environment, when there's been no economic incentive to instill digital transmissions in those environments. So we think that's an issue certainly that needs to be addressed.

For effective selective routing among the PSAPs, the solution needs to be obtained very quickly. We know already that our results in our integration tests and TruePositions and U.S. Wireless and others have provided for real time selective routing, based on the locations, Phase II locations. Other techniques have only been demonstrated to come along significantly later with their first fix.

We feel in the specification of a location standard, that the Commission needs to pay close attention to insure that these life saving services are available on a high percentage. Some circular probable statistics have been cited, in which a half to a third of the data for the callers could be ignored. The current standard is from the mean square and that could be maintained at a high percentile basis to insure services for all.

The only other issue I would address, in the network which -- next slide, please -- network, which obtains measurements from sensory stations and provides it by datalinks to central stations for location calculations -- next slide -- can be implemented with various options. The top one is a totally independent overlay in which there is no connection whatsoever. All of the results we have

published in the record and that you have seen there for years have been obtained in this manner. This manner requires the duplication of monitoring facilities to pick up the calls and the channel assignments. The partially integrated forum uses cuing from the network system to tell you what channels to process, and perhaps piggybacks on the data links. But the bottom approach is a fully integrated approach in which the overall location command and control and the location calculations all could be implemented in the general purpose processors of the network, leaving as the only hardware augmentation those particular signal acquisition and data extraction facilities that produce the physical characteristic measurements. And I thank you for your attention.

MR. HATFIELD: Thank you very much and thank you, again, for keeping to our time constraints. The next presentation will be by SigmaOne Communications.

MR. KAHAN: Hi, my name is Dennis Kahan and I'm CEO of SigmaOne. My presentation is divided into two parts. The first part will be a somewhat general overview of what SigmaOne does and why it is different than some of the other network based competitors and then we'll take a look at how network based systems look in comparison to handset approaches.

SigmaOne as a company has been around since

November, 1997. It is a partnership with a very large Israeli company known as Tadiran Ltd. We have been in the business for quite a long time in terms of location. Tadiran has developed numerous systems for military and civilian location purposes and is also ISO 9000 qualified, in terms of manufacturing, which becomes important when you want to look at stability of a company.

My partner and I were originally founders of a company called Teletrac, which we believe today is still the most accurate land based system in the United States. As you've already heard, there are three different -- excuse me, there are four different types of technologies that can be used for location. SigmaOne actually uses two of those technologies. It's a combination of a hybrid TDOA, which is Time Difference of Arrival, and Angle of Arrival system.

I won't try to go into the details of how the technologies work, other than to say that when you mathematically and in the real world combine two locations of technologies together, you will always get a better result than if you simply use a single technological approach.

Angle of Arrival, itself, has lots of good advantages, and as I go through the presentation, I don't want anyone to misunderstand me. I think that there are benefits to time difference of arrival. I think there are

benefits of angle arrival. I actually like the radio camera approach, and there are virtues to the GPS system. There are, however, very serious issues regarding timing and deployment, which I think will ultimately determine which way the FCC and the Commission should go in terms of deploying 911 technologies.

Back to Angle of Arrival. It's excellent when you need a two-site solution. It's extremely high accuracy for two of the different error interface technologies, amps and TDMA, especially under five miles. It's a band-width insensitive, which means that it can also handle TDMA and GSM, as well. One of the things that was mentioned earlier, and I will highlight them because they are true, a limitation of angle arrival is that it requires an antenna and that does raise issues regarding where you're going to place them and what kind of problems it causes for carriers. It is also range dependent, which means that if you go beyond the five to six mile range, you start to lose in terms of accuracy.

Because of the limitations, SigmaOne also uses a Time Difference of Arrival system. Now, Time Difference of Arrival has a lot of advantages that overcome some of the problems that you'll see in Angle of Arrival systems. You get to use the existing cellular arrays, which reduces costs and also makes it much easier to implement. It has a range

independent accuracy, which means that it's accurate to 100 miles and accurate to 20 miles. It's accurate to 50 feet, as long as you can receive the signal.

Because of the way Time Difference of Arrival works, it's very, very good for the wide band systems, in particular, GSM and CDMA. You do need three sites for accuracy, as opposed to two. Now, SigmaOne, because it combines AOA and TDOA together, doesn't have the capability of using two or three sites. It is somewhat less accurate in narrow band systems, but I do believe that some of our competitors have done some very good work in the narrow band area and TDOA systems will work quite well in the amps and in the CDMA arena.

What I'd like to do now is do a very quick overview of the system. It's not a live demonstration, but it's a demonstration that we have -- unfortunately -- oh, there we go. This is a replay demonstration that we gave to some of the PSAP people that have come over to our neck of the woods, which is Woodland Hills, California. Is there a way to move that up a little bit? There we go.

The screen on the right is a little bit better than the screen on the left. You can't see that dot very well, so I apologize. When we run tests, we actually use differential GPS. I think GPS is a great technology. Differential GPS in our case is a $5,000 box with an antenna

that is wonderful. It sits right on top of a very big truck. We use that and the red dot that you see is the differential GPS.

On the left hand side, I've got to apologize. You cannot see that red dot over there. On the right hand side, you can actually see, to the extent you guys can squint over there, you can see the red dot moving. The green dot is our analysis of the location. You'll see up on the right hand side over here how accurate we are. That accuracy is critical. The SigmaOne system, which has been up and running for a year in the Los Angeles basin, it's a technical trial. It has in one signal accuracy of 200 feet. I want everyone to keep that in mind, because the one signal accuracy of 200 feet is in a light urban and suburban area, it's not a downtown area. But it is so accurate that when we hear claims about GPS and how accurate they are, you need to understand that the network technology people have moved well beyond the FCC requirement of 410 feet.

I'm going to move on to just sort of keep everything in the program going. Am I hitting that little thing over there? There we go. What I'd like to do is mention one other thing that's very important for SigmaOne. We have filed a patent last year which allows us to increase the sensitivity for location purposes of adjoining base stations, so that we have very, very high in building

penetration. We've been running tests in Israel, which is where our R&D site is located, and that site, those tests have shown that we can do excellent in building penetration, so that even if a single site can only receive that signal because of the attenuation, because it is additional processing gain, we have tremendous in building penetration well beyond the 14 to 15 feet you'll typically hear on some of the other technologies.

IN terms of the status of where we are, our one signal accuracy is 200 feet. Again, it's not in downtown area, it's in a light urban, suburban area. And our 90 percent accuracy is 410 feet. We have three major typical trials planned in the United States in the next six months. They'll be TDOA, AOA trials, in which we will be doing location both on the control channel and the reverse control channel and on the race channel itself in its dual mode.

Because of the way our system works, as I mentioned, we have an excellent real implementation which allows us to do two sites. What I'd like to do now is talk a little bit about how network based systems look in terms of cost and some of the other issues that the FCC is very concerned about. The most important thing for us to set the record straight is that there are many vendors out there on the network side that have location solutions that are quite inexpensive. Assuming that you had a $20,000 cell site

location, that $20,000 has the ability to handle a cell site with 1,500 consumers on it.

What that means is that the true cost is $13 per subscriber. That's a number that becomes very important. When you look at a handset solution, one of the things that's very interesting is that you never really find out what the cost is. What you find out is what the component costs are, which are typically about $10 and I think that's very accurate for very large systems. But I've never seen anyone go into a car dealership and say, what is the component cost of a radiator or the component cost of an engine? The real question is, what is the cost to the retail consumer?

SigmaOne believes that when you add up all the costs, the advertising, the model change, the design, all of those things, we're going to start to see a retail cost for a consumer between $50 and $100 or more per handset. That comes out for 1,500 subscribers to $75,000 to $150,000 in comparison.

Another issue that has not been raised and I would like to raise that's very important, network based solutions do require cost recovery, including the SigmaOne system. In comparison, handset solutions don't talk about it. The truth of the matter is that handset solutions cost considerably more and if you're going to want the carriers

to implement them, you must give the carriers a cost recovery mechanism. You can talk about deadlines all day long -- short deadlines, long deadlines. The truth is that unless you give them cost recovery, you're not going to be able to get them to deploy handset solutions, either.

One thing that I have been particularly disappointed with is the fact that the October 2001 deadline seems to be slipping both for the network based people and for the handset people, as well. Originally, the Bureau said, you know what? Let's have an early start date. And we look at the implementations that are being implemented, that early start date has turned out to, well, if I sell one handset and if I sell that one handset by September 30 in the year 2001, I've got an early start date.

To me, that's not an early start date. I'm going to skip over very quickly to what I call the reality of the dream, because I've only got a minute left. I already mentioned that early start date issue. I urge the FCC to make sure that an early start date means something, not one consumer on September, 2001.

The other thing that I'd like to just point out is that when you talk about accuracy, you've got to make sure that the public safety community wants that accuracy and is willing for a delay. The 90 meter CEP that people are talking about does not save additional lives. SigmaOne has

got that capability. I believe other network capable companies do, as well. Ninety meters won't do it and if you issue a regulation and you want to have a waiver, make it something that really will make a difference for the PSAPs and not the handset vendors arguing that that accuracy makes a difference. Ninety meters does not make a difference. Thank you.

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

MR. STILP: Good afternoon. My name is Lou Stilp and I'm the founder and executive vice president of TruePosition. TruePosition is a network based system that relies on Time Difference of Arrival and pathfinder technologies, in addition to others. It's a low kit existing, unmodified phones. As Dr. Birchler pointed out, the technology is compatible with almost all interfaces -- amps, TDMA, CDMA, GSM and IDEN.

TruePosition has to date invested about $60 million and about 300 man years in both the technology, development, trialing and commercial operation of the systems. We are currently installed on almost 200 cell sites in two different cities in the U.S., in the Philadelphia area market, covering about 2,000 square miles, and in the Houston area in Southwest Houston, covering about 150 square miles. And in these areas, the terrain includes

both urban, suburban, waterways and rural areas.

The Philadelphia, when we talk about it being an affiliate of the MSA, in fact, includes a good portion of Southern New Jersey, where cell sites are spaced on the order of 15 to 20 miles apart.

For the last year, year and a half, TruePosition has been running a technology forum, if you will. While we're here to talk about technology for one day, the truth is that TruePosition has been locating phones for 18 months now. Actually longer when you consider the New Jersey trial, which began in just a small part of that area, in the beginning of 1997. There has been an open invitation to the Commission to come visit these sites and see these systems in live operation, so without having to rely on any of the record of the written documents and claims that people make, TruePosition has got live systems that can be witnessed.

In the corner of this conference room, TruePosition has brought a lap top computer which is dialed in live. The dots that you see coming up on the screen are actually live 911 calls, as well as some test calls going on in both the Philadelphia and in the Houston systems. We obviously can't control how many 911 calls happen during the course of this afternoon. Any calls that come in, though, you can see live exactly as a PSAP operator would see them.

To talk about the current status of our system,

the directive that TruePosition submitted has a fair amount of details about our system in there. Just to summarize, amps has been in operation in the field since the beginning of 1997, as confirmed by the New Jersey report that was issued almost two years ago this month.

TDMA has been in live operation in the field since February of 1999, so that's bout four and a half months now. CDMA has been in the lab for some time. It is about ready within weeks of going into the field, with the cooperating carrier. Similar to the type of approaches that other presenters have mentioned here, TruePosition for CDMA does not require powering up of the CDMA phone. That is, we also have a unique approach that increases signal processing about 30 db above what a base station typically experiences. And so, while a lot of standards committees have considered the need to turbo power the phone, we don't require that in order to obtain our location accuracy.

In terms of talking about location accurate system, again, TruePosition has submitted a fair amount of detail about the systems that have been deployed up there. Before I talk about accuracy, one has to consider the following two things. Number one, since the system has gone live in Houston, which is about four months now, we have located well over a million calls in Houston. The Philadelphia system, which has been operating over about

2,000 square miles they mentioned, is now between four million and five million separate calls that have been located.

This is not just from one phone making repeated calls, or two phones. If you were to search our database, there are close to half a million separate names in our database, from testing for accuracy as well as testing for various applications. So if you consider that we're just on the A side carriers of both of those markets, we have already located more than 1 percent of the phones that are in circulation now for one half of the cellular operators that are out there.

Talking about the accuracy, TruePosition does not have strong opinions about R-MAS versus the 67 percent WEAC proposal versus 90 percent CEP. The reason is, we can meet all of those standards. We've been meeting them since the very beginning and we meet them today. Exact numbers have been included in separate ex partes, are that over 67 percent of the calls have been located within 85 meters, which is equivalent to 280 feet. Greater than 36 percent of these calls have been located within 30 meters, which is about 100 feet, and greater than 22 percent, or about one quarter of the calls, have been located within 15 meters or 50 feet.

TruePosition does not suffer from a yield problem

as experienced by some handset solutions. That is, we locate every single call. So the issue for us is not locating every single call, it's how accurate is each percentage of calls falling within. The accuracies that I've quoted are based upon a single location fix per call. As is well known, TruePosition locates call based upon the initial control channel burst. That is, for all those error interfaces, at the moment someone presses 911 send, there's a short burst that goes out from the phone to the cell site to begin initiating the call.

We begin calculating location from the very moment the send button is pressed and that transmission goes out. For an amp phone, we're talking a 100 millisecond burst. For a TDMA phone, we're talking a 20 millisecond burst. For CDMA as another example, we're talking 160 millisecond burst. And so, for these single burst type of location solutions that we've done so far, the accuracies that I've just discussed apply, and so the system already meets any of the three standards that the Commission has considered applying now.

If one looks from where we are right now to where we're heading, the next logical step that TruePosition is going to complete by year end is what is called voice channel tracking. Voice channel tracking adds another benefit to the location solution we have today, and that is,

one gets more than one opportunity to locate the call. When one considers the calls that have the most impact on 911 systems, when people are truly lost and when they're trapped under a car, as a recent example happened in April in Ft. Wayne, Indiana, there are more than 30 seconds or more than a minute or more than two minutes in which to locate that caller. That gives more than one opportunity to try to determine location for the caller.

As all location solutions have demonstrated, when you perform more than one location estimate on a single caller, all the location estimates tend to cluster around the caller's true position. And so, if the accuracy was perhaps 300 feet of the first estimate, by the time you've done two or three or four estimates, that accuracy is now closing in with 200 feet and then 100 feet and then 50 feet. The advantage of the approach that TruePosition and others take up here in locating on the very first burst is that location is made within the current FCC spec in time for selective routing to occur. And so, we can all determine on the network side, because we start from the control channel burst, within two to three to four seconds, way in advance of the requirements of 911 selective routing, the first location estimate has been made.

If there is a case where someone is trapped and it runs into minutes, there are many, many, many more

opportunities on the voice channel to improve accuracy. The other advantage of the voice channel -- and this is something that we're working on in particular as a joint development effort with Ericsson is that the power of the phone and how the phone transmits can be controlled by the cellular network. So while GPS solutions are limited to the signals that are now fixed by the satellites up in space and cannot be changed, what the phone does can be controlled by the network and what the location system does can take advantage of that.

There are a couple of technical questions that have been kind of brought up in the course of the record in preparing for this forum today and I'm going to talk about a few of them. Number one is real solutions. In talking about real solutions, I want to put the problem in context. When one considers a single carrier at a time, greater than 90 percent of the cell sites in this country have two or more cell sites located within 10 to 15 miles of them. So a single solution approach can work for more than 90 percent of the cell sites in this country.

Other remaining cell sites, another 5 percent of the cell sites, have one other cell within 15 miles of it. And so there are two cell site solutions can work for those additional 5 percent. So we're now covering 90 to 95 percent of the solutions, using the technology that have

been talked about just today.

When one now begins to expand the kind of technologies that apply to this and expand kind of the creative solutions to apply for the remaining 5 percent, two things need to be said. Number one, you can begin to consider more than one carrier's towers. One of the questions that may be asked this afternoon is whether location systems can work with more than one carrier market. World areas, in particular, will take advantage of that, so you now have carriers, so you now sell sites from two separate carriers that can be used in deploying location technology, providing location solutions.

Also, only one can continue to layer on the different type of technical approaches. As you heard from Dr. Hilsenrath, they actually have one cell site solutions that can operate in those remaining 5 percent of cases.

Second question that has been brought up and Mr. Kahan has already addressed it, is that network solutions are, in fact, cheaper than handset solutions. TruePosition has submitted ex parte comments indicating that its cost range is between 25 cents to 40 cents per subscriber. We've used these numbers as kind of a common point in which to talk about cost of location solutions. The reason these solutions can be so inexpensive is that they are -- the costs, as Dennis mentioned, get averaged over a large number

of subscribers.

I guess I'd like to conclude some of my comments with some of the mystique about GPS solutions. I, like most of you, have been through most of the record that has been submitted for the GPS tests that have been done out there to date. The majority of testing that has been conducted has been conducted with external antennas. So if we're supposed to be tasked with finding existing phones or phones that people would buy, the truth is that most of the testing that has been conducted out there simply hasn't been done with internal antennas.

As I've gone through the example of the most recent testing done in Tampa, very few results, as a matter of fact, no details have really been disclosed for what the results are with internal antennas, so that is something this Commission really needs to address. That is, if we're talking about what type of solutions are out there, they need to be focused on what type of phones people rely on.

Do I still have time?

THE TIMEKEEPER: You have about one minute.

MR. STILP: Sorry about that. There's a lot of conditions and qualifications that must be applied to handset-based solutions. I've come up with a list of about ten or 12 different "ifs," all of which must be satisfied to get to the type of location solutions that public safety

people want to buy. They want to locate all people, they want the accuracy to be good and they want everybody to be located as soon as possible. Thank you very much.

MR. HATFIELD: Okay, thank you and I'll thank you also for keeping with our schedule.

Now, we're going to shift to the handset-based solutions and our first presenter is from SnapTrack.

MR. BELL: Gee, I didn't know we had the option not to stay on schedule, so I'll try to maintain the trend. And thanks for the intro from my friend at TruePosition.

I'm Walter Bell. I'm vice president of engineering at SnapTrack. I will be doing the presentation, however, our CTO and co-founder, Norm Croster -- Norm, if you can raise your hand -- has been kind enough to join us from Boston. He was actually in Boston this morning and took a rapid shuttle to get here. He received an Ion Award for outstanding contribution to GPS technology this morning. Ion is essentially like the Nobel Prize of GPS, so during the Q&A session, Norm will be joining me in responding to questions.

Yes, like the Oscar for GPS. Just briefly, my background is 20 years in telecommunications. Norm has 20 years working on very hard sensitivity receiver technology, primarily in the Government sector. And the company was founded to apply high sensitivity approaches to GPS by

leveraging the wireless network. So this is our business.

Our personal location technology, as I mentioned, is really focused on how to combine GPS receiving capability with a cell-based wireless network. It is inherently interface independent. I do need to correct a statement that was made earlier during the intro section. Our technology does apply to amps as well as the other digital interfaces that were mentioned. It's a client server technology, so we divide the location to termination task between a client that is in the mobile device and a server that sits out of the network.

There was a number of reasons for that architecture, but among them are very high performance and very low cost in the mobile device, by spreading out the tasks between the client and the server. The technology works by extracting some key information from the wireless network. Again, we're taking advantage of the network and, for example we use the approximate location of the mobile device that's provided by the cell station ID and we use the carrier frequency in order to have a lower cost solution for the handset.

It is a software based solution and I think this is a very key tenant to our technology. Our signal processing is done as software. We leverage the DSP, the digital signal processor that's already in the phone, to

rapidly process a one-second snapshot of data and we used software based signal processing schemes that are fast convolution based, so that we can apply a lot of processing power to that one second of data.

I need to correct one other thing in the introduction, and I know it's hard for the Motorola person to cover all the technologies. But our technology also has the ability on networks that are not time-synchronized, that is, non-DMA networks, to provide the time solution without adding any hardware to the network. It is a software-based solution that we've developed and it is currently being commercialized in Japan and we've used it extensively for field tests.

So again, we do not require the network impact that was mentioned in the introduction for non-time synchronized systems.

Let me use the pointer here so everybody can see it. The system is fundamentally, as I described it, as a client, in the handset device, there is a partial GPS receiver in the handset. The server sits out on the network and is connected to a wide area reference network of standard GPS receivers. This is deployed nationwide and it takes about nine reference receivers that cost roughly $10,000 each to cover the entire U.S. And SnapTrack will provide this service to all of our carrier partners.

There is a data connection between the client and the server at the start of the session to exchange a small amount of data. It's roughly 100 or 200 bytes of data in each direction. The server does the final determination after the client has made some signal processing measurements and then the location is passed through several different means over to the PSAP operator.

In a trial we did last summer, among the one network trial in Denver, we passed this data over to the PSAP operator, using the existing PSAP infrastructure, the existing alley equipment, and it was essentially no change to the operator's hardware. Next slide.

I think it's important to first compare SnapTrack to conventional GPS. You can see the SnapTrack performance in this column, conventional GPS over here. GPS is very powerful. It was developed for location and, for no other reason, however, it was developed to work on the heads of missiles in situations where you had open sky visibility.

So to apply it to a handset, we really needed to go to a much more sensitive, much faster approach. And as you can see, we have much higher accuracy than conventional. This is because the server provides a number of types of error correction, as well as the higher sensitivity allows us to see more satellites.

Our time for six is in seconds, so I'll talk more

on that in a second, whereas conventional GPS can take up to 15 minutes if it has to read satellite information. We don't have to read satellite information. That's part of the key to the architecture. We have excellent yield. We have a roughly 20 db gain in sensitivity over a conventional GPS. That's our current sensitivity and we have schemes in place under development for another six or seven db.

A very nominal power consumption, because the system is only on for a few seconds. Remember, we're just taking one snapshot of data for one second and so we shut down most of the rest of the circuitry and then the entire processing is a few seconds more and then it turns off, and that's compared with high ongoing power consumption of conventional GPS.

And the key again is that it's a software-based technology, so there's minimum costs on the hardware side, and this really makes it viable for use in the handsets. I'm not going to try to read all of this slide. In fact, I think the key here is on the SnapTrack wireless A-GPS side, I'll summarize that and then you can read the comparison with the network overlay approach.

The bottom line is we have really negligible network impact. We do use server, but it's really just a software, a piece of software that can run on existing network platforms and that single server can cover a huge

geographic region. In fact, could cover all of the U.S. if chosen to deploy that way.

With only a single base station in communication, we can provide a cold start, first fix, one sigma accuracies in the three to 75 meter range. And the average accuracy over a typical cell phone environment is in the 20 meter range. You do have to modify the handset. Clearly, that's one impact of a handset-based solution. However, we believe and I'll show cost numbers in a minute, that those costs are very reasonable, relevant to the performance that you achieve.

Part of the thrust for SnapTrack in commercializing our technology is through test groups. These are carrier and manufacturer test groups to evaluate SnapTrack and partly to serve as a focal point for the standards activities. You can see the CDMA test group membership that's all of the key carriers and manufacturers and their interface. And partly, that has helped us launch with other location providers standardization work for CDMA, which is also -- and also is launching now a GSM standardization work. So that work is well along. Next slide.

We have always felt that the true test of any location technology is to do it in the field. I have here with me, and we've made most of these available to the FCC,

a stack of our test reports. These are audited reports and contain great detail on our performance, but it's clear it includes all major error interfaces as you see on the slide. Next slide.

The Tampa test is the most recent on the CDMA side and we are operating within the CDMA network, so we're getting the network information described. We provided or that test was done with prototype handsets from various handset manufacturers. This is the Motorola Star Tec version I have in my hand, that does include an internal antenna that was used for the test. Next slide.

I'm going to skip through this slide. It talks about how the server was integrated into the network. We were using standard circuit switch data, because that's what was available. The next test will be using standard based data communications. Next slide.

MR. HATFIELD: You need to wrap up.

MR. BELL: Okay, this is really the final slide I need to talk to. This shows our performance in terms of time to cold start and a 67 percent CEP accuracy for a number of different environments. On the right, you can see where we were 18 months ago. The heavy rectangular is the data from the Tampa test and then the stars are where we will be 12 months from now, based on our implementation plans that are underway. You can see the performance