

UNITED STATES PATENT AND TRADEMARK OFFICE  
BEFORE THE PATENT TRIAL AND APPEAL BOARD

IPR2023-00319  
PATENT 10,693,700  
CASE NO. IPR2023-00319  
ATTORNEY DOCKET: 19688-0196IP2

LG ELECTRONICS, INC.,  
Petitioner,  
vs.  
CONSTELLATION DESIGNS, LLC,  
Patent Owner.

REMOTE DEPOSITION OF  
GIUSEPPE CAIRE, PH.D.  
March 19, 2024

REPORTED BY: Laura H. Nichols  
Certified Realtime Reporter,  
Registered Professional  
Reporter and Notary Public

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| Exhibit 1001                                                                                                                                      | 49 |
| Patent: US 10,693,700 B1                                                                                                                          |    |
| Exhibit 1010                                                                                                                                      | 12 |
| California Institute of Technology,<br>Jet Propulsion Laboratory, New Technology<br>Reporting Form, NTR Number 44810<br>(Provisional Application) |    |
| Exhibit 1015                                                                                                                                      | 12 |
| Patent: US 7,978,777 B2                                                                                                                           |    |

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Exhibit 1030 147

Paper: Non-Uniform Constellations  
for Next-Generation Digital Terrestrial  
Broadcast Systems; Author: Manuel  
Fuentes Muela, June 2017

Exhibit 2001 10

Declaration of Giuseppe Caire  
Regarding Patent Owner's Preliminary  
Response for Inter Partes Review of U.S.  
Patent NO. 10,693,700

Exhibit 2012 8

Curriculum Vitae: Giuseppe Caire,  
Ph.D., August 2022

Exhibit 2015 30

Paper: Bit-Interleaved Coded  
Modulation, Published in IEEE  
Transactions on Information Theory, Vol.  
44, No. 3, May 1998

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Exhibit 2025 8  
Second Declaration of Giuseppe  
Caire for Inter Partes Review of U.S.  
Patent No. 10,693,700

S T I P U L A T I O N

IT IS STIPULATED AND AGREED, by and between the parties, through their respective counsel, that the deposition of GIUSEPPE CAIRE, PH.D. may be taken before Laura H. Nichols, Commissioner, Certified Realtime Reporter, Registered Professional Reporter and Notary Public;

That it shall not be necessary for any objections to be made by counsel to any questions, except as to form or leading questions, and that counsel for the parties may make objections and assign grounds at the time of trial, or at the time said deposition is offered in evidence, or prior thereto.

1 I, Laura H. Nichols, a Certified  
2 Realtime Reporter and Registered Professional  
3 Reporter of Birmingham, Alabama, and a Notary  
4 Public for the State of Alabama at Large, acting as  
5 Commissioner, certify that on this date, as  
6 provided by 37 CFR § 42.53, the Federal Rules of  
7 Civil Procedure of the United States District  
8 Court, and the foregoing stipulation of counsel,  
9 there came before me remotely via Zoom, on March  
10 19, 2024, commencing at 10:03 a.m. EDT, GIUSEPPE  
11 CAIRE, PH.D., witness in the above cause, for oral  
12 examination, whereupon the following proceedings  
13 were had:

14  
15 GIUSEPPE CAIRE, PH.D.,  
16 having been first duly sworn, was examined and  
17 testified as follows:

18  
19 EXAMINATION BY MR. KHAN:

20 Q. Dr. Caire, thank you very much for  
21 making yourself available today for this  
22 deposition.

23 I will try to take breaks in between,  
24 maybe every hour or so. But should you feel the  
25 need to take a break, please just let me know a few

1 minutes ahead of time so that I can wrap up my line  
2 of questioning; is that okay with you?

3 A. Sure.

4 Q. Great. And during any of the breaks  
5 today, do you understand that you are not allowed  
6 to discuss the substance of your deposition  
7 testimony until your cross examination is  
8 completed?

9 A. I understand.

10 Q. And will you agree to let me know if  
11 at any point anyone communicates with you in any  
12 manner during the course of the deposition today?

13 A. Yes.

14 (Exhibit 2012, having been previously  
15 marked for identification, was  
16 presented in this deposition.)

17 Q. (BY MR. KHAN:) Thank you. For the  
18 purposes of our conversation today, is it okay if I  
19 refer to Exhibit 2025 as your second declaration?

20 (Exhibit 2025, having been previously  
21 marked for identification, was  
22 referenced in this deposition.)

23 A. That is fine. 2025.

24 Q. (BY MR. KHAN:) And do you have a  
25 copy of that exhibit with you, a clean copy?

1           A.       Yes, I have. It is here in front of  
2 me.

3           Q.       Do you understand that one of the  
4 reasons for today's deposition is for the  
5 petitioner in this IPR proceeding to get additional  
6 clarity regarding your statements in your second  
7 declaration?

8           A.       I understand.

9           Q.       Do you understand that your testimony  
10 today is sworn testimony, taken under oath?

11          A.       I understand.

12          Q.       Do you understand that the oath you  
13 have taken today is as solemn as the oath you would  
14 take as if you were testifying at a trial in court?

15          A.       I do.

16          Q.       And do you understand that your  
17 deposition testimony can be used in a subsequent  
18 brief in the proceedings or at trial?

19                   MR. DIXON: Objection, form.

20          A.       I do.

21          Q.       (BY MR. KHAN:) Are you taking any  
22 medications that would prevent you from answering  
23 the questions completely and truthfully, to the  
24 best of your ability?

25          A.       No.

1           Q.       Is there anything else that would  
2 prevent you from answering the questions completely  
3 and truthfully, to the best of your ability?

4           A.       No.

5           Q.       Do you understand that you are being  
6 deposed today for statements made in your second  
7 declaration that was submitted in support of  
8 Constellation's patent owner's reply in  
9 IPR2023-0031, which relates to U.S. Patent Number  
10 10,693,700?

11          A.       Yes. I understand.

12          Q.       For purposes of brevity, I will refer  
13 to the IPR as the 319 proceedings and the Patent  
14 10,693,700 as the '700 Patent; is that okay?

15          A.       It is okay.

16                   (Exhibit 2001, having been previously  
17 marked for identification, was  
18 referenced in this deposition.)

19          Q.       (BY MR. KHAN:) The two declarations  
20 that you submitted in these proceedings, did you  
21 write them yourself?

22          A.       Yes, I wrote myself with the help of  
23 the law firm.

24          Q.       Now, other than the attorneys you  
25 were working with, was there any other individual

1 involved in writing or preparing your declaration?

2 A. No.

3 Q. And how long would you say,  
4 approximately, did it take for you to work on  
5 these -- on your second declaration?

6 A. Approximately -- I don't remember  
7 exactly the number of hours that I billed for this  
8 work, but approximately eight, ten hours.

9 Q. Okay.

10 A. This includes of course, also, the  
11 reading of the documents, reading of the other  
12 declarations; it is not just writing the  
13 declaration itself.

14 Q. Have you been deposed before in any  
15 other case?

16 A. No.

17 Q. Did you review your first and second  
18 declaration in this IPR in preparation of this  
19 deposition?

20 A. Yes, I did.

21 Q. In those declarations, you mentioned  
22 a number of documents that you have reviewed in  
23 forming your opinions. Did you also review those  
24 documents?

25 A. Some of them.

1           Q.     Did you review the Board's  
2 institution decision?

3           A.     No.

4           Q.     Did you review the Provisional  
5 Application 60933319, also referred to as Exhibit  
6 1010?

7                     (Exhibit 1010, having been previously  
8 marked for identification, was  
9 referenced in this deposition.)

10          A.     Can you please repeat which exhibit?

11          Q.     (BY MR. KHAN:) Yes, it is Exhibit  
12 1010, 1010.

13          A.     Not recently.

14          Q.     Did you review it while preparing  
15 your second declaration?

16          A.     No. I reviewed it when I prepared my  
17 first declaration.

18          Q.     And did you review U.S. Patent Number  
19 7978777, which is Exhibit 1015?

20                     (Exhibit 1015, having been previously  
21 marked for identification, was  
22 referenced in this deposition.)

23          A.     Okay. I reviewed this -- this patent  
24 at the time of the first declaration, and I only  
25 reviewed the Patent '700 at the time of the second

1 declaration.

2 Q. (BY MR. KHAN:) Sorry, just to be  
3 clear, you reviewed Exhibit 1015, the '777 Patent,  
4 at the time of preparing your first and your second  
5 declaration; is that right?

6 A. No, it is not correct. At the time  
7 of the second declaration, I reviewed only the '700  
8 Patent.

9 Q. Okay. Thank you. Is this your first  
10 case in which you have served as an expert?

11 A. No.

12 Q. Do you have a list of cases in which  
13 you have served as a patent expert?

14 A. I don't.

15 Q. Would you be able to give me an  
16 approximate of how many cases you have worked on as  
17 an expert, how many patent cases you have worked on  
18 as an expert?

19 A. Yes, I can provide, it is very  
20 simple -- two, two other cases in the past.

21 Q. And what technologies were those  
22 cases in?

23 A. Wireless communication technology.

24 Q. Were they also related to  
25 Constellation -- I'm sorry. Scratch that.

1                    Were those cases also Constellation  
2 cases?

3                    A.        No, they were not.

4                    Q.        If we were to request a list of cases  
5 you worked on, and assuming Constellation's counsel  
6 has no objections to that, would you be able to  
7 provide that list in the future?

8                    A.        For one case, yes. Another case, no.

9                    Q.        Okay. And is that for  
10 confidentiality reasons?

11                   A.        Yes.

12                   Q.        Okay.

13                   (Off-the-record discussion.)

14                   A.        Excuse me, how do you see Exhibit  
15 Share?

16                   THE REPORTER: Off the record?

17                   MR. KHAN: Yeah, can we get off the  
18 record?

19                   (Off-the-record discussion.)

20                   MR. KHAN: Okay. We can go back on  
21 record, Dr. Caire, if you are ready.

22                   A.        Yes, I am ready.

23                   Q.        (BY MR. KHAN:) Dr. Caire, do you  
24 stand by all the statements you made in both your  
25 first and second declarations?

1           A.       Yes, I stand by the statements.

2           Q.       Do you still believe that the  
3 challenged claims are not anticipated or rendered  
4 obvious by the references presented in the  
5 petition?

6           A.       Can you clarify? I don't understand  
7 the question.

8           Q.       So the question is: Do you believe  
9 that the challenged claims in these IPR proceedings  
10 are not anticipated or obvious, based on the  
11 references that were cited in the petition?

12          A.       Excuse me. Are you referring to the  
13 challenged claim in the first declaration, the  
14 challenged claim in the second declaration?

15          Q.       Oh, we can just talk about Claims 5,  
16 Claim 5, if you would like, or claims -- yeah.

17          A.       Yes. Yes, I still believe they are  
18 not anticipated by those references.

19          Q.       What is your understanding of when a  
20 claim is anticipated?

21          A.       I don't fully understand the  
22 question. I just said that the claim is not  
23 anticipated, so -- what do you mean by where it is  
24 anticipated?

25          Q.       Well, like you said, you said the

1 claim is not anticipated. So my question is: What  
2 does it mean for a claim to be anticipated?

3 A. Is it a general question, what does  
4 it mean when a claim is not anticipated, is it an  
5 abstract question or it is a specific question for  
6 this claim and these references?

7 Q. It is a general question: What does  
8 it mean for a claim to be anticipated?

9 A. Well, as far as I understand, a claim  
10 is anticipated when a so-called POSITA can easily  
11 deduct the claim from a reference that would stand  
12 before the patent or something like that. I don't  
13 have a legal -- legal expertise here. I am an  
14 academic.

15 So in my view, I can assess the  
16 novelty of a contribution at a scientific level. I  
17 cannot assess the novelty of a contribution in the  
18 legal sense. But this is my understanding,  
19 basically.

20 Q. And in your answer, you mentioned  
21 that a POSITA can easily deduct -- deduct a claim  
22 from a reference. What do you mean by "easily  
23 deduct a claim from a reference"?

24 A. So easily deduct in the sense that,  
25 today, what is described in the claim is

1 essentially already in some paper somewhere else,  
2 and after minor changes, a person skilled in the  
3 art will derive to the same thing.

4 Q. So if a person of skill in the art  
5 would have understood from the description in a  
6 document that the claim features are disclosed,  
7 then that document anticipates the claims; is that  
8 correct?

9 A. I think that one has to be a bit more  
10 specific than that because one has to establish  
11 basically the distance between one -- say a  
12 scientific document describing some ideas and the  
13 precise content of a patent.

14 So that is, I guess, it is a little  
15 bit what we are discussing here, is whether --

16 Q. Can we --

17 A. What?

18 Q. Sorry. Go ahead. I didn't want to  
19 interrupt you. Sorry. Were you finished with your  
20 answer?

21 A. Yeah.

22 Q. Okay. Sorry.

23 A. So the answer -- the answer is  
24 finished. Again, we are talking about something in  
25 the abstract. In the abstract, it is difficult to

1 say, because how can you draw a line in the  
2 abstract, right? One has to be specific, and then  
3 we can -- we can discuss something specific. But  
4 in the abstract, how you say that this is easy,  
5 this is difficult or this is not anticipated is a  
6 little bit up in the air.

7 Q. In your answer, you said one has to  
8 establish the distance between the document and the  
9 contents of the patent.

10 A. Right.

11 Q. At what point -- what is that -- what  
12 does that distance have to be for something to be  
13 -- for that scientific document to anticipate the  
14 patent?

15 MR. DIXON: Objection. Sorry.

16 Q. (BY MR. KHAN:) Is it --

17 A. Again, I don't think that there is an  
18 absolute metric. It depends on the context. If  
19 you are talking about that scientific publication  
20 and say is this new with respect to that? Well,  
21 this is up to the reviewers and the editor to  
22 decide if the idea -- if there's enough novelty,  
23 enough contribution for publishing. Because a  
24 patent is up to the patent office probably or court  
25 to establish that. Again, there is no absolute

1 semantic metric that can establish this distance.

2 Q. So if the patent office thought  
3 something was really obvious in view of a  
4 particular reference, they would find that  
5 reference anticipates the patent; is that right?

6 A. To the best of my knowledge, this is  
7 how patent offices work. They go through -- cite a  
8 lot of references, prior art, and they establish if  
9 something has sufficient novelty to be granted as a  
10 patent or not. And many times they deny because  
11 there is not enough novelty. And so normally this  
12 is the job. You would trust the patent office with  
13 this job.

14 Q. Do you have patents of your own?

15 A. Yes.

16 Q. How many?

17 A. Twenty-eight, twenty-four. I don't  
18 have a precise memory of that.

19 Q. Have you been involved in the  
20 examination process of those patents?

21 A. On the side of the inventor, yes.

22 Q. Did you provide legal arguments or --  
23 I'm sorry. Scratch that.

24 Did you provide technical arguments  
25 or legal arguments in support of the patents you

1 applied for?

2 MR. DIXON: Objection, form.

3 A. Can I answer? So working with the  
4 patent lawyers that filed the patent, of course,  
5 there was a review process and a back and forth  
6 between the patent office and the law firm who  
7 filed the patent. And I provided technical  
8 arguments to respond to the objections of the  
9 patent office. And this may go through several  
10 rounds.

11 Q. (BY MR. KHAN:) So it is fair to say  
12 that issues like obviousness or anticipation are  
13 things that you have had to deal with for your own  
14 patent applications?

15 A. Yeah.

16 MR. DIXON: Objection, form.

17 A. It happened that the patent office  
18 found that one invention was included in something  
19 else. And we had to comment on the novelty and the  
20 differences with respect to some published papers  
21 and the invention and eventually the patent was  
22 granted. So this is as far as I can understand  
23 about, you know, the concept of the novelty and  
24 anticipation, based on experience, not on legal  
25 arguments, because I am not a lawyer.

1                   Q.       (BY MR. KHAN:) Who determines what  
2 is obvious in a patent?

3                   A.       Who?

4                   Q.       Yes.

5                   A.       Well, again, on the side of an  
6 inventor, I guess an inventor believes that his  
7 invention is new and nonobvious. The patent office  
8 may come back with comments and say oh, this  
9 reference, this reference, this reference make your  
10 invention obvious. This claim cannot be taken and  
11 so on and so forth. And then the inventor may  
12 argue otherwise.

13                               And then at the end, if the patent  
14 office is convinced, the patent is granted. Maybe  
15 some claims are scrapped from the patent because  
16 they are not accepted, and at the end, whatever is  
17 written there is written there. That is my  
18 understanding of the process.

19                   Q.       So when obtaining a patent, it is the  
20 inventor and the patent office that determine when  
21 a claim is obvious; is that right?

22                   A.       I would say so, until there is a  
23 lawsuit and somebody else has a different opinion,  
24 and a court overrules and says no, this is -- you  
25 know -- so -- but until the patent is not

1 challenged, I guess that is it. This is a matter  
2 of the inventor and the patent office.

3 Q. So when a patent is challenged, like  
4 the '700 Patent has been challenged, who determines  
5 what is obvious?

6 A. Ultimately or in the process?  
7 Because it is clear that there are divergent  
8 opinions here, so there are different experts with  
9 divergent opinions and eventually a court will make  
10 a decision; I don't know.

11 Q. Is there a standard for determining  
12 obviousness of the '700 Patent?

13 A. I don't know.

14 Q. In your declaration, you mention a  
15 POSITA. What does POSITA stand for?

16 A. Now I do not remember exactly the  
17 acronym, but the -- according to my knowledge, this  
18 means an individual skilled in the art or something  
19 like that.

20 Q. And who is one of skilled in the art  
21 in the context of the '700 Patent?

22 A. Well, one skilled in the art in this  
23 context is a telecommunication engineer with  
24 experience in digital modulation systems and  
25 channel coding and physical layer. Physical layer

1 meaning the layer interface of a communication  
2 system, a wireless communication system mainly.

3 Q. And how much experience does this  
4 person of ordinary skill in the art have to have?

5 A. Okay. I would say probably a person  
6 with a Ph.D. in electrical engineering, specialized  
7 with a thesis done in these topics, and possibly  
8 some years of work after Ph.D. in these topics.  
9 These are fairly advanced topics that are not  
10 taught in undergraduate or even master-level  
11 courses. So it requires courses -- advanced  
12 courses in digital communication plus direct  
13 experience, research experience.

14 Normal students, in my experience,  
15 cannot read and understand papers like the ones  
16 that are in the exhibits. Simply -- I'm not aware  
17 of any program where a student after a course would  
18 just read this paper and understand, to the point  
19 of actually implementing or designing a system.

20 Q. You mentioned that this person of  
21 skill in the art would also have some years of work  
22 experience after their Ph.D.

23 How many years of work experience  
24 would this person have?

25 A. That is really hard to say. It

1 depends on what type of work experience. It could  
2 be if the Ph.D. is precisely on these topics, like,  
3 for example, the person from the University of  
4 Politecnica de Catalunya, it is clear that this  
5 person knows everything. If somebody who had a  
6 Ph.D. in digital communications and information  
7 theory, knows what capacity is, what the Gaussian  
8 channel is, but has never worked in coded system  
9 and a physical layer, this probably requires one or  
10 two years' experience. It depends. It could be  
11 zero years of experience if the Ph.D. is on these  
12 topics, precisely on these topics. But how many  
13 people have -- a handful, no more, probably.

14 Q. Does this person of skill in the art,  
15 in the context of the '700 Patent, have to have a  
16 certain number of paper publications or conference  
17 publications?

18 A. Does not have, is not a requirement,  
19 of course. If a person has the type of background  
20 I just described, so a Ph.D. in the area, is most  
21 likely. In almost any Ph.D. program I am aware of,  
22 requirements to defend a thesis is to have also  
23 publications on the thesis topic. So it is  
24 presumable that a person of this kind would have  
25 papers on the topic, yes.

1           Q.       And when you are determining what is  
2 obvious or not obvious in the context of the '700  
3 Patent, what time frame do you look at in making  
4 that determination of obviousness?

5           A.       In the sense of prior art?

6           Q.       Yeah, so for example, if I am looking  
7 at the '700 Patent to determine what is obvious to  
8 a person of ordinary skill in the art, can I look  
9 at the date that the patent issues and determine  
10 the obviousness as of that date?

11          A.       So when I considered this question on  
12 obviousness, I looked at the papers that were  
13 mentioned in -- so the -- how do you call this, the  
14 exhibits, right? Several papers were mentioned. A  
15 few papers were considered during my first -- to  
16 prepare my first declaration. Other papers were  
17 mentioned and were considered to prepare the second  
18 declaration.

19                   So the time frame referred to those  
20 papers, right? Yeah, so basically spans the years  
21 of these papers. I don't remember exactly the  
22 years of the various publications but.

23          Q.       But is there a particular date that  
24 you can start? I mean, for example, can we go back  
25 to the year 1800 to determine obviousness of this

1 technology?

2 A. Of course not. Clearly, the patent  
3 refers explicitly to the so-called BICM capacity  
4 also known as part of the coding capacity. This  
5 concept was introduced in one of my papers, so  
6 19 -- I don't remember, 1993, '92, something like  
7 that. This paper is very highly cited and this  
8 methodology of the BICM has been adopted in a  
9 variety of communication systems. In this paper,  
10 we have introduced this metric for the goodness of  
11 constellations and the binary labeling of  
12 constellations.

13 The patent clearly uses this metric  
14 to compare different constellations in terms of  
15 gain and capacity, SNR, at which certain capacities  
16 are achieved. So I would say the time frame should  
17 go from that seminal paper to -- to the time of the  
18 first summation of these ideas, because in my  
19 understanding, this patent was granted in 2020, but  
20 it is a long process of -- of patenting that  
21 started much, much before. Something like 2008,  
22 maybe. So I think the right frame to consider  
23 this -- this nonobviousness is between the first  
24 paper on BICM and 2008, so the first submission of  
25 the preliminary patent idea. Anything that came

1 later, well, there were already papers, even from  
2 the author of the patent, there were already papers  
3 out, so once the paper is out, anybody can pick  
4 up --

5 (Off-the-record discussion.)

6 A. Yes, once a paper is out in the open  
7 literature, any other author can, of course,  
8 reference to this paper or even not reference to  
9 this paper sometimes and pick up some ideas, do  
10 some improvements and then publish -- try to  
11 publish some other papers, if the reviewers and the  
12 editor of a journal or the technical program  
13 committee of a conference decide that the follow-up  
14 papers are novel enough -- and that is, again, a  
15 rather arbitrary process, based on experience --  
16 then the paper will be published.

17 And if the authors are honest and  
18 they reference prior art, if the reviewer may force  
19 the author to reference prior art, sometimes it  
20 happens that a paper has clearly picked up some  
21 ideas that were published before and without  
22 reference, they just do something else, do some  
23 improvements and the paper is published.

24 Unfortunately the process of academic review and  
25 acceptance of journals and conference papers is not

1 infallible, so this may happen.

2 But nevertheless, in the area, in the  
3 scientific community, people normally keep track of  
4 the history of ideas and can say okay, this was  
5 proposed there and this may be the same idea  
6 reemerged there, etcetera, etcetera, so this is how  
7 it works in academia.

8 Q. So in your answer, you mentioned that  
9 a person of ordinary skill in the art who would be  
10 considering the question of the obviousness of the  
11 claims in the '700 Patent would consider the time  
12 period between your seminal paper in 1993 to around  
13 the time of 2008.

14 Why did you choose your seminal paper  
15 as a starting date?

16 A. Because before that, the concept of  
17 parallel decoding capacity and BICM was not even  
18 invented so anybody who would have come up with a  
19 similar idea before us -- well, they would have  
20 anticipated us and now it would reference somebody  
21 else and not my paper, so that is pretty obvious.

22 Q. Do you know how many times your paper  
23 was cited?

24 A. About three thousand five hundred  
25 times, more or less. It is still my most

1       referenced paper.

2               Q.       So do you believe yourself to be the  
3       creator of BICM?

4               A.       Well, the idea came up in a previous  
5       paper by Zehavi, under the name of "pragmatic coded  
6       modulation." In fact, we reference this Zehavi  
7       paper in our case, in our paper. But this was  
8       restricted to 8PSK -- it is a modulation format, it  
9       is a constellation with eight points equally spaced  
10      on a circle, it is called 8PSK, phased shift  
11      keying.

12                      And in that paper by Zehavi, there  
13      was no notion of the capacity of this scheme. It  
14      only proposed this as a low complexity version of  
15      Ungerboeck coded modulation which was the dominant  
16      approach to construct the signal space codes at the  
17      time. Ungerboeck -- Gottfried Ungerboeck proposed  
18      this coded modulation approach in 1982, and for  
19      about ten years, this scheme, so-called the trellis  
20      coded modulation and TCM were the dominant way of  
21      constructing codes for the physical layer. And then  
22      in our papers, we considered his idea of including  
23      a bit interleaving between a binary code and a  
24      constellation and differently from Zehavi, we also  
25      considered the optimal way of producing soft matrix

1       for the bits -- so-called demapper, so the optimal  
2       way of producing the demapping. And also we  
3       provided a formula for the capacity of the  
4       equivalent channel from the binary input before the  
5       interleaver to the soft output after the  
6       deinterleaver. And this is what is referred to in  
7       the patent as part of the coding capacity.

8               So although the idea in my paper was  
9       not entirely new, the analysis, the information  
10      that is already inside in providing a capacity  
11      formula, is -- was the first time. And this idea,  
12      as you can see, has gone a long way.

13             (Exhibit 2015, having been previously  
14             marked for identification, was  
15             referenced in this deposition.)

16             Q.       (BY MR. KHAN:) The BICM paper you  
17      are referring to, is that Exhibit 2015 that you  
18      submitted in these proceedings that -- I'm sorry,  
19      that Constellation submitted in these proceedings,  
20      the title is "Bit-Interleaved Coded Modulation" and  
21      it is an IEEE Transactions on Information Theory  
22      publication.

23             A.       Exhibit 2015?

24             Q.       Yeah.

25             A.       I don't think I have it with me. Can

1       you please share it?

2               Q.       I can maybe share my screen and you  
3       can let me know -- I just want to make sure I am  
4       looking at the right thing so -- can you see my  
5       screen?

6               A.       Yes.

7               Q.       Is this the document you are  
8       referring to?

9               A.       Yes. So as usual, in the -- in my  
10       scientific community, it is customary to publish  
11       something in short form in conferences and possibly  
12       in journals with a short turnaround. And then the  
13       conception information theory, unfortunately, has a  
14       very long turnaround, is a very long review  
15       process. So at the time we have published the  
16       preliminary version with already the formula for  
17       the -- part of the coded capacity in conference, in  
18       ISIT, I don't remember which year but a few years  
19       before. Then there is a short paper, I think  
20       Communication Letters which is a British journal  
21       that appeared I think in '97, and then finally the  
22       long paper appeared in '98.

23                       But this is due to the fact that the  
24       review process of these papers is very long. And  
25       so it is necessary to publish an idea in short form

1 to have it out, you know, before somebody else  
2 comes up with the same thing. So I say '98. But  
3 the formula was already known -- in fact, the  
4 acronym was already known maybe one or two years  
5 before.

6 Q. Okay. Thank you. So even though  
7 this paper was published in 1998, really the idea  
8 had been formulated -- the idea of the BICM had  
9 been formulated before that, and you had done some  
10 earlier publications, even before this paper; is  
11 that right?

12 A. Yeah, I think that the -- if I am  
13 not -- okay. I cannot be very precise. I should  
14 look at my list of references.

15 But I think that we had a paper in  
16 ISIT, which is the International Symposium for  
17 Information Theory, it is the main conference on  
18 information theory, I believe that appeared maybe  
19 in '95 or '96.

20 Q. Okay. You mentioned this idea of  
21 parallel decoding capacity was part of the patent,  
22 and you had discussed it in your paper.

23 The patent also recites -- sorry, the  
24 Claim 1 of the patent also recites a receiver. Was  
25 a receiver also known at the time of your paper?

1 MR. DIXON: Objection, relevance.

2 A. Honestly, I do not understand the  
3 question.

4 Q. (BY MR. KHAN:) Okay. The Patent  
5 Claim 1, the '700 Patent Claim 1 recites in part a  
6 receiver capable of receiving signals via a  
7 communication channel having a channel  
8 signal-to-noise ratio.

9 A. Uh-huh. Yeah.

10 Q. Was such a receiver known in the art  
11 at the time your paper was published in 1998?

12 MR. DIXON: Objection, relevance.

13 A. Can I -- may I answer to the  
14 question?

15 MR. DIXON: Yes, I will instruct you  
16 not to answer when --

17 A. Okay. So I have to qualify my answer  
18 here. The patent describes a receiver formed by a  
19 demodulator, a demapper and a decoder.

20 So a receiver as an object that can  
21 receive signals and turn them into bits, into  
22 information bits. But you find it in every  
23 communication system, every digital communication  
24 system since the inception of digital  
25 communication. So that is a well-known concept.

1                   A receiver decomposed into these  
2                   three components, and in particular, the role of  
3                   the demapper. The demapper is the device that  
4                   takes INQ samples from the demodulator and creates  
5                   so-called soft bitwise metrics, also referred to as  
6                   LLRs, local likelihood ratios of these bits. Feed  
7                   them into a deinterleaver and eventually, after  
8                   deinterleaving, these metrics represents the  
9                   so-called soft symbols or soft observations that go  
10                  into the decoder, and the decoder eventually, based  
11                  on that, restores -- tries to restore the original  
12                  information messaging bits. So zeros and ones.  
13                  But this particular structure is specific of BICM.  
14                  A receiver of this kind was not known or was not  
15                  proposed before it was hinted in some sense with a  
16                  suboptimal way of communicating the bit metrics in  
17                  the Zehavi paper, and it was formalized more  
18                  precisely in our set of works on BICM.

19                Q.        (BY MR. KHAN:) When you say "our set  
20                of works in BICM," did you mean by your paper on  
21                BICM?

22                A.        Yes. Yes. Our, meaning me and my  
23                coauthors in that ISIT conference, a small journal  
24                and information theory transaction paper.

25                Q.        So the receiver that is in Claim 1 of

1 the '700 Patent, that include a demodulator,  
2 demapper and decoder. This is something that a  
3 person of ordinary skill in the art would have  
4 understood as described in your BICM paper; is that  
5 right?

6 MR. DIXON: Objection, form and  
7 relevance.

8 A. It is correct that in my paper on  
9 BICM, a receiver formed by these three components  
10 is described. In fact, any -- by definition of the  
11 scheme, any BICM scheme works in this way. If a  
12 scheme does not work in this way, it is not a BICM.  
13 It is very simple.

14 Q. (BY MR. KHAN:) And the  
15 constellations that are described in Claim 1, your  
16 paper regarding BICM, does it also provide guidance  
17 to one of ordinary skill in the art regarding these  
18 types of constellations?

19 MR. DIXON: Objection, form.

20 A. I didn't understand. You say the  
21 size of the constellation or what?

22 Q. (BY MR. KHAN:) No. I was just  
23 mentioning that the claim -- Claim 1 has these  
24 constellations, right?

25 A. Right.

1           Q.       And you have mentioned that your  
2 paper describes a receiver like the one in Claim 1.  
3 And so I am just trying to understand that, you  
4 know, that your paper, it also describes the kind  
5 of constellations that are recited in Claim 1.

6           MR. DIXON: Objection, form.

7           A.       Okay. So in my paper, we have  
8 examples. So the BICM is a general technique. It  
9 can be applied to any constellation, any binary  
10 labeling, of course, with different performances or  
11 any binary code. It is just a general technique.

12                 The ultimate metric to assess the  
13 goodness of a constellation under BICM decoding is  
14 this parallel decoding capacity by Shannon theorem,  
15 that is the ultimate rate you can achieve.

16                 In my paper, we have only examples  
17 concerning uniformly spaced QAM constellations and  
18 uniformly spaced PSK constellations. So the  
19 constellation described in Claim 1 that does  
20 explicitly say known uniform constellation are not  
21 described in my paper. Not even an example with  
22 nonuniformly spaced constellations.

23           Q.       (BY MR. KHAN:) So your paper is  
24 different from Claim 1 in that it does not describe  
25 the use of nonuniform constellations; is that

1 right?

2 A. My paper -- this is one aspect, not  
3 the only one, in which my paper differs from Claim  
4 1.

5 Q. What are some other aspects?

6 A. For example, Claim 1 makes explicit  
7 reference of LDPC codes. In my paper, at the time  
8 of writing, LDPC codes were essentially unknown,  
9 not yet fully invented. So clearly we didn't make  
10 any reference to LDPC codes.

11 At the time of writing my paper, for  
12 example, we didn't consider the pairing of  
13 constellations with specific coding rates and their  
14 SNR intervals in which this pairing is  
15 outperformed, so a set.

16 In here, in the claim, it talks about  
17 a plurality of multidimensional symbol  
18 constellation of plurality of coding rates, so  
19 nothing of that is included in the paper because  
20 the paper was just a basic idea of BICM. So how to  
21 match a binary code with a constellation through  
22 bit-interleaving and soft demapping.

23 Q. In your second declaration, you also  
24 referred to the U.S. Patent 7,978,777, which is  
25 Exhibit 1015, as the Barsoum patent -- I'm sorry,

1 as the Barsoum document. And you mentioned that it  
2 provides written description for the challenged  
3 claims; is that correct?

4 A. I don't remember exactly. I have  
5 to -- if you tell me in which --

6 Q. Sure.

7 A. -- part of the patent -- the  
8 declaration you referred to, I can read.

9 Q. So I guess the heading, Section 3 of  
10 your declaration says: Barsoum provides written  
11 description for the challenged claims.

12 That can be found on Page 3 of your  
13 second declaration. Do you see that?

14 A. Yes. Yes, I can see that. And  
15 Barsoum is Exhibit 1015?

16 Q. Yes.

17 A. Yeah, okay. Right. That is right.  
18 So as far as I understand, Barsoum, 1015, or the  
19 Patent '777 is almost identical in the claims with  
20 respect to Patent '700.

21 Q. And so what does it mean for a patent  
22 document to provide written description for the  
23 claims?

24 A. Well, the claim is described, and it  
25 is in writing; this is what it means. It is also

1       cited here.

2               Each of the plurality of different  
3       nonuniform multidimensional symbol constellations  
4       is capable of providing a greater parallel decoding  
5       capacity at specific SNR than the other symbol  
6       constellations in the plurality of multidimensional  
7       symbol constellations at the same SNR.

8               Q.       When you say that the claim is  
9       described, what do you look at to determine whether  
10      the claim is described?

11              MR. DIXON:  Objection, form.

12              A.       Well, I look at the patent, I look at  
13      the description.  There are pictures, there are  
14      examples.  There is a high level description, and  
15      then there is a -- there are charts that show  
16      exactly what is written here.  There's an example  
17      of nonuniformly spaced constellation with each one  
18      having a range of SNR which provides the best  
19      results in the example.  So.

20              Q.       (BY MR. KHAN:)  Okay.  Thank you.

21              MR. KHAN:  We have just crossed the  
22      one-hour mark.  Would you like to take a  
23      five-minute break or would you like to continue?  I  
24      am okay either way; it is up to you.

25              A.       Yeah, five minutes break is good.

1 MR. KHAN: Okay. How about we  
2 reconvene at 11:20 Eastern. Is that okay? That is  
3 about eight minutes?

4 A. That is okay for me.

5 MR. KHAN: Good.

6 (Whereupon, a break was had from  
7 11:13 a.m. until 11:26 a.m. EDT)

8 Q. (BY MR. KHAN:) So before the break,  
9 we were talking about the written description. If  
10 something is just claimed in a patent without any  
11 additional description of the features, is that  
12 sufficient to satisfy the written description  
13 requirement?

14 MR. DIXON: Objection, form.

15 A. I don't know. I'm not a legal  
16 expert, I'm not a patent lawyer. I would say that  
17 if something is claimed without description, any  
18 description, probably not. But, again, what is a  
19 description?

20 Q. (BY MR. KHAN:) Yeah. And I think  
21 that is what I am trying to understand, because you  
22 made a statement in your declaration that there's  
23 written description for the claim.

24 So I am trying to understand how, you  
25 know, you came about that conclusion. I will ask a

1       few other questions, hopefully, to get a sense of  
2       how you came to that conclusion.

3               A.       Uh-huh.

4               Q.       You had mentioned earlier that you  
5       have also had some experience with your own patent  
6       applications, right?

7               A.       Uh-huh.

8               Q.       So when we talk about written  
9       description for claims, are you aware that  
10       sometimes when you are working on a patent  
11       application, the claims in the beginning, when you  
12       submit an application, can be revised or amended in  
13       that back and forth with the patent office, and  
14       then ultimately you come out with a set of claims  
15       that are issued with a patent?

16                       Are you familiar with that?

17               A.       Yeah. Moderately familiar, yeah.

18               Q.       So the purposes of written  
19       description -- do we look at the claims that were  
20       filed initially with the application, or do we look  
21       at the claims that were filed with the issued  
22       patent?

23                       MR. DIXON: Objection to form.

24                       MR. KHAN: I'm sorry. Let me clarify  
25       that. That is slightly incorrect.

1 Q. (BY MR. KHAN:) For the purpose of  
2 determining written description, do we look at the  
3 claims that were submitted initially with the  
4 patent application, or do we look at the claims  
5 that have been issued with the patent at the time  
6 of the patent issuance?

7 MR. DIXON: Objection to the form.

8 A. All of them. All what I have -- all  
9 of what I had is the patent that was issued. So I  
10 have -- I don't know what were the claims filed at  
11 the time of the first filing of this patent.

12 Q. (BY MR. KHAN:) So is it fair to say  
13 that you did not look at the claims that were  
14 initially filed for the '700 Patent or the '77  
15 Patent -- '777 Patent, sorry?

16 MR. DIXON: Objection to form.

17 A. I will repeat. I have whatever is in  
18 the exhibits, and to the best of my understanding,  
19 the Patents '777, '700 are the one, the documents  
20 that are eventually issued. When it is marked U.S.  
21 Patent blah, blah, blah, this means it is an issued  
22 patent. I don't have the history of the back and  
23 forth between the inventors and the patent office.

24 Q. (BY MR. KHAN:) Okay. So you looked  
25 at the claims that were issued with the patent; is

1       that correct?

2               A.       Yes.   That is correct.

3               Q.       And that is the same for the '700  
4       Patent and the '777 Patent?

5               A.       I don't understand the question.   You  
6       mean --

7               Q.       When you were looking for written  
8       description support or a determination of written  
9       description support of the challenged claims, you  
10      looked at the language of the claims that were part  
11      of the issued claims in the '700 Patent; is that  
12      correct?

13                      MR. DIXON:   Objection to the form.

14               A.       It is correct.   I looked at the  
15      language in the patent document under my  
16      possession, which is the issued patents.

17               Q.       (BY MR. KHAN:)   Do all of the claim  
18      terms in a claim have to be explicitly recited in a  
19      patent for there to be written description for  
20      those claim terms?

21               A.       I don't understand the question.

22               Q.       So a claim is made of various claim  
23      terms; is that correct?

24               A.       Uh-huh.

25               Q.       Sometimes some terms are explicitly

1       recited in the patent specification, and sometimes  
2       they are not.

3                       So my question is: When a claim term  
4       is recited in the claims but it is not recited in  
5       the specification of a patent, does that claim term  
6       have written description support in that patent?

7               A.       To the best of my understanding, when  
8       there is a conceptual equivalence, some term may be  
9       different or may be missing. But when the context  
10      is clear, I would say that the claim is described.

11              Q.       I see. So when a person of skill in  
12      the art reads the patent and it is really obvious  
13      that a claim term is part of the description, then  
14      that claim term would have written description  
15      support; is that right?

16             A.       I cannot make a general statement. I  
17      give you an example. At some point, it may be -- I  
18      don't remember now exactly. It may be that at some  
19      point in the description of the invention, the term  
20      "maximization" is used and in a claim is -- the  
21      term "optimization" is used. But the underlying  
22      optimization problem is referring to maximizing a  
23      reward function, in the specific case, the parallel  
24      of the coding capacity with respect to the point of  
25      the constellation.

1                   In this case, I think even if the  
2                   term is different, the meaning is identical. There  
3                   is no possibility of misunderstanding or  
4                   equivocation. And so I would say that in this  
5                   case, this would be okay. There may be other  
6                   examples for which this is not okay. But these  
7                   have to be produced on a case-by-case basis. I  
8                   cannot make a general statement, an absolute  
9                   general statement.

10                  Q.        So you are saying that maximization  
11                   is identical to optimization; is that right?

12                  A.        No. I didn't say that. I said that  
13                   in the context of an optimization problem where the  
14                   goal is to maximize a certain objective function,  
15                   optimization and maximization are synonyms.

16                           Of course, if the optimization  
17                   problem was minimizing a cost function, then, of  
18                   course, they would not be synonyms.

19                  Q.        I see. So it is the purpose of the  
20                   optimization is -- is -- okay. You mentioned  
21                   earlier in your answer, when there's a conceptual  
22                   equivalence, some term may be different or may be  
23                   missing.

24                           What did you mean by conceptual  
25                   equivalence?

1           A.       I mean when different terms have the  
2       same meaning in a specific context, like  
3       maximization and optimization in the previous  
4       example.

5           Q.       And what determines whether they have  
6       the same meaning or not? Is that something that  
7       would just be really obvious to a person of  
8       ordinary skill in the art?

9                   MR. DIXON: Objection, form.

10          A.       Well, yes. I -- I think that it  
11       should be obvious for a person skilled in the art.  
12       Of course, a person who is not skilled in the art  
13       and just looked at the terms may see -- may not get  
14       the context or may not get the meaning. So they  
15       just see two different words.

16                   But if you know the context and you  
17       know the -- you know the problem, a person skilled  
18       in the art determines the two terms in that context  
19       are equivalent.

20          Q.       (BY MR. KHAN:) You just mentioned  
21       that a person skilled in the art would determine  
22       that the two terms in that context are equivalent.  
23       And to make that determination, the person of  
24       ordinary skill in the art would rely on their  
25       knowledge and what would have been obvious to a

1 person of ordinary skill in the art to reach the  
2 conclusion that those two terms are equivalent; is  
3 that right?

4 A. So a person skilled in the art would  
5 use his knowledge to make that determination. And  
6 sometimes this determination or this equivalence is  
7 a mathematical equivalence.

8 In my previous example, an  
9 optimization problem whose goal is to maximize a  
10 reward function, optimization, maximization are  
11 mathematically equivalent. In other contexts, this  
12 may be a semantic equivalence. If I say I and Q of  
13 a signal are the two components of the real and  
14 imaginary parts of a complex signal, they are  
15 essentially semantically equivalent, right? They  
16 mean the same thing, but the terms are different.

17 Q. So if one term is recited in the  
18 claim, another term is used in the specification,  
19 but it would have been obvious to a person  
20 ordinarily skilled in the art that the two terms  
21 are the same thing, then you make that  
22 determination that that claim term recited in the  
23 claims has written description support? Is that  
24 right?

25 A. Based on my expert opinion, since I

1 think I can be considered an expert in the field,  
2 if my determination is that these terms are  
3 equivalent, I will make this -- this determination.

4 So again, it is experience, context  
5 and meaning.

6 Q. We talk about meaning. How -- what  
7 is a standard that you use to determine the meaning  
8 of claim terms?

9 A. Excuse me. I didn't understand.

10 Q. In your last answer, you talked about  
11 determining what terms mean, right?

12 A. Right.

13 Q. And whether they are equivalent or  
14 not. So what is a standard that you use to  
15 understand what a claim term means?

16 A. Well, the common knowledge in a  
17 certain technical area that people skilled in that  
18 technical area know.

19 So if I say I and Q components are  
20 real and imaginary part of a complex signal, a  
21 person that knows digital communication understands  
22 that these two terms mean the same thing. Again,  
23 just an example. Somebody who does not know  
24 anything about digital communication, probably,  
25 because the words are different, does not make this

1 association.

2 Q. So basically the standard that you  
3 use is what a person with experience in that art  
4 would have determined that word to mean?

5 A. Yes. It is when a person with  
6 experience or background in the area determines  
7 that the meaning is the same.

8 Q. And if two words are not the same,  
9 then they use their experience and background to  
10 make a determination whether or not it is obvious  
11 these two terms are the same, right?

12 A. Yes. This happens all the time in  
13 scientific papers.

14 Q. Can I ask you to turn to Claim 1 of  
15 the '700 Patent?

16 A. Claim 1 of the '700 Patent?  
17 (Exhibit 1001, having been previously  
18 marked for identification, was  
19 referenced in this deposition.)

20 Q. (BY MR. KHAN:) And the '700 Patent  
21 is the patent at issue that is Exhibit 1001.

22 A. Yes. Yes. I have it here.

23 Q. Do you have a clean and unmarked copy  
24 in front of you?

25 A. It is unmarked, although there are

1       some -- some color.

2               Q.       So there's no additional writing on  
3       there, is there?

4               A.       There is no additional writing.

5               Q.       That is fine. So it is just some  
6       highlights, right?

7               A.       Yes, so Claim 1?

8               Q.       Yes, Claim 1. It starts on Column  
9       13?

10              A.       Yeah. Yeah. I have it. So should I  
11       read it?

12              Q.       No, you don't have to. I will start  
13       asking questions. In the process, we will probably  
14       end up reading it together.

15              A.       Okay.

16              Q.       Do you recall earlier we talked about  
17       the receiver in Claim 1? That receiving limitation  
18       of Claim 1 recites: A receiver capable of  
19       receiving signals via communication channel having  
20       a channel signal-to-noise ratio.

21                      Do you see that?

22              A.       Yes.

23              Q.       Do all channels have a channel  
24       signal-to-noise ratio?

25              A.       No.

1           Q.       When does a channel not have a  
2 signal-to-noise ratio?

3           A.       So in communication theory, as well  
4 as information theory, a lot of different channel  
5 models are used. For example, a very much used  
6 channel model is called the binary symmetric  
7 channel.

8                   The binary symmetric channel is a  
9 channel where the inputs is binary, so zero or one.  
10 The output is also binary, zero or one. And the  
11 channel simply corresponds to a random bit flip, so  
12 a zero can be turned into a one with probability  $P$ .  
13 And one can be turned into a zero with also  
14 probability  $P$ .

15                   So this model, for example, is a  
16 channel where the notion of signal-to-noise ratio  
17 is irrelevant. The relevant notion is the  
18 probability of error, so the probability  $P$  for  
19 which the channel inverts a bit.

20                   That is an example of a channel where  
21 the notion of signal-to-noise ratio is not  
22 applicable.

23           Q.       So my question was a little bit  
24 different. What you told me is whether or not  
25 signal-to-noise ratio is relevant. My question was

1       whether all channels have a channel signal-to-noise  
2       ratio, not whether the signal-to-noise ratio is  
3       relevant or not.

4               A.       I think I answered your question in  
5       the negative by providing an example for which of a  
6       channel that has no notion of signal-to-noise  
7       ratio. So not all channels have signal-to-noise  
8       ratio. And I provided an example.

9               Q.       What is it -- what's the minimum it  
10      takes for a channel to have signal-to-noise ratio?

11              MR. DIXON: Objection, form.

12              A.       So communication channel is a  
13      mathematical model of a physical object, or a  
14      physical phenomenon, right? Whenever the  
15      underlying physical phenomenon consist of sending a  
16      waveform to a radio channel, a cable, whatever,  
17      physical, and the communicative effect of  
18      disturbances in the channel and terminal noise in  
19      the receiver circuitry, antenna, amplifier, wave  
20      guides, whatever is done there, it can be modeled  
21      as an additive noise.

22              Additive noise means that at some  
23      point in the receiver chain, we can represent the  
24      received signal as the sum of a sort of  
25      transformation function of the transmitted signal

1 plus additive noise, then we can define the ratio  
2 of the power of the received signal divided by the  
3 power of the noise at that point. And this is, by  
4 definition, signal-to-noise ratio.

5 So it is the ratio of two powers.  
6 One is the power of the received signal at the  
7 certain point of the receiver chain divided by the  
8 power of the noise at the same point, provided  
9 that -- provided that the channel operates in an  
10 additive sense.

11 So the noise is an independent --  
12 statistically independent or at least uncorrelated  
13 additive signal that is added to the received  
14 signal. Okay.

15 So virtually any channel that models  
16 a physical phenomenon in which some additive noise  
17 is present.

18 Q. (BY MR. KHAN:) Moving to the next  
19 limitation, the demodulator -- the receiver  
20 includes a demodulator that is capable of  
21 demodulating a received signal into a demodulated  
22 signal.

23 Do you see that?

24 A. Yes.

25 Q. What does a demodulating operation

1 involve in the context of the '700 Patent?

2 MR. DIXON: Objection, relevance.

3 A. In this context, a demodulator  
4 involves a number of standard operations that are  
5 found in a typical receiver chain.

6 It may involve, because -- again, it  
7 depends on which kind of signals we are talking  
8 about. It may involve operations like frequency  
9 translation, so frequency shift from a modulated  
10 pass bandwidth to the base band, low pass  
11 filtering, and sampling of the I and Q components  
12 of the base band signal.

13 So basically all the operations that  
14 are necessary to go from a continuous time pass  
15 band signal, which is received from a cable, from  
16 an antenna, say from the physical medium, to a  
17 discrete time sample signal in real and imaginary  
18 part or I and Q components.

19 This is what usually the standard  
20 termination that you find in textbooks referred to  
21 a demodulation or demodulator.

22 (Off-the-record discussion.)

23 Q. (BY MR. KHAN:) The claim recites  
24 that the demodulator is capable of demodulating.  
25 What do the words "capable of" mean to you?

1 MR. DIXON: Objection, relevance.

2 A. Capable means able to do the  
3 operations that I just described.

4 Q. (BY MR. KHAN:) So in your opinion,  
5 Claim 1, the demodulator in Claim 1, sorry, does  
6 that have to perform the demodulating or does it  
7 just have to be capable of performing the  
8 demodulating?

9 MR. DIXON: Objection, relevance.  
10 And, Mr. Khan, this is entirely outside the scope  
11 of either of his declarations.

12 MR. KHAN: Claim 5 depends on Claim  
13 1, so it's entirely within the scope of the  
14 termination, the written description of Claim 5.

15 MR. DIXON: This is not at all within  
16 the scope of his declaration. So you're free to  
17 ask questions that are within the scope of his  
18 testimony. This is a cross-examination. He has  
19 not opined on this claim limitation, and it's  
20 outside the scope of his deposition.

21 MR. KHAN: He's opined on the written  
22 description of Claim 5, which includes Claim 1. Of  
23 course you're free to make your objections, I'm  
24 not -- no issues there. But, you know, I can still  
25 ask these questions. They're within the realm of

1 Claim 5.

2 Q. (BY MR. KHAN:) Sorry. So we were  
3 saying -- the question was: What do the terms  
4 "capable of" mean to you in the context of the '700  
5 Patent claims?

6 MR. DIXON: Objection, relevance.

7 A. So all these patents describe method  
8 and apparatus, and this is standard language. And  
9 a method and apparatus describe -- so an apparatus  
10 capable of doing something, it means it does  
11 something, right?

12 So if you're describing a receiver  
13 composed of a demodulator and a demapper, and a  
14 demodulator is capable of demodulating a signal, it  
15 means that it does that, right? Because it is an  
16 object that implements a function. And  
17 implementing a function means capable of doing that  
18 function, right?

19 Because in my view, this means that  
20 the demodulator demodulates the signal. Otherwise,  
21 why should it be there?

22 Q. (BY MR. KHAN:) So with this claim  
23 limitation regarding the demodulator, and  
24 specifically the words "a demodulator capable of  
25 demodulating a received signal," mean exactly the

1 same thing if I were to say "a demodulator that  
2 demodulates a received signal"?

3 A. Yes.

4 MR. DIXON: Objection, relevance and  
5 scope -- or form.

6 A. In -- to the best of my knowledge,  
7 these two sentences in this context are completely  
8 equivalent.

9 Q. (BY MR. KHAN:) In the next  
10 limitation or demapper, it recites: A demapper,  
11 coupled to the demodulator, capable of determining  
12 likelihoods using the demodulated signal and a  
13 multidimensional symbol constellation selected from  
14 a plurality of multidimensional symbol  
15 constellations.

16 Do you see that?

17 A. Yes.

18 Q. What is a multidimensional symbol  
19 constellation?

20 A. I don't understand. What is?

21 Q. Yes, what is.

22 A. It is a set of points in a real space  
23 or complex space of dimension greater than one. So  
24 not points on a real line that represent pockets or  
25 bits.

1                   So a symbol constellation is the set  
2 of points representing amplitude and phase of the  
3 signal at a given, say, modulation interval, so  
4 over time, such that every point has an amplitude  
5 and a phase or a real and imaginary part. Or if it  
6 is in a dimension greater than two, this concept  
7 can be generalized, such that eventually every  
8 point corresponds to a binary label.

9                   And so demodulated signal, the --  
10 encodes these bits into labels, and the labels into  
11 points, the points into amplitude and phase of a  
12 signal.

13                Q.       You mentioned that they can be  
14 dimensioned greater than two.

15                A.       Correct.

16                Q.       What is a third dimension in a  
17 multidimensional symbol constellation?

18                A.       Mathematically, there is no limit in  
19 the dimensionality of the constellation. One can  
20 design constellations in very high dimensions.

21                   As a matter of fact, a constellation  
22 in dimension larger than two will always be  
23 eventually translated in a signal, and the signal  
24 is characterized by an amplitude and phase, or as a  
25 complex number transmitted at every sample.

1 Amplitude and phase is a polar representation. And  
2 real and imaginary parts is the characterization,  
3 representation of a modulated signal.

4 So eventually, if a symbol  
5 constellation is defined in dimension larger than  
6 two, it will always be mapped into a sequence of  
7 complex numbers.

8 It is, I would say, very common in  
9 the implementation of digital communication systems  
10 to consider constellations, let's say  
11 two-dimensional constellations, such that the  
12 points, are, in fact, just one complex number or  
13 amplitude and phase, hmm? But the literature has  
14 considered many other options. So there is no  
15 limit in the dimensionality of a constellation  
16 mathematically. Right?

17 Q. Thank you. I appreciate from your  
18 answer that there would be no limits to the number  
19 of dimensions. But my question was when there is a  
20 third dimension, what is that third dimension in a  
21 multidimensional symbol constellation?

22 A. Well, specifically to respond to your  
23 answer, suppose that a three-dimensional  
24 constellation would be a constellation whose points  
25 are defined by three real components. And then in

1 order to transmit those points, you have to map  
2 them in some way in a modulated signal. And these  
3 may be, you take them in group of two, you make  
4 six, you transmit pairs or points in the real and  
5 imaginary parts of complex numbers.

6 But nevertheless, the constellation  
7 itself is defined in three dimensions. That's very  
8 possible and has been proposed in some papers. For  
9 example, you can take the vertexes of a tetrahedron  
10 and use them as constellation points.

11 Q. Does the '700 Patent describe a  
12 constellation with three real components?

13 A. No.

14 Q. Does the '700 Patent constellation  
15 describe a constellation with three or more real  
16 components?

17 MR. DIXON: Objection, form.

18 A. The '700 Patent explicitly mentioned  
19 that -- okay. It is at the top of Column 13: In  
20 general it is possible to design N-dimensional  
21 constellations and associated labelings, and then  
22 it goes on.

23 So it admits that -- it admits that  
24 further process could be applied to N-dimensional  
25 constellation. N is a variable; it could be three,

1       it could be four, it could be one hundred.

2                       It also acknowledges that the  
3       optimization involved in these high dimensional  
4       constellations and the demapper would be very  
5       complex. And this, by the way, is not written in  
6       the patent, but this is the reason why people  
7       typically consider two dimensions.

8               Q.       I'm sorry. Just so I understand,  
9       what is the reason why people typically consider  
10      two dimensions?

11              A.       Complexity.

12              Q.       Oh, I see. Okay. At this part, the  
13      section of Column 13 that you cited, I understand  
14      it reads that it's possible to design N-dimensional  
15      constellations and associated labelings. Is that  
16      what you were referring to?

17              A.       Correct.

18              Q.       But that doesn't describe or mention  
19      real components.

20                      MR. DIXON: Objection, form.

21              A.       Okay. If you read this patent:  
22      Rather than designing constellation in 1-D, PAM for  
23      instance, and then extending to 2-D, QAM, it is  
24      possible to take direct advantage in the  
25      optimization step, blah, blah, blah. And then: In

1       general it is possible to design N-dimensional.

2               So here, a person like me, reads that  
3       one dimension -- 1-D means one real component. 2-D  
4       means two real components. And therefore, by  
5       logical extension, anybody with a little bit of  
6       logic and mathematical skills would understand that  
7       N-dimensional means N real components.

8               And there is absolutely no loss in  
9       generality, because if N is even, you can always  
10      put the N real component as real and imaginary part  
11      of N half complex numbers, and the reason  
12      isomorphism between these two spaces. So you can  
13      map one into the other. So there is no loss of  
14      generality in considering N real components. In  
15      fact, it's more general than N complex components.

16              Q.       (BY MR. KHAN:) So you're saying that  
17      a person like you, when they read one dimensional,  
18      two dimensional, they would understand that it's  
19      obvious that this means one dimensional -- sorry,  
20      one real component or, correspondingly, two real  
21      components; is that right?

22              A.       What is written here, right, is 1-D,  
23      PAM -- PAM means pulse-amplitude modulation, so the  
24      modulation only in the amplitude; the amplitude is  
25      a real number -- extending to 2-D, QAM, that means

1 quadrature-amplitude modulation, so two real  
2 components means real and imaginary part of a  
3 complex number.

4 So amplitude -- two modulation in  
5 quadrature of phase, and then N dimensional by  
6 extension, one, two, N, you understand that these  
7 means N real components.

8 Q. Yeah, I guess that's the part that  
9 I'm a little bit confused. Because I don't see  
10 that section recite the word -- in that section, I  
11 mean that Column 13 Lines 1 through 10 that we have  
12 been discussing, that it recites the words  
13 "components."

14 But it's my understanding you're  
15 saying that -- and you can correct me if I'm wrong  
16 here. My understanding of what you're saying is,  
17 you know, a person of ordinary skill in the art  
18 reading this section would have found it obvious  
19 that when you're designing constellations in 1-D  
20 and then extending them to 2-D, you would be using  
21 one real component for the 1-D and two real  
22 components for the 2-D; is that right?

23 MR. DIXON: Objection, form.

24 A. So let me qualify. I said before  
25 that constellations are a set of points in a space.

1 Set of points in a space are represented as  
2 vectors, and the elements of the vector are called  
3 components. This is like a standard mathematical  
4 language.

5 So a vector in 1-D is simply just one  
6 component, it is just one number. A vector in 2-D  
7 is two numbers. A vector in 3-D is three numbers.  
8 These numbers are called components of a vector.  
9 When I say 2-D or two components, it is the same  
10 thing. Mathematically, these two things are  
11 synonyms.

12 So anybody with reasonable  
13 mathematical skills and knowledgeable in this  
14 technical area understands it.

15 Q. (BY MR. KHAN:) The basis of their  
16 understanding would be -- would be -- sorry.  
17 Scratch that.

18 (Pause.)

19 Q. (BY MR. KHAN:) Okay. So if I  
20 understood what you just said, you said that the  
21 constellations are a set of points in space, and  
22 they can be represented as vectors. Elements of  
23 the vectors are called components. Is that right?

24 A. That is correct.

25 MR. DIXON: Objection, form.

1           Q.       (BY MR. KHAN:) And so a vector in  
2 1-D just has one component, a vector in 2-D just  
3 has two components, and a vector in 3-D has three  
4 components. In that passage, Column 13, Lines 1 to  
5 11, would you agree that the terms "vector" and  
6 "components" are not recited?

7           A.       Yes. It's evident by reading the  
8 passage that those two words are not present in  
9 this passage.

10          Q.       But according to you, it would have  
11 been obvious that the '700 Patent contemplates this  
12 vectors and components; is that right?

13                   MR. DIXON: Objection, form.

14          A.       As I said before, a constellation, a  
15 signal constellation is a set of points in a  
16 certain geometric space. Points in space are  
17 represented in possible ways -- possible, say,  
18 system of coordinates.

19                   In particular, when we represent them  
20 in Cartesian coordinates, so in the classical  
21 system of octagonal access, a point in space is  
22 given as a string of numbers where the first number  
23 corresponds to its first coordinate, according to,  
24 for example, the X axis. The second number  
25 corresponds to its coordinate in the Y axis, and

1 the third number, if there are three, or the fourth  
2 number, if there are four, or etcetera -- you can  
3 generalize the concept, right? That's a standard  
4 in algebra, so standard math.

5 So from the moment that you talk  
6 about constellations, you're talking about a set of  
7 points. A set of points in space. And vectors are  
8 representing these points as a list of components  
9 with respect to a coordinate system is standard  
10 math.

11 So even if these words are not  
12 explicitly mentioned here, it is obvious that a  
13 constellation is a set of points. Points are  
14 vectors.

15 This is how we represent points in  
16 space is a vector that goes from the origin of the  
17 coordinates to the system and the tip indicates the  
18 point in space, right? Linear algebra.

19 Q. (BY MR. KHAN:) Okay. And just to  
20 understand, earlier you had said that the set of  
21 points in space can be represented by vectors. But  
22 then you also said that it can be given as a string  
23 of numbers.

24 A. Right.

25 Q. Can you explain, is it both? Is it

1 one or the other or --

2 A. No. No. It's the same thing. Once  
3 you fix a system of coordinates, a vector is  
4 expressed as this list of the components with  
5 respect to that system of coordinates.

6 Maybe I give you an example. Suppose  
7 we consider point in the geometric space, the  
8 three-dimensional real space in which we live,  
9 right? Unless you are Einstein, and then the space  
10 is four dimensional because you also have time.

11 But let's say we are in Newtonian  
12 physics, we use three dimensions, so we have three  
13 components. We fix our system of coordinates, and  
14 we call the unit vectors pointing in the  
15 directional three axis as I, J and K. The end  
16 point, any point in space, can be written as X  
17 times I plus Y times J plus Z times K.

18 So it is this linear combination of  
19 the three versers with coefficients. Now, if the  
20 three versers are fixed, you don't need to write  
21 them. You just write the point as X, Y, Z. X, Y,  
22 Z is a list of numbers. It's a little column or a  
23 little row of three numbers, X, Y, Z. This is the  
24 same as the vector XI times YJ plus Z times K.

25 So the two things coincide once you

1 fix a system of coordinates. And since -- the way  
2 we represent constellation points is through the  
3 points or the components. It's also in the patent  
4 you have these tables with components and real and  
5 imaginary parts.

6 Q. Thank you for the explanation. I  
7 appreciate it.

8 (Off-the-record discussion.)

9 Q. (BY MR. KHAN:) Going back to Claim  
10 1, the component of the demapper, it also is  
11 capable of determining likelihoods. Do you see  
12 that?

13 A. Yes.

14 Q. What are the likelihoods that are  
15 being determined?

16 MR. DIXON: Objection, relevance.

17 A. Okay. So here I need to get  
18 technical to answer your question. A demapper is a  
19 mathematical operation. I'm not commenting on how  
20 this is implemented. It can be implemented by a  
21 computer or by a hardwire VSI circuitry. I don't  
22 know.

23 But it is a mathematical operation  
24 that given a received signal sample, which is the  
25 output of the demodulator is a received signal

1 sample, imagine that Y received signal, symbol is a  
2 complex number, real or imaginary part, or a vector  
3 of two components, XY.

4 Given that number, given that sample,  
5 and knowing the position of the constellation  
6 points and their binary label, the demapper  
7 produces something called log likelihood ratios for  
8 the bits of the label.

9 There is a mathematical formula, for  
10 example, written and explained in my 1998 paper,  
11 that allows the computation of this log likelihood  
12 ratios. Likelihoods are like a common friendly  
13 term used in engineering. More precisely one would  
14 call them likelihood ratios or log likelihood  
15 ratios when we work in the logarithmic domain as it  
16 is usually done, but this is kind of irrelevant.

17 So what is a likelihood ratio? For  
18 every bit in the signal label, you have two  
19 hypotheses. This bit could be a zero, this bit  
20 could be a one. And then you have an observation,  
21 which is your received signal sample.

22 The likelihood ratio is simply the  
23 ratio of the probability that that bit is a one  
24 given your observation divided by the probability  
25 that bit is a zero, given your observation. So it

1 is the ratio of the a posteriori probability of the  
2 bit being one divided by the bit being zero where a  
3 posteriori means given the condition of the  
4 observation of the received signal.

5 Q. (BY MR. KHAN:) Is this likelihood  
6 different if the received signal has a  
7 one-dimensional constellation compared to a  
8 received signal that has two-dimensional  
9 constellations?

10 A. The mathematical formulation is  
11 identical and applies to any -- any constellation,  
12 any dimension as long as it has a binary labeling,  
13 which is the case. The way to compute it may be,  
14 of course, different, depending on the shape of the  
15 constellation, the dimension and -- so one has to  
16 consider case by case in the actual computation.

17 But the formula ideally is the same.  
18 How you decompose it and you actually compute it  
19 depends, of course, on the formula of the  
20 constellation.

21 Q. Okay. So let's use a specific  
22 example. Say you have a PAM 8, one signal line,  
23 and you have a 64 QAM in the other signal. Would  
24 the likelihoods of these two demodulated signals be  
25 the same or different?

1 MR. DIXON: Objection, form.

2 A. Frankly, I do not understand the  
3 question.

4 Q. (BY MR. KHAN:) Can you let me know  
5 which part you don't understand so I can hopefully  
6 clarify?

7 A. Yes. The problem is "be the same,"  
8 be the same meaning the same value, the same number  
9 or the same general expression?

10 General expression means an  
11 mathematical expression that can be written for any  
12 constellation, any binary labeling --

13 Q. Yeah, thank you for that. I should  
14 clarify. I understand from your last answer that  
15 the mathematical formula is the same regardless of  
16 the -- there's a dimensionality here.

17 My question was: The likelihood  
18 values, when this particular patent limitation  
19 talks about determining the likelihood. So my  
20 question is: The likelihood value that's  
21 determined of, say, a PAM 8 demodulated signal, is  
22 that the same as the likelihood values of a QAM 64  
23 signal?

24 MR. DIXON: Objection, form.

25 A. As a general statement, without any

1 further qualification, the answer is generally no.

2 Q. (BY MR. KHAN:) Okay. A demapper can  
3 be -- can process one-dimensional symbol  
4 constellations -- sorry. Let me scratch that.

5 Is it possible for a demapper to  
6 determine the likelihoods of a one-dimensional  
7 symbol constellation?

8 A. Yes, it's possible.

9 Q. And is it possible for a demapper to  
10 determine the likelihoods of a two-dimensional  
11 symbol constellation?

12 A. Yes, it's possible. It is not going  
13 to be the same demap -- the formula is the same.  
14 When you implement it, you will see there will be  
15 some differences, but the formula is the same  
16 because you can write it in terms of probabilities.  
17 Then you have to explicitate the formal  
18 disprobabilities, and then is where the formula of  
19 the constellation plays a role.

20 Q. You mentioned that it's not going to  
21 be the same demapper. How is the demapper  
22 different for a one-dimensional constellation and a  
23 two-dimensional constellation?

24 A. I can only answer this question  
25 through getting really into the specifics. Do you

1 want me to do it? I can do it.

2 Q. Yeah, please. Please do. I mean,  
3 you are educating me in the process, so I  
4 appreciate it, yes.

5 A. Okay. Can we perhaps bring up my '98  
6 paper?

7 Q. Yeah. Absolutely. I'll -- okay.  
8 Can you see the screen?

9 A. Yes.

10 Q. Yeah.

11 A. So if you scroll down, slowly, such  
12 that -- no, keep going. Keep going. Keep going.  
13 Keep going. Okay.

14 Okay. So we can see here in Equation  
15 7, we see a formula that describes what we call a  
16 bitwise metric. In fact, this is equivalent to  
17 this notional likelihoods. And you can see here --  
18 now, forget about these two distinctions, perfect  
19 CSI, no CSI, that's irrelevant, it's just a formula  
20 of probability distribution involved.

21 But we see here that this likelihood  
22 is a function of the received signal, indicated as  
23 a vector  $\mathbf{Y}$  at the certain time instant  $K$  prime  
24 comma  $B$ .  $B$  is the bit in position  $I$  of the label  
25 of -- of the constellation point. And this is

1 given as the logarithm of the sum over all possible  
2 signals  $X$  in the subconstellation that has bit  $B$  in  
3 position  $I$  of these probabilities.

4 So these probabilities, one has to  
5 explicitate that form. And this depends on the  
6 type of channels we are talking about. For  
7 example, for the Gaussian additive noise channel,  
8 this probability will be a Gaussian distribution.  
9 And a Gaussian distribution can be written in any  
10 dimension.

11 Now, you see here this is general,  
12 expressed in general for a general multidimensional  
13 point  $X$  and  $Y$ . One writes here in this -- instead  
14 of this  $P_{\text{sub-}\theta} Y \text{ given } X$ , you write down the  
15 expression of the corresponding Gaussian  
16 distribution, and you have your explicit formula  
17 for the likelihood of the bit  $B$  in position  $I$  of  
18 the label. And this is where the dimension and the  
19 form of the signal plays a role.

20 So that's the general formula. You  
21 plug in the specific expression of the probability,  
22 and you have the specific case. And of course this  
23 would be different, depending on the constellation,  
24 depending on the dimensionality, etcetera.

25 Q. So thank you for that explanation. I

1 think it's consistent with what you were saying  
2 earlier about the formula can be the same,  
3 regardless of the dimensionality. Is that right?

4 A. That's correct.

5 Q. My question was more towards the  
6 design of a demapper. Do you use the same design  
7 of a demapper for a one-dimensional constellation  
8 compared to the design of a demapper for a  
9 two-dimensional constellation?

10 A. This depends on how the constellation  
11 is formed. One of the advantages of producing  
12 nonuniform QAM constellation by alternativizing two  
13 PAM constellations and using a particular binary  
14 labeling is that the demapper becomes decomposable,  
15 so you can demap using two one-dimensional  
16 demappers operating on the real and imaginary part  
17 of the signal.

18 If this particular structure is not  
19 used, then the demapper will have to operate  
20 directly on the two-dimensional signal, so it is  
21 not decomposable. And this, of course, differs in  
22 complexity. And this is also acknowledged in the  
23 patent where they say that the resulting receiver  
24 demapper is more complex.

25 So the general statement is no, every

1 constellation and labeling has its own demapper.  
2 In some special cases, these operation can be  
3 decomposed and, therefore, resulting in a lower  
4 complexity.

5 Q. And the decomposable design, that's  
6 for, say, multidimensional constellations, for  
7 example, two-dimensional constellation that has  
8 been formed by orthogonalized one-dimensional  
9 constellations; is that right?

10 MR. DIXON: Objection, form.

11 A. It is right in the sense that that's  
12 certainly a sufficient condition. Whether this is  
13 also the only possible case, I don't know. People  
14 have tried all sort of low complexity approaches  
15 here and there. I cannot have a full spectrum of  
16 the literature. But definitely this composition is  
17 possible in the case of when the constellation is  
18 constructed in this way.

19 Q. (BY MR. KHAN:) Would you agree with  
20 me that the multidimensional symbol constellations  
21 recited in Claim 1 do not require these  
22 multidimensional constellations to be formed by  
23 orthogonalizing one-dimensional constellations?

24 A. I agree that in Claim 1, there is no  
25 mention of producing QAM constellation by

1 orthogonalizing PAM constellations. So the claim  
2 is generally referred to multidimensional symbol  
3 constellations.

4 MR. KHAN: We have been going for an  
5 hour twenty minutes. I know it's also past  
6 lunchtime. So, you know, I'm happy to take a break  
7 here, I'm happy to continue, either way. Do you  
8 have a preference, Dr. Caire?

9 A. I'm okay. I don't know. Whatever  
10 everybody wants to do.

11 MR. KHAN: Okay. I want to be  
12 mindful of William and Laura also. Maybe if it is  
13 okay, we can go on for another ten, fifteen minutes  
14 and then take a lunch break. Does that sound okay  
15 to everyone?

16 MR. DIXON: Yep.

17 MR. KHAN: Thank you. I appreciate  
18 that.

19 Q. (BY MR. KHAN:) Claim 1 also recites  
20 a decoder. What is the primary function of a  
21 decoder?

22 A. So the decoder receives from the  
23 demapper the likelihoods of the bits of the labels  
24 of the constellation symbols in a scrambled order,  
25 thanks to this process called bit-interleaving.

1 And uses these likelihoods, which are soft values.  
2 It means they are not zeros and ones. They are  
3 unquantized real numbers or quantized in practice  
4 in a particular implementation of a serial, these  
5 would be quantized in a certain finite mathematics.  
6 But for our purposes here and for the theory, they  
7 are treated as unquantized real numbers.

8 As these were the outputs on a  
9 virtual channel with binary input and after given  
10 by these likelihoods, and then it applies a  
11 decoding algorithm to recover the original binary  
12 message that was transmitted.

13 Q. In this case, the decoding algorithm  
14 that is used, is that an LDPC-based decoding  
15 algorithm?

16 A. Yeah, I assume so. It is written  
17 here, says based upon a low density parity check  
18 code. So LDPC.

19 Q. Does a decoder take into account the  
20 phase value of symbols?

21 A. No. The scheme works in the  
22 following way. The demapper produces these  
23 likelihoods. So the likelihoods, as you -- as we  
24 have seen before, apart from the logarithm  
25 operation, which is just sort of rescaling of

1 things, is essentially a probability. Is  
2 essentially like how likely a certain bit is a zero  
3 or a one, given the received signal.

4 The decoder takes these values which  
5 are real numbers -- there is no phase value at this  
6 point -- and applies a suitable decoding  
7 algorithm -- there are many possibilities. Of  
8 course, this depends on the nature of the code. If  
9 the code is an LDPC, the decoder will use an LDPC  
10 decoder. If the code is a convolutional code, it  
11 will use one of the algorithms proposed for  
12 convolutional codes and so on and so forth.

13 But the demapper provides a sort of  
14 universal interface, such that given the output of  
15 the demapper, the decoder can take those outputs  
16 and treat them as the output of a new channel that  
17 incorporates mapping points and constellations,  
18 transmission, demodulation, demapping in like a  
19 packet. Sort of like a box.

20 So the decoder is essentially  
21 agnostic at this point, is agnostic of the nature  
22 of the channel. As long as it has these  
23 probabilities, it can run the decoding algorithm.  
24 We say this is likely is formed by sufficient  
25 statistics. So it is enough to know this to make

1 an optimal decision.

2 Q. You mentioned that the likelihood is  
3 kind of like a -- the likelihood that a certain bit  
4 is a zero one given the received signal. Did I  
5 understand that right?

6 A. Yes, that is correct.

7 Q. So when there are a bunch of bits  
8 that are close to each other, does that impact the  
9 likelihood?

10 MR. DIXON: Objection, form.

11 A. Well, "impact the likelihood" is not  
12 the right term. The BICM capacity or the parallel  
13 decoding capacity is the sum of the model  
14 informations between each bit of the label and the  
15 output signal. If one bit in the label  
16 distinguishes between points that are very close to  
17 each other, the term in the sum would be very  
18 small. So it is not impacting the likelihood,  
19 which is a random variable and depends on the  
20 particular noise realization. But we may say that  
21 if one bit in the label distinguish between points  
22 that are very close to each other, then the  
23 contribution of that bit to the overall parallel  
24 decoding capacity will be very small.

25 And this, by the way, is seen in many

1 papers who have considered the optimization of QAM  
2 constellations, so in two dimensions. When you  
3 have a sort of clustering, when you optimize the  
4 constellation with sixteen points, for example, at  
5 low signal-to-noise ratio, so you fix a  
6 signal-to-noise ratio that is small. And then you  
7 start from sixteen points, you run your  
8 optimization algorithm, and you will see that these  
9 points coalesce in clusters, points that are very  
10 close to each other, which means that the relevant  
11 information, the bits in the label that carry  
12 relevant -- relevant means amount of information  
13 that is significantly nonzero -- are the bits that  
14 distinguish the clusters, not the bits that  
15 distinguish the points in the cluster. But this is  
16 a natural process in the optimization is if it  
17 happens that some points coalesce in a cluster,  
18 well, this is -- it has to be so. It means that  
19 some bits carry very small informations.

20 Q. (BY MR. KHAN:) You mentioned that  
21 when you have some sort of clustering, you can set  
22 the optimization for a low signal-to-noise ratio.  
23 Why do you do that?

24 A. Actually I didn't say that. I said  
25 that when you set the optimization -- so the

1 signal-to-noise ratio at which the optimization is  
2 preferred to be a low value, for example, zero to  
3 B, suppose I go into optimize my constellation for  
4 zero to B. Zero to B is a low value. Why is it a  
5 low value? It means that the signal and the noise  
6 have the same power, right? Zero to B means that  
7 the ratio is one, so same power.

8 Channel capacity at zero to B is one  
9 bit per second per hertz. Or if you want, it is  
10 equivalent as what you would achieve, roughly  
11 speaking, with a QPSK. So four points equal a  
12 space in the four quadrants with a coding rate one  
13 half. So every bit in the label carries a half of  
14 a bit. You have two bits in the label. You have  
15 one bit, one information bit per complex symbol or  
16 one half information bit per real dimension.

17 This is what Shannon says. We cannot  
18 do better than that.

19 So if I ran the optimization starting  
20 from a large dimensional -- not large dimensional,  
21 sorry, a large-size constellation -- large size  
22 means many points on the complex plane, and I ran a  
23 good optimization algorithm, these points will  
24 somehow cluster such that they -- at the end, the  
25 resulting constellation looks like essentially the

1 four points I just described. So it is not that if  
2 you have clustering, you optimize a low signal --  
3 if you optimize a low signal --

4 (Off-the-record discussion.)

5 A. I said it is not that if you have  
6 clustering, you optimize at low signal-to-noise  
7 ratio. Rather, it is the opposite. If you  
8 optimize a low signal-to-noise ratio, you will see  
9 some form of clustering.

10 Q. (BY MR. KHAN:) Thank you. I  
11 appreciate that. So it is the other way around,  
12 right?

13 A. Yeah.

14 Q. Okay. And so --

15 (Pause.)

16 Q. (BY MR. KHAN:) So going back to the  
17 claim, in the -- in the -- in these steps for the  
18 decoding and the demodulation and the demapping, so  
19 these three steps, demodulation, demapper, decoder,  
20 which one of these steps factors in the phase value  
21 for the different symbols?

22 A. So the phase value of the symbols is  
23 used in the demapper. If you represent the symbols  
24 in real, imaginary parts or in amplitude and  
25 phase -- it is like points in the complex plane --

1 the demapper must know the position of the symbols,  
2 they must know the constellation. So this is where  
3 the phase value of the symbols are implicitly used,  
4 whether -- it depends on the type of constellation.

5 If it is, for example, a phase type  
6 of constellation, like a PSK constellation, then  
7 only the phases are relevant. If it is a QAM  
8 constellation, then phase and amplitude or  
9 equivalent, real and imaginary part, is relevant.  
10 But this is where explicitly or implicitly the  
11 phase value of the symbols in the constellation is  
12 used.

13 (Off-the-record discussion.)

14 Q. (BY MR. KHAN:) So in order to  
15 determine the likelihoods of a multidimensional  
16 symbol constellation, is it fair to say that the  
17 demapper would then use phase value of different  
18 symbols in the multidimensional symbol  
19 constellation?

20 A. Not --

21 MR. DIXON: Objection to the form.

22 A. -- necessarily. Not necessarily. As  
23 I said before, it depends on the nature of the  
24 constellation.

25 Q. (BY MR. KHAN:) Okay. Could you

1 clarify? I thought I understood if it is a  
2 multidimensional symbol constellation, they  
3 typically have some sort of -- points typically  
4 have amplitude and phase, right? Is that right?

5 A. That is correct. Every point in,  
6 let's say, two real dimension can be considered as  
7 a point in -- as a complex number. And complex  
8 numbers have two canonical representations. One is  
9 in real and imaginary parts. Those are two real  
10 numbers. Or in polar form, as an amplitude and a  
11 phase.

12 So whether the demapper uses the  
13 polar form coordinates system or the Cartesian form  
14 coordinate system depends on the constellation,  
15 depends on how you implement the demapper. So the  
16 demapper may use real and imaginary parts or  
17 amplitude and phase. It really depends on the  
18 nature of the constellation.

19 Q. So -- what you are saying is  
20 basically -- sorry. Let me -- let me get some  
21 clarification.

22 My understanding of what you just  
23 said is that the demapper can use, among other  
24 things, two parameters. Those parameters can take  
25 the form of either a real or imaginary part or

1 amplitude and phase; is that right?

2 A. It is right. But I would -- I would  
3 like to understand if you are talking about -- when  
4 you say the signal, you refer to the signal points  
5 in the constellation or the received signal, what  
6 we have called Y in the paper, in the patent, is  
7 normally X is the transmit signal, so it is a point  
8 in the constellation; Y is the received signal.

9 What are you referring to in your  
10 question because --

11 Q. Sure. So maybe -- thank you. So I  
12 should maybe be a little more clear here.

13 When I look at the claim limitation  
14 of the demapper, it says using the demodulate  
15 signal, determining the likelihoods using the  
16 demodulate signal, right?

17 And it is my understanding that this  
18 demodulated signal -- I'm sorry. It says  
19 demodulated signal and a multidimensional symbol  
20 constellation. So it is my understanding that then  
21 when a multidimensional symbol constellation is  
22 part of the demodulated signal, right, that then,  
23 in the case, for example, of a two-dimensional  
24 constellation, you would then -- the demapper would  
25 use two parameters, you know, either the real and

1       imaginary or the -- the amplitude and phase.

2                       MR. DIXON: Objection.

3               Q.       (BY MR. KHAN:) That is what I was  
4       trying to get at. Is that right?

5                       MR. DIXON: Objection, form.

6               A.       It is generally right. The demapper  
7       would take the received signal sample Y, either in  
8       real and imaginary part or in amplitude and phase,  
9       and would calculate the likeliness of the bits of  
10      the labels by applying the formula we have seen  
11      before, which involves also the points of the  
12      constellations which would also be represented  
13      either in real and imaginary parts or amplitude and  
14      phase.

15              Q.       And when you have a one-dimensional  
16      symbol constellation, as in the demodulated signal,  
17      the demapper would just have one parameter instead  
18      of two parameters to perform the demapping; is that  
19      right?

20                      So, for instance, if it is the case  
21      of, you know, real and imaginary parts in the case  
22      of a one-dimensional constellation, you would just  
23      have the real part and there would be no imaginary  
24      part; is that correct?

25              A.       It is a little bit more complicated

1       than that. So if I may say --

2               Q.       Sure.

3               A.       Okay. Okay. So a pass band channel,  
4       for example, a radio channel around a certain  
5       carrier frequency, when the demodulator translates  
6       the signal from the carrier frequency to the base  
7       band always generates, in principles, a complex  
8       signal. Complex means that there is one component  
9       modulating the carrier in phase; the other  
10      component modulating the carrier in quadrature for  
11      the pure fact that when you have a sinusoid. A  
12      sinusoid at a given frequency is defined by --

13                   THE REPORTER: I didn't understand  
14      that.

15              A.       I repeat. For the simple fact than  
16      when you modulate a sinusoid, so a carrier, the  
17      sinusoid at a given carrier frequency is defined by  
18      its amplitude and its phase. So the modulated  
19      signal has always two parameters, amplitude and  
20      phase. If for some reason the information is only  
21      encoded in the amplitude, then the demodulator,  
22      which always operates something called carrier and  
23      phase recovery, which means it is able to  
24      distinguish between the in-phase and the quadrature  
25      components, in this case will only extract the real

1 part of the signal, which is a real number and  
2 therefore -- and so it is the amplitude.

3 Now, one can distinguish about  
4 coherent demodulation, noncoherent demodulation,  
5 perfect carrier recovery, carrier recovery with  
6 error, etcetera, etcetera, etcetera, and we can go  
7 on and recite the whole book in this communication,  
8 and probably this would be inappropriate.

9 However, in almost all modern  
10 communication systems, carrier recovery is done  
11 very precisely, which means that the demodulator is  
12 able to lock into the phase of the modulating  
13 carrier and recover the real part and the imaginary  
14 part of the signal with an extremely small phase  
15 error, which means that essentially it can  
16 distinguish very well between these two components  
17 and now, if for some reason, the information is  
18 only contained in the real part, then we will have  
19 only the amplitude of modulation. And if the  
20 information is contained in the real and imaginary  
21 parts, then we have the two dimensions. It is as  
22 simple as that.

23 Q. (BY MR. KHAN:) Okay. I will try  
24 to -- thank you for the explanation. I will try to  
25 follow.

1 I understand you are saying the  
2 modulated signal can have these two components, but  
3 the demapper that we are working with in the claim  
4 uses a demodulated signal, right?

5 A. Right. Right.

6 Q. So we are not dealing with a  
7 modulated signal with the demapper; we are dealing  
8 with a demodulated signal, right?

9 A. That is correct. The demodulated  
10 signal is the signal that you obtain by translating  
11 the frequency. The moderated signal to the base  
12 band after recovering timing for sampling and  
13 carrier phase to distinguish between real and  
14 imaginary parts. This is all the operational  
15 demodulator, and the demodulator outputs two  
16 samples, I, Q, real, imaginary, in general. That  
17 is the general scheme.

18 Q. Yeah. So I understand that the  
19 output of the demodulator can have a real and  
20 imaginary part -- identify the real and imaginary  
21 part of the signal.

22 Now, for a one-dimensional  
23 constellation, is the output normally just the real  
24 part of the signal?

25 A. Yes, it is. A typical example is a

1 base band transmission. In base band transmission,  
2 which means no carrier modulated signal, you simply  
3 transmit that frequency to zero, and this is done  
4 in certain applications, then only amplitude  
5 modulation is used. And in this case, you will  
6 only have the real part.

7 (Off-the-record discussion.)

8 Q. (BY MR. KHAN:) And I guess  
9 consistent with that, when you have a  
10 two-dimensional symbol constellation, then you can  
11 have the real and imaginary part, right, and that  
12 information is then used by the demapper?

13 A. That is correct.

14 Q. Okay.

15 MR. KHAN: Okay. I went past my  
16 fifteen minutes. Sorry about that. It's 1:30. We  
17 can take a lunch break. How long of a break would  
18 you like for lunch? If there's no -- I want to be  
19 respectful of your time. We can do like -- do you  
20 prefer forty-five minutes for lunch or one hour?  
21 What, do you have a preference?

22 Okay. If no preference, then maybe  
23 -- it's 1:30, approximately 1:30 now. How about we  
24 reconvene at 2:15? Does that sound okay?

25 A. (Nodding.) Yes.

1 MR. KHAN: Fantastic. Great. Thank  
2 you. We'll talk to you at 2:15.

3 (Whereupon, a break was had from 1:28  
4 p.m. until 2:25 p.m. EDT)

5 Q. (BY MR. KHAN:) Welcome back,  
6 Dr. Caire. We were just going through Claim 1  
7 before the break. And Claim 1 and Paragraph 5 of  
8 your second declaration used the term "degree of  
9 freedom."

10 A. Yes.

11 Q. All right. Do you see that? And  
12 also that section that you were referring to  
13 earlier in the '700 Patent, which is the Column 13,  
14 like Lines 1 to 11, right, that also -- do you see  
15 on Line 5 it uses the term "degree of freedom"?

16 A. Yep. Yes, I see.

17 Q. What does the term "degree of  
18 freedom" mean in the context of the '700 Patent?

19 A. Right. So degrees of freedom in this  
20 context means the number of parameters with respect  
21 to which a constellation is optimized. And in  
22 particular, when we talk about the optimization of  
23 the constellation points, this will be the  
24 coordinates of the points.

25 So if we work in two dimensions, we

1 have two degrees of freedom. If we work in one  
2 dimension, we have one degrees of freedom.

3 But --

4 Q. Okay.

5 A. But degrees of freedom in general, in  
6 the context of optimization is the number of  
7 variables -- it is a little bit of a vague concept.  
8 In this concept there's not like a very strict  
9 definition. But it is essentially the number of  
10 variables that you can queue up in the -- in the  
11 optimization.

12 In engineering, it can be used in --  
13 with a little bit of a loose sense. You will see  
14 the degrees of freedom concept appearing with  
15 different meanings in many different contexts. But  
16 in this context, I interpret this as the parameter  
17 used for optimization.

18 Q. Okay. So is it fair to say like the  
19 PAM, a constellation has one degree of freedom?

20 A. It's fair to say that the way this  
21 constellation -- that this term is used in the  
22 patent express -- expresses this -- this concept,  
23 yes.

24 Q. All right.

25 A. I --

1           Q.       And is it fair to say that QAM has  
2 two degrees of freedom?

3           A.       Yes, although the degrees of freedom  
4 can be constrained. So when we talk about the  
5 optimization problem, we have an objective function  
6 and a set of constraints. So variables may not be  
7 independently chosen.

8                    So this is slightly debatable.  
9 Because problems, optimization problems have  
10 constraints. And then I would say it depends on  
11 the constraints.

12           Q.       Does the optimization depend on the  
13 constraints or the degrees of freedom depend on the  
14 constraints?

15           A.       So in an optimization problem -- an  
16 optimization problem is defined by an objective  
17 function, which is the function we want to maximize  
18 or minimize, depending on the nature of the  
19 function. The function is a function of several  
20 variables.

21                    And then we have a constraint set in  
22 general. Of course a special case of an  
23 optimization problem is an unconstrained  
24 optimization without constraints.

25                    But if we -- in the general setting,

1 we have a constraint of optimization, and the  
2 constraints may be due to various reasons. They  
3 may be -- the energy of the constellation may be  
4 constrained to be unit energy, the -- et cetera.  
5 We have several different constraints.

6 Now, the constraint set is the domain  
7 over which we optimize, right? So we have to  
8 measure the function of many variables and then we  
9 have a domain. And we look for the maximum in this  
10 domain.

11 Now, the constraint set may reduce  
12 the degrees of freedom of the optimization in the  
13 sense that although the function is a function of,  
14 for example, several variables, the constraint set  
15 may impose a relation between these variables such  
16 that the possible points to be considered live in a  
17 lower dimensional space.

18 And then it's a little bit of a  
19 debate, I would say in terminology, right? I will  
20 say that some people may look at degrees of freedom  
21 in the sense of the number of variables of the  
22 objective function. Some people may say degrees of  
23 freedom is the dimensionality of the constraint  
24 space.

25 Sometimes this constraint space is

1 the dimensionality that -- like, for example, a  
2 sphere in three dimension is a three-dimensional  
3 body. But if I constrain these variables to lie on  
4 the surface of the sphere, what is that? A surface  
5 is a two-dimensional manifold but lives in a  
6 three-dimensional body. Is the problem  
7 three-dimensional or two-dimensional? It's a  
8 little bit of a question, right? You can find both  
9 cases.

10 Q. That seems like there are a lot of  
11 different -- just a lot of different parameters and  
12 information to consider when you're thinking about  
13 the degrees of freedom and optimization; is that  
14 right? I mean -- yeah.

15 A. Yeah. I would say degrees of freedom  
16 in an optimization is a little bit of a soft  
17 concept, I would say, is a little bit of a soft  
18 concept.

19 Q. And by soft, do you mean like vague  
20 or open or -- I'm trying to understand what you  
21 mean by that.

22 MR. DIXON: Objection, form.

23 A. I mean that you may find some authors  
24 that would loosely refer as degrees of freedom as  
25 the number of variables with respect -- appearing

1 in -- say with respect to the optimization.

2 So if you have a function of four  
3 variables, you say okay, it's a four-dimensional  
4 optimization problem. Four degrees of freedom.  
5 But maybe the constraint set imposes a relation  
6 between these variables, so you're moving a  
7 manifold that is a surface that maybe is a  
8 three-dimensional body in a four-dimensional space.

9 So on the other hand, there is no  
10 efficient representation in three dimension because  
11 the manifold is complicated, so you're still moving  
12 in a four-dimensional space. But the constraints  
13 it imposes these variables to be in a certain  
14 relation, so there are points on a  
15 three-dimensional manifold. That's why I say it's  
16 a little bit of a soft concept.

17 Q. (BY MR. KHAN:) And so the -- and so  
18 to understand -- all right. So what I understand  
19 is that different authors may refer or mean  
20 different things when they say degrees of freedom,  
21 and when they talk about optimizing degrees of  
22 freedom, it could mean different things.

23 MR. DIXON: Objection, form.

24 A. Optimizing degrees of freedom is not  
25 what I meant. It is more like in how many ways or

1       how many variables you can operate in the  
2       optimization process. Right?

3               Q.       (BY MR. KHAN:) Well, I'm trying to  
4       ask you, I -- what I asked you earlier was, you  
5       know, there's a QAM of two degrees of freedom, and  
6       you said, well, it depends on the constraints. And  
7       then you said, well, it depends on how a person of  
8       ordinary skill in the art -- I'm sorry, what was  
9       the word, how some authors would refer to the  
10      degrees of freedom.

11               So I'm trying to understand then like  
12      are they just different understandings of what  
13      degrees of freedom are, it depends on the context,  
14      or how do you figure out, if I have a QAM  
15      constellation, you know --

16              A.       Right.

17              Q.       -- is that two degrees of freedom or  
18      something else? How do you figure that out?

19              MR. DIXON: Objection, form.

20              A.       Okay. I can explain -- I can give  
21      you my opinion, and then -- or -- and/or my opinion  
22      on the meaning that is used in the patent. They do  
23      not coincide, necessarily.

24              So you want my opinion in general  
25      or --

1           Q.       (BY MR. KHAN:) I am happy to hear  
2 both. I'm getting educated in the process, so I'm  
3 happy to hear both.

4           A.       Okay. So I would consider fair -- a  
5 fair definition of degrees of freedom in an  
6 optimization problem the number of variables that  
7 can be set independently to explore the domain over  
8 which the optimization is performed, which, in this  
9 case, for a constellation where -- of N points,  
10 each point corresponds to two real coordinates,  
11 real imaginary part, with a constraint on the total  
12 average power, which means one over M sum of the  
13 square of the coordinates of the point equal to  
14 one, reduces to two M minus one, three variables.

15                   So I would say that the optimization  
16 problem has two M minus one variables that you can  
17 freely set to explore the domain of the  
18 optimization.

19                   So I don't think that the  
20 optimization of a PAM constellation has one degrees  
21 of freedom. I don't think that the optimization of  
22 a QAM constellation has two degrees of freedom. In  
23 general, you can move -- every point of the  
24 constellation is defined by either one or two  
25 parameters, so the real component or real and

1       imaginary components. And this is what I would  
2       define as degrees of freedom of the optimization  
3       problem.

4                       Now, having said that, I believe that  
5       the patent, as well as other authors, in  
6       particular -- now I don't remember exactly. I  
7       should take a pause and review it.

8                       But I think that in the ISTT and  
9       probably in other papers, the term "degrees of  
10      freedom" if ever used is referred to the dimension  
11      of the signal set, because this is the usual term  
12      used in digital communications to express how many  
13      real symbols we can transmit per unit interval, per  
14      symbol interval.

15                      So PAM has -- transmits one  
16      amplitudes. QAM transmits one real and one complex  
17      amplitude or one amplitude and one phase, so it's  
18      usual to refer to degrees of freedom as the  
19      dimension over the real dimensions of the  
20      constellation. And this is different from the  
21      degrees of freedom in the optimization problem, is  
22      not the number of variables that you optimize; it  
23      is the dimension of the constellation.

24                      In the patent, this is expressed in  
25      this way.

1 (Pause.)

2 (Off-the-record discussion.)

3 Q. (BY MR. KHAN:) So I understand  
4 you're saying that in the '700 Patent and the '777  
5 Patent, the degrees of freedom essentially refer to  
6 the number of dimensions of the constellation.

7 Is that correct?

8 A. That's my understanding.

9 Q. And -- but you said that when it  
10 comes to optimizing, the optimization problem, the  
11 degrees of freedom can mean something other than  
12 the number dimensions.

13 Is that correct?

14 A. This is what I would use when talking  
15 about degrees of freedom in an optimization  
16 problem.

17 Q. So your understanding of degrees of  
18 freedom is a little bit different from what the  
19 understanding -- other than what the degree of --  
20 sorry. Scratch that.

21 So your understanding of the degrees  
22 of freedom is a little different than the way  
23 somebody would have understood "degree of freedom"  
24 to mean in the '700 and '777 Patents; is that  
25 right?

1           A.       Let me be more precise. In digital  
2 communication, degrees of freedom can be used in  
3 several different ways, depending on the context.  
4 It is customary to refer to degrees of freedom in  
5 the transmission of a signal as the dimension of  
6 the symbols that you transmit.

7                   So a complex signal or a real and  
8 imaginary part, I and Q, two degrees of freedom per  
9 symbol. That's usual language. And I believe that  
10 the patent uses these degrees of freedom  
11 terminology in this context.

12                   Essentially, dimensionally the  
13 constellation is -- is sort of synonymous of  
14 degrees of freedom, which is the usual way -- it's  
15 used in many -- in many -- in many references, the  
16 usual way of referring to degrees of freedom in  
17 this context.

18                   Then I wanted to be precise and say  
19 if we talk about an optimization problem, this  
20 would not be the way I refer as degrees of freedom  
21 of the optimization problem. The optimization  
22 problem, I would refer to the number of degrees of  
23 freedom of the optimization problem as the number  
24 of independent variables that need to be set in  
25 order to fully explore the constraints of the

1       problem.

2               Q.       And when these -- so when you say the  
3       optimization problem, right, I'm trying to  
4       understand that. So in Column 13, Lines 4 and 5,  
5       right, it says the optimization step of the  
6       additional degree of freedom, right?

7               So now does that -- does that involve  
8       the degree of freedom -- sorry. Should that be --  
9       should the use of degree of freedom in that  
10      sentence be construed consistent with the  
11      optimization problem or according to like the  
12      number of dimensions?

13              MR. DIXON: Objection, form.

14              A.       In this context, this is consistent  
15      with the number of dimensions for the following --  
16      in the following sense: What is written here is  
17      that it is possible to take direct advantage in the  
18      optimization step of the additional degrees of  
19      freedom presented by an extra spatial dimension.

20              So this means that if one optimized  
21      the constellation directly in two dimensions, one  
22      can take advantage with respect to if one imposes  
23      the constraint that the constellation must be a  
24      broader constellation, broader meaning optimizing  
25      two PAM, because, of course, one is in a special

1 case of the other. So in this case, you have  
2 enlarged the surface space, and this can yield  
3 additional direct advantage as is written here.

4 So this paragraph essentially, in my  
5 opinion, states that extending the optimization  
6 directly in the two dimensions, one can obtain  
7 additional advantage, which is understandable,  
8 because if you relax the constraints, the  
9 constraint set, you can get better results. That  
10 is a matter of life, right? This is how  
11 optimization problems work. If one is a relaxation  
12 of the other, you can find something better.

13 Q. (BY MR. KHAN:) How did you determine  
14 that your understanding of degrees of freedom was  
15 different than the one in the patent, the '700  
16 Patent?

17 A. Now, maybe I didn't express myself  
18 fully correctly. What I wanted to say is that we  
19 have to distinguish the way that the -- the usage  
20 of the terms "degrees of freedom" in the patent,  
21 which seems to me consistent with the  
22 dimensionality of the signal set.

23 Q. Okay.

24 A. And they use degrees of freedom that  
25 I would use refer to an optimization problem, which

1 is, I would say, consistent with the mainstream  
2 optimization theory that you can find in books.

3 Q. Okay.

4 A. But if I had to use degrees of  
5 freedom to refer to a signal, I would use degrees  
6 of freedom in the same way it is used in the  
7 patent, because this is a usual way that you find  
8 definition of degrees of freedom when referring to  
9 a modulated signal.

10 Q. Okay. And so in the context of the  
11 '700 and '777 Patents, when they say degrees of  
12 freedom -- sorry.

13 In the context of the '700 and '777  
14 Patents, a 1-D constellation has one degree of  
15 freedom and a 2-D constellation has two degrees of  
16 freedom?

17 A. That's correct. In this context,  
18 this is the way they say.

19 Q. Going back to constellation  
20 designing, can constellation points be nonuniformly  
21 spaced in one dimension by uniformly spacing  
22 another dimension?

23 A. Yes. I certainly can state an  
24 example where spacing is uniform in the Y axis and  
25 nonuniform in the X axis.

1           Q.       So is it -- I'm sorry. I am not an  
2 expert in the field. But is it accurate to say  
3 that -- is it the same thing to say that  
4 constellations can have nonuniform space points in  
5 one degree of freedom and not in the other degree  
6 of freedom?

7           A.       According to the commonly accepted  
8 language, I would say yes, it is fair to say that  
9 the constellation can have this.

10          Q.       And when you have nonuniformly spaced  
11 points in a -- along one degree of freedom in a  
12 multidimensional constellation, and the spacing is  
13 adjusted for those constellation points in a  
14 nonuniform way, how does that impact the SNR, if at  
15 all?

16          A.       If the constellation has the same  
17 average power, so one over the number point sum of  
18 the magnitude of squares of the distance of the  
19 points from the origin is the same as it is in this  
20 optimization. You always have to normalize the  
21 average power; otherwise, the optimization doesn't  
22 make sense. Then, of course not. The spacing of  
23 the points provided that the sum of the square is  
24 divided by the number of points is constant has no  
25 impact on the SNR because the SNR is the average

1 transmitted power. So the average single power  
2 over the average noise power and the average single  
3 power is defined as these normalized sum. Like if  
4 you want, it is the second moment of the  $X$   
5 variable.  $X$  is randomly distributed over the point  
6 of the constellation.

7 So you normalize the second moment.  
8 Otherwise your optimization point doesn't make  
9 sense, right? One could get a higher capacity  
10 simply by blowing up this number, and you have like  
11 a very large SNR, and you cannot compare two  
12 constellations with different second moment. It is  
13 an unfair comparison.

14 Q. I see. So you mentioned this like  
15 one over the sum of the square. I'm sorry, but I  
16 don't follow --

17 A. Sorry. One over  $M$ .  $M$  is the number  
18 of points. So it is like -- it is like an  
19 empirical mean, right, one over  $M$  times sum over  
20 the terms. And the terms you sum is the square  
21 distance between the origin and the points.

22 Q. Okay. Hmm. Thank you. Was that  
23 equation in the '700 or '777 Patents, do you  
24 recall?

25 A. I need to look at it. I don't recall

1 if there is an equation -- but -- okay. In the  
2 '700 Patent it is written -- maybe it is before.  
3 Give me five minutes.

4 Q. No problem. Take your time.

5 A. I've checked, there is nothing else,  
6 because I see where it is written, but there may be  
7 some kind of places -- hmm.

8 (Pause.)

9 A. Okay. Seems that the only place  
10 where SNR is defined is Column 13, Line 24: The  
11 average SNR of the system remains the same as in  
12 the case of the AWGN channel, and then you see that  
13 there is expectation of  $X^2$  divided by  
14 expectation of  $N^2$ . Expectation of  $X^2$   
15 is the second moment of the constellation points.  
16 Expectation of  $N^2$  is the variance of the  
17 noise. And this is how in communication theory you  
18 usually define SNR.

19 Q. (BY MR. KHAN:) Yeah, I guess my  
20 question is a little different. This you are  
21 saying is the definition of SNR. What I was asking  
22 for is that earlier equation that you kept  
23 mentioning, one over  $M^2$  or  $M$ , something of  
24 that --

25 A. But that expectation is, if you write

1 explicitly, is exactly what I -- what I said,  
2 because what does it mean expectation? When you  
3 use the points with the same probability, one over  
4 the number of points, which is always the  
5 assumption in this case, which is always the case  
6 when you have a linear code like an LDPC driving  
7 mapping, the bits are uniformly distributed. So  
8 the labels are uniformly distributed. So they  
9 appear with the same probability, one over M where  
10 M is the number of points.

11 So this expectation explicitly is  
12 written as what I just said. But, of course,  
13 written as an expectation of an operator  
14 mathematically is the same as long as the context  
15 is clear. If you have to calculate the second  
16 moment, you would use the formula I just said in  
17 words, basically.

18 (Pause.)

19 Q. (BY MR. KHAN:) Okay. So I  
20 understood -- I guess my earlier question was, you  
21 know, you know, how does -- when you modify the  
22 spacing in a nonuniform constellation, how does  
23 that impact the SNR. You said first you have to --  
24 I guess there's understanding that the  
25 constellation still has to -- before and after the

1       shifting, it has to have the same average power.  
2       And then you have to normalize the average power.  
3       And then you can determine the SNR from there.

4                     Is that right?

5             A.       That is correct.

6             Q.       Okay. And going through these sort  
7       of steps would have been something very obvious to  
8       a person ordinarily skilled in the art?

9             A.       Well, from the moment you say  
10       optimizing the capacity for a given SNR, the  
11       constraint is that -- in the SNR is given. So all  
12       the constellation of when you are moving the points  
13       using your optimization algorithms, you cannot  
14       change the SNR because it is for a given SNR. So  
15       that is talking about --

16            Q.       I'm sorry. That wasn't my question,  
17       though. That wasn't my question, though. All  
18       right.

19                    My question -- like you talked about  
20       these steps, right, these steps that you performed  
21       to determine the SNR. And I said all that would  
22       have been very obvious -- all that would have been  
23       obvious to a person of ordinary skill in the art  
24       familiar with this technology?

25            A.       I -- I am afraid I am not -- I do not

1 understand the question. What steps are you  
2 referring to?

3 Q. Okay. So you had mentioned that you  
4 have to -- when I asked how do you determine -- how  
5 does it impact the SNR when you move the points,  
6 right, at that point you said: Well, first you --  
7 I can go back and read the transcript. One second.

8 Yeah. "So first you have to  
9 determine the before and after shifting, there's  
10 the same average power. Then you normalize the  
11 average power, and from there you can determine the  
12 SNR."

13 That was the steps I am talking  
14 about.

15 MR. DIXON: Objection, form.

16 A. So a bit more precisely. Before  
17 after the shifting means considering the  
18 optimization problem, right? I shift the points to  
19 try to maximize capacity at a given SNR.

20 So for every shift, this number -- so  
21 this second moment must be the same. Now,  
22 normalize means that this number is equal to one.  
23 It doesn't need to be equal to one as long as you  
24 fix it and then, as you move the points, the points  
25 are moving in a way that this number remains

1 constant; otherwise, your optimization doesn't make  
2 sense. It is not an optimization for a given SNR  
3 anymore.

4 So this number, this second moment,  
5 at every level of the shifting must remain constant  
6 or, in other words, imposing the second moment  
7 equal to one without loss of generality. We can  
8 always choose it equal to one, so normalize, and  
9 then adjust the noise power to such that one over  
10 noise power is equal to the SNR that we want.  
11 Because only the ratio counts; it is not the  
12 absolute value of the numerator and denominator.

13 Then this is a constraint in the  
14 problem. A constraint in the problem means that  
15 the physical solution must satisfy this constraint.  
16 So if you take like before and after the shifting  
17 as before, say, before the optimization and after  
18 the optimization, yes.

19 If we have optimized for a given SNR,  
20 before the optimization, after the optimization,  
21 this second moment must be the same.

22 I cannot hear you anymore.

23 Q. (BY MR. KHAN:) Thank you. I  
24 appreciate the explanation. I have a similar  
25 question.

1                   So you have nonuniform,  
2 multidimensional constellation, say, a  
3 two-dimensional constellation and you adjust the  
4 spacing between the points, how does that impact  
5 the parallel decoding capacity?

6                   A.       Generally speaking, the parallel  
7 decoding capacity depends on the constellation and  
8 on the binary labeling. So if you modified the  
9 position of the point by adjusting their spacing,  
10 the parallel decoding capacity changes.

11                   Now, whether it increases or it  
12 decreases depends on how you adjust the points,  
13 right?

14                   Q.       So if you were trying to identify a  
15 constellation that provides a greater parallel  
16 decoding capacity, is it typically like you just  
17 adjust the spacing of the points in the  
18 constellation until you get a maximum value for the  
19 parallel decoding capacity, or is it that or is it  
20 something else involved in the process?

21                   MR. DIXON: Objection, form.

22                   A.       Okay. In full generality, as I said  
23 before, the parallel decoding capacity depends on,  
24 let's say, three things: One is the  
25 signal-to-noise ratio; two, the constellation;

1 three, the binary labeling of the points of the  
2 constellation.

3 So suppose that we are optimizing the  
4 parallel decoding capacity for given SNR. So the  
5 SNR is fixed, which means, as we said before, that  
6 we can normalize the second moment of the  
7 constellation to one and then we set the noise  
8 power as one over SNR. So the SNR is fixed to some  
9 value SNR. That is one constraint.

10 Then more than adjusting the spacing  
11 between the points, which is ambiguous because on  
12 the Claim, the spacing between the points can go in  
13 many directions, I would say adjust the position so  
14 the coordinates of the points, trying to maximize  
15 your objective function, which is the parallel  
16 decoding capacity.

17 How to do it is a different story.  
18 There are several optimizers. The problem is  
19 highly noncomplex, nonlinear, so it is a tough  
20 problem for which there are several methodologies  
21 that can be used.

22 Third, one should also in principles  
23 look at the labeling. The binary labeling has an  
24 impact on the parallel decoding capacity. Having  
25 said that, the optimization of the labeling is even

1 a much tougher problem because the labeling is  
2 nondifferential.

3 So, for example, techniques based on  
4 stochastic gradient search, simulated annealing and  
5 things like that that assume some sort of  
6 differential ability cannot be applied. So it is  
7 customary in, I would say, almost all works that  
8 were given as exhibits, including the thesis, to  
9 fix the labeling to be so-called binary reflected  
10 gray or quasi gray.

11 Gray labelings are labelings for  
12 which labels of points, nearest neighbors' points  
13 differ by a single bit. And it is well-known,  
14 since my original papers and several papers after  
15 that, that these type of labelings are, I would  
16 say, pragmatically optimal under the parallel  
17 decoding capacity, in the sense that I am not aware  
18 of other type of labelings that have shown  
19 significant advantages or even small advantages.

20 So because the optimization problem  
21 is differential with respect to the point  
22 coordinates and nondifferential with respect to the  
23 labeling, and experience many papers, years and  
24 years of simulations have shown that this quasi  
25 gray or gray labelings are essentially optimal,

1        what people has done, including the DeGaudenzi, the  
2        thesis, virtually all of the papers that have been  
3        shown, is to fix the labeling to be gray or quasi  
4        gray if gray is not possible and then optimize the  
5        coordinates of the points.

6                    (Off-the-record discussion.)

7                Q.        (BY MR. KHAN:) Dr. Caire, the  
8        communications systems of Claims 1 and 5, does that  
9        include a storage unit?

10                MR. DIXON: Objection, relevance.

11                A.        I need to read the text.

12                    (Pause.)

13                A.        I am afraid I cannot answer to the  
14        question. I don't understand what you mean by  
15        including a storage.

16                Q.        (BY MR. KHAN:) The question was  
17        whether the claim -- the communication system of  
18        Claims 1 and 5 includes a storage unit.

19                MR. DIXON: Objection, form and  
20        relevance.

21                A.        A fair answer may be that storage  
22        units may be needed in the implementation of such  
23        system. Virtually any computer has a storage unit  
24        to receive blocks or receive signal. The LDCP  
25        coder has storage. Firmware is stored somewhere.

1       So virtually any digital communication system makes  
2       use of some storage units.

3               If by including a storage unit you  
4       mean like a hard disk or a large RAM of memory to  
5       store large portion of the bits or the signal, not  
6       necessarily; it depends. But if we go into the  
7       circuits and depending on how they are implemented,  
8       generally speaking, probably yes. It is  
9       implementation dependent. But it is hard to think  
10      about how such a system, even an LDPC decoder, you  
11      have to store the block of data somewhere to decode  
12      them.

13             Q.       (BY MR. KHAN:) The claim doesn't  
14      recite an LDPC decoder, right?

15             A.       Well, I think it does. A decoder  
16      coupled to a demapper capable of using the  
17      likelihood --

18                     (Off-the-record discussion.)

19             A.       "A decoder coupled to a demapper  
20      capable of using the likelihoods determined by the  
21      demapper to provide a sequence of received bits  
22      based upon a low density parity check (LDPC) code."

23                     So there is a decoder to decode an  
24      LDPC code. This is an LDPC decoder.

25             Q.       (BY MR. KHAN:) This decoder could

1 use -- could use other codes as well, right?

2 MR. DIXON: Objection, form.

3 A. I don't understand the question.

4 Q. (BY MR. KHAN:) Well, my  
5 understanding is you are saying that the claim has  
6 an LDPC decoder because it recites that the decoder  
7 here can provide a sequence of received bits upon  
8 an LDPC code; is that right, even though -- sorry,  
9 essentially even though the claim does not  
10 explicitly recite an LDPC decoder?

11 MR. DIXON: Objection, form.

12 A. So a decoder able to decode an LDPC  
13 code is, by definition, an LDPC decoder. Can one  
14 use the same decoder to decode another code? If  
15 the decoder is a soft -- implemented in software  
16 like in a software implementation, yes, the decoder  
17 is just a computer that runs the program. If you  
18 load a different program, it will decode a  
19 different code.

20 If the decoder is a chip that can do  
21 only one thing because it is highly optimized to do  
22 one thing, then, no, because a decoder can decode a  
23 class of codes, as it has been designed to decode.  
24 And since this is hardwired on the other side, it  
25 cannot do other things. So I don't know what

1 the -- the department says a decoder capable of  
2 using to decode a low density parity check code.

3 Q. (BY MR. KHAN:) And earlier I asked  
4 you if the claim system includes a storage unit,  
5 and you said probably, yes. Is that right?

6 MR. DIXON: Objection, form.

7 A. I said that it is hard to think of a  
8 digital -- a digital receiver, meaning by the whole  
9 ensemble of processing described here, that does  
10 not have any storage unit. So almost any digital  
11 receiver has storage units.

12 Q. (BY MR. KHAN:) So to be clear, I'm  
13 not asking about any digital receiver; I am asking  
14 you about the claimed communication system in  
15 Claims 1 and 5.

16 A. Uh-huh.

17 Q. Does that include a storage unit?

18 A. I believe that is virtually  
19 impossible to implement what is referred here  
20 without any form of storage unit.

21 Q. And you agree that storage unit is  
22 not recited explicitly in Claim 1 or Claim 5?

23 MR. DIXON: Objection, form.

24 A. It is not explicitly referred to  
25 because, I mean --

1 Q. (BY MR. KHAN:) Does Claim 1 and  
2 Claim 5 -- sorry, do Claim 1 and Claim 5 include a  
3 communication path between the recited receiver and  
4 a transmitter?

5 MR. DIXON: Objection, relevance.

6 A. Can you repeat the question? I  
7 didn't understand.

8 Q. (BY MR. KHAN:) Sure. Again, looking  
9 at the claim still. So do Claims 1 and 5 include a  
10 communication path between the recited receiver and  
11 a transmitter?

12 MR. DIXON: Objection, relevance.

13 A. A path between the receiver and the  
14 transmitter -- so in Claim 1 and 5, there is no  
15 mention of transmitters. So I don't think that it  
16 is explicitly mentioned, a path between receiver  
17 and transmitter. That in this case would be a  
18 feedback channel, a controlled feedback channel.  
19 You said from receiver to transmitter. So going  
20 backward.

21 Q. (BY MR. KHAN:) And to be clear, that  
22 feedback channel is not recited explicitly in the  
23 claims; is that right?

24 MR. DIXON: Objection, relevance.

25 A. In those two claims, it --

1 Q. (BY MR. KHAN:) Yeah, Claims 1 and 5.

2 A. Yeah, in those two claims, it is not  
3 explicitly recited as far as I see.

4 Q. Claim 5 uses the term "parallel  
5 decoding capacity." What does that mean?

6 A. In the parallel decoding capacity is  
7 the capacity of the bitwise channel that we have  
8 discussed for -- for almost the whole morning. So  
9 is that -- that information that is defined in my  
10 paper is -- we call it the BICM capacity, and then  
11 somebody else started calling it parallel decoding  
12 capacity. But they are synonyms.

13 Q. So what is it defining, like what is  
14 a parallel decoding capacity defined?

15 MR. DIXON: Objection, form.

16 A. So if you remember, we already  
17 explained how the demapper reduces these  
18 likelihoods for the bits over the signal label.  
19 Now, and how we can think about the channel before  
20 the mapping and the channel after the demapping as  
21 for every label position, one bits come in, zero  
22 one, and one real number, its likelihood goes out,  
23 and the bits come in the same label. So a  
24 constellation would be two to the small M points  
25 has a binary label of M bits that come in at the

1 same time, say, packed in the same label and spits  
2 M likelihoods at the demapper.

3 So three things: These bitwise  
4 channels as parallel channels, the sum of the  
5 capacities of each of these channels yields the  
6 parallel decoding capacity.

7 Q. (BY MR. KHAN:) Does increasing the  
8 number of dimensions in a signal constellation  
9 impact the parallel decoding capacity of that  
10 signal?

11 MR. DIXON: Objection, form.

12 A. I think that the question is imposed.  
13 It may or may not. It depends on the  
14 constellation. It depends on the labeling. It  
15 depends, of course, to have -- to respond to the  
16 question, first of all, we have to agree that we  
17 are talking about capacity expressed as bits per  
18 dimension; otherwise it is not --

19 (Off-the-record discussion.)

20 A. Bits per dimension. So bit per  
21 dimension, otherwise, of course, if I doubled the  
22 dimension and I get more bit per symbol. But, you  
23 know, you have to normalize bit per dimension. And  
24 then, of course, the impact -- it may impact, it  
25 may not impact. It depends what you do, right?

1           Q.       (BY MR. KHAN:) Can you give me one  
2 example of each one where increasing the number of  
3 dimensions does impact the parallel decoding  
4 capacity and one example in which it does not  
5 impact the parallel decoding capacity?

6           A.       Yeah. So measuring the capacity in  
7 bit per real dimension, consider the simple case of  
8 a binary modulation. So for BPSK you send a zero  
9 as a plus one amplitude. A one is a minus one  
10 amplitude. And depending on the signal-to-noise  
11 ratio, the capacity is whatever it is. There is a  
12 formula and you calculate.

13                   Now, for the same signal-to-noise  
14 ratio, we use a QPSK. And now you can send zero  
15 zero, zero one, one zero, one one on a Gaussian  
16 additive noise channel, the capacity per real  
17 dimension is exactly the same. Of course, the  
18 capacity in terms of bit per symbol or bit per  
19 symbol interval doubles because now we are sending  
20 two real dimension in a symbol interval because we  
21 are exploiting also the imaginary part of the  
22 signal. So we are now modulating both amplitude  
23 and phase or -- no, amplitude and noise, a QSPK.  
24 So only the phase. Or if you want real imaginary  
25 part or interface and other components of the other

1 carrier.

2 So we are filling one more dimension,  
3 but in terms of bit-to-real dimension, the capacity  
4 will be the same. Now, an example in which the  
5 capacity is not the same would be -- let's say not  
6 necessarily the same would be -- would be an  
7 example in which the constellation in two  
8 dimensions is not the Cartesian product of two  
9 identical one-dimensional constellations. But in  
10 labeling and position of the points, in this case,  
11 not necessarily the capacity remains the same.  
12 Right.

13 (Off-the-record discussion.)

14 MR. KHAN: Thank you for the  
15 explanation.

16 Q. (BY MR. KHAN:) I would like to turn  
17 to Figure 1 --

18 MR. KHAN: Actually, you know what,  
19 we've been going for about an hour twenty minutes  
20 now. Would it be okay we take a break? How about  
21 a five-minute break then, come back at 3:55?

22 MR. DIXON: That works.

23 MR. KHAN: Thank you.

24 (Whereupon, a break was had from 3:49  
25 p.m. until 3:58 p.m. EDT)

1           Q.       (BY MR. KHAN:) So we were talking --  
2 before the break, we were talking about parallel  
3 decoding capacity. And I asked you what it meant.

4                   Is it fair to say that the parallel  
5 decoding capacity in the context of Claims 1 and 5  
6 refers to the capacity of the decoder to perform  
7 parallel decoding?

8           A.       No.

9           Q.       How would you describe it, then?

10          A.       So the parallel decoding capacity is  
11 a property of the channel that goes from the bit  
12 labels to the bitwise likelihoods, so it is a  
13 property of the constellation of the labeling of  
14 the channelling signal-to-noise ratio, for example,  
15 and the demapper, although the demapper implemented  
16 in the optimal way, so producing likelihoods  
17 according to the formulas that we have seen is  
18 uniquely fixed by the rest, so it's not really a  
19 property of the demapper unless one uses a  
20 suboptimal algorithm.

21                   It's not a property of the decoder.  
22 The decoder can be designed depending on the code,  
23 and in general, the capacity -- in general,  
24 capacity is a property of the channel, it is not a  
25 property of the code.

1           The capacity is the best rate you can  
2 achieve with unrestricted coding complexity, so  
3 when you have some optimal code, right, it is the  
4 best you can do.

5           Q.       So I should probably rephrase my  
6 question a different way. How does a receiver use  
7 a parallel decoding capacity information?

8           A.       How the receiver uses the parallel  
9 decoding information? In a direct sense, in no  
10 specific way. I can elaborate on that if you want.

11          Q.       Sure, please.

12          A.       So in a system as is described in the  
13 patent, based on a plurality of signal  
14 constellations and coding rates, or LDPC codes, if  
15 you want, as it is described, the receiver can be  
16 configured by the transmitter such that the  
17 receiver knows what it is going to receive because  
18 the receiver can receive a certain combination of  
19 constellation and binary code. So a certain coding  
20 and modulation scheme.

21                 We have a library of coded and  
22 modulation schemes. All together, the receiver is  
23 instructed by the transmitter through control  
24 mechanisms that are not explicitly described here.

25                 So as long as the receiver can

1 operate according to any of the modes specified in  
2 these plurality, then the transmitter will instruct  
3 the receiver what to do before sending. And this  
4 is done in like virtually any -- any modern  
5 communication system that uses a plurality of  
6 coding rates and constellations does this.

7 Q. Okay. And I'm sorry. How does  
8 parallel decoding capacity fit in here?

9 A. Well, it is a little bit indirect.  
10 So we know the disclosure here talks about the  
11 plurality of different nonuniform multidimensional  
12 symbol constellation where every member of this  
13 plurality provides a greater parallel decoding  
14 capacity at a specified SNR than other members in  
15 the plurality.

16 So the way a system of this kind  
17 would work is that through some control mechanism,  
18 for example, probing, previous information -- this  
19 can come from different ways, depending on the  
20 operating SNR of the receiver, which may depend on  
21 where the receiver is or the distance being  
22 transmitted on the receiver, the best scheme is  
23 selected for that operating SNR, and then the  
24 transmitter uses the scheme and the receiver uses  
25 the scheme to receive.

1                   So there is normally an agreement  
2 phase in which the receiver must know what the  
3 transmitter is doing, and this agreement is done in  
4 many ways, as long as the transmitter and receiver  
5 agree on what to use. And what to choose for every  
6 range of SNR is the member in the plurality of  
7 constellations that gives the best capacity.

8                   This basically is how an adaptive  
9 coded modulation scheme would work. WiFi does the  
10 same and LTE does the same. 3G does the same, 5G  
11 does the same. So -- many systems --

12                Q.       And how does parallel decoding  
13 capacity fit in?

14                   Let me rephrase that. Sorry. Let me  
15 be a little more precise.

16                A.       Yes.

17                Q.       You described a control mechanism  
18 through which information is sent from the  
19 transmitter to the receiver and has a bunch of  
20 information, and the transmitter and receiver will  
21 be configured accordingly. I understand that. And  
22 that can be adaptive in nature. I understand that.

23                   But my original question was related  
24 specifically how parallel decoding capacity fits  
25 into the scheme. And I didn't hear you say

1 anything about that.

2 So my question, again, is how does  
3 parallel decoding capacity fit into this --

4 A. Well, this plurality of  
5 constellations is designing a way that for -- in  
6 different ranges of SNR, you have one member of the  
7 constellation that gives the best parallel decoding  
8 capacity in this -- among the plurality.

9 So basically you have an operating  
10 range of SNRs for which you use constellation and  
11 coding, Number 1. Open range of SNR is Number 2,  
12 etcetera, etcetera, so the parallel decoding  
13 capacity is used as a design criteria, as an  
14 optimization criterion.

15 Once you have frozen your set of  
16 constellations and coding rates, since the  
17 parallel -- now you have like a one-to-one mapping,  
18 so you map SNR into -- this is one way of doing  
19 things. It's not written here.

20 The only thing that's written here is  
21 that the example, so the plurality of different  
22 nonuniform multidimensional symbol constellations  
23 is capable of providing a greater parallel of  
24 decoding capacity at that specific SNR than the  
25 other symbol constellations in the plurality of

1 multidimensional symbol constellations at the same  
2 SNR.

3 (Pause.)

4 Q. (BY MR. KHAN:) When you add the  
5 system to the transmitter and receiver and the  
6 receiver receives a signal, and then it will  
7 perform the demodulator, demapper and decoder  
8 system, that signal that it receives, it is not  
9 going to be -- sorry, receives and processes in  
10 those steps, is not going to be identical to the  
11 signal that is sent by the transmitter; is that  
12 correct?

13 MR. DIXON: Objection. Form and  
14 relevance.

15 A. Generally speaking, it is not to  
16 be -- it is not going to be identical because of  
17 the noise of -- effects of the channel. So it  
18 depends on the channel.

19 Q. (BY MR. KHAN:) Yeah. And so the --  
20 the demodulator, demapper and decoder are  
21 effectively processing that signal that's received  
22 to essentially reconstruct the data signal at the  
23 receiver; is that right?

24 MR. DIXON: Objection, form and  
25 relevance.

1           A.       Yes. They're all of the --  
2 demodulator, demapper and decoder is to recover the  
3 information bits that were sent by the transmitter.

4           Q.       (BY MR. KHAN:) Is it possible for  
5 the constellations that are determined on the  
6 receiver, from the signal that's received, to be  
7 different from the constellations that are part of  
8 the signal that was originally transmitted from the  
9 transmitter?

10                   MR. DIXON: Objection, form and  
11 relevance.

12           A.       I do not understand the question.

13           Q.       (BY MR. KHAN:) Okay. So my  
14 understanding is that when a signal is received,  
15 like we've discussed, it's not identical to the  
16 signal that's initially transmitted by the  
17 transmitter. And so the receiver will then process  
18 the received signal and try to extract the data.  
19 And in doing so will basically use the type of  
20 constellations and try to determine the location of  
21 the symbols and bits in the received signal; is  
22 that right?

23                   MR. DIXON: Objection, form and  
24 relevance.

25           A.       Not -- not completely right.

1 Q. (BY MR. KHAN:) Okay.

2 A. Not completely.

3 Q. Please feel free to correct me.

4 A. Okay. Okay. So the receiver, as an  
5 example, but in particular the demapper -- let's  
6 focus on the demapper -- must know these famous  
7 probabilities that we have seen, probability of the  
8 received sample  $Y$  given the transmitted -- a  
9 postulated transmitted symbol  $X$ .

10 This is obtained through a  
11 mathematical expression that represents what the  
12 channel does to the signal. So this probability is  
13 called a transition probability of the channel,  
14 input  $X$ , output  $Y$ . So  $P(Y|X)$  is a  
15 distribution of the output given the input.

16 Of course, the input is not known.  
17 If the receiver knows  $X$  already, then the game is  
18 over, right? The receiver has to somehow guess.  
19 But, in fact, it does not guess  $X$ .

20 What the receiver needs to know is  
21 the expression of that transition of probability,  
22 calculate the likelihoods of the binary bits that  
23 label all possible symbols of the constellation,  
24 calculate those likelihoods, send them to the  
25 decoder and let the decoder figure out directly the

1 information bits.

2 Now, in order for this to be  
3 possible, the receiver must know what  
4 constellation, including the position of the points  
5 and the labeling has been sent. Otherwise the  
6 receiver is mismatched.

7 For example, if I speak Italian and  
8 you can only understand English, I may say the  
9 right thing but your receiver does not have the  
10 code, does not have the knowledge to decode, right?

11 In particular, in order to write  
12 these probabilities, you must know, the receiver or  
13 the demapper -- the demodulator is more general,  
14 right, it has only to produce Y. There's other  
15 things, frequency translation, phase  
16 synchronization, timing synchronization, all this  
17 is standard operation that the demodulator does.

18 But after that when it extracts the  
19 complex symbol Y from the demodulator, we have to  
20 calculate these likelihoods. And this requires the  
21 knowledge of the signal set, so the constellation  
22 and labeling that was transmitted. Otherwise we  
23 have a mismatched receiver, and the mismatched  
24 receiver is going to produce garbage because it's  
25 mismatched.

1           The decoder is going to make a lot of  
2 errors because a mismatched decoder and mismatched  
3 receiver probably is not going to perform well,  
4 right?

5           So that knowledge is like, what I  
6 said before, agreeing between transmitter and  
7 receiver what was sent. It doesn't mean that what  
8 is received at Y is an unmodified sample, it would  
9 be too easy, right, then you could just do it  
10 without any coding. We have to undo the effect of  
11 the channel, we have to undo the effect of the  
12 noise.

13           But this knowledge, this common  
14 knowledge is needed so that the demapper does the  
15 operation it's supposed to do. Without this  
16 knowledge, we have a mismatched decoder, and the  
17 mismatched decoder may make many more errors than  
18 what it's supposed to do.

19           Q.       (BY MR. KHAN:) Yeah. I wanted to  
20 turn to Figure 5 of the '777 --

21           A.       5?

22           Q.       Yeah, '777 Patent.

23           A.       Figure 5 of the patent?

24           Q.       Yeah.

25           A.       Of the '700 Patent?

1 Q. Yep.

2 A. Okay. One second.

3 (Pause.)

4 A. Okay.

5 Q. (BY MR. KHAN:) And I should ask,  
6 before I move on, we have had a couple of breaks  
7 today. Have you spoken to Constellation's counsel  
8 during any of these breaks?

9 A. No.

10 Q. Okay. Thank you.

11 At a high level, can you describe  
12 what Figure 5 is generally disclosing?

13 A. Yes. This figure is disclosing a  
14 flow chart of an optimization where the input is  
15 the constellation size, so the number of points and  
16 the desired capacity. It is the target capacity at  
17 which we want to work. And the flow chart  
18 describes rather general optimization cycle for  
19 which, first of all, a check on the validity of  
20 this input parameter is made.

21 Of course,  $\eta$  must be less than the  
22 maximum possible rate that -- end point  
23 constellation can carry, which is locked to  $N$  bits.  
24 Then an SNR, a tentative initial SNR is set, which  
25 is given by the SNR at which the Gaussian capacity

1 is equal to  $\eta$ . Then for that target SNR, the  
2 M-Ary constellation is optimized. So the  
3 constellation is optimized for that target SNR. So  
4 SNR in equal to SNR out. This gives a certain  
5 capacity.

6 Now, this capacity could be -- is  
7 unspecified here. It could be parallel, equal in  
8 capacity or simply the constellation capacity,  
9 which is the capacity of the signal set. This  
10 gives a new SNR out.

11 A test is made if any improvement was  
12 made. If no more improvements, or the improvement  
13 is less than some Epsilon, then we accept the  
14 result. Otherwise, this result is fed back and an  
15 iteration is repeated until the condition is met.

16 So this flow chart at a very high  
17 level describes a way to actually minimize SNR to  
18 achieve a certain rate, a target baggage rate. And  
19 since capacity is monotonically increasing  
20 functional SNR, minimizing SNR for a certain rate  
21 or maximizing capacity for a given SNR is  
22 equivalent in the sense that the locus of these  
23 points, if I sweep over a range of rates or a range  
24 of SNRs, gives the same curve.

25 So it's two different ways of doing

1 the optimization. One is fix SNR and maximize the  
2 capacity or fix the rate and minimize SNR.

3 Q. (BY MR. KHAN:) And the last step is  
4 the output of the constellation, is that referring  
5 to when the transmitter outputs the constellation  
6 and sends it out?

7 A. The last step, output constellation,  
8 this would be the optimized constellation. This is  
9 a flow chart for output constellation, this is how  
10 you design the constellation. Then when you  
11 have -- you repeat these for several different  
12 rates, you select your example, whatever it is  
13 called in the patent, not collection, not example,  
14 they say plurality, right? And then you use it so  
15 that the optimization is not performed online  
16 during the run time. It is when you design the  
17 system.

18 Q. Yeah, I guess my question was the --  
19 this -- this implement -- this method that we see  
20 in Figure 5 --

21 A. Uh-huh.

22 Q. -- it ends with an output  
23 constellation step, right; do you agree with that?

24 A. It ends with the output  
25 constellation. So -- but the output constellation

1 means it is the output of the optimization method  
2 is a constellation.

3 Q. Yeah.

4 A. So it is output -- it is not an  
5 adjective, it is a verb. It is the method, output  
6 of constellation.

7 Q. Okay. And who outputs the  
8 constellation?

9 A. Well, the optimization method.

10 Q. The method includes steps, but it  
11 doesn't perform the steps, right? Who is  
12 performing the steps?

13 A. I don't understand the question.  
14 This is a flow chart.

15 Q. Yeah.

16 A. A flow chart is a sequence of actions  
17 with possible recursive -- in --

18 THE REPORTER: I can't understand  
19 you. With possible what?

20 A. Recursions. It's like recurrent,  
21 recursion.

22 THE REPORTER: Recurrences?

23 A. Yeah, in softer language, in people  
24 who do -- a recursive algorithm is an algorithm  
25 that goes back on itself, like iterative, right?

1 THE REPORTER: Okay. I think I've  
2 got the word now. Thank you.

3 Q. (BY MR. KHAN:) So I understand that  
4 Figure 5 is showing the flow chart. My question  
5 was who was implementing this method that you see  
6 in Figure 5?

7 A. Who is in the sense of a person or a  
8 machine?

9 Q. That is -- that's what I'm asking  
10 you.

11 A. So a system designer would implement,  
12 turn this flow chart into a code, use the  
13 optimization code to design constellations and then  
14 have this as a result. Pick for every range of SNR  
15 the best constellation and build the corresponding  
16 plurality. And this would be how you design the  
17 system.

18 THE REPORTER: Hold on just a second.  
19 I think Mr. Khan is frozen.

20 A. Yeah, I see that.

21 (Off-the-record discussion.)

22 Q. (BY MR. KHAN:) So Figure 5 shows a  
23 flow chart. Who or what implements the method  
24 shown in Figure 5?

25 A. Okay. So who, I don't know. Anybody

1       who wants to design a system as described in this  
2       patent can follow this method, which means take the  
3       flow chart, write a code that operates according to  
4       this flow chart, pick several choices for the  
5       parameter  $\eta$  and  $M$ , design the code that would  
6       generate resulting constellations and then compare  
7       them in terms of which one yields the largest  
8       parallel decoding capacity in which interval SNR  
9       and create this -- whatever it is called in the  
10      patent, multiplicity of constellations or example  
11      of -- I would call it example of constellations.

12               So this describes a possible  
13      optimization that one would use repeatedly to  
14      design an example of constellations with these  
15      properties.

16              Q.       So what device would be executing  
17      this code to generate the resulting constellation?

18              A.       Well, first of all, because the  
19      constellations are optimized, so you need an  
20      optimization. The optimization is iterative. And  
21      this is a possible way to do these optimizations.

22               Even in this flow chart, there are  
23      several options, because optimize M-Ary  
24      constellation for SNR in to Block 56, this, even in  
25      the patent, is written it can be done in many ways.

1       Because for a nonconvex problem like this one,  
2       there are several approaches for optimizing, right?  
3       Depends on the constraints, it depends on what you  
4       want to do.

5                       But this is a general approach, a  
6       general, say, structure of a possible optimization  
7       code to perform this design, to design an example  
8       of constellations.

9               Q.       I understand, but that wasn't my  
10       question. My question was what device would be  
11       executing this code to generate the output  
12       constellation?

13              A.       I thought it was who. So what  
14       person. But what device? Okay. So these would be  
15       any computer that ran some programming language in  
16       which this code can actually be written. I don't  
17       know. I can do it in Python. Somebody else can do  
18       it in MATLAB. It is a common programming language  
19       for scientific calculus computation.

20              Q.       With the computer that you just  
21       mentioned, would this computer be the receiver or  
22       would it be the transmitter?

23              A.       No. Not at all. As I said before,  
24       this optimization is performed offline. It is at  
25       the time of design of the constellations, not at

1 the time of transmission and reception.

2 So this could be a laptop, this could  
3 be a main frame, this could be whatever you want to  
4 use to run your optimization and design your  
5 plurality of constellations. This optimization is  
6 not performed at the run time, the run time, as you  
7 use the system.

8 Q. I see. So the optimization is not  
9 performed by the receiver or the transmitter; it's  
10 some other computer that's designing the  
11 communications between --

12 A. Exactly.

13 Q. I see.

14 A. Exactly. So the optimization is  
15 performed offline. It determines plurality of  
16 constellations with those properties. Once this  
17 plurality is frozen, is agreed upon, one can put it  
18 into a standard -- at the end, the transmitter may  
19 only choose one out of the plurality, depending on  
20 what the system wants to do, depending on what rate  
21 you want to transmit, what is your SNR, etcetera.

22 Q. And going back to Column 13, of the  
23 '700 Patent --

24 A. Uh-huh.

25 Q. -- the patent says that: The

1 complexity of the optimization step grows  
2 exponentially in the number of dimensions as does  
3 the complexity of the resulting receiver demapper.  
4 Such constructions constitute embodiments of the  
5 invention, etcetera.

6 Do you see that?

7 A. Yep.

8 Q. Okay. Why does the complexity of the  
9 resulting receiver demapper increase exponentially?

10 A. Okay. That's very difficult to  
11 explain.

12 Q. I can ask a --

13 A. I can explain it. I can explain, but  
14 I need a little bit of time.

15 Q. Okay.

16 A. So suppose -- suppose that you have a  
17 certain PAM constellation with, let's say, just to  
18 be practical, sixteen points. So your sixteen  
19 points means that the labels are four by four bits,  
20 because two to the four is sixteen.

21 So the demapper must construct a four  
22 likelihoods for these four bits, and every  
23 likelihood, as we have seen, is formed by the sum  
24 of probabilities and how many elements in this sum.

25 In this case, it will be eight

1 elements. Why eight? Because for every bit  
2 position, we have exactly eight points for which  
3 this bit is a one, and eight points, the complement  
4 eight points for which this bit is a zero.

5 And since you have to form the  
6 likelihood for zero and one, at the end, you end up  
7 making the sum of sixteen terms. Every probability  
8 is a term in the sum.

9 So now suppose that we go to a  
10 constellation which is a two-dimensional  
11 constellation with the same number of point per  
12 dimension, so we go to a sixteen by sixteen. So  
13 this will be at two hundred fifty-six point  
14 constellation on the plane. And suppose that this  
15 constellation is not an orthogonolized sixteen  
16 point by sixteen point.

17 So now we need to compute two hundred  
18 fifty-six terms. And then rearrange them in the  
19 sums because we do not have this decomposability.

20 So we go from sixteen terms to  
21 sixteen square. And if we keep going like this for  
22 any new dimension, without the decomposability  
23 property, say we go to three dimension, we would go  
24 to sixteen to the Q. And then sixteen to the  
25 fourth. And this is an exponential growth.

1           If we do have decomposability, so we  
2       impose as a constraint of our optimization problem,  
3       the orthogonalized form, then the growth is linear  
4       because we need to compute sixteen plus sixteen,  
5       which means two times sixteen and then three times  
6       sixteen, four times sixteen.

7           So the coefficient -- did I mention  
8       the coefficient instead of being in the exponent is  
9       multiplicative so we have linear growth, right?  
10      And linear growth is very good, is basically the  
11      best you can do. Exponential is very bad.

12           Q.      In -- flipping over to your  
13      declaration, second declaration, Exhibit 2025. In  
14      Paragraph 4, the last sentence, you state: This  
15      disclosure of Barsoum conveys to the POSITA that  
16      the patent owner was in possession of a system as  
17      recited in the challenged claims.

18           A.      This disclosure of Barsoum conveys to  
19      the POSITA that the patent owner was in possession  
20      of a system as recited in the challenged claims.

21           Q.      Thank you for that. What does it  
22      mean to be in possession of a system?

23           A.      In this context, I believe that in  
24      possession of a system means to be in possession of  
25      a plurality of constellations, a demodulator,

1 demapper and decoder that performs the operation  
2 described in the disclosure.

3           However, this system could be a  
4 software implementation. It doesn't necessarily  
5 correspond to a piece of hardware. For example, a  
6 system, a communication system can be simulated, it  
7 can be simulated in software and perform exactly  
8 the operations. And this is not for -- for a  
9 patent. It is not written anywhere that the patent  
10 corresponds to a piece of hardware, also because  
11 the hardware today is probably a piece of software  
12 executed in a highly efficient hardware.

13           Most of the modems are soft modems  
14 that operate in so-called softer radio approach, so  
15 the distinction between software and hardware is  
16 more and more vague.

17           Therefore, I assume that these people  
18 that describe the system and publish results about  
19 its performances have at least the code that  
20 performs the operation described in the disclosure.

21           Q.       So when you say possession of a  
22 system, is that like somebody who has bought the  
23 system or is using the system, the claimed  
24 communication system?

25           A.       Most probably they have written the

1 software that does whatever is described there. If  
2 they publish the results, they have, you know,  
3 generated the result in some way, this means having  
4 a piece of code that will generate these results.

5 Q. So if you have the code, you possess  
6 the system?

7 A. Yeah.

8 (Exhibit 1030, having been previously  
9 marked for identification, was  
10 referenced in this deposition.)

11 Q. (BY MR. KHAN:) Okay. I wanted to  
12 turn to the Exhibit 1030, 1030. That is the  
13 Fuentes PhD thesis.

14 A. Okay.

15 Q. Do you have that in front of you?

16 A. I do have it, yes.

17 Q. Do you have a clean copy?

18 A. Yes.

19 Q. Great. Otherwise it is in the  
20 exhibit portal if you would like, an electronic  
21 version.

22 A. If you want to share it on the  
23 screen, maybe we can see the same thing.  
24 Otherwise --

25 Q. Okay. Okay. Can you see my screen?

1           A.       Yeah, it is coming.

2           Q.       All right. You see Figure 1.2 in the  
3 Fuentes reference; do you see that?

4           A.       Yes.

5           Q.       It has three images. The one on the  
6 left is a uniform QAM. The one in the middle is a  
7 1D-64NUC. And the one on the right is a 2D-64NUC;  
8 is that right?

9           A.       This is what is written in the  
10 caption, yes.

11          Q.       The image in the middle, which is the  
12 1D-64NUC, why is it called 1D-64NUC, 1D as in  
13 one-dimensional?

14                   MR. DIXON: Objection, form.

15          A.       This is the terminology used in this  
16 thesis as well as in some other documents, and it  
17 is a terminology that I don't necessarily agree  
18 with because, technically speaking, these are  
19 points in the complex plane. So they are two  
20 dimensional points with a real and imaginary part  
21 or an amplitude and phase.

22                   The reason why it is coded this way  
23 is that this constellation is formed by taking the  
24 real part and the imaginary part from a  
25 one-dimensional PAM constellation and

1 orthogonalizing or, more precisely, creating a  
2 Cartesian product where the two components are all  
3 the possible combinations from the first  
4 constellation in the real part and the second  
5 constellation in the imaginary part.

6 So I don't agree with this  
7 terminology, but this is the terminology that they  
8 choose to use in this thesis, and this is the way  
9 the terminology was adopted in certain standards.  
10 And so it is probably a good idea to keep the  
11 terminology at this time just for sense of clarity.

12 Technically speaking, this is points  
13 on a complex plane, and they are real parts,  
14 imaginary parts or amplitude and phase. So that is  
15 a QAM constellation. And, therefore, is  
16 two-dimensional, no matter how it is created.

17 Q. (BY MR. KHAN:) On Page 21, the next  
18 page, where it says reference, Fuentes says that --  
19 this is the fourth line from the top, it says: The  
20 complexities with QAM constellations and 1D-NUCs  
21 can be drastically reduced by using a  
22 one-dimensional demapper, thanks to the squared  
23 shape of the constellations. This demapper,  
24 nevertheless, cannot be used with 2D-NUCs, period.

25 Do you see that?

1           A.       Yes.

2           Q.       Why can the one-dimensional demapper  
3 be used for 1D-NUC but not for the 2D-NUC?

4           A.       Well, first of all, this statement is  
5 not completely correct because this property is not  
6 only a property of the constellation but also of  
7 the labeling. So two conditions must exist, is  
8 that the constellation must be a Cartesian product,  
9 and the labeling must also be a Cartesian product.

10                   If I take even a uniformly spaced QAM  
11 and I do a labeling that is not a Cartesian  
12 product, the demapper would be full complexity, all  
13 the points as we have discussed before.

14                   When these two conditions hold, then  
15 because of this Cartesian product structure or  
16 orthogonalization structure, if you want, the  
17 demapper can operate separately on the real and  
18 imaginary part. So you have, in fact, two parallel  
19 demappers operating on the real and imaginary part.  
20 So we go from that exponential to linear  
21 complexity. In other words, in our -- in this  
22 specific case, instead of having to compute two  
23 hundred -- what was this, sixty-four, sorry,  
24 sixty-four terms in our demapper, we would only  
25 compute sixteen plus sixteen.

1                   And in addition, this sixteen plus  
2                   sixteen can be done in parallel, meaning that you  
3                   have one demapper operating the real part of  
4                   computing the sixteen terms, one demapper operating  
5                   on the imaginary part to compute sixteen terms. So  
6                   there is a drastic reduction of number of  
7                   operations and also execution time because you can  
8                   parallelize the operations instead of serialize.  
9                   So that is why.

10                  But a correct statement would also  
11                  include the labeling, sorry. However, in this  
12                  thesis, it is said that the labeling is gray, gray  
13                  labeling or so-called binary reflective gray  
14                  labeling. So basically it is always given for  
15                  granted that the labeling is fixed and has this  
16                  property. That is why probably this is not said  
17                  explicitly here.

18                  Q.        I am going back to Figure 1.2.

19                  A.        Uh-huh.

20                  Q.        The image on the right-hand side,  
21                  that is a 64 point nonuniform constellation, right?

22                  A.        Right.

23                  Q.        The image in the middle is also a 64  
24                  point nonuniform constellation, right?

25                  A.        That's correct.

1 Q. And in your opinion, both of those  
2 are two-dimensional; is that right?

3 A. Yes. They are points on the plane,  
4 so they are two-dimensional.

5 Q. Sorry. Sorry. One second. Sorry.  
6 Can you see my screen again?

7 A. Yes, I can.

8 Q. Okay. I am looking at Figure 1.2  
9 again. The figure on the left, that is a QAM,  
10 right?

11 A. Correct.

12 Q. And the figure in the middle is a  
13 QAM, right?

14 A. The figure in the middle is a -- I  
15 didn't understand.

16 Q. A QAM, QAM, Q-A-M?

17 A. All these three figures are QAM. QAM  
18 means quadrature amplitude modulation, which means  
19 that the modulate, the amplitude of the carrier in  
20 quadrature of phase, which means you are modulating  
21 the amplitude of cosine and the sine. So any  
22 constellation made of points in the plane can be  
23 transmitted by modulating the amplitude of two  
24 carriers' signals at the same frequency in phase  
25 quadrature. That is why it is called QAM. That is

1 it.

2 Q. Okay. The difference between these  
3 three, the center one and the right one -- sorry,  
4 the center image and the right image is they have  
5 been optimized differently; is that right?

6 A. The one in the center and the one on  
7 the right, yes, they are optimized in a different  
8 way.

9 Q. Going back to the claims, Claim 1 of  
10 the '700 patent --

11 A. Okay.

12 Q. Sorry. I am in Claim 5. So Claim 5.

13 A. Yes.

14 Q. Claim 5 recites: Wherein each of the  
15 plurality of different nonuniform multidimensional  
16 symbol constellations.

17 Do you see that?

18 A. Yes.

19 Q. Do each of the plurality of different  
20 nonuniform multidimensional symbol constellations  
21 have to have the same number of constellation  
22 points?

23 A. Frankly, this is a point on which the  
24 patent is not so clear, because here is written the  
25 communication system of Claim 1. In Claim 1 it is

1 written: Plurality of multidimensional symbol  
2 constellation comprises a plurality of different  
3 nonuniform multidimensional symbol constellations  
4 having the same number of constellation points.

5 Nevertheless, in the following  
6 claims, we see the communication system in Claim 1  
7 wherein, and then we see sixteen points. And then  
8 we see sixty-four points and then two hundred  
9 fifty-six points and then one thousand twenty-four  
10 points.

11 So my interpretation is that for  
12 every number of points, you have a plurality. The  
13 plurality, the plurality basically consists of  
14 changing the position of those points, such that  
15 you have -- for every given scenario, you have an  
16 optimized constellation. But then the following  
17 planes hint to the fact that there are several  
18 pluralities, sixty-four points, sixteen points, two  
19 hundred fifty-six points, one hundred twenty-four  
20 points.

21 So since I, frankly, do not exactly  
22 know what the -- we may imagine that we have  
23 several pluralities, as described by Claims 2, 3,  
24 4, 5 -- no, 2, 3 and 4, which also corresponds to  
25 some of the plots, like, for example, in these

1 plots, we have these loci of points, like, for  
2 example, Page 36, Figure 16B or all these other  
3 figures, we see loci of points versus capacity. So  
4 for example, Figure 16A, thirty-two optimized for  
5 joint capacity. And then we see the loci of the  
6 thirty-two points versus the capacity.

7 (Off-the-record discussion.)

8 A. And in Figure 16B we have PAM 32  
9 optimized for parallel decoding capacity, where  
10 this diagram of the position of the points is  
11 represented versus SNR.

12 So it seems to me that this shows the  
13 best position of the point for every SNR for  
14 thirty-two points. And then you have another one  
15 for sixteen points and then you have another one  
16 for whatever.

17 And when you alternatize, you have  
18 the square of that.

19 Q. So Dr. Caire, I just request that we  
20 just answer the question that I had asked. Sorry.

21 My question was really focused on  
22 Claim 5 and what -- whether -- I will repeat the  
23 question. Whether Claim 5 says the plurality of  
24 different nonuniform multidimensional symbol  
25 constellations, whether that plurality has the same

1       number of constellation points. Now, from what I  
2       understood your answer was, it is not clear. It  
3       could be or it could not be.

4               But I don't want to put words in your  
5       mouth. So can you -- can you confirm that that was  
6       the correct understanding or if there is a  
7       different understanding?

8               A.       I confirm that, in my opinion, it is  
9       not clear.

10              Q.       In your previous answer you had cited  
11       to Figure 16A and 16B; is that right?

12              A.       Yes.

13              Q.       Would you agree with me that Figure  
14       16A and 16B are one-dimensional -- related to  
15       one-dimensional PAM constellations?

16                      MR. DIXON: Objection, form.

17              A.       Well, it is written on the figure, so  
18       that is undeniable.

19              Q.       (BY MR. KHAN:) Would you agree with  
20       me that Claims 1 and 5 are directed to nonuniform  
21       multidimensional symbol constellations?

22              A.       Again, it is written in the claim, so  
23       they refer to nonuniform multidimensional symbol  
24       constellations. And one way to build these  
25       constellations is to orthogonalize, so it's one way

1 of doing it. It is also discussed in my -- what is  
2 called, my statement.

3 Q. Thank you, Dr. Caire. I will just  
4 request again to just answer the question, please.  
5 I am aware of what is in your declaration, so I  
6 appreciate that. You know, to the extent you would  
7 like to clarify, that is fine. But if you have  
8 answered the question, then I just request you stop  
9 there.

10 Okay. Now, earlier you had mentioned  
11 that the configurations that are used in  
12 communication systems between transmitters and  
13 receivers are adaptive in nature.

14 Do you recall that?

15 A. Yeah, I said they may be.

16 Q. Yeah, so they can be adaptive in  
17 nature.

18 A. They can be.

19 Q. Okay. Do you think that the  
20 communication system in Claims 1 and 5 can be an  
21 adaptive system?

22 A. Absolutely. A communication system  
23 described in Claim 1 and 5 describes a system for  
24 which the constellation and the code can be chosen,  
25 depending on various criterion. But basically

1       mainly on the operating SNR and the rate we want to  
2       achieve. And this is the definition of adaptation.

3               If the system was not adaptive, there  
4       was no need for a plurality of constellations.

5               MR. DIXON: We have been going for  
6       about an hour and a half. Do you think it would be  
7       a good time to take a break?

8               MR. KHAN: Yeah, sure. Sorry I got  
9       carried away. Yeah. Yeah. Happy to take a  
10      five-minute break. Or Dr. Caire, if you would like  
11      longer, that is fine too. It is okay with me.

12              A.       That is fine. No problem.

13              MR. KHAN: All right. Should we  
14      reconvene at 5:36 p.m.?

15              MR. DIXON: Sure.

16              MR. KHAN: Thanks.

17                      (Whereupon, a break was had from 5:31  
18                      p.m. until 5:37 p.m. EDT)

19              Q.       (BY MR. KHAN:) So by rules, we have  
20      to keep this under seven hours, so we are into the  
21      last hour. I promise you, this is coming to an end  
22      soon. But thank you for your time again today. I  
23      appreciate it.

24                      A couple of questions. Right before  
25      the break, we were talking about the adaptability

1 of the communication systems. So the claim recites  
2 a plurality of multidimensional symbol  
3 constellations, excuse me. Does that plurality of  
4 multidimensional symbol constellations include  
5 symbol constellations over a large course of time,  
6 over a certain time period? Or is that that one  
7 particular instance?

8 A. I don't quite --

9 MR. DIXON: Object to form.

10 A. -- understand the question.

11 Q. (BY MR. KHAN:) I'm sorry. What was  
12 the answer?

13 A. The answer is that I do not  
14 understand the question.

15 Q. I see. So maybe I can paint the  
16 situation out.

17 You had said that, you know, the  
18 system can adapt; at different times it will be  
19 using different, you know, constellations. And so  
20 I imagine over the course of time, one year or  
21 however long, you will have a whole set of  
22 different plurality of symbol constellations that  
23 you have been -- that you have used, right?

24 A. (Nodding.)

25 Q. So the question is, the plurality of

1 multidimensional symbol constellations that is  
2 recited in Claims 1 and 5, does that refer to all  
3 of those constellations over a time period or a  
4 subset of that?

5 MR. DIXON: Objection, form.

6 A. Okay. So there is no reference on  
7 how adaptivity is obtained and over which time  
8 horizon. But let me give you a few examples.

9 So an adaptive communication system  
10 is a system that can change the transmission, say,  
11 coded modulation scheme depending on needs. Now,  
12 what are those needs? It depends on the system.

13 For example, suppose that we have a  
14 system that scales on different time frames,  
15 different set of users. Some users are fixed users  
16 and have a large dish antenna or something like  
17 that, so they enjoy a large SNR because they have a  
18 good antenna.

19 Other users are mobile users and they  
20 have a small portable like handset antenna. And  
21 maybe they are in a car or, you know, they are  
22 mobile, so their channel is less good.

23 So the system may, depending on how  
24 many users of one type, how many users on the other  
25 type, request of what type of traffic, high

1 definition video versus low definition video,  
2 decide that this frame is going to use this coding  
3 modulation scheme and this other frame is using  
4 this other coded modulation scheme and so on and so  
5 forth.

6 In this case, for every frame, there  
7 is a preamble that all receiver can be called that  
8 says this frame uses this scheme, and then the  
9 receiver that can decode these schemes will apply  
10 the corresponding coded modulation schemes to  
11 decode the data, which is called the payload in the  
12 frame.

13 The next frame, it could be after ten  
14 milliseconds or one second, depending on what kind  
15 of standards we are talking about. So it could be  
16 very fast or medium. It could be dedicated to  
17 another set of users and use another element in  
18 your plurality. And so on and so forth.

19 So this would be an adaptive system  
20 that, depending on traffic conditions, different  
21 type of users on different frames and serve them  
22 with different coding modulation schemes.

23 Another example could be what is then  
24 today in, for example, 5G or WiFi where the  
25 adaptation is based on channel state information

1       that comes from the uplink. So the users send  
2       their signal in the uplink, the access point,  
3       measure the quality of the channel. And so we know  
4       we can serve this user with this scheme, that user  
5       with that scheme, and depending again on traffic,  
6       it is going to instruct what to do, what the next  
7       frame will be, and the users decode whatever they  
8       are supposed to decode.

9               So in one case, in the second case,  
10       for example, the adaptivity may be dictated by  
11       channel state information. The first case may be  
12       more applicable to a broadcast system where there  
13       is not necessarily an individual feedback channel  
14       and the adaptation is used simply by statistical  
15       properties like the system knows that seventy  
16       percent of the users are fixed, thirty percent of  
17       the users are mobile and the fixed user receives a  
18       high definition TV and the mobile user receives  
19       standard definition TV, just an example. So based  
20       on this microscopic traffic activity that can be  
21       measured, the system scales the frames and the  
22       users they appropriate coded modulation schemes.

23               So the adaptation in a sense can be  
24       fast, alternating different type of coded  
25       modulation schemes at the frame rate, which can be

1 as fast as ten milliseconds, for example. But the  
2 parameters that dictate these adaptations can be  
3 low, like traffic conditions, or very fast, like  
4 almost instantaneous or like instantaneous  
5 information, like in WiFi.

6 Q. Yeah, thank you. So I think I  
7 understand what you are saying.

8 But I wanted to ask my question  
9 somewhat to be maybe to be a little clearer. The  
10 claim recites the plurality of multidimensional  
11 symbol constellations, and it also says that the  
12 demapper selects a multidimensional symbol  
13 constellation from a plurality of multidimensional  
14 symbol constellations. The question was that at  
15 that plurality of multidimensional symbol  
16 constellations, is that something that is basically  
17 collected over time, you know, and then just one of  
18 them is selected like -- like what is that body of  
19 plurality of multidimensional symbol  
20 constellations?

21 MR. DIXON: Objection, form.

22 A. It is like a library. The system  
23 includes a library of possible constellations and  
24 codes. This is called a coding and modulation  
25 scheme. We have a collection of schemes, and

1 depending on what I explained before, one is used  
2 in this frame, the next one maybe is used in the  
3 next frame and so on and so forth.

4 So the multiplexing -- the  
5 multiplexing of this plurality over time, frequency  
6 and sometimes even over space when multiple antenna  
7 techniques are used, but this is not described in  
8 this patent, is a different problem, is a different  
9 issue. How you multiplex this plurality over time,  
10 frequency and space is part of the adaptation  
11 mechanism and the multiplexing techniques. As long  
12 as you have this library and adaptivity or, you  
13 know, depending on various circumstances, elements  
14 in this library are used.

15 Q. (BY MR. KHAN:) I see. So within  
16 this library of multidimensional symbol  
17 constellations, there's also a subset of different  
18 nonuniform symbol constellations that have the same  
19 number of constellation points?

20 A. This is my understanding.

21 Q. I see. And so when the -- in Claim  
22 5, when you have the, you know, the plurality of  
23 different nonuniform symbol constellations, it is  
24 capable of providing a greater parallel decoding  
25 capacity than all the other symbol constellations

1 in that library, right? How does it do that when  
2 the library has a sort of a collection of  
3 everything -- all the different possible  
4 constellations? How does it figure out --

5 MR. DIXON: Objection to form.

6 Q. (BY MR. KHAN:) So to be clear, how  
7 does it figure out that it is greater than  
8 everything else that is in the library?

9 MR. DIXON: Objection to form.

10 A. How? By comparison. Every  
11 constellation, which means position of the points,  
12 number of points, labeling has a parallel decoding  
13 capacity curve as a function of SNR. You look at  
14 all the curves, and you see the one that is on top  
15 of all the others for each SNR. So you take like  
16 the upper and the lower of these curves, and these  
17 curves, they intersect. So one is on top of all  
18 the others in a certain interval SNR; another one  
19 is on top of all the others in another interval SNR  
20 and so on and so forth, and this is what is written  
21 here.

22 Q. (BY MR. KHAN:) I see. If I could  
23 direct your attention to Figure 4A of the patent.

24 A. 4A? Yes.

25 Q. In Figure 4a, you see there is

1 letters B, X and Y?

2 A. Yes.

3 Q. Do you know what those mean?

4 MR. DIXON: Objection, relevance.

5 A. Well, I assume B is a binary input.

6 X is the constellation point. Y is the received

7 signal, the output of the channel.

8 Q. (BY MR. KHAN:) Okay.

9 MR. KHAN: No further questions for  
10 me. Thank you very much, Dr. Caire.

11 A. Okay.

12 MR. DIXON: Can we please take a  
13 quick break? I think we'll have a very short  
14 redirect, and then hopefully we'll be done.

15 MR. KHAN: Okay.

16 (Whereupon, a break was had from 5:59  
17 p.m. until 6:00 p.m. EDT)

18

19 EXAMINATION BY MR. DIXON:

20 Q. Dr. Caire, thanks for hanging on for  
21 a little bit longer. I just have a couple of  
22 questions, and to keep this on the shorter side,  
23 I'll ask that you just respond yes, no or ask for a  
24 clarification if you can't give a yes or no.

25 A. Okay.

1           Q.       Do you recall Mr. Khan asking whether  
2 or not each of the plurality of different  
3 multidimensional symbol constellations have to have  
4 the same number of constellation points?

5           A.       Yes.

6           Q.       Can you please read the limitation of  
7 Claim 1 that appears at Column 13, Lines 58 through  
8 61 of the '700 Patent? So that's Exhibit 1001.

9           A.       From the beginning?

10          Q.       So starting from the beginning of  
11 Line 58 on Column 13.

12          A.       Okay.

13          Q.       Through Line 61.

14          A.       So: Wherein the plurality of  
15 multidimensional symbol constellations comprises a  
16 plurality of different nonuniform multidimensional  
17 symbol constellations having the same number of  
18 constellation points, where the constellation  
19 points are nonuniformly spaced in each degree of  
20 freedom available to the multidimensional symbol  
21 constellations.

22          Q.       So that limitation states that the  
23 plurality of multidimensional symbol constellations  
24 have the same number of constellation points,  
25 right?

1           A.       Yes.

2           Q.       So taking that a step further, each  
3 of the plurality of different nonuniform  
4 multidimensional symbol constellations have the  
5 same number of constellation points in Claim 1,  
6 right?

7           A.       I do not understand what each of the  
8 plurality means. It can mean two different things.

9           Q.       What do you mean by it can mean two  
10 different things?

11          A.       Well, it may mean that we have  
12 different pluralities but the number of  
13 constellation points is the same across all the  
14 pluralities or we have different sets of  
15 constellation, each one of which is called a  
16 plurality and each one which has, among inside the  
17 set, the same number of points, but across  
18 different pluralities, we have different set of  
19 points.

20                   And I tend to agree with the second  
21 version because the rest of the patent talks  
22 explicitly about sixteen point constellation,  
23 sixty-four point constellation, two hundred  
24 fifty-six point constellation, one thousand  
25 twenty-four point constellations.

1                   Q.       So if we just focus on Claim 1  
2       itself.

3                   A.       Uh-huh.

4                   Q.       Claim 1 just recites a plurality; is  
5       that right?

6                   A.       A plurality, exactly.

7                   Q.       And Claim 1 says for that plurality,  
8       each of those have the same -- each of those  
9       constellations have the same number of  
10      constellation points, right?

11                  A.       Yes. A plurality is like a set.  
12      Each of -- each constellation in that plurality has  
13      the same number of points.

14                  Q.       And so if we go to Claim 5, that  
15      depends on Claim 1, correct?

16                  A.       Yes.

17                  Q.       And Claim 5 also refers to Claim 1's  
18      plurality of symbol constellations, right?

19                  A.       This is where my understanding is not  
20      so clear, because Claim 5 says wherein each of the  
21      plurality of different nonuniform multidimensional  
22      symbol constellations. So each of the plurality in  
23      English doesn't make sense, because each of, you  
24      want the plural. So pluralities.

25                           Each of the plurality is each

1 constellation in the plurality has would make  
2 sense. Each of the pluralities would make sense.  
3 This is where I think I do not understand what the  
4 patent means.

5 Q. It doesn't say each of the  
6 pluralities, correct?

7 A. It says each of the plurality.  
8 Unless each of the plurality means each member in  
9 the plurality of. So each of could mean in the  
10 sense that it means that it is one plurality with  
11 many members and this is consistent with Claim 1.

12 Q. You agree that that's a reasonable  
13 reading of Claim 5?

14 A. In view of English grammar, I think  
15 it would be the most reasonable reading.

16 Q. And that's consistent with Claim 1,  
17 correct?

18 A. Yes.

19 Q. And so in view of that reading, do  
20 you agree that each of the plurality of different  
21 nonuniform multidimensional symbol constellations  
22 have the same number of constellation points in  
23 Claim 5?

24 A. Yes.

25 Q. Okay.

1 MR. DIXON: I have no further  
2 questions. Thank you, Dr. Caire.

3 MR. KHAN: Maybe just give me a  
4 minute.

5 (Whereupon, a break was had from 6:07  
6 p.m. until 6:09 p.m. EDT)

7 MR. KHAN: I'm ready to go back on.

8 MR. DIXON: I'm ready as well.

9

10 REEXAMINATION BY MR. KHAN:

11 Q. Great. All right. Dr. Caire, you  
12 were just asked a few questions from  
13 Constellation's counsel regarding Claims 5 and 1;  
14 is that right? And you had expressed, I guess,  
15 some lack of clarity in Claim 5, particularly with  
16 the phrasing of each of the plurality of different  
17 nonuniform multidimensional symbol constellations.

18 If you were to make it clear, how  
19 would you revise the claim to make it clear?

20 A. I would have written: Wherein each  
21 constellation in the plurality is capable of  
22 providing a greater blah, blah, blah.

23 Or more precisely: Wherein each  
24 nonuniform multidimensional symbol constellation in  
25 the plurality is capable of providing a greater

1 parallel decoding capacity at specific SNR,  
2 etcetera. This would have been the completely  
3 unequivocal statement.

4 Q. And the plurality that you mentioned,  
5 is that the plurality of different nonuniform  
6 multidimensional symbol constellations, or is it  
7 the plurality of multidimensional symbol  
8 constellations?

9 A. Plurality means that -- plurality is  
10 a set. It means many elements. Every element is a  
11 no uniform multidimensional symbol constellation  
12 and different, of course, because if they would be  
13 the same, it would be just one, right? Instead,  
14 multiplicity doesn't count, so they have to be  
15 different, otherwise it would be just one symbol  
16 constellation. Plurality means that there are many  
17 different, right?

18 Q. Yeah, I guess my question is what  
19 follows the plurality. Was it going to be the  
20 plurality of multidimensional symbol constellations  
21 or a plurality of different nonuniform  
22 multidimensional symbol constellations, which one  
23 of those two?

24 A. It is a plurality of different  
25 nonuniform multidimensional symbol constellations.

1 And from Claim 1, with the same number of  
2 constellation points, different because they differ  
3 in the position of the points.

4 Q. I see. Okay. So to make this claim  
5 clearer, you would have rewritten this claim to  
6 say: Wherein each nonuniform multidimensional  
7 symbol constellation in the plurality of different  
8 nonuniform multidimensional symbol constellations  
9 is capable of providing a greater parallel decoding  
10 capacity, and then the rest of the claim?

11 A. That's correct.

12 MR. DIXON: Objection, form.

13 Q. (BY MR. KHAN:) And that would help  
14 you understand, I guess, the claim better, right,  
15 or interpret it better?

16 A. To the best of my understanding, this  
17 is what the claim says. But it is -- as I say,  
18 maybe it's my English limited capability, but it  
19 took me a moment to understand.

20 MR. KHAN: Okay. Well, I think your  
21 English is fine. So thank you, I appreciate your  
22 time today. No further questions from me.

23 MR. DIXON: No further questions from  
24 us either.

25 THE REPORTER: Okay. Do y'all want

1 Dr. Caire to read and sign?

2 MR. DIXON: Yes, please.

3 THE REPORTER: And, Mr. Dixon, do you  
4 want an expedited transcript too?

5 MR. DIXON: Kevin, what do you think?

6 I'm leaning towards yes, but I'll let  
7 Kevin make the ultimate decision on that.

8 MR. AMENDT: Yes, please.

9 THE REPORTER: And do y'all want  
10 rough drafts?

11 MR. KHAN: Yes, please.

12 MR. DIXON: Yes, please.

13

14

15 (Deposition concluded at 6:14 p.m. EDT)

16

17 FURTHER THE DEPONENT SAITH NOT

18

19

20

21

22

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24

25

DEPONENT'S CERTIFICATE

I, GIUSEPPE CAIRE, PH.D., the witness  
herein, have read the transcript of my testimony  
and the same is true and correct, to the best of my  
knowledge. Any corrections and/or additions, if  
any, are listed separately.

GIUSEPPE CAIRE, PH.D.  
c/o Mr. Williams S. Dixon  
Mintz, Levin, Cohn, Ferris,  
Glovsky and Popeo, P.C.  
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Sworn to and subscribed before me, this the  
day of , 2024, to certify which witness my  
hand and seal of office.

NOTARY PUBLIC

C E R T I F I C A T E

STATE OF ALABAMA  
JEFFERSON COUNTY

I hereby certify that the above and foregoing deposition was taken down by me in stenotypy, and the questions and answers thereto were reduced to typewriting under my supervision, and that the foregoing represents a true and correct transcript of the deposition given by said witness upon said hearing, to the best of my ability.

I further certify that I am neither of counsel nor of kin to the parties to the action, nor am I in anywise interested in the result of said cause.



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TN LCR No. 679, Exp. 6/30/2025  
Transcript Certified on 3/20/2024

1 Williams S. Dixon, Esq.

2 wsdixon@mintz.com

3 March 20th, 2024

4 RE: LG Electronics Inc v. Constellation Designs LLC  
5 3/19/2024, Giuseppe Caire , Ph.D. (#6603556)

6 The above-referenced transcript is available for  
7 review.

8 Within the applicable timeframe, the witness should  
9 read the testimony to verify its accuracy. If there are  
10 any changes, the witness should note those with the  
11 reason, on the attached Errata Sheet.

12 The witness should sign the Acknowledgment of  
13 Deponent and Errata and return to the deposing attorney.  
14 Copies should be sent to all counsel, and to Veritext at  
15 cs-midatlantic@veritext.com.

16 Return completed errata within 30 days from  
17 receipt of testimony.

18 If the witness fails to do so within the time  
19 allotted, the transcript may be used as if signed.

20  
21  
22 Yours,

23 Veritext Legal Solutions  
24  
25

LG Electronics Inc v. Constellation Designs LLC

Giuseppe Caire , Ph.D. (#6603556)

E R R A T A S H E E T

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Giuseppe Caire , Ph.D.

Date

1 LG Electronics Inc v. Constellation Designs LLC

2 Giuseppe Caire , Ph.D. (#6603556)

3 ACKNOWLEDGEMENT OF DEPONENT

4 I, Giuseppe Caire , Ph.D., do hereby declare that I  
5 have read the foregoing transcript, I have made any  
6 corrections, additions, or changes I deemed necessary as  
7 noted above to be appended hereto, and that the same is  
8 a true, correct and complete transcript of the testimony  
9 given by me.

10  
11 \_\_\_\_\_  
12 Giuseppe Caire , Ph.D.

\_\_\_\_\_ Date

13 \*If notary is required

14 SUBSCRIBED AND SWORN TO BEFORE ME THIS

15 \_\_\_\_\_ DAY OF \_\_\_\_\_, 20\_\_\_\_.

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Federal Rules of Civil Procedure

Rule 30

(e) Review By the Witness; Changes.

(1) Review; Statement of Changes. On request by the deponent or a party before the deposition is completed, the deponent must be allowed 30 days after being notified by the officer that the transcript or recording is available in which:

(A) to review the transcript or recording; and

(B) if there are changes in form or substance, to sign a statement listing the changes and the reasons for making them.

(2) Changes Indicated in the Officer's Certificate. The officer must note in the certificate prescribed by Rule 30(f)(1) whether a review was requested and, if so, must attach any changes the deponent makes during the 30-day period.

DISCLAIMER: THE FOREGOING FEDERAL PROCEDURE RULES ARE PROVIDED FOR INFORMATIONAL PURPOSES ONLY.

THE ABOVE RULES ARE CURRENT AS OF APRIL 1, 2019. PLEASE REFER TO THE APPLICABLE FEDERAL RULES OF CIVIL PROCEDURE FOR UP-TO-DATE INFORMATION.

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