Dr. Irwin M. Jacobs, Founder, Qualcomm, Inc.
Keynote Address*

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[Professor Adam Mossoff]

Dr. Jacobs stands in very good company in terms of the revolutionary impact that he has had on all of our lives with his innovative and creative endeavors. And so, without much further ado, because I know you want to hear from him and not from me, I'm very happy and pleased to invite Dr. Jacobs to the stand to give his keynote address. Thank you.

[Dr. Irwin M. Jacobs]

Adam, thank you very much. Great pleasure to be here today. I must say I've enjoyed the sessions this morning, even though they brought back a number of memories that dip of past and present difficulties. But this whole area is clearly one of great interest and, in fact, has greatly impacted my life over the last many years. as was mentioned, I started out as an academic. I was trained as an electrical engineer, taught at MIT, taught at UCSD, and started my first company. It was not at all a planned event, but because of having published the textbook on digital communications—which was I think the first one published—when I came to California there were all these requests for consulting. I mentioned that to a couple of colleagues from UCLA and they said, "let's start a company on sheer consulting." And that's how the first company Linkabit actually started.

At the time I really didn't know anything about intellectual property, about IPR. There was no education on that as I was coming along. And so, it was through Linkabit really that I first had some of my exposures to the importance of intellectual property. One of our early products there was for the government—to build a satellite terminal for the government to communicate very critical messages, among other things. And we came up with the idea of doing that, rather than as most people at the time were doing it with lots of hardware, to in fact have a central processor unit and do a lot of it in software. There were no CPUs available as one chips at the time, there

were several chips available, and so we had to invent our own processor which had 32 instructions. I think, for those of you in the know, is the first perhaps RISC (reduced instruction set computer) type processor around. It was before it really came out of the university, it was about 10 years later. This was the mid-70s and we actually were able to go ahead and competitively win a first production contract because we had a much smaller unit, a much more effective unit than our competitors. And then, because we were able to convince the government that the processor, this RISC processor, was proprietary that we ended up with all the follow-on production. Which turned out, of course, to be a great plus for Linkabit.

And so that got me thinking a bit further about intellectual property. Another course in that education had to do with another product. We wanted to contract with HBO to build a scrambler from satellite initially to cable heads, for HBO. And we were moving ahead and almost ready to go into manufacture of these what I'll call "professional descramblers". And a group went to Congress, a group that represented backyard dish owners went to Congress and said, "look, we're willing to pay something for the descrambler but they can't simply take away our ability to receive these satellite signals." And so, it looked like Congress was going to take some action, and HBO therefore decided to pull back from the idea of scrambling. And that's where my next piece of education came in.

One of the companies that had a contract with HBO pointed out that they had a 'most favored nation clause', which I'd never heard of before, but a 'most favored nation clause' in their contract. if these people are getting it for free, he should get it for free—this was John Malone. And that convinced HBO, "well, somehow we better move and make a home unit". And so—luckily, by the way, we were able at that time to use software that was still in the universities, but we'd been gathering it to understand it a little better, to design integrated circuits and to build a low-cost, reliable home descrambler—turned into a great business. But the idea of getting some more intellectual property issues. I didn't realize it, but Ron Katznelson just reminded me that in fact that was Linkabit's, of one of its earliest if not its first patent, ended up being on VideoCipher. So, we did get into that area. And then the last thing I'll mention from Linkabit: we had a contract with a company called IMM (International Mobile Machines), which has now become InterDigital, to develop a digital phone for them. We selected TDMA (time division multiple access) for that phone, but it was under contract, so they kept all the intellectual property rights—which came back, and I'll touch on that, to bite us a little later. But again, when I realized all the emphasis they were putting on that and being able to go out and patent, and owning the patent—that again was an important aspect.

So, we sold, as was mentioned, Linkabit in '80, I stayed on until '85, retired, managed to stay retired for three months, and decided that wasn't much fun—or my wife, Joan, decided to throw me out of the house or something. In any case, we decided to start Qualcomm. And when we started Qualcomm, we didn't really have any products in mind, we didn't have a business, we couldn't possibly have gotten or raised any funding, didn't have the proper Excel spreadsheets, whatever. But we thought, "well, digital and wireless—there's going to be some growth coming up here and that we'll get together maybe." As I again told my wife, Linkabit had grown very large, we'll get Qualcomm up to maybe a hundred people.

Well it turned out a couple of months into Qualcomm we're doing consulting jobs for Hughes on a satellite communication system, for a mobile satellite system—that is, for mobile users—and they had asked us to review their proposal and technical approach that had been filed with the FCC. And on the second meeting, driving home, I suddenly realized that perhaps something called code division (CDMA) would be better than the approach they were following, which was the usual approach of time division actually combined with frequency division multiple access, that there might be an argument in favor of code division. By the way, the reason for thinking about that: it was a mobile situation. In a mobile situation part of the time you stop and listen, or you stop and think, that is you're not using the channel. But it's hard to give that channel away and then get back in time if you're an individual user. And so, it didn't work with standard technology but maybe CDMA (code division), which is limited by the total amount of interference affecting the communication channel, maybe when you stop talking, you stop creating interference, you can get more users. And so, we began to explore that. Unfortunately, Hughes warned that they were not going to be able to get a license for two or three years. I had to put a whole consortium together, everything slowed that down, and so their support of CDMA ended. And we, at the time, were too small, didn't have funding really to continue, but we did have some very good ideas. We'd worked them through enough that we did write the first patent on the CDMA, and actually a couple years later after we had the patent, published a paper on it—so we had set it aside.

Our first product at Qualcomm was something for providing communications to the long-haul and medium-haul trucking industry. We called that Omnitracs—a small satellite terminal that used satellites designed for talking to big dishes, but to use it for trucking communications. And that required a significant amount of technology, both the spread spectrum type of technology that we then used in CDMA antenna technology and one that I'm kind of proud of in that GPS wasn't available at the time, and so we needed to provide the location of the trucks. How are we going to do that? Well, we had a communication signal that was a megahertz wide and realized that, if we provide another narrow signal from a second satellite several degrees away, we could occasionally look over at it and from that, and a little information about terrain, calculate the location very well. So, we built our own GPS system prior to GPS, and we did patent that as well. It turned out that Omnitracs went on, and I think Qualcomm sold it about five years ago, but it was a great cash generator for many, many years, so that turned out to be very valuable to us.

In any case, as soon as we had our first contract on the Omnitracs, we took that cash flow and came back and started looking at CDMA. So this was the Fall of '98.. '88! At this age, decades get mixed up very quickly! Fall of '88. And we looked at it again and it took until about February or March where we had done enough to decide, yes, this really looks competitive for the transition from the first generation analog cellular to the second generation digital cellular. And we felt, okay, we can go out and talk with the industry. The problem was the industry had already gone out and had a big battle between TDMA and FDMA, a vote on TDMA in January.

People had looked at CDMA, thrown up their hands—too complicated—hadn't really followed it. And so the vote was between TDMA and FDMA. TDMA won, and so starting January of '89 the industry was on a march toward standardizing and then going ahead with TDMA. In Europe there was a similar TDMA called GPS, wider bandwidth because they had separate frequency that had been assigned so they could do that. In any case, the world was going ahead with

TDMA. We came along about March. I began to talk with some operators—the only reason they would listen is that TDMA might buy three times as many subscribers in a given frequency band per antenna than the initial analog, whereas CDMA we said 10 to 20 times perhaps and that was enough of a potential economic incentive. So, we did get a little bit of support.

But we made a presentation to a large group, about this size actually, in Chicago and I thought somebody was going to say, "there's the problem", but nobody did. But nobody believed it either because there weren't slides, there weren't the PowerPoints at that time, there were just slides. And we had to go ahead and build a demonstration. So, we built a demonstration unit and finished it, again, in the fall of '89. So, it took one year from thinking about it again, through getting the first demonstration unit, inviting people in to see this demonstration. And it turned out to be successful, a few glitches here and there, but the demonstration itself went through successfully. And the problem was that to drive our mobile phone around took a van—wasn't going to be too commercial! And so, the question was, of course, how do you get a commercial both phone and network equipment base stations? And to do that we had to develop chips. To develop chips was going to be a very expensive proposition.

So, how do you raise money to develop the chips that do the R&D? And so, we came up the realization that since the operators were interested, that they could talk to their manufacturers and get them—say, "hey you really ought to look at that" and then we could go to the manufacturers and offer a license for CDMA. The license would have a significant upfront payment that would allow us to do our R&D; and should this ever be commercial, which nobody really believed, there'd be a small royalty involved. And so, we did that—AT&T was the first, this was before they spun out, the first one to sign up and there were several others, and Motorola, and so we did get a reasonable number of companies to support it that signed up for this license. Putting together a license you have to think through, you know, what should be in that license? Clearly 'most favored nation', otherwise these people won't sign up, but what else might be in there? And the question is what patent should be included? And so, we very quickly decided rather than licensing a few individuals we'll license everything. And so, whatever patents we'd come up with then or for the next n years would be included in the license. So, there won't be any fights over licensing issues going forward. And that's how we signed them up.

Also, how much should the royalty be? Well, it had to be small enough so that it's not going to impact the growth of the industry, we want that to be able to continue rapidly, but had to be something of interest to us to allow us to keep the R&D going, et cetera. So, we did get those signed up. And then two years after that fall demonstration in '89, so in fall of '91, we had a demonstration with now commercial-sized handsets and commercial-sized base stations. This was a technology available for use. The industry still wasn't quite convinced, obviously, because they've been working now for a couple years hard on TDMA. And so, luckily, they set up a meeting where they compared the results of what was supposed to be commercial TDMA with our just-barely available CDMA. And lucky at that meeting the TDMA sounded terrible! This was a meeting in Dallas, if I recall correctly, in December. The CDMA, we had done video—so they could see where the van was driving, they could see the radio signals, what they look like, the multipath, the whole handoffs between, the whole works. In any case it was convincing enough that in January the Cellular Telephone, at that time, Industry Association voted to be able to have a second standard. And so, our original licenses were all pre-standard, so was not

standard essential patents at the time because there was no standard. That issue, of course, continues to come up. And we had set the royalties rate at that point, the number of patents. The royalty rates have only gone down, the patents have only gone up, but there's still, of course, fusses about these issues. In any case we entered into a standards-setting process—they took a while to get that going—in June we had already put together a standards document.

I must say that it then took a year and a half, through to the summer of '93, for the standard to come out. Year and a half everybody then complained—this is much too rushed, much too fast—but we had done so much homework working with other companies who always had the reason CDMA wasn't going to work. We went out and tested with them during that interim period, convinced them that it did work, found out more data ourselves to be able to use for the standard discussions. And so, we did get that completed in July of '93—the first standard issuance. But before that, several months before that, we were sued by InterDigital, at the time, over claiming that some of the work we had done, some of the patents they had on TDMA applied to CDMA. And so, we went into, actually, a trial before a judge in Philadelphia. And that was when I got another lesson on patents. Partway in, we had discovered that one of our confidential documents was in someone's possession on the other side, and our lawyers, when they found out that, went to have a sidebar meeting with the judge. And there was some discussion going on, and then they came back, and they reported to me that they had described this block diagram that they had shown to the judge. and then at the end of that discussion the judge said, "and by the way, who is Mr. Block?" That convinced us that maybe this was not the best way to make these technical decisions! Because they had a problem, we had this problem, we managed to get the whole thing done out of court—we ended the case at that point. But I've never forgotten Mr. Block and that issue can come up further.

So we moved ahead, obviously, with CDMA and immediately end up with what's been called "religious wars" because GSM in Europe—there was an agreement, an MOU among the different governments to only use that technology—so there was no way to get CDMA in there. They were helping spread CDMA to other countries, and so there was the battle in second generation which was mostly voice-oriented between the TDMA and CDMA. But CDMA is very suitable for data and so, thinking about a third generation of cellular, everybody realized: how do we go to have both voice and data be able to be transmitted efficiently? And all the companies that were on TDMA tried to find some way other than CDMA, finally threw up their hands, and we ended up with discussions. Those discussions got pretty bitter because they were trying to find ways within CDMA—how we get around the basic patents and so on, and a lot of discussion. And I kind of tried to influence it, "okay, you're going to use the wider bandwidth because in Europe, you had more bandwidth to play with. But don't make the parameter so different that we can't put it all into one ship and have phones that roam everywhere." And so, that ended up being a bit of contention, and I finally had to go visit the EU, the Commissioner on Innovation or Competition. Competition, I guess. Anyway, and we had this rather heated discussion of several people from the EU, and they finally came down at the end of that meeting and said, "look, we are going to consider not allowing you to have royalties in Europe if you don't come around" or whatever. We've done that, they claimed, with some pharmaceuticals. I thought that whole thing was weird... In any case we ignored that.

We eventually came to an agreement with Ericsson because we made a strategic decision about that time, and this was about 19—keep my decade straight here—99 or so. I should have mentioned the first system commercially launched was in Hong Kong in '95. So the standard was finished in July of '93, first system launched in Hong Kong in '95, the next two systems launched in South Korea in '96. Where were those phones manufactured? They were all manufactured in San Diego because, until that time, we hadn't convinced anybody that they ought to take a chance and manufacture CDMA phones. In '99 we then made a strategic decision that we really wanted to have manufacturers available everywhere in the world—let's go to a horizontal model. We can provide the chips, software, technology and let lots of manufacturers make phones that were ideal for their individual areas. So, we made that strategic decision. We ended up selling our infrastructure to Ericsson, and settled some of these outstanding issues with Europe, and sold our handset division.

And so, we then focused on technology which, where we receive income from the licensing side use that to pay for continuing to develop new technology. But to then embed the technology in ships and software that we could sell broadly. And so that was the business model, the strategic model we came up with in '99 and have followed—really Qualcomm's followed that pretty much ever since. I must say, and there's been some allusions to these things and these meetings, obviously, that that motto works very well. We felt we had well-protected patents, that we would have this licensing income coming in, and we were able to take that and do lots of additional R&D. For example, GPS has been mentioned. we were the first to put GPS into a chip and into a phone. GSM folks, for example, fought that for a few years, but we could see that that was going to lead to all kinds of new applications. We also developed the first application, downloadable applications for the phone. And so, that was one of the benefits of having this continued income stream—not just relying on what's been done but let's keep running with that. There were other technologies that we continued to develop. we began to look ahead to the next generation, which is something called OFDMA (orthogonal frequency division multiple access) and even though with CDMA we had a very strong position, the world's going to keep changing, more bandwidth going to become available, and so began to move in that direction as well.

And so I think the model that we followed, of having this intellectual property being continually generated bringing in a return on that intellectual property, not just relying on that but then doing the R&D and putting out the chips and software—which by the way, is the largest revenue generator for Qualcomm—being able to follow that and continue to move the industry forward. People have often asked me, you know, "did I anticipate where this all might go?" And the answer I often give is that, "well every so often". For example, in 2000 we came up with the idea of high data rate (HDR) use for the technology which we put into the CDMA, and then later put into the more recent technologies, that provided ways of getting—basically send the package to the user that has the strongest signal: noise ratio in any given time and then a packet to the next one, and since that keeps going up and down that gives you further efficiency. We came up with a number of better ideas again using this R&D capability to benefit the industry. We also then realized that your device you carry around with you—that's where I keep my device—the device you carry around with you is going to be a very powerful computer. And I think about 2000 I said, "it's probably going to be the only computer most of us need out several years from now." And so, we began to worry how do you get high performance computing without using much energy? And again, went back across the risk reduce instructions that processes which was a

return to our old background in some sense. And so, these innovations just kept moving ahead and I think have been very, very positive. But just thinking back that, without having what we believe was a strong position that could allow us to license the patents, get income, use that for R&D, et cetera, that we wouldn't've, for example, been able to—back in the Omnitracs they get that, so we had cash coming in—and then be able to develop the CDMA, move onto the next generations, bring in all kinds of capabilities. So, I think the point of these meeting here today, and I guess the Institute, is that protecting intellectual property, having that available, is very critical for what was then a very small company being able to grow. Currently now small companies, large companies being able to make use of that, get a return on their innovation, and be able to then reinvest that. So, very strong supporters of what's going on here. Thank you very much for this symposium.

[Applause]

Actually, I ought to add one thought. China came up this morning as well. I made the first presentation in China to a large group, also with mostly government but industry—or what industry existed then, mostly ministry people—on CDMA, and they were very knowledgeable about that. Then we went through a period where, you know, we'll give you the market, you give us the technology. What good's the market without a profit on the technology? So, we had those discussions, went on for nine years before we finally did get CDMA into China. And during that period there was efforts to get a joint venture. We couldn't ever get that because the people representing the joint venture, Factory such-and-such, had their idea of what Chinese law was. Our lawyers had a different idea of what Chinese law was, nobody could quite agree on what the law was. And it just seemed too dangerous to perhaps get involved. We finally did get that straightened out and ready to go in around '99, and we were just getting ready to sign some contracts when we accidentally bombed the Chinese embassy in Belgrade, and that stopped us for another year. We were all set to sign some contracts again and a Chinese jet flew into one of our reconnaissance airplanes. That stopped us for another year! So, we had great trouble. Just one final comment on that. All the analysts said—you know, we were celebrating, we finally got into China. All the analysts, the Wall Street analysts were saying, "why did I worry? Why did Qualcomm put so much time and effort into China? There are already 260 million subscribers to cellular in China—that's about the entire middle-class. There's no room for any further growth." Sometimes, don't listen to consultants or outside advisors. In any case, thank you all very much.

[Applause]

[Prof. Mossoff]

Dr. Jacobs has graciously agreed to answer questions from the audience. Does anyone have any questions?

[Audience Member]

My brother, Dr. Ronald Wong, sends his regards to you from China. He got his PhD from the Center for Wireless Communications from UCSD, sponsored by you. He got his PhD through your sponsor. He sends his best regards to you from China and sent me here to tell you he's in

charge of the Wireless Communications Project for the Smart City for the Olympics in China. He wants your opinion! He met you in 2006 in Finland at the IEEE conference. He took a photo with you then.

[Dr. Jacobs]

Oh, please tell him thank you very much.

[Audience Member]

I'll take a photo with you later!

[Dr. Jacobs]

Right, very good, right. But also, education is one of the areas we've been very interested in and providing lots of support. So, one of those is UCSD School of Engineering, since I taught there. And it's kind of fun to see all of the graduates coming from that. We were discussing a little earlier the need for design thoughts and openness to getting any engineers thinking more broadly. So, one of the things my wife and I helped on was putting an art piece up on one of the engineering buildings. If you ever go there, you'll see a house almost falling off the building called Falling Star, I think. It says engineers should be somewhat whimsical as well.

[Audience Member]

I just took a look at the 1969 Data Compression Patent. [Dr. Jacobs: oh!] There's a good argument that it would probably be ineligible subject matter. Question: what would you have done if, a priori, it was 75-80% likely that you wouldn't have been able to get patent protection? What would you have done as a business?

[Dr. Jacobs]

Well in the case of Qualcomm twice basically you had to—make that three times, perhaps—bet the business on moving ahead with an idea and not moving ahead. So Omnitracs, well, we thought we had some patent. There was a very well-funded competitor there, but we thought we had some patents, we thought we had a better approach. And we almost went bankrupt until we finally got the first customers on that. But without knowing we had protection we probably wouldn't have moved ahead on that one. CDMA clearly, I mean was one thing to take it through the demonstration phase which, by working days and nights for six months we were able to demonstrate at work, but then to make the investment of developed chips that could go commercial, build that ability to make handsets—because nobody else would make them for us—make the infrastructure—nobody else would make that—connected to networks and switches. I mean it was really nice experiment. Without thinking we really had strong patents and then being able to get some licensing, obviously, that would not have gone ahead. And I must say the ongoing business model where, again, funding is coming in from licensing and paying for some very extensive R&D, which I think has really caused this industry to grow very, very rapidly. Without that we would have been in great trouble. By the way, talking about

growing rapidly in competition, I have to be careful because I keep getting triggered by different ideas.

Anyway, another country we had great competition with was India. it was a monopoly among a few European-equipped operators. They had the highest-priced equipment and the highest-priced airtime of, I think, anywhere in the world and so, very few subscribers. And we went in, but we couldn't get the government to agree to give us a mobile license. Luckily there was two government companies providing wireline service and they were six years behind delivering service, and so we were able to get an agreement that we could provide wireless—equivalent of wireline service, put a phone in your home that's wireless, or your business office in particular. Then people found they could pick those up put them in their car and drive around, so we ended up with legal battles that went on forever. And finally, the Minister of Communications threw up his hands and said, "okay we'll issue a broad license." So, all these things keep happening.

[Audience Member]

As an electrical engineer, and an IEEE member, and a lawyer who advises startups, you've had the benefit of looking back at what you did with Linkabit and Qualcomm. And I'm wondering if there's anything that you see as a missed opportunity and regret with respect to—I understand what CDMA is, and most of the technologists here do, but the public, the lay-public. Is there something you could've done to better brand Qualcomm and CDMA's contribution so that—much like Intel is advertised. Is there something you could have done that you regret? I'm curious.

[Dr. Jacobs]

Well that issue always has come up, Intel inside, should there be a Qualcomm inside equivalent? Of course, now we have Snapdragon which, in fact, is, I think, a moderately-recognized name. but in thinking about that I always decided, "well, if I have to put a few million into the advertising versus R&D, let's do the R&D". And since we were not—in the end, we made a very conscious decision not to go out and compete with our own customers. That they would do the advertising. We did, though, require that on the phones there was a little thing on the phone that said CDMA, for example, by Qualcomm. But very quickly it became less and less observable until you finally needed to have a microscope to be able to see it. One thing we did do though is—San Diego ran into great trouble. They have a football, and baseball stadium at the time. They were trying to bring in the Super Bowl one year, they had expanded the stadium, the NFL said no you have to do these additional things. The court case came up that prevented them from using some funds to do those additional things. I said when I was speaking up there, "well, have you ever thought about having a corporate sponsor for the stadium?" They needed 18 million at that time, I think San Francisco was going a million a year for the naming—things have changed quite a bit. So, for 18 million we got 20 years name so Qualcomm Stadium. So, Qualcomm for many, many years people either knew Eudora or they knew the stadium.

[Audience Member]

Thank you, Dr. Jacobs, so much for coming and joining us, and telling your story and the story of the company. I'm curious, you've obviously had a tremendous career of creating a range of innovative products, and there must be a little secret sauce or secret management or something that you, or you and your team, have done differently than, you know, obviously myriad of companies that never get even close to your success. So, if there's anything you've reflected on that you were doing in the management level, or the hiring, or in that sort of human capacity it'd be great to hear your thoughts.

[Dr. Jacobs]

I think it was great advantage to coming into industry after being an academic, and being around very good academic research universities because you work with students, you work with other faculty members, ideas flow openly. And you look and try to see how to proceed ahead, come up with a good idea, you don't do it necessarily yourself. You give it to a student, ask that student to go off and work on it. Well, a company can work the same way, and so we always tried to keep it very open to new ideas, continue invite people in that can perhaps give some lectures or spend their sabbatical. How do we keep it intellectually alive? And I think that has had, over the years, a very good payoff. The other aspect, of course, is to try to find very good people to work with, give them exciting things to do, a good environment. But also, don't have an organization and then hire people to fill the places in the organization—try to find very good people and then you shape the organization around the people. And often you'll find people with strengths direction A, direction B, direction C, they're terrible on D. Okay, well organize it so we can make use of those strengths. Something else I found very helpful back in the Omnitracs day—we were going to provide a communication system for the trucking industry. You know, we'll give you two-way communications position location, you do the rest. Well I found out when I went out to start talk—because I was marketing person, I'm talking with all the companies—that that wasn't enough. What are we going to do with this information? So, we had to get into their logistics system and their software and help them develop ways of integrating everything together, making it more efficient. And so, after that I also tried to make sure that engineers would have some time where they go out and have some experience with customers. Now you can't get your ideas only from customers—people don't know what can be done, and so you want to bring some ideas and see and then understand their problems. How might that get integrated? And this idea that you can't necessarily trust the customer base, I often come back. Back again, about 2000-2001 we were working hard to put cameras on phones, and, at that time, whomever I spoke to said, "why would I ever want a camera on my phone?" So you can't—you should listen to your customers but not too carefully sometimes.

[Prof. Mossoff]

Dr. Jacobs, I actually want to ask a question. You talked a little bit about the standard setting struggles with CDMA but weren't there also technological problems as well? In terms of there was a lot of pushback from people who were saying this wasn't even possible or feasible? There's a story I heard about a physics professor who actually was attacking you in print—could you talk about that a little bit more?

[Dr. Jacobs]

Yeah, these 'religious wars' got kind of extreme at various times and, actually after we had already launched in Hong Kong, there was a front-page story in The Wall Street Journal saying that my hype may be costing U.S. operators billions of dollars because I'm forcing them to consider this CDMA, this unproven technology. And in that they quoted a Stanford professor who said that "CDMA violates the laws of physics". Some people didn't understand probability well enough. You take all the bad things that happen, you add them up, yes, it's not good. But if you average them everything came out okay. So, one other interesting thing about that is well, since we're in this issue of fake news and what's going on—at that time it was all print. And so, this article came out, I wrote a response back to The Wall Street Journal, which they never published, unfortunately. And about two weeks later I had to go to a meeting in Paris, I think it was. And when I arrived there everybody came over to congratulate me on this great story in The Wall Street Journal! So, it's just getting some ink that was all that counted, and I don't think anybody really read the details! It worked out well.

[Prof. Mossoff]

It's awesome that we all benefit from violations of the laws of physics. Are there any other there any other questions? Well I don't see any. Before you step down, so as a token of our appreciation for coming and speaking at our conference we wanted to give you this book. It's by a historian of technology, Harold Evans. It's called They Made America and it has chapters dedicated to Samuel Morse and Colt, and even the inventor of Barbie, and all these people. And I look forward to Harold Evans' second edition of this where he has a chapter with you in there. So, thank you very much.

[Applause]

**** We would like to thank Scalia Law 2L and CPIP Research Assistant Christianne Wolfsen for putting together this transcript.***