or an**
15 **airplane-to-earth or an earth-based vehicle. So we**
16 **had to take all those considerations in to see what**
17 **type of device was best suited for that and what was**
18 **available and cheap.**
19 Q. So you said SPADs were involved with your
20 work in the McDonnell Douglas days; correct?
21 **A. No, not to the extent that they were**
22 **implemented in systems. But we were watching**

14

1 **developments and who was developing what type of**
2 **device, and we would talk with people across the**
3 **industry -- whether it was Osram or Sony or Ball**
4 **Aerospace, developed a lot of APDs. And so we would**
5 **look at what's happening, and we would actually do**
6 **fact-finding visits to these various vendors to see**
7 **what was going on with devices that they were**
8 **developing, so that we could incorporate them into**
9 **future -- you know, future systems.**
10 Q. Did you ever incorporate SPADs into future
11 systems?
12 **A. Myself, no.**
13 Q. Why didn't you use SPADs in any of the LiDAR
14 systems that you worked with?
15 MR. HAGIZ: Objection, form.
16 **A. By the time I left that industry and actually**
17 **ended up as vice president of engineering for**
18 **Polaroid, and so we changed hats, and so outside of --**
19 **when I left Polaroid, and doing some consulting with**
20 **Scram, we considered SPADs for some particular**
21 **applications. And this involved some handheld**
22 **illuminators, using diode lasers, and we considered**

15

1 **putting a SPAD in there to give us increased**
2 **performance.**
3 **But did I ever build a system with one?**
4 **No. Did I design? I had some paper designs with**
5 **them, but never incorporated them.**
6 Q. And what do you mean by a handheld
7 illuminator?
8 **A. This would be for a soldier on the front**
9 **lines. And what they would do, it would be a**
10 **flashlight-sized object that would have in the same**
11 **focal plane a diode emitter, a bunch of laser diode**
12 **emitters, and a detector array, so that they could**
13 **illuminate an object, and that object could then give**
14 **information to other people, like an airplane flying,**
15 **or it could come back and give information to the**
16 **people who are there, such as range and range rate,**
17 **velocity.**
18 Q. So you mentioned that you worked on a LiDAR
19 system for Scram; correct?
20 **A. The handheld illuminator.**
21 Q. And was that a LiDAR system?
22 **A. Technically, yes, because it did range.**

16

1 Q. But ultimately, you said, you did not use a
2 SPAD in the Scram system; is that correct?
3 **A. Right. But let me just say this: The type**
4 **of detector -- this really -- to a device person like**
5 **myself, and also I wear my system hat, whether I put a**
6 **photoconductor in there or whether I put a resonant**
7 **cavity device or whether I put an APD or a SPAD or**
8 **whatever, it all boils down to system sensitivity and**
9 **noise-equivalent power or signal-to-noise ratio. So**
10 **it really doesn't matter.**
11 **And each device has its own special**
12 **characteristics, and SPADs, because you're operating**
13 **in the breakdown region, you have to consider multiple**
14 **arrays, because you have to quench one and still be**
15 **able to detect your incoming signal.**
16 **So, you know, the pixel considerations are**
17 **multi-SPAD for a pixel, as opposed to a single diode.**
18 **So you have those things, and it's all very**
19 **straightforward engineering.**
20 Q. What did you use in the Scram system as a
21 photodetector?
22 **A. We used the photodiode, an array of**

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1 **photodiodes.**
2 Q. Why didn't you use a SPAD in the Scram
3 system?
4 **A. We didn't have the volume and the power**
5 **required at that point, and we wanted a simple system.**
6 Q. What do you mean, that you didn't have the
7 volume?
8 **A. Well, this was in the 2008 time frame. And**
9 **we didn't have -- at that point SPADs were not really**
10 **well developed. And so consequently we went with**
11 **something that had to be cheap, which was an**
12 **off-the-shelf array.**
13 **And cheapness and volume -- so if you have**
14 **something that's like a flashlight and you want to put**
15 **your arrays in there and you want a very simple**
16 **operation and you want it to be able to be**
17 **field-fixable, there wasn't a lot known about, you**
18 **know, how reliable and all the ilities about SPADs.**
19 **So we went with something that was very, very off the**
20 **shelf.**
21 Q. You said you went with photodiode; is that
22 correct?

18

1 **A. Uh-huh.**
2 Q. And were photodiodes cheaper than SPADs?
3 **A. At that point.**
4 Q. And did SPADs take up a larger volume than
5 photodiodes?
6 **A. Not really. You know, it really is a**
7 **question of cost. And the other thing is, the**
8 **reliability and the manufacturers, who's manufacturing**
9 **them in those time frames.**
10 **And at that particular time frame, there**
11 **was a lot of research and development being done in**
12 **the SPAD-type devices. And so we decided to go for**
13 **something that was very simple. And this was for the**
14 **Korean Army, basically, that we did this. So it had**
15 **to be very fast and very quick and very reliable.**
16 Q. What do you mean by you had to go with
17 something that was very simple?
18 **A. Not complicated. And that's not to imply**
19 **SPADs are complicated. The idea is, I have to fit it**
20 **in here. It has to work. And this program was only**
21 **like a nine-month program. So it had to be a quick**
22 **turnaround.**

19

1 Q. And what would have caused the turnaround to
2 be longer if you used SPADs?
3 **A. Unavailability.**
4 Q. Have you ever worked on a rotating LiDAR
5 system?
6 **A. Plenty. The one that comes to mind in terms**
7 **of rotational -- I mean, there are many, many**
8 **different types of rotational systems, and I've worked**
9 **on a lot of FLIR systems. Those are forward-looking**
10 **infrared, which are rotational.**
11 **Back in the early days at Honeywell we**
12 **actually had a FLIR system, and there was a unique**
13 **rectangular mirror that had mirrors on four sides that**
14 **could only be made by diamond turning. And**
15 **Polaroid -- or Honeywell had the patents on a lot of**
16 **diamond turning early in the '70s. And this system**
17 **rotated this way. So you had linear arrays of items**
18 **which eventually were replaced by focal planes, and it**
19 **spun this way to give you an image from the scene as**
20 **well as rotating this way.**
21 **So this could either rotate 360 degrees**
22 **while spinning like this, or it could look in a given**

20

1 **direction.**
2 **And these were for various types of**
3 **platforms to mount on. And in those days you had**
4 **linear arrays, so you had to scan and construct a**
5 **scene using, you know, strips of the scene and then**
6 **put them together. And so it created a lot of signal**
7 **processing.**
8 **And so basically the drive for arrays came**
9 **by the fact that I don't want to have this narrow**
10 **strip and be putting it together all the time. So**
11 **what they did was went to arrays and you could go to**
12 **staring systems and you could take those staring**
13 **systems and put them on gimbals and rotate them in**
14 **various directions.**
15 **Essentially we built -- I was involved in**
16 **programs for several different LiDAR systems -- for**
17 **laser altimeters, for space applications, for range**
18 **finders, for wind velocity measurements. We actually**
19 **built a system that we put out in Colorado on Tabletop**
20 **Plateau, which is sort of an oxymoron, for actually**
21 **doing wind velocity measurements, and that was a**
22 **360-degree system.**

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1 Q. The Honeywell system you're describing, in
2 that system was it the mirror that rotated?
3 **A. Yes. The mirror rotated axially. So it was**
4 **rotating this way. So if you can imagine a cylinder**
5 **rotating this way, and four sides -- each time the**
6 **cylinder rotated, you have four different images**
7 **you're going to get.**
8 **And in addition to that, it rotated....**
9 **Sorry about that. So it also -- I should**
10 **have used this. So it's rotating this way, but at the**
11 **same time it's rotating this way. So it rotates**
12 **vertically as well as horizontally.**
13 **And these were pretty crude systems early**
14 **on, but they became very, very sophisticated. And**
15 **they're probably -- they were then all -- a lot of the**
16 **early imaging systems, the rotational ones in this**
17 **direction were replaced by staring arrays as focal**
18 **planes became more prevalent, where you had, like,**
19 **1028-by-760 focal planes. Then you could have the**
20 **whole scene and there was no need to rotate this way,**
21 **but you could just rotate this way.**
22 Q. The handheld system you worked on for Scram,

22

1 that wasn't a rotating system; correct?
2 **A. No, that was just -- you know, the rotator**
3 **was the soldier, actually.**
4 **I might say, throughout my career also at**
5 **McDonnell Douglas we did various LiDAR systems on a**
6 **quick turnaround for some special projects. I'll just**
7 **leave it like that.**
8 Q. When did you last participate in designing a
9 LiDAR system?
10 **A. In a LiDAR system? Does an expert witness**
11 **count? I participated in a LiDAR system in 2018,**
12 **which involved replacing the pitot tubes on airplanes.**
13 **And the pitot tubes are the biggest source of crashes**
14 **of airplanes, because it's an open tube with a**
15 **diaphragm in it and all kinds of objects, from ice to**
16 **bird stuff, gets in it, and you lose all kinds of**
17 **information on aerodynamics.**
18 **And so that was to replace the pitot tubes**
19 **with a LiDAR system, and the LiDAR system was a**
20 **scanning system, and it would take both -- it would**
21 **bounce off the aerosol content. You had a scan, it**
22 **would give you air speed, it would give you all the**

23

1 **good things that a pitot tube does.**
2 **And so we went through that whole thing,**
3 **including eye safety, detection capability, detectors,**
4 **lasers, the whole nine yards.**
5 Q. What kind of photodetector was involved in
6 that system?
7 **A. That was a Ball Aerospace -- I believe it was**
8 **a Ball Aerospace avalanche photodiode.**
9 Q. Was that as an expert or in industry?
10 I'll repeat the question. The experience
11 you were just describing, was that as an expert or for
12 industry?
13 **A. That was an expert.**
14 Q. And was that a rotating system?
15 **A. Yes.**
16 Q. When did you last design a LiDAR system?
17 **A. Probably in the 2008 time frame.**
18 Q. And that was your work for Scram?
19 **A. Right.**
20 Q. How has the LiDAR field changed since the
21 2008 time frame?
22 **A. I don't think very much, because -- a little**

24

1 **anecdote here, if I may.**
2 **My -- back at McDonnell Douglas and even**
3 **back at Honeywell the basic components of a LiDAR**
4 **system are very similar, and the techniques that you**
5 **use are basically the same. I mean, the question is,**
6 **you're going to capture a scene, and what part of the**
7 **scene are you going to look at? Are you only going to**
8 **look at forward-looking? Are you going to look at**
9 **360? Are you going to look at 180? So that**
10 **determines the way you design this system.**
11 **And then the components -- the components**
12 **change, but there's always the point where when you're**
13 **designing --**
14 **Okay, in the early days the first LiDAR**
15 **systems that we actually built involved CO2 lasers.**
16 **And why did we choose CO2 lasers? Because they were**
17 **the most powerful laser at that point and we could get**
18 **it in a small package. So we could do ranges out to**
19 **six, seven hundred kilometers. And what type of**
20 **diodes we chose? We chose either photoconductors or**
21 **photodiodes. We chose photoconductors initially**
22 **because they were more reliable and could be produced**

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1 easily. Then we went to photodiodes. And then the
2 progression goes on.
3 Now, as I left there and went to GE, we
4 used CO2 for the wind velocity because that was the
5 ranges that we need on a satellite-based system. At
6 McDonnell Douglas we sort of had a change in pace,
7 because we were looking at -- and component technology
8 started to come along. And I might emphasize the fact
9 that while I was at both McDonnell Douglas and GE I
10 became involved in diode laser research and detectors
11 and components for diode lasers. And so as diode
12 lasers became more and more powerful, we could go to
13 and look at other detection capabilities for using
14 diode lasers. And avalanches actually turned out to
15 be really well suited for that. Also, we could do --
16 if we had something even more sensitive, we could go
17 on.
18 Now, we also along the way -- so the
19 technology is very simple in terms of LiDARs. LiDAR
20 basically is light detection and ranging, or LaDAR,
21 people like to talk about, is laser detection and
22 ranging. So it doesn't matter. They're

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1 interchangeable.
2 But the technique is very similar. I send
3 out a pulse of light, it bounces off the object. I
4 combine it, and knowing the time of flight and the
5 pulse, I can calculate how far away that object is,
6 and using techniques, I can also calculate velocity,
7 and if I had arrays, I can put an image together.
8 And so we went to scanning systems at
9 first because of linear arrays, so we could scan part
10 of the system. Then as time got better, we would go
11 to a range of devices, because we could get the whole
12 enchilada in one picture right away.
13 So it's basically the same technology.
14 What has changed is more powerful lasers -- and I'm
15 talking about semiconductor lasers, going from edge
16 emitters, which were cleaved crystals, to vertical
17 cavity devices. I'm talking about wavelengths, what
18 wavelengths are you working with, and diode lasers
19 tend to lend themselves to some of the eye safety
20 lasers.
21 So there's a whole -- there's a whole
22 range of devices here that you can choose from. And

27

1 so, you know, when I sit down to design a device, I
2 go, okay, what's the mission, what's the system, and
3 these are my laser sources, these are my detectors.
4 Now, what's the range? Okay, I get that. So I can
5 choose certain components. Does it have to be
6 eye-safe or does it not have to be eye-safe? Does it
7 have to be a humongous one, I could fill the room and
8 fly on a 747? We've done those, also. Or does it
9 have to be something that fits in a package like this?
10 So there was a whole range of things. And
11 my experience includes things like LAWS, laser
12 atmospheric wind sensor; Mars Observer laser
13 altimeter. Near Earth Asteroid Rendezvous; we built
14 some things for that. We also did, let's see --
15 there's a whole bunch of things here.
16 Just various things like that. And also
17 we were one of the first people that developed VCSELs,
18 and we developed waveguided devices that you could
19 actually induce a signal using the waveguide, amplify
20 it, and actually use a turning mirror to get a
21 vertical cavity.
22 So there's a whole plethora of things that

28

1 we did that all came together in designing LiDAR
2 systems.
3 Q. Where was it that you worked on the
4 waveguided system you were just mentioning?
5 A. That was GE and McDonnell Douglas. I had a
6 diode laser group, and we actually produced diode
7 lasers. We actually built some of the early --
8 It was this big and this big. It was
9 about a foot by a foot or a foot and a half by a foot
10 and a half square of diode lasers stacked for actually
11 pumping the Lawrence Livermore laser fusion project.
12 So I got involved with diode lasers there.
13 We also at GE made our own detectors.
14 Similarly at McDonnell Douglas we made our own
15 detectors. And so having the capability of doing
16 diode lasers plus detectors and putting them together
17 was a natural.
18 Q. How were the waveguides used in those
19 systems?
20 A. We were actually doing couples of things with
21 the waveguides. We actually used guided waves for
22 some totally reconfigurable networks and switches for

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1 the F-18 and F-15 fighters. So the idea was to
2 replace all the copper with fiber optic components,
3 and you needed switches. And so these -- and so you
4 need to guide the light. And so we were using that to
5 guide the light.
6 We also used -- were looking at detection
7 capability and detectors. And I had a group working
8 on, we called them at the kinoform optics. But it was
9 diffractive optical lenses. These were small
10 miniature lenses that could either be put on the diode
11 laser or it could be put on the array of photodiodes.
12 And so what you would have would be
13 these -- they're like miniature waveguide devices.
14 And you would put these on the arrays of devices, and
15 you could have your incoming radiation light-focused
16 on those devices.
17 So -- and that technology goes back to --
18 like Finlan and Company -- '86 through '90, in that
19 particular time frame.
20 Q. And you said you were involved with working
21 on a waveguide system that involved a rotating mirror;
22 is that correct?

30

1 A. No. Okay, this was for switching, optical
2 switching.
3 So what we actually did was, you could
4 take an incoming light beam --
5 One of the big things in fiber optics is
6 amplifiers. And so you want to have your light wave
7 traveling down your fiber optic. When it gets to a
8 point, you want to be able to break that beam and
9 split it into two different channels. And so we
10 worked on techniques for splitting the beam in
11 different channels.
12 And the question is what happens to your
13 signal-to-noise ratio in each of those channels. And
14 so it happens that you can just switch or break that
15 beam so many times before your signal-to-noise ratio
16 goes crazy.
17 So what we did is, we actually did a thing
18 with waveguides that were actually doped, so that we
19 could get amplification, so that when you split your
20 signal you would then amplify that signal, and then
21 you could split it again and amplify it.
22 Now, you go oh, this is great, right? I

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1 can always get that signal out. It's not as simple as
2 that, because, okay, so you split your signal, you're
3 going to decrease your signal-to-noise ratio. You
4 split your natural signal, and if you maintain the
5 magnitude of the signal, then you amplify it, you're
6 also amplifying the noise.
7 So the moral of the story is you can do
8 more switching operations than splitting with these
9 doped waveguides than you can with an undoped
10 waveguide.
11 So this allows you to switch maybe a
12 thousand times more before your signal-to-noise
13 degraded than you could with an ordinary type switch.
14 But you could also apply that -- and we
15 were looking at putting that onto devices and receive
16 devices, so that if you took a photodiode and you put
17 a waveguide, doped waveguide onto that to amplify the
18 signal before it went into the detector -- and we were
19 throwing all kinds of schemes around like that and how
20 you would do it.
21 So that's basically some of the experience
22 I have in that.

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1 Q. Did you ever implement a system that used the
2 waveguides to guide light to photodetectors?
3 A. Yeah, it was similar with microlenses on top
4 of the photodiode arrays and also all the filtering
5 and all the other paraphernalia that goes along. So
6 the answer's yes.
7 In parallel to that we had a lot of
8 research projects that were going on to look at these
9 various techniques.
10 Q. We might be covering some material we've
11 already covered here, but I want to march through the
12 different LiDAR systems you listed in your declaration
13 and get some details about each of those.
14 So first if you want to turn to Paragraph
15 9. This is on Page 3 of Exhibit 1003.
16 A. What page is it?
17 Q. Page 3 of Exhibit 1003. And this is where
18 you discuss a LiDAR system during your time at
19 Honeywell; correct?
20 A. Yes.
21 Q. When was your involvement with this LiDAR
22 system you describe here?

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1 **A. That one was '76. The Honeywell system?**
2 **Yes, '76.**
3 Q. And you list a range here, during 1976 to
4 1985. But with your answer there, are you saying that
5 you only worked on this LiDAR system during some of
6 the beginning of your tenure at Honeywell?
7 **A. Oh, no, throughout. I developed both**
8 **detectors as well as the system. And actually you had**
9 **a breadboard system put together by the end of '77.**
10 Q. And what photodetectors did this system use?
11 **A. I used a photodiode, and this was done in a**
12 **heterodyne mode.**
13 Q. And what was this system intended to be used
14 for?
15 **A. Laser radars -- and my funding came out of**
16 **the ballistic missile defense advanced technology**
17 **center. And it was basic research for using it in**
18 **terms of a classic radar-type device to find range and**
19 **range rate.**
20 Q. What optical elements did this system have on
21 the receive side?
22 **A. In terms of lenses and filters and things**

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1 **like that? A whole bunch of them. And so you're**
2 **working --**
3 **These frequencies were in the infrared,**
4 **and it was at 10.6 microns, which is quite far out**
5 **there in the infrared.**
6 **And so you had a lot of special optics**
7 **that had to be designed, and you had to filter out all**
8 **the background radiation and things like that. And so**
9 **we used a whole range of different optics.**
10 Q. Was this a time-of-flight system?
11 **A. Oh, yeah.**
12 Q. Do you know if Hesai owns any Honeywell
13 patents?
14 MR. HAGIZ: Objection to form.
15 **A. No idea.**
16 Q. And then if you want to turn to Paragraph 10
17 of your declaration, which is on Page 4.
18 **A. Yep.**
19 Q. Do you see this is where you discuss -- you
20 discuss your work for General Electric, or GE?
21 **A. Uh-huh.**
22 Q. So you discuss here a laser radar system;

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1 correct?
2 **A. Yes.**
3 Q. What is the difference between a laser radar
4 system and a LiDAR system?
5 MR. HAGIZ: Objection to form.
6 **A. Not really anything. You're doing range and**
7 **you're doing range rate, and they're actually one and**
8 **the same thing.**
9 **The thing you find is that the wording in**
10 **this area is pretty sloppy. I mean, they're all light**
11 **detection and ranging. It's just wordology.**
12 Q. What photodetectors did this GE system use?
13 **A. These were photodiodes, and these were**
14 **photodiode arrays. And this was an interesting**
15 **system, because one of the applications was to be able**
16 **to track an object across the horizon. So it's a scan**
17 **system, but you had to be able to tell what quadrant**
18 **that was. So we had to use an array of photodiodes to**
19 **do the imaging to actually get that information, and**
20 **at the same time, in terms of noting distance, we had**
21 **to know velocity. And, of course, these systems can**
22 **be used for velocity, because the timing between the**

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1 **pulses can give you distance, but also the time**
2 **between different pulses can also give you the**
3 **velocity.**
4 Q. And you said this was a scanning system?
5 **A. Yes.**
6 Q. What do you mean by "scanning system"?
7 **A. Because you had to track an object across the**
8 **horizon. So you had to be scanning up and down. And**
9 **in those days we wanted to make it as simple as**
10 **possible. So we did a 180 rotational system like**
11 **this -- because this was ground-based and you're**
12 **looking off on the horizon.**
13 Q. And just for the record, what you're showing
14 with your hand there was a 180 system that goes back
15 and forth; is that correct?
16 **A. Yeah.**
17 Q. Okay.
18 **A. Well, it could equally have gone 360 if we**
19 **put a different gimbal on it.**
20 Q. And do you know if Hesai owns any GE patents?
21 MR. HAGIZ: Objection to form.
22 **A. No idea.**

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1 Q. Just to loop back on the Honeywell system:
2 Was that a rotating system?
3 **A. Yes.**
4 Q. How did the rotation --
5 **A. That was on a gimbal. The Honeywell system?**
6 **That was on a gimbal looking in this direction.**
7 **And we looked at schemes -- we were also**
8 **looking at these systems for helicopter wire**
9 **avoidance. So you had to be scanning the horizon in**
10 **front of you. We also looked at this for nape of the**
11 **earth and terrain following, which you're doing up and**
12 **down and side to side.**
13 **So there's all kinds of techniques. But**
14 **there's nothing magic about scanning, and it just**
15 **depends what the system requirements are. And there**
16 **are gimbals out there that can scan 360 or 180 or**
17 **whatever, and it's really not a big issue.**
18 **I might say, one of the programs I worked**
19 **on was a passive program, called MaxiGaze. And**
20 **basically this system looked out the side of an**
21 **airplane, and it painted an image in the vertical**
22 **direction. And as the airplane flew along in paths**

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1 **like this, it could paint the whole scene that it was**
2 **looking at over in this direction.**
3 **And that was because they were limited to**
4 **the types of arrays that they could have put in it.**
5 **And I might say, that was a surveillance-type camera,**
6 **that's the platform I think you're all familiar with.**
7 **But it's still flying today. But it's a different**
8 **system.**
9 Q. And again, just for the record, for this
10 Honeywell system, the rotation you're describing there
11 was back and forth in like 180 degrees? Is that
12 correct?
13 **A. Yeah.**
14 Q. How -- strike that. What was the scanning
15 speed of the Honeywell system?
16 MR. HAGIZ: Objection to form.
17 **A. The speed, the slew rate? I don't know. I**
18 **mean, that's too far in the distant past.**
19 Q. Same question for the GE system: Do you
20 recall?
21 **A. No.**
22 **My involvement with scanning systems were**

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1 **the fact that I would tell my mech. guy, mechanical**
2 **engineer, to actually -- "this is the scan rate I**
3 **want. These are the latencies. These are the things.**
4 **Now go find me the gimbal and scanner that does that."**
5 Q. Next let's turn to the McDonnell Douglas work
6 you did. This is on Page 5, Paragraph 12. So what
7 was your involvement with this -- these LiDAR systems
8 for MOLA?
9 **A. We developed the laser and the pumping system**
10 **and recommended the detectors for it. We joked,**
11 **because that one exploded midcourse. And so we joked**
12 **that when they turned the laser on, the satellite**
13 **exploded. That didn't happen. That was just....**
14 Q. So did you build that whole system or a part
15 of it?
16 **A. No, we supplied the diode laser part, or**
17 **the -- we supplied the laser for that.**
18 Q. So you didn't work on the receive side of
19 that system; is that correct?
20 **A. No, we had recommendations for it.**
21 Q. And what was your recommendation for type of
22 photodetector?

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1 **A. That was a photodiode system that we**
2 **recommended, high sensitivity with improved gain.**
3 Q. And was that a rotating system?
4 **A. Yes.**
5 Q. How did the rotation take place?
6 **A. Wait a minute. We're talking about --**
7 Q. McDonnell Douglas.
8 **A. That one was -- I'm trying to think. I**
9 **believe that was a 180 rotation system.**
10 Going back to GE: GE, when we built the
11 Wind Sounder, was a 360 system, and that's the one we
12 tested out at Tabletop Plaza. But this was 180,
13 because you're moving ahead and you're just looking in
14 this direction.
15 Q. How did the rotation work in a 360 system?
16 **A. We had a gimbal, and the gimbal was -- it was**
17 **a really complex gimbal. It rotated this way and you**
18 **could do an XYZ rotation, very complex, because you**
19 **had to scan the whole sky and the whole region.**
20 **And then we were looking at -- that was a**
21 **trailer-based system that we put in. And then we**
22 **looked at all the system performance specifications**

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1 **for a satellite. But it never flew.**
2 Q. And by "gimbal" do you mean a rotating
3 mirror?
4 **A. Yeah. Gimbals are -- there's a company that**
5 **just, believe it or not, specializes in building**
6 **gimbaled systems. And they do -- these gimbaled**
7 **systems do very high, precise rotation. They can do**
8 **the whole 360. God, it's hard to explain. They can**
9 **do three axes and things like that.**
10 **A lot of the helicopters that you fly --**
11 **you see flying, like the fire departments' for imaging**
12 **and looking at infrared imaging of buildings and**
13 **things like that, they have a gimbal in that little**
14 **housing in front, and that's looking all over the**
15 **place.**
16 **So that's pretty standard technology, and**
17 **they do -- it's common.**
18 Q. Do you know if Hesai owns any McDonnell
19 Douglas patents?
20 MR. HAGIZ: Objection to form.
21 **A. No.**
22 Q. Finally, let's talk about your work for

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1 Scram. You say this was a small, handheld -- sorry,
2 strike that.
3 So this is Paragraph 13, on Page 5 of
4 Exhibit 1003. You say -- do you see where you say, "I
5 was involved in building a small handheld infrared
6 LiDAR for target designation"?
7 **A. Uh-huh.**
8 Q. What do you mean by "small" here?
9 **A. Police flashlight type size.**
10 Q. I think we've been going for about an hour,
11 so how about we take a quick, five-minute break.
12 (Recess taken.)
13 MR. LAUPPE: Back on the record.
14 Q. Dr. Shanley, let's take a look at Paragraph
15 154 of your declaration, Exhibit 1003. This is on
16 Page 90.
17 **A. What page?**
18 Q. Page 90.
19 **A. Okay.**
20 Q. Do you see where you say, "Pacala expressly
21 teaches that its optical receivers may be a detector
22 array, including a SPAD array"?

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1 **A. Yes.**
2 Q. And do you see that you cite Exhibit 1004,
3 Paragraph 14?
4 **A. Okay.**
5 Q. Let's take a look at Exhibit 1004, which is
6 U.S. Patent Publication No. 2014/0211194A1. Like I
7 say, it's Exhibit 1004 in this proceeding. And please
8 go to Page 1 of the document, which is four pages into
9 the actual printed document.
10 Do you see Paragraph 14, starting at the
11 lower right column?
12 **A. Yes.**
13 Q. And then turning to the next page, do you see
14 that paragraph continuing halfway down the left column
15 on the page?
16 **A. Yes.**
17 Q. So where in this paragraph does Pacala
18 expressly teach that its optical receivers may be a
19 detector array, including a SPAD array, per your
20 declaration?
21 **A. Well, it starts talking about the SPAD arrays**
22 **at the end of that paragraph. And then I go to say,**

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1 **"Because of the recovery time associated with**
2 **individual SPADs, a POSITA would have understood that**
3 **a single SPAD could not be used to represent a pixel."**
4 **That's true cross the board. From my experience and**
5 **from looking at a SPAD and the recovery times, you**
6 **would have to have multiple SPADs representing a**
7 **single pixel, because while one is saturated, you**
8 **still have to detect a signal. So you quench that**
9 **circuit and you still have other elements in that**
10 **pixel that can be used to detect the incoming**
11 **radiation.**
12 **So I think that's the point, the fact that**
13 **he alludes to SPADs, and a POSITA would really say,**
14 **well, a single SPAD would not do it, because the**
15 **recovery time is not fast enough.**
16 Q. And so you said that Pacala's teaching of the
17 use of SPADs comes at the end of Paragraph 14. Is
18 there any other teaching of SPADs in Pacala, Exhibit
19 1004?
20 **A. No. But as I said, a POSITA -- the fact that**
21 **he alludes to SPADs and the fact that a SPAD can't be**
22 **operated as a standalone detector for these types of**

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1 **systems, one would conclude that you would have to use**
2 **arrays to represent a single pixel.**
3 Q. And why can't a SPAD be used as a standalone
4 detector in this type of system?
5 **A. Because the recovery time of a single pixel**
6 **would negate what you're trying to do with the system.**
7 **That's a standard technique in the field**
8 **with SPADs. So I use multiple SPADs in my detector to**
9 **represent a single pixel. And as I explained in the**
10 **early part of my declaration, if you go to the figure**
11 **talking about SPADs -- it's in the early part -- and**
12 **there is an IV characteristic that is exhibited, that**
13 **shows the various regions of a diode.**
14 **It's Page 23, and the figure on that page**
15 **shows you that, if you have a photodiode, you tend to**
16 **operate photodiodes in a linear mode, and that's that**
17 **flat region, but the gain is only one. So one photon**
18 **in, one gain of one out. If you ever operate in the**
19 **avalanche mode, you can get a gain of 10 to the**
20 **thousand. And if you work in the single-photon mode,**
21 **you can get gains over a million.**
22 **But the problem is, you're down in the**

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1 **knee of that curve, and you're going to break down.**
2 **So once you do your detection, you have to really get**
3 **out of that place on the photodiode curve. So you**
4 **quench it. You basically shut that circuit off so**
5 **that it goes back to zero and then rebias that**
6 **detector.**
7 **And so once Pacala says, "I'm using**
8 **SPADs," you automatically know I have to have an array**
9 **for a single pixel.**
10 Q. Do you see where -- strike that.
11 Do you see at the end of Paragraph 14 of
12 Pacala, Exhibit 1004, it says -- it references the
13 "pixels of a detector array, e.g., single-photon
14 avalanche diode (SPAD) array"? Do you see that?
15 **A. Yes.**
16 Q. What does "e.g." mean here?
17 MR. HAGIZ: Objection.
18 **A. They're just talking about an ASIC in the**
19 **processing and control of devices using an integrated**
20 **circuit. And usually the way people do is, they start**
21 **out with a Xilinx and then they burn a routine for**
22 **controlling the photodetector circuits. And then, if**

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1 **you have a large-enough volume, you'll actually burn**
2 **that -- a single ASIC. Otherwise you'll use a**
3 **programmable for initial applications. But that's**
4 **just referring to the ASIC and the control of those**
5 **devices, which would involve the bias of the**
6 **detectors. The photodiode, as I explain, would work**
7 **in the linear mode.**
8 Q. Is your answer complete?
9 **A. Yes.**
10 Q. What other types of detectors would a POSITA
11 have understood could be used in the system?
12 MR. HAGIZ: Objection, form, scope.
13 **A. What other types of detectors besides SPADs?**
14 **Is that the question?**
15 Q. Correct. So I'm just trying to point you to,
16 you know, the disclosure here is "e.g., single-photon
17 avalanche diode (SPAD) array." I'm just wondering:
18 What else could be included in that e.g.?
19 MR. HAGIZ: Same objections.
20 **A. One could use a photodiode. One could use a**
21 **photoconductor. One could use an avalanche**
22 **photodiode. But he chooses the SPAD because it's the**

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1 **best for his application.**
2 Q. Let's go back to your declaration, Exhibit
3 2003, back to Paragraph 154, which is on Page 90. Do
4 you see toward the bottom of Paragraph 154 where you
5 say, "This is also confirmed by Pacala-803, which
6 describes 'single-photon avalanche diode (SPAD)
7 arrays' as a type of photodetector (contrasted with
8 avalanche photodiodes and PIN diodes, which are not
9 described as an 'array')?" Do you see that?
10 **A. Yes.**
11 Q. Is Pacala-803 one of the references you're
12 combining in ground 1?
13 **A. Yes, we used that in preparing for the**
14 **declaration.**
15 Q. But my question is: Is Pacala-803 part of
16 the obviousness combination for ground 1?
17 MR. HAGIZ: Objection to form.
18 **A. Well, I say in my declaration it's confirmed**
19 **by 803. So I think that speaks for itself. I mean,**
20 **Pacala-803 confirms that, you know, SPADs are a type**
21 **of photodetector that can be used.**
22 Q. Does Pacala-803 disclose the same invention

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1 as the Pacala reference Exhibit 1004?
2 **A. Can we look at the 803?**
3 Q. Sure. I'm going to introduce Pacala-803,
4 which is Exhibit 1014.
5 MR. HAGIZ: I don't know if your general
6 question is still pending, but if it is, I'll object
7 to form and scope.
8 **A. Okay, what was the question?**
9 Q. Does Pacala-803 disclose the same invention
10 as the Exhibit 1004 Pacala reference?
11 MR. HAGIZ: Objection, form, scope.
12 **A. 803 is complementary to the -- to Pacala --**
13 **the '194.**
14 Q. And what do you mean by "complementary"?
15 **A. In that it explains further types of devices**
16 **that could be used. And if we look at the -- it**
17 **further describes the photodetector types, including**
18 **single-photon and avalanche. It includes the SPADs,**
19 **the avalanche photodiodes, the PIN diodes. But it**
20 **doesn't allude to them in any array-type thing.**
21 **So it just confirms the previous patent.**
22 Q. But is Pacala-803 describing the same system

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1 as the '194 Pacala reference, Exhibit 1004?
2 MR. HAGIZ: Objection to form and scope.
3 **A. It describes different aspects of the system.**
4 Q. Is Pacala-803 related to the Pacala Exhibit
5 1004 reference?
6 MR. HAGIZ: Object to form.
7 **A. I believe I state that in my declaration,**
8 **that the use of SPADs -- so if we look at the**
9 **combination provided, you know, in a declaration, we**
10 **talk about the recovery time. But it's also confirmed**
11 **by Pacala-803, which describes these devices used in a**
12 **LiDAR system.**
13 Q. I'm going to introduce another exhibit. This
14 is Exhibit 1006, which is the Droz reference you
15 discuss in your declaration. And this is U.S. Patent
16 No. 10,605,984. And Droz is spelled D-r-o-z.
17 Let's go to column 5, line 23. Do you see
18 the sentence starting at column 5, line 23, discusses
19 a light detector array called an SiPM?
20 **A. Yes.**
21 Q. And that stands for silicon photomultiplier;
22 correct?

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1 **A. Yes.**
2 Q. Then starting at column 5, line 27, do you
3 see where Droz says, "Light detectors 112, 114, et
4 cetera, may include various types of light detectors.
5 In one example, detectors 112, 114, et cetera, include
6 SPADs"? Do you see that?
7 **A. Yes.**
8 Q. So SiPMs can be made up of SPADs; correct?
9 **A. Repeat that, please.**
10 Q. SiPMs can be made up of SPADs; is that
11 correct?
12 **A. A silicon photomultiplier?**
13 Q. Correct.
14 **A. I'd have to look at the device structures.**
15 **But, I mean, it is a device structure. But SPADs**
16 **have --**
17 **We have to look at the device structure.**
18 **So the same thing with an MPCC. These devices are all**
19 **made out of silicon. But the question is, what is the**
20 **form of the p-n junction, and, you know, is it -- how**
21 **many layers are in there and how it operates. I'd**
22 **have to look at that.**

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1 Q. But can an SiPM be made up of SPADs?
2 MR. HAGIZ: Objection to form.
3 **A. It's possible. I don't know. I wouldn't**
4 **venture without looking at the device structures and**
5 **the manufacturers and how they're constructed. But, I**
6 **mean, the bottom line is that SPADs and all these**
7 **devices are either silicon or, depending on**
8 **wavelengths, you could have gallium arsenide.**
9 Q. Let's turn to Exhibit 1001, which is the '405
10 patent. This is U.S. Patent No. 11,175,405. And I'm
11 going to take you all the way to the end. Can you
12 turn to Page 68, which is columns 55 and 56.
13 **A. Okay.**
14 Q. And can you look on column 56, go down to
15 line 49.
16 **A. Okay.**
17 Q. And this is part of claim 21. Do you see
18 where it reads "a light transmission module
19 coupled" -- sorry, I'm looking in the wrong place.
20 Move down to line 56 instead. Do you see
21 that?
22 **A. Okay.**

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1 Q. So starting there, "a light sensing module
2 coupled to the platform and comprising a bulk receiver
3 optic, an aperture layer comprising a plurality of
4 apertures separated by a stop region"? Do you see
5 that?
6 **A. Yes.**
7 Q. What is your understanding of a stop region?
8 MR. HAGIZ: Objection to form.
9 **A. A stop region in an optical term basically**
10 **stops light from propagating in that area.**
11 Q. So I'd like to talk about your combination
12 between Pacala and Droz. We can go to that part of
13 your declaration, if you'd like, but I'd just like to
14 sort of talk in general about it.
15 In your combination between Pacala and
16 Droz, the waveguides of Droz would be part of Pacala's
17 light sensing module; is that correct?
18 MR. HAGIZ: Objection to form.
19 **A. The waveguides, you know, are -- yes.**
20 Q. And in Pacala -- this is Exhibit 1004 -- the
21 light sensing module spins or rotates; is that
22 correct?

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1 MR. HAGIZ: Object to form.
2 **A. In Pacala, yes.**
3 Q. So the waveguides in the Pacala-Droz
4 combination would spin or rotate; is that correct?
5 **A. Yes.**
6 Q. How much would the combined Pacala-Droz
7 system weigh?
8 MR. HAGIZ: Objection to form, scope.
9 **A. I can't answer that because I don't know -- I**
10 **mean, it's --**
11 **I can't answer that because I'd have to do**
12 **a whole system analysis to look at the weight of the**
13 **thing, including bias circuits and the whole thing.**
14 Q. How large would the Pacala-Droz system
15 combination be?
16 MR. HAGIZ: Objection to form and scope.
17 **A. Again, I really can't answer that. I don't**
18 **know dimensions of objects and the system requirements**
19 **and things like that.**
20 Q. What would the mass distribution be for the
21 combined Pacala-Droz system?
22 MR. HAGIZ: Objection to form and scope.

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1 **A. I can't -- I haven't calculated mass**
2 **distribution in many, many years. So, you know -- and**
3 **not knowing the form and the materials and all of that**
4 **involved, I couldn't venture a guess.**
5 Q. So what would you need to know before you
6 could calculate the mass distribution for the Pacala-
7 Droz system?
8 MR. HAGIZ: Objection, scope.
9 **A. I'd need to know all the materials in the**
10 **system. There's a whole bunch of physics parameters**
11 **that I'd have to know. I'd have to know all the --**
12 **you're talking about optics and things like that.**
13 **Yeah, I would venture not to guess. And**
14 **usually what they do in the industry is, basically,**
15 **the mechanical CAD programs will talk with the optical**
16 **CAD programs and come up with the optimum design.**
17 **Then you can get all of these quantities out of those**
18 **programs, including the -- you know, you can run the**
19 **PTRAN and thermal analysis and all the other things.**
20 **And that flops out of all the CAD programs today.**
21 **Back in the old days we had to do all of that stuff.**
22 **It wasn't easy.**

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1 Q. Would a POSITA have had that information?
2 **A. Would who?**
3 MR. HAGIZ: Objection to form.
4 **A. Oh. Yeah. Oh, yeah. I mean, myself, today,**
5 **I myself can run the CAD programs and top-level. But**
6 **a mechanical engineer out of school or an optical**
7 **engineer or an electrical engineer, they all can run**
8 **these programs that does it.**
9 **And basically, between the optical CAD and**
10 **the mechanical CAD, it talks about how you wrap metal**
11 **around these objects once you've done your optical**
12 **design. It gives you the whole list of materials and**
13 **all the parameters associated with the materials and**
14 **the optics. And then the same thing happens with the**
15 **CAD programs. And then there's interfaces that marry**
16 **the two. And you can get all this information, just**
17 **drops out.**
18 **So you'll get the form, fit, and function,**
19 **including weight and all this right out of those**
20 **systems.**
21 Q. But you didn't do that analysis for the
22 Pacala-Droz combination; correct?

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1 MR. HAGIZ: Objection to form.
2 **A. I don't have any of the data to do it.**
3 Q. Would a person of ordinary skill in the art
4 have had the data to do that analysis?
5 MR. HAGIZ: Objection to form.
6 **A. They could do that analysis --**
7 Let me caveat that by saying: If they
8 came to me and said design this system, then the
9 answer is yes, I could do that analysis. Okay? And a
10 POSITA could do that, also.
11 But you have to remember that usually the
12 way these things are done is that there's a team of
13 people, and there's the system guy who sets all the
14 requirements, and he sort of runs the whole program.
15 And then there's the optics guy saying, "Well, you've
16 got to design optics for such-and-such a thing." And
17 the electrical engineering guy says, "Okay, this is
18 going to be my focal plane. This is going to be my
19 laser. These are my electronic requirements." And
20 then there's the mechanical guy, that says, "Okay, you
21 guys, give me all that stuff and then I'll wrap my
22 metal around it and design all the housing and stuff

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1 like that."
2 So each of these areas in the team would
3 understand the overall systems part of it and then how
4 to craft this into a unique operating, functioning
5 system.
6 Q. So is it your understanding that a POSITA
7 would be a team here?
8 MR. HAGIZ: Objection to form.
9 **A. Most definitely. But I might remark that the**
10 **team possesses overlapping skills. And so there are**
11 **certain members of the team who could run all of those**
12 **programs and do all of that analysis. But in -- what**
13 **happens in a practical purpose is that you have this**
14 **team because you want to run things in parallel. And**
15 **if you had one person doing all these things, they**
16 **would have to do it sequentially. I do my optics**
17 **design. Then I would have to run my optomechanical**
18 **design, and I would have to do my electronics design**
19 **and all of that.**
20 **So you have to have a team to put all**
21 **these pieces together.**
22 Q. How many manhours would you estimate would be

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1 required to construct the Pacala-Droz combination
2 system?
3 MR. HAGIZ: Objection to form and scope.
4 **A. To answer -- I really can't comment on that.**
5 **But it's indeterminate unless you do --**
6 **I'd have to sit down and cost the whole**
7 **program out. And usually the way this is done and the**
8 **way I've done it many, many times in the past is set**
9 **out my overall system flow and the requirements. And**
10 **then I would say I need so many hours of a mechanical**
11 **person, I need so many hours of an electrical person,**
12 **I need so many hours of a physics guy, so many hours**
13 **of an optics guy, a technician to put this thing**
14 **together.**
15 **And so, you know, taking 2,000 hours as a**
16 **man-year, I would put a flow diagram or a flow sheet**
17 **together or an Excel spreadsheet with all this**
18 **information on it and come up with the total hours for**
19 **constructing a system like this. And that's how we**
20 **did LAWS and that's how we did our handheld**
21 **illuminator and the other objects. Handheld**
22 **illuminator was easy to do because it was a small**

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1 **system.**
2 Q. Ballpark, do you think it would require more
3 than a man-year or less than a man-year?
4 MR. HAGIZ: Objection to form.
5 **A. I really can't answer that. I mean, that's**
6 **hard.**
7 **So the question is, starting from what's**
8 **the known information? I couldn't quantify that. I'd**
9 **have to know, you know, what the team was, who the**
10 **team was, what they were going to give me, what**
11 **resources were available, and things like that.**
12 **And I might caveat that also saying that**
13 **when you start a system like this, you start looking**
14 **at components and component availability and things.**
15 **And I've been on systems where you required a detector**
16 **array which wasn't off the shelf. And so you had to**
17 **visit vendors and say, "Hey, I want a 1080-by-1024**
18 **array." And so it's not really quantifiable until you**
19 **have a lot of information.**
20 Q. How would the Droz waveguides impact the
21 gyroscopic forces in the Pacala system?
22 MR. HAGIZ: Objection to form and scope.

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1 **A. Can you further elaborate on that question?**
2 Q. In your opinion, would the Droz waveguides
3 impact the gyroscopic forces in the Pacala system?
4 MR. HAGIZ: Objection to form and scope.
5 **A. Meaning the rotational forces? These are --**
6 **Basically, the way I look at this, these**
7 **are all optomechanically configured, so that it could**
8 **have no effect. But that depends on how good your**
9 **design is, so that something doesn't go flying off and**
10 **stuff like that. But I would venture to say once it's**
11 **designed, no effect.**
12 Q. Have you analyzed a Waymo device?
13 **A. A Waymo? No. I looked at some of the**
14 **patents. And it was interesting to me when that case**
15 **first came out -- or the --**
16 **Well, let's see. I got interested in it**
17 **when the lawsuit appeared. And just being interested**
18 **in LiDAR systems, I looked at what that system was.**
19 **But I don't really have any -- except there was a**
20 **patent that was a Waymo patent that we looked at.**
21 Q. Let's go to Paragraph 208 of your
22 declaration, which is on Page 123 of Exhibit 1003.

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1 **A. Okay.**
2 Q. Got there?
3 **A. Yes.**
4 Q. In Paragraph 208 do you see where you say,
5 "Hall teaches that collection optics 116 may 'include
6 four lens elements 116A-D arranged to focus collected
7 light 118 onto each of the array of detecting elements
8 113'"? Do you see that?
9 **A. Yes.**
10 Q. And then moving down to figure 5, reproduced
11 on the next page, do you see elements 116A through D?
12 **A. Yes.**
13 Q. So in your proposed Hall-Borowski-Spector
14 combo, what happens to elements 116A to 116B?
15 MR. HAGIZ: Objection to form.
16 **A. Can you clarify what you're asking?**
17 Q. Sure. So if you look --
18 Turn to Page 130 of your declaration.
19 **A. Okay.**
20 Q. Do you recognize figure 4A on Page 130?
21 **A. Let's see. Can I look at --**
22 Q. Feel free to look at the context here.

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1 **A. What is that from? That's from the....**
2 **That's from Spector? Do we have the**
3 **Spector patent?**
4 Q. Yes, of course. So I'm going to introduce
5 Exhibit 1005, which is the Spector patent. That's
6 U.S. Patent No. 10,473,766.
7 So figure 4A is from Spector; correct?
8 **A. Yes.**
9 Q. And so you propose that the Hall and Spector
10 references, it would have been obvious to combine
11 those references; correct?
12 **A. Yes.**
13 Q. So in that combination -- strike that. That
14 combination would include -- strike that.
15 **A. Do you want to take a quick bio break?**
16 Q. Sure. Let's take a quick break.
17 (Recess taken.)
18 Q. So, Dr. Shanley, we were just talking about
19 Page 124 of your declaration. If you turn now to Page
20 125, Paragraph 210, do you see where you say, "In the
21 Hall-Borowski-Spector combination, Hall's LiDAR system
22 is implemented based on Spector's suggestion to use an

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1 aperture array to reduce cross-talk at the light
2 detecting elements"? Do you see that?
3 **A. Yes.**
4 Q. So, then, turning back to Page 124, figure 5:
5 How, in your opinion, would an aperture array be
6 incorporated into the Hall system shown in figure 5?
7 MR. HAGIZ: Objection to form.
8 **A. Let me just go back in terms of using**
9 **apertures. Now, in a system composed of optics,**
10 **you're going to have many, many different places that**
11 **you can put apertures, and a lot of this has to go**
12 **back to one does a stray light analysis.**
13 **And what you would do -- as I explained in**
14 **my declaration, stray light can consist of many**
15 **different things, and there's a whole list in my**
16 **declaration of where stray light comes from.**
17 **So apertures, "apertures" or "baffles,"**
18 **can be used at strategic points in the optical system**
19 **to eliminate light that you don't want.**
20 **Now, when we're talking about the**
21 **combination of the patents here and apertures, we're**
22 **talking about apertures to limit stray light onto the**

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1 **SPADs. We're also talking about apertures to define**
2 **and be part of the field of view of individual pixels**
3 **in the array. So apertures can have twofold effects.**
4 **So if you're talking about some apertures**
5 **to be used to define a pixel field of view, which is a**
6 **portion of your image that's coming back, you can have**
7 **an aperture at the pixel. If you have stray light and**
8 **cross-talk, because you don't want light from this**
9 **field of view getting into this other field of view,**
10 **you can restrict that with apertures also.**
11 **So the placement of apertures in a system**
12 **depends upon what you're doing. And the patents here**
13 **teach that you have fields of view each with**
14 **individual detectors -- or pixels; excuse me, pixels.**
15 **You have to limit the amount of stray light from pixel**
16 **to pixel. So you use apertures for that. As well as**
17 **it has a dual procedure to -- or dual process to limit**
18 **your field of view to a specific region of the image.**
19 Q. And so we're talking here about the Borowski
20 system.
21 **A. Yes.**
22 Q. The Hall-Borowski-Spector combo. Is that

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1 right?
2 **A. Yes.**
3 Q. So in your view, what would happen to the
4 optical elements 116A through 116D in the
5 Hall-Borowski-Spector combo?
6 MR. HAGIZ: Objection to form.
7 **A. By "happen" -- what do you mean by "happen"?**
8 **Just for clarification.**
9 Q. Would optical elements 116A through 116D be
10 in the combined Hall-Borowski-Spector combination
11 system?
12 **A. Let's see. There would be some form of**
13 **optics in the Hall-Borowski combination. And I might**
14 **say, most optics -- and I can't really infer what the**
15 **optical -- or what the characteristics are of that**
16 **chain of optical elements without doing an analysis.**
17 **I would, a POSITA, assume that it's a**
18 **telecentric set of elements -- i.e., telecentric being**
19 **the magnification is maintained everywhere in that**
20 **system.**
21 **So the answer is I really can't be**
22 **definite in terms of whether it's one, two, three --**

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1 **you know, those number of optical elements or a**
2 **different number. It depends upon what the design is.**
3 Q. Can you go to Paragraph 44 of your
4 declaration, which is on Page 20. This is, again,
5 Exhibit 1003.
6 **A. Page 44. What paragraph?**
7 Q. Sorry, I confused you. Paragraph 44 on Page
8 20.
9 **A. Okay, got it.**
10 Q. And do you see at the bottom of Paragraph 44
11 where you say, "SPADs, in particular, are considered
12 to be optimal in many applications because they can
13 attain a high gain which enables them to detect a
14 single photon"? Do you see that?
15 **A. Yes.**
16 Q. What do you mean by "optimal" here?
17 **A. Will give you the best signal-to-noise ratio**
18 **in the system, or the most sensitive. The fact that**
19 **you're able to detect a single photon and not packets**
20 **of photons.**
21 Q. Do SPADs have disadvantages?
22 MR. HAGIZ: Objection to form.

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1 **A. You have to be very careful with their**
2 **operating point, because you're in that region of**
3 **breakdown. So you would have to make sure your**
4 **quenching circuits are operating properly and your**
5 **design is proper, so you don't go into breakdown and**
6 **you destroy the diode itself.**
7 Q. Have you designed a quenching circuit for
8 SPADs?
9 **A. I've designed quenching circuits for APDs and**
10 **things like that. And that's way back when that's in**
11 **the standard electrical engineering stuff.**
12 Q. You said you designed a quenching circuit for
13 APDs. Have you designed one for SPADs?
14 **A. No, I haven't. But I imagine they're**
15 **similar. I mean, quenching circuits are quenching**
16 **circuits. So, you know, you have some capacitance and**
17 **some things to shut it off and turn it on quickly and**
18 **looking at switching times. And then that all can be**
19 **the controller that can all be put into an ASIC. So**
20 **it's not a difficult thing to do. I think any --**
21 **probably a senior electrical engineer in college could**
22 **do that, or maybe even a junior. My grandson, who's a**

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1 **junior in high school, I taught him some of that**
2 **stuff, and he actually can do that.**
3 Q. Do photodetectors other than APDs and SPADs
4 require the use of quenching circuits?
5 MR. HAGIZ: Objection to form.
6 **A. The other photodetectors require some type of**
7 **circuit for control and collection of the information,**
8 **to basically cleanse the well.**
9 **The only thing I know where you would have**
10 **to quench something and reset it would be something**
11 **like a charge-coupled device, which are arrays of**
12 **elements, and they're used in cameras and things for**
13 **visible wavelengths. But photodiodes, you're**
14 **operating -- if we go to my ID diagram, here**
15 **someplace -- on Page 23 -- photodiodes, you're**
16 **operating in that linear mode. So your circuitry's**
17 **going to be different for them. For avalanche**
18 **photodiodes, you're going to be in this breakdown**
19 **region, so you have to carefully design how your**
20 **circuitry works there. But it's this region here**
21 **where you have the gain in that silicon -- or single**
22 **photon that you can get into thermal runaway. So you**

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1 **have to have that quenching very fast.**
2 **So whereas for a photodiode or**
3 **photoconductor, you really don't. It's a different**
4 **circuit.**
5 Q. So what happens with SPADs if you don't have
6 a quenching circuit?
7 **A. Okay, I have a lot of experience with that.**
8 **Initially --**
9 **So you have this IV characteristic; okay?**
10 **And if you start biasing here and you continue**
11 **biasing --**
12 **So what you have is current and voltage**
13 **characteristic here, and this is voltage here, and**
14 **this is current on this axis.**
15 **So if you continue biasing -- and what**
16 **happens is, when you operate down here, it's going to**
17 **automatically increase to go to infinity. So what**
18 **happens is this whips back to zero, and you may burn**
19 **your diode out. You may just destroy it. I've seen**
20 **things where they actually go into thermal runaway and**
21 **all you have is a heated mess of semiconductor there.**
22 **I've done many of those.**

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1 Q. Do you know the cost of designing a quenching
2 circuit for SPADs?
3 MR. HAGIZ: Objection to form, scope.
4 **A. I don't know the cost exactly. But I would**
5 **say an engineer could do that in probably a morning.**
6 Q. Can you go to Paragraph 50, on Page 24.
7 **A. Okay.**
8 Q. And this is going to roll over to the next
9 page. Do you see where you say, "Noise and
10 interference can affect the sensitivity of the
11 system -- for example, the ability of the LiDAR device
12 to accurately detect objects at longer ranges, or in
13 poor weather conditions. They may be particularly
14 problematic in systems that employ SPADs, because even
15 a single errant photon may cause a false positive
16 detection, while also rendering the SPAD inoperable
17 until it is quenched"? Do you see that?
18 **A. Yes.**
19 Q. Is that a disadvantage of SPADs in LiDAR
20 systems?
21 MR. HAGIZ: Object to form.
22 **A. It's a disadvantage of a single SPAD. That's**

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1 **why people use multiple SPADs for a pixel. It's an**
2 **advantage, then, because you can go to multiple**
3 **pixels. So while you're quenching this device, you're**
4 **still looking out there with that other element in**
5 **your pixel.**
6 **So that pixel is always on and ready to**
7 **detect radiation.**
8 **So SPADs basically are optimum for**
9 **signal-to-noise ratio in this method.**
10 Q. But for other types of photodetectors, you
11 don't need to use an array, because there's not the
12 recovery timing issue; correct?
13 MR. HAGIZ: Objection to form.
14 **A. That's correct. Actually, with some arrays**
15 **you can just have the array and you don't need to use**
16 **multiple elements for a pixel -- though there may be**
17 **some advantages for multiple elements for a pixel.**
18 **But it's my experience in designing a system, if you**
19 **can make your signal-to-noise ratio or your noise-**
20 **equivalent-power numbers with a single element, you're**
21 **better off, because that consumes both electrical**
22 **power, and it might make for a smaller package or**

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1 things like that.
2 So, yes, the answer's yes.
3 Q. So if I refer to the challenged claims of the
4 '405, do you understand what I mean there?
5 Let me repeat the question. If I refer to
6 the challenged claims of the '405 patent, do you
7 understand what that means?
8 A. Yes.
9 Q. And the challenged claims are the claims that
10 are being challenged in this proceeding. Correct?
11 A. Yes.
12 Q. Did the challenged claims of the '405 patent
13 satisfy a long-felt but unsolved need?
14 MR. HAGIZ: Objection to form, scope.
15 A. I'm trying to....
16 Well, it's my opinion, when I read the
17 claims, that these particular ones, there was a large
18 base of knowledge that a POSITA would have. And I
19 struggled with -- I don't want to be sarcastic. Let
20 me see how I can say this.
21 I struggled with -- a good designer would
22 automatically know these things. With the sea of

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1 knowledge that's out there, in designing a particular
2 system like this, a good designer and design team
3 would have this knowledge already, to be able to put a
4 system together with all of these parts that are
5 listed in the claims.
6 Q. Do you know if there are commercially
7 successful embodiments of the challenged claims of the
8 '405 patent?
9 MR. HAGIZ: Objection to form and scope.
10 A. I don't want to assume anything, no. But
11 these are known techniques, and I'm sure they're used
12 in patents. But I couldn't, at this point, without,
13 you know, searching the literature, say yes or no. I
14 mean, there are references -- Lincoln Labs did a lot
15 of things, not commercially available, but a lot of
16 things with LiDAR systems and SPADs, and various
17 companies in --
18 There's also the whole other world where
19 there's bunches of things that are done that are never
20 reported in the literature.
21 Q. Does Ouster manufacture products that embody
22 the '405 patent claims?

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1 MR. HAGIZ: Objection to form, scope.
2 A. I don't really know much about Ouster's
3 product line.
4 Q. Do you know what the Consumer Electronics
5 Show is, or CES?
6 A. Yes. Oh, yeah.
7 Q. Are you aware that Ouster was a CES
8 Innovation Award honoree in 2019?
9 MR. HAGIZ: Objection to form and scope.
10 A. Yeah, I saw that. I have a history of going
11 to CES. We actually exhibited a lot of products at
12 CES when I was with Polaroid.
13 Q. Are you aware that Ouster was a CES
14 Innovation Award honoree in 2020?
15 MR. HAGIZ: Objection to form and scope.
16 A. No.
17 Q. How about are you aware that Ouster was a CES
18 Innovation Award honoree in 2023?
19 MR. HAGIZ: Objection to form and scope.
20 A. No.
21 Q. But you were aware of its award in 2019?
22 A. Yeah, I saw that headline once. I mean, CES

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1 is CES. It's -- how can I say this? It's interesting
2 with innovative products, and the whole auto LiDAR
3 situation has gotten a lot of press and things. It's
4 sort of interesting.
5 But that doesn't necessarily mean that
6 they're judged technically -- I mean, it's a show
7 award, and it's a showy thing. And it reminded me --
8 putting exhibits in CES reminded me of my son's
9 pinewood derbies, where everybody is tweaking and
10 fixing things. It's much like its cousin, Photokina,
11 in Cologne, which occurs every year also.
12 Q. Does Hesai sell products that use SPADs?
13 MR. HAGIZ: Objection to form and scope.
14 A. I haven't looked at Hesai's product line, and
15 I assume by their patent that they do.
16 Q. Did Velodyne use SPADs in LiDAR systems?
17 MR. HAGIZ: Objection to form and scope.
18 A. I would have to look that up. Offhand....
19 Q. Did Waymo use SPADs and LiDAR systems?
20 MR. HAGIZ: Objection to form and scope.
21 A. I'm not sure. I'd have to look that up. If
22 they were smart, they would.

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1 Q. Can you identify any LiDAR systems sold prior
2 to the '405 patent that used SPADs?
3 MR. HAGIZ: Objection to form and scope.
4 **A. No, I'm not basically -- you know, I know**
5 **there are LiDAR systems using SPADs that have flown,**
6 **by NASA and people doing LiDAR-based geophysical**
7 **measurements and things like that. But commercially,**
8 **no.**
9 Q. Have the challenged claims of the '405 patent
10 been licensed?
11 MR. HAGIZ: Objection to form, scope.
12 **A. I don't know.**
13 Q. Has Hesai licensed the challenged claims of
14 the '405 patent?
15 MR. HAGIZ: Same objections.
16 **A. And my answer is I don't know.**
17 Q. Have the challenged claims of the '405 patent
18 been praised?
19 MR. HAGIZ: Objection to form and scope.
20 **A. Have been praised? I don't know.**
21 **Well, the only thing I'll say is that a**
22 **lot of the information in that patent is very -- from**

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1 **a LiDAR designer, and having worked with LiDAR for 40**
2 **years, it's obvious what they are, to a designer. So**
3 **I don't know what the commercial world would do.**
4 Q. Was there industry skepticism about the use
5 of SPADs in LiDAR systems prior to the '405 patent?
6 MR. HAGIZ: Objection to form and scope.
7 **A. I don't know, but I don't see why there**
8 **should be. Lincoln Labs and other organizations had**
9 **put a lot of research and development, and Sony --**
10 **about a year ago I was looking at Sony's product**
11 **lines, and I noticed they had some SPAD arrays that**
12 **looked absolutely magnificent. But that's about all I**
13 **know.**
14 Q. Did others fail in the area of the challenged
15 claims of the '405 patent?
16 MR. HAGIZ: Objection to form and scope.
17 **A. I don't know.**
18 MR. LAUPPE: I think we're pretty close to
19 done, so how about we take another ten-minute break,
20 just to see if I have any further questions. We
21 should be close. Thank you.
22 (Recess taken.)

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1 MR. LAUPPE: Back on the record.
2 Q. Dr. Shanley, you mentioned that you weren't
3 aware of any commercial LiDAR devices that use SPADs
4 prior to the '405 patent; is that correct?
5 **A. Yes.**
6 MR. HAGIZ: Objection to form.
7 Q. But you indicated that there were possibly
8 some noncommercial LiDAR devices prior to the '405
9 patent that use SPADs; is that correct?
10 **A. Yes.**
11 Q. So what were those devices?
12 **A. I would assume that a lot of people doing the**
13 **geophysical imaging and NASA programs and things like**
14 **that have gravitated to using SPADs.**
15 Q. So you said you assume that those systems use
16 SPADs?
17 **A. I would think so.**
18 Q. What's your basis for thinking that?
19 **A. They're more sensitive detectors. And I**
20 **might say also, the commercial availability of the**
21 **arrays -- because Sony and Osram and a whole bunch of**
22 **people are now supplying SPADs, SPAD arrays.**

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1 Q. And you say now supplying SPAD arrays, Sony,
2 Osram. I mean, do you know how long they've been
3 providing SPAD arrays?
4 **A. I would assume over the last three or four**
5 **years, though I don't know that's true. We could go**
6 **back and compile a history. But it's just my gut**
7 **feeling that that technology has really matured to be**
8 **cheap and off-the-shelf -- though prior to that people**
9 **probably --**
10 **You know, if I needed a SPAD array and it**
11 **wasn't available, I would go directly to the**
12 **manufacturer and fund a program to actually build me**
13 **these detectors for a specific application.**
14 Q. So can you name a specific system prior to
15 the '405 patent that used SPADs in a LiDAR system?
16 **A. Not at this point.**
17 Q. I think that's all the questions I have for
18 today.
19 MR. HAGIZ: I have one really quick point
20 of clarification.
21 EXAMINATION
22 BY MR. HAGIZ:

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Q. Dr. Shanley, I think before the last break you were asked if Hesai sells products that use SPADs, and your response was, "I haven't looked at Hesai's product line. I assume by their patent that they do." Which patent were you referring to when you said that?

A. They -- maybe I was....

I'm not sure, to tell you the truth. I assume they had patents in this area.

Q. Well, are there any specific Hesai patents that you looked at in connection with your declaration that you're referring to?

A. No, I can't remember.

MR. HAGIZ: That's all I have.

A. The only thing I did with Hesai was, when we initially talked about who the company was, I looked at, I think, their website and saw where it was located in Shanghai, and I recognized that whole area as an automotive area. But that was about it.

MR. HAGIZ: That's all I have.

Anything else, Patrick?

MR. LAUPPE: No, that's all for me.

(11:45 a.m.)

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CERTIFICATE OF SHORTHAND REPORTER - NOTARY PUBLIC.

I, Alan H. Brock, Certified Reporter and Notary Public within and for the Commonwealth of Massachusetts, do hereby certify:

That James F. Shanley, Ph.D., the witness whose deposition is hereinbefore set forth, was duly sworn by me before the commencement of such deposition and that such deposition was taken before me and is a true record of the testimony given by such witness.

I further certify that the adverse party, Hesai Technology Co., Ltd, was represented by counsel at the deposition.

I further certify that the deposition of James F. Shanley, Ph.D. occurred at the offices of Cooley LLP, 500 Boylston Street, Boston, Massachusetts on Thursday, June 6, 2024,commencing at 9:14 a.m. to 11:45 a.m.

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 any of the parties to this action, and that I am in no way interested, financially or otherwise, in the outcome of this matter.

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IN WITNESS WHEREOF, I have hereunto set my hand this 6th day of June, 2024.

My commission expires:
March 25, 2027.

Alan H. Brock

Alan H. Brock, RDR, CRR

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