improvements, both in terms of first fix and accuracy. This is coming from the use of faster DSP and improved GPS algorithms. Thank you.

MR. HATFIELD: Thank you very much. Our next presenter is from Sirf Technology.

MR. CHADHA: Hi, my name is Kanwar Chadha. I'm the founder of Sirf Technology. Sirf is a start up company focused on providing GPS chip set and core IB for multiple markets. And today we will discuss the E-911 based solutions based on handsets.

I do want to emphasize upfront that whatever location technology we choose as a country, we have to focus on where the future potential is, not necessarily where the existing infrastructure is. The technology has to be useful to consumers for E-911, and potentially for evaluative services. And significant investment, whether it's in millions or tens of millions or hundreds of millions, is going to be needed to make the technology and infrastructure work together. It's important to invest that wisely.

Main features of Sirf's location architecture is that it's based on GPS in handsets. It does improve on the performance of traditional GPS technologies and we'll go over some of the things it does better. It supports more than the standard GPS, as well as more than just network-assisted GPS. In fact, it has three modes. It supports

autonomous, network-assisted and network-driven environments and I'll talk a bit about that.

It can provide location information independent of the networks, so it will work in amps, D-AMPs, GSM, CDMA, any kind of environment. We do believe that open interface standards will drive the technology into the marketplace and there is significant activity going on in DIA groups to standardize on the error interfaces.

One thing about handset technology is that it allows people to get the technology at a price point in a manner, and keep aware of the technology as it changes. And we'll go over some of those.

Why GPS? As my colleague from SnapTrack has already talked about, there is significant investment going into building a location infrastructure based on GPS. And we are taking advantage of that infrastructure and combining it with some of the wireless network's capability. It has a much better potential for consumers in the long run. With DGPS, you can get accuracy five to 15 meters. And today, DGPS are expensive, but in the next two to three years, there will be a nationwide deployment of DGPS, so any GPS chip set itself will be able to receive the DGPS signal, just like we receive the signal from the GPS satellites and get that accuracy.

It does provide compatible decross (phonetic)

multiple networks and, as you have seen the results from SnapTrack, as well as you will see some of the trials done by IDC, we can support multiple networks very easily.

One thing to keep in mind is handsets upgrade is very fast. So thinking with Legacy issue, we have to keep in mind, people do upgrade their handsets. And every two to three years, you will see that enough, that most of the handsets will have this technology built in. And with proper implementation, carriers, that rate can be improved even more.

And the technology cost, we have to believe in the silicon and the volume. Every two to three years, the silicon enables you to put more and more features into the architecture, and the volumes of handsets will drive the cost down. What used to be $100,000 computer a few years back probably you can get for $599 today. And similar things are going to happen with the handset DGPS technology.

There are some problems with traditional GPS in terms of performance, as well as accuracy in open canyons, dense foliage, indoors. But there is no reason why those problems cannot be addressed by common architectures good for autonomous GPS, as well as for wireless assisted GPS. Other issues with GPS have been power consumption, size, cost and how to integrate into the handsets.

What Sirf has done is, first of all, we have

improved the performance of autonomous GPS. It's very important to have a good autonomous GPS performance, because that gives you the maximum freedom from various networks. This is a default mode for getting a position if the network assist does not work. So having a good autonomous GPS performance is good. And the results we have show that it's reasonable to expect that autonomous GPS will work reasonably well in open canyons, in one to two story houses, as well as in one to two story parking lots.

Obviously, in a multi-story building and some of the more complex environment, you will have some issues. But probably the money is better spent that you're getting the consumer to use wireless phones in those kind of environments.

Also, with the wireless assist, especially in terms of getting some type of assist, you can improve the performance accuracy more. Power consumption, site and cost can easily be handled by looking at the silicone technology curve. A GPS receiver is this size, which is pretty easy to put into a handset. And this is a free functional GPS receiver. In the handset, you can share some of these resources and the size is probably more like this chip.

So the size constraints, the power constraints, can easily be handled just looking at the packaging of silicone technology.

Let us look at three modes I talked about. These are slightly different from what Dr. Birchler described initially. The autonomous mode is a traditional GPS mode where all calculation is done in the handset. We define that network-assisted mode where the calculation is still done in the handset, but the network provides certain assists and the assists are approximate location, DGPS correction if it's not directly from the loss of satellite, and the data, with traditional GPS receivers, we need to collect from the GPS satellites.

The third, approach is the network central or network-driven approach, where you can combine GPS with other network-based technologies to get the position. There are different trade offs. Autonomous more clearly has the lowest impact on the infrastructure, and as I said, this is a default mode. If nothing else works, GPS autonomous mode will give you a position independent of any network. And the performance of autonomous mode can be improved by having some sophisticated software so that the autonomous mode keeps the GPS receiver in what we call a hard mode, and you will get a positioning anywhere between three to eight seconds with that mode.

That assisted mode, of course, overcomes some of the start up performance issues and provides the capability in indoor type of environment. Network driven does have

some impact on the similar side, the network side, in terms of band width and computations, but that one piece there is, you could combine GPS with some network centered technologies like has been done in CDMA network.

We also have to keep in mind what the consumer is looking for. They are not only looking for emergency assistance. In the long run, they are looking for certain services, in terms of navigation, in terms of tracking, in terms of finding their kids. And flexible architecture allows them to have all these capabilities. Autonomous mode probably is very useful for navigation and tracking. Network assisted and network driven modes are useful for on demand positioning such as in emergency response.

Their expectations are, instant position, accurate and for almost free. And I think these can be met. This is an example of some of the drives. We have done two, open canyon and like San Francisco. And you can see the satellite visibility is going to be pretty low in this kind of environment.

But even in an autonomous mode, the accuracy of GPS is pretty good. The solid line is the actual track and the line which goes around, the blue line, is what GPS receiver tells you. So it's easy to achieve reasonable accuracy, even in autonomous mode in an open canyon type of environment.

As for the cost issues concerned and Legacy handsets, first of all, with the GPS attachment, you can upgrade some of the Legacy handsets. Obviously not all, but a significant amount of those could be upgraded. And as we see the IDC integration, which means you integrate the silicone used for GPS with wireless silicone, the cost can be brought down to easily less than $10.

In the end, what you will get is a form which not only provides the E-911, but provides other benefits to the consumer for getting location based services. The technology is available today. It is cost effective and generally will meet lower costs by taking advantage of the volumes of handsets. You can provide a retrofit. The accuracy is much better and will improve with time as the GPS infrastructure evolves and it's compatible across multiple networks.

If you look at the future potential, this is the foundation we are laying down for location-based services and emergency response is probably one of them. Consumers will pay for the capability they get in the handsets. Thank you.

MR. HATFIELD: Thank you very much and you've all done such a good job of keeping on time that we're actually a little bit ahead. So what I thought I'd do here is let each of you maybe respond to what you heard, one or two

additional points that you wanted to make and were unable to, I would welcome that now. And why don't we start back over here with -- oh, I'm sorry. Sorry about that. We're not running so well. I didn't have enough coffee this morning to make up for last night.

MR. KNAPP: But now that you've had fair warning --

MR. HATFIELD: Right, so, I'm very sorry. We'll start with the representative from Aerial Communications.

MS. FRASCO: Thank you very much. My name is Beth Frasco. I'm head of radio planning for Aerial Communications. I'm responsible for the design, planning and strategy of our current and future radio networks. As a part of my responsibilities for the last year and a half or so, we've been looking at ALI issues for my company and how we're going to comply with the FCC's Phase II mandate. And among the various positioning methods that we've looked at, I'm going to be speaking about the Enhanced Observed Time Difference Method, which I'll call E-OTD from this point forward. Next slide, please?

First of all, let me make one thing really clear. We're not a vendor, we're not a manufacturer, we're an operator. We're a consumer of this technology to meet the FCC's Phase II mandate. We're in a very specific situation. We're a PCS A and B block licensee. We've been in operation

for just about two years now. It's a fairly small installed base of customers. We also use GSM technology which makes us in a particular category, as well.

Let me tell you about a particular situation. We believe that this particular method that I'm speaking about, E-OTD, has some really attractive components to it for us, and we would like to have -- it makes the option to use this particular technology, which is handset based, desirable. Next slide, please.

Just a quick overview of E-OTD. It is a triangulation based technique. It does require multiple base stations to do positioning, and it is a handset based solution. The one thing that is quite unique about E-OTD in comparison to the other methods that we've seen today is that it does not use GPS in the handset. It does not use any GPS receivers in the handset.

However, it does require some modifications to the handset, largely in the form of software modifications. The other thing that's sort of unique about this method is that it's very GSM specific. In fact, when the original GSM specifications were developed a number of years ago, the founding fathers and mothers of GSM anticipated a need for positioning technology down the line, and they realized that there were certain hooks that already existed in the technology that could be used for positioning and they

conceptualized this particular method as a solution for that. Next slide, please.

So what is it about GSM that lends itself to this particular positioning technology? I'm going to give a 30 second overview of how GSM works for those of you that may be unfamiliar. Well, GSM network, unlike some other digital cellular networks, is unsynchronized. We mean that the base stations transmit within a frame structure that is known only to the base station itself.

However, for mobile to make a call, every mobile needs to be aligned with a particular base station's frame structure. The base station is going to be carrying that call. So to facilitate that synchronization, the base stations regularly emit a synchronization burst. And all mobiles will monitor the synchronization bursts of not only their own serving cell with which they will align their internal clock, but also all the neighbor cells in the surrounding area. We call this presynchronization.

So the mobile basically all the time has knowledge of the time differences between the base station that it's being served by and all the surrounding base stations. And this is what we're really leveraging in the E-OTD method. And we're building on this capability and extending it to do positioning. This makes E-OTD a very elegant solution and simplifies the installation costs, implementation costs and

hardware and software required to achieve the FCC mandate. And I'll explain more about this as we go on. Next slide, please.

So how E-OTD works, it's very similar to the network-based methods that we've already talked about today, except it operates in the reverse. Instead of making measurements on the uplink, we are making measurements now on the down link. The mobile itself is making the measurements of the arrival time of bursts from each of its neighboring base stations in addition to its serving base station. The mobile then reports those arrival times back to the network and the network can use that information to triangulate position.

But to do this, it needs three things. The coordinates of the base stations, the arrival time of each bursts that are reported from the mobile itself, and finally, the timing differences or timing offsets between all the base stations, because remember, the network is unsynchronized. We obviously know the first bit of information and the second two are what we need to implement hardware and software to obtain. Next slide, please.

Some of you talk about what kind of hardware and software we have to implement at our base stations to make this work. And for a carrier, we can talk about pure technology issues. To some extent, the thing that really

makes or breaks our ability to be compliant are the really very practical and sometimes mundane implementation issues.

You can see from this slide a kind of a block diagram of the hardware that's needed at the base station. There are several ways to actually accomplish the task that needs to be done here, but this is one particular implementation. Remember that what we need from the base station is knowledge of the absolute time of transmission of the burst from the base station.

So essentially what I have is a mobile that notes the transmission of the bursts and the GPS receiver which can then be used to time stamp that burst with an absolute time reference. That same note in the box can then transmit that information back to the network via the base station with which it is co-located.

Now, from a carrier's point of view, this is really attractive, because it facilitates a very rapid and very efficient implementation of this outside hardware. We don't have to actually add any additional antennas, lines or feeders, which would be very costly and very time consuming as we'd have to reinforce structures, negotiate with landlords or perhaps even build new structures. We also don't need to impede on our existing radio infrastructure, namely the lines and antennas, which are for most operators, the Achilles heel of their network. And we don't need to

incur any performance degradation on those links, which could potentially impact the voice performance of our network.

So it's quite important to us to consider these issues. Next slide, please.

On the handset side, for the implementation, again remember that this a pretty elegant solution. We're building on something that the handset already does and we're extending it. And what we need to, essentially, is make the measurement more precise. So because of already making these measurements, I don't need to change the physical hardware of the phone. I don't need to change the antenna structure and I don't need to change the DSP or RF hardware, because the phone is already making these types of measurements. Well, again, what I do need to do is enhance that measurement. I need to make it more accurate and more precise. And so what I need now is some additional cells on the phone that's going to do three things.

First of all, it will employ some more sophisticated multi-path ejection techniques to more efficiently discriminate the line of site component between the base station and the mobile phone and therefore, get the true time delay between the two points.

We need to employ some integration techniques to improve the detectability of the burst, and finally, we need

to have some software so that the mobile can report that measurement back to the network. Now, let me just say that I picked my handset here because it matches our logo, not as endorsement of any particular vendor. That was a joke. Okay, next slide, please.

Okay, another thing that's quite important to us as a vendor -- I'm sorry, as an operator -- is that we want to have a wide variety of manufacturers to select from. E-OTD has been developed in T1P1.5 and the standardization work has been in by major manufacturers and vendors and also operators in the GSM community. So you can see that this list is quite extensive and included several of the major GSM manufacturers.

So this is important to me from a carrier, not only for having a choice by view, but because it insures me that I will have options to pick from that are very competitive, have the lowest possible price and also have been driven to the technological limits. That's the end of the slides.

In summary, I just want to say that E-OTD for us is a very elegant solution, in that it's building on the existing functionality of the network. The benefits this gives us as an operator is a very elegant and simple installation, fairly rapid installation of the technologies, improve our ability to comply with the FCC Phase II mandate.

And because as you can see and as you've seen, the changes and hardware that we need to implement in the network and in the handset are fairly simplistic, and not all that expensive, we can also be assured of a lower cost solution. Thank you very much.

MR. HATFIELD: Thank you very much and we'll turn now to the final handset presentation by Integrated Data Communications.

MR. PRESTON: Yes, sir, do I get all the rest of the time?

MR. HATFIELD: No, no, we'll split it up.

(Laughter.)

MR. PRESTON: I'm Dan Preston, chief technical officer of IDC. We're in a place called Bainbridge Island, Washington, which is about six miles due west of the Space Needle. It's appropriate that I'm last, because we're actually an L Commerce business. I need to explain that a little bit. We're in the commercial public safety business, web applications, things like that.

I took a unique approach about two years ago to solve this problem. We could only deal with the tools that we had at that particular time to solve this problem for public safety and the thing that I had rented was, at ten cents a minute, was the call pack or the voice channel. We drew up protocols that were basically, that are networking

dependent, and transmitted data within the call pack.

It's a handset based solution. We supported GPS -- I guess we lost our slides -- there we go. We supported GPS during the trial and at the King County last year. We support any satellite position type technology. We also support any other type of technology, where the XY can be driven out to the handset, or it can be generated to handset.

We did a trial in Seattle, King County, Seattle, and I'm sure that by now, many folks in the audience have seen the results of the trial. We did it to satisfy public safety. The folks at public safety, we sat down with them and asked, how would you guys like to really solve this? And they sat with us for some months, talking about technology, the capability of the technology, and what we thought we could do.

Back up to the first concept of L Commerce, we're developing products now for fourth quarter '99 release. We don't need the wireless carrier's infrastructure to be changed to make our solution work. Next slide.

Basically, when I looked at the problem, the question was, how could I make the wireless carrier look like part of the LEC or part of the public switch telephone network? How could I make the wireless carrier, or how could I make the wireless handset look like an extension of

the LEC or look like an extension of the call taker? And again, it was a call path method. Call path is not an unusual method, CAMA signalling, Feature Group B signalling has been around for many years. Next slide.

The folks in Seattle in public safety were concerned about real test, real venues, real call takers, real trunks, real vendors. We went out, we put together this public safety trial and we forced canopy -- that was like double, triple canopy inside Seattle. Urban canyons -- if you folks haven't been up to Seattle recently, we've got lots of seven-story buildings, albeit lead on the outside, quite a bit of the time -- suburban and mountains. Next slide.

We did a six-month trial with King County. We actually sat down and brought together all of the incumbent facility and all of the incumbent facility providers, the folks from SCC, who do the standard alley type work and so on. Marla said, though -- Marla Davis is the King County E-911 director -- and she said that 125 meters was a good try, but she wanted to know if we could get it down to 40 feet. She wanted to know if we could route calls to the appropriate PSAPs. Could we refresh the data in band, or could we refresh the data? Could we find 90 percent of all the callers? Could we integrate this in three real PSAPs, which are call takers? And that she would provide to us

cooperation from the land line carriers, vendors and public safety.

The mantra of what we did was, if we could satisfy public safety, we had a hell of a commercial business. So we set about trying to basically raise the bar on public safety and then create this public business. Next slide.

The good news we found 100 percent of the callers. Now, these are 100 percent of the location-enabled handsets, and we had 30 handsets for this particular trial. I've spent a lot of time talking to the FCC about how do I present the data. There were three ways to present it. The least conservative method here was to give you the raw data. A next lesser conservative measure would be to do some RSM averaging and finally some CEP-type averaging.

The good news is we found 100 percent of callers -- when I talked to Marla Davis, approximately 48 percent of her calls come from rural highways and things like that. And I believe that in that area, we found basically 48 percent of her calls at less than 70 feet. Now, this was an early generation GPS-type system. Next slide.

The other issue public safety had was, we couldn't solve this with just one handset, one technology. In the upper corner here, in the upper left corner, there are basically a description of the different handsets that we use in the trial. In the lower corner is the error

interfaces that we used during the trial. CDMA is disproportionately large for a couple of reasons. One was, it was for us, one of the easiest mediums to get data across. And two, GTE Wireless provided the support from their switch, so we do all of our routing on the GTE network. Next slide.

What's driving location technology? A funny thing happened on the way to the FCC. Commercial public safety rose to the surface. What I mean by that was, because we're in the call path, there are commercial type applications, road assistance, personal security, telematics, that we can transmit data on and enable today.

Commercial concierge type services, AVL, asset tracking, commercial applications view of the Internet, panic buttons, phone finders or family finders or so on. I think the important thing the FCC needs to know is that call centers and hosting infrastructure are being built today for this demand. There are a number of groups that are doing this. I can't discuss -- we'll hear later this summer, but this is coming to fruition and hopefully by the end of this year, you'll be able to get these kinds of services. Next slide.

We come into this trial, one of the questions we're asked is, what's the state of GPS technology? And you've heard from all the handset makers here ahead of us or

handset providers. One thing we found was GPS technology is evolving rapidly. We went into this trial and rephrased the product that we tested with and by the end of the trial, we found a marked improvement, 245 percent better with later versions of the Sirf Technology.

Commercial products, again, are months away. The commercial goal, as you heard from Kanwar, wireless coverage should be available wherever, or rather, locations should be available wherever the wireless coverage is available. Approach works, one other issue that wasn't talked on a lot about and that's the right to privacy. One of the issues is with any handset-based solution, you can shut it off. You can disable it like caller blocking.

Finally, I'd like to thank you for the opportunity to present this. IDC would like to be considered amongst the players in this public safety arena. We're here now and we're not going to go away. Thanks.

MR. HATFIELD: Thank you very much, and then, as I started to say before, we do have a few minutes, so I will start back at the right hand side and maybe about a minute for each, any final wrap up comments.

DR. HILSENRATH: An hour worth of comments. It is primarily around the maturity. I think that we're looking -- it should be obvious after these presentations -- we're looking at two types of technologists around the table.

We're looking at one type of technologist to have a very simple and straightforward avenue of relocating. By that, we're looking at another technology, equally interesting, with a major launch issue out there, which is how to get this technology into the hands of tens of million subscribers. I think that it's quintessential to the discussion around the table here. Not only how innovative the technology is, but how simple is the vehicle of delivering it into a mass, horizontal, type of market.

MR. HATFIELD: Thank you. KSI?

MR. MALONEY: I provided my summary earlier. I'll just restate it. With the infrastructure approach, location technology is here today to do real time call routing and all requirements for all phones, those that exist and our in your hands right now and any that will occur in the future.

MR. HATFIELD: You probably should identify yourself for the record.

MR. KAHAN: Hi, my name is Dennis Kahan with SigmaOne. I'll say something that might sound out of context. I don't really think the issue is technology at all. Five years ago, the FCC had a wonderful idea to how you save lives and how you protect people from serious injury. They set a date of October, 2001.

That date for many reasons has slipped, and now the FCC is considering the possibility of letting it slip

more. There are 70 million handsets out there that don't have GPS capability or E-OTD capability. They can be located. You must create an environment in which all handsets will be located.

MR. STILP: Lou Stilp from TruePosition. I feel like I wouldn't be here if the question hadn't been raised over a year ago about whether handsets now can qualify for consideration under 94-102. I'm not sure if I misunderstood Mr. Bell about the test results that have been submitted into the record. I've spent a great deal of time going through test results that are in the record and I guess the things that concern me are there are more than 20 separate tests that are described in here, and not a single mention of what one looks like with an internal antenna.

And if that's an internal antenna, I guess I'm still going to keep this phone.

It is a very key question, because the sensitivity that network assisted provides is only 14 db and one of the test results that is described in here is that eight db of that is lost in going to internal antenna. There's a chart in here that shows an awful lot of data that simply isn't explained away. Yields below 60 percent, below 80 percent. As a matter of fact, almost a quarter of the test results had a yield of less than 80 percent. That means all these people weren't found or wouldn't have been found. And test

results that are way above 90 meters -- which is what's being offered here.

So I think we must consider carefully what exactly is being tested and whether those results have any bearing on reality when one talks about the handsets that people want to buy.

MR. HATFIELD: Mr. Bell?

MR. BELL: Gee, I think I just had to change my one minute here. Let me first say, I think the real issue here on GPS is how to commercialize it in the handsets. Our cost estimates that we're being told for first generation integrated implementations are in the $7 to $10 range. The incremental cost to the handset. That includes antenna, that includes licensing, and we're being told that will drop dramatically as law gets applied. These are standard processing elements.

And to that end, my last slide, which I ran out of time on, we have both equity partnerships and license agreements with Motorola and TI, who combined to provide a large majority of the global wireless components. And the real key here is that this is going to be put into those handsets so that it's available to everybody. It's being driven down and it will be included as a standard feature as handsets get deployed, going forward.

And then, finally, relative to the test results,

I'm not sure which public release of our test results are being referred to. We have release to the FCC and the document package it received last week. Great detail on our test results. Most of what's on the stack here, and we'd be glad to respond to questions from the FCC on those results.

MR. HATFIELD: Mr. Chadha?

MR. CHADHA: I think --

MR. HATFIELD: Could you identify yourself?

MR. CHADHA: Yes, my name is Kanwar Chadha from Sirf Technology. I think the question here is we are looking at that technology investment and infrastructure investment, looking five to ten years ahead and we have to look at what is the technology best for the future, not necessarily the technology best in the past.

I come from the computer industry and in the early 80s, mainframes were a proven technology, and if we had invested more in them, I think the PC revolution would not have happened. Five years back, amps was a proven technology, and as the rest of the world has proven, going to digital in the long run was a much better choice. So I think we have to look at not necessarily where the technology is today, we have to look at where it's going to be five to ten years from now.

As SnapTrack as mentioned, they have aligned up with a number of semiconductor vendors. Sirf has aligned up

with Nokia and Ericsson, which are the major suppliers of digital handsets, at least. So I think in the future, the location technology is going to be part of the handsets, and the costs will be taken care of using the most -- we have to see what is the best technology for the future.

MS. FRASCO: I'm Beth Frasco from Aerial Communications. I'd just like to say that I think that the FCC had a very successful history of converting competitive and technological neutrality and I think that the same lessons apply here.

I think that as my colleague to my left mentioned, we need to mindful of not only what the current capabilities are, but what the future capabilities are, as well. We're going to be making decisions here that are going to affect the industry for a long time to come. We're also leaders, when you look at the world wide stage on this particular technology. I'd like to see the FCC, notwithstanding all the comments that have been made here today, take a position that does encourage development in the positioning technologies and in the locationing site of our industry. And I think that allowing the maximum number of options to carriers will allow that, and, whether they be handset based or network based. And I think that the market and the capabilities and the technologies will be proven in good time. Thank you.