LOCKHEED MARTIN CORPORATION

Moderator: Courtney Chambers
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Courtney Chambers: At this time I'd like to give you today's speaker on low cost mapping of submerged vegetation, Bruce Sabol.

Bruce is a research civil engineer with the Environmental Systems branch in the Environmental Laboratory at the Engineer Research and Development Center also known as ERDC. Mr. Sabol's present emphasis is in development, testing and simulation of remote sensing sensor systems for military and environment applications. This has included testing and simulation, support for military target acquisition programs using radar, thermal infrared, visible light, laser, acoustic and seismic sensors. Bruce has developed and holds patents in digital image processing techniques for wildlife synthesis using thermal infrared cameras and techniques for wildlife senses - excuse me - and in hydro acoustic signal processing techniques for detecting and mapping submerged aquatic vegetation. He has Corps district experience from the Detroit district. During this he was involved with environmental aspects of maintenance, judging and water quality issues.

And if you'd like more information about Bruce you can read about his education and other background experience in his bio posted on the Learning Exchange with the rest of today's meeting documents. And we're very thankful for his willingness to share with us today. Okay.

At this time Bruce, I'm going to give you the presenter rights and we can begin our presentation.

Bruce Sabol: Thank you Courtney.

Courtney Chambers: You're welcome.

Bruce Sabol: Hopefully I live up to that bio. I'm going to do one thing before we get going and that is the - okay, I've got the cursor.

Courtney Chambers: Yes. And we can see that red dot Bruce.

Bruce Sabol: Yes, okay. Very good. Thank you everybody for spending - taking the time to listen in. What I wanted to do today was talk about a technology that was developed at ERDC and by and large has been operational for a number of years. But we have recently done some upgrades to it in terms of changing the hardware that should make it considerably more affordable for agencies that don't have the equipment budget that the original system required.

Also just for purposes of understanding here, submerged vegetation - we're really referring to a bottom rooted vegetation that grows upward in the water column. This is typically not emergent and it's definitely not floating. So this tends to be the type of vegetation that is most difficult to see and characterize. So that is the focus of the talk today. Okay. Now why we need...

Courtney Chambers: Bruce, can I interrupt a minute? They're having a hard time hearing you. Would you mind speaking into your handset?

Bruce Sabol: Let me see if I can crank up the level and just give it a minute and see if that's any better. Is this - it's on max. Is that any better now? I can go to handset if need be. Hello?

Courtney Chambers: Yes. I'm still here Bruce. If you really don't mind, the handset might be the safest way to go to insure everyone's hearing you okay.

Bruce Sabol: Okay. I'm going to hit the speaker button here and go to handset. If I lose it I'll call back immediately.

Courtney Chambers: Is that better participants? Okay. It sounds like I've gotten one feedback that says that they can hear you fine. Okay.

Bruce Sabol: Okay. Well we'll do it that way.

Courtney Chambers: All right. Thank you.

Bruce Sabol: Okay. Why you would want to know any of this in the first place - the primary intention in the original development was for planning for nuisance aquatic control operations where you wanted to detect early in the growth stage, the plant so you could plan the control and if for instance you were using chemical, you would hopefully use much less of it and be able to effect control before it took over the water column.

After we began using this we realized there was another whole area of use and that has been primarily in the SAV mapping associated with dredging operations, particularly in estuarine and coastal areas where you - for instance you have sea grass and you want to protect it since it's a valuable resource.

Beyond that there's a host of things you can do with it - monitoring for restoration or various sorts of environmental ecological studies. And we've even used it for hydrographic mapping in cases where there is vegetation that prevents finding the bottom.

The existing techniques - the standard techniques typically available are really - range from aerial and satellite imagery which of course gives you a large instant area view at once so it's very good for large area mapping. The difficulty being that detection is frequently confounded by turbidity wind conditions, clouds and a variety of things which typically results in some underestimation of coverage.

At the other extreme is physically getting there, looking at it, grabbing it, diving it - I don't know, whatever. Of course this is the highest quality data. You can do species composition and other things that you would need. Of course it's very labor intensive, expensive and slow.

The basis of acoustics which I expect most everybody's familiar with, is sending out a short pulse of high frequency energy and measuring the echo return from things it encounters, typically material in the water column - plankton, fish, always the bottom or almost always the bottom and SAV.

And this involves coming up with a measured return of the energy coming back and that's typically what the item that is used for the signal processing. Here is a fairly typical echogram representing a transect from deep on the left to shallow on the right into a sea grass bed. The vertical axis is depth, the horizontal axis is basically distance along the transect also corresponding to ping number. And the colorization represents echo intensity with the hot colors being most reflective.

And typically what you see, there are certain common features, almost always some surface noise that's the result of surface bubbles and transducer ringing. Typically there's a quiet zone below that before anything is encountered. On the far left here we're in an unvegetated area.

And the bottom is quite an intense echo return also quite sure driven largely by the pulse duration. Farther on you get into a large area of sea grass where you have a much more distributed - spatially distributed energy return from the echo.

And these are some of the features that we commonly use. Below that it looks like you're seeing something into the bottom that's almost a mirror image of the plants above. In fact this is just reverberation that's really no depth penetration beyond a few centimeters into sand.

Here's another shot of pretty much the same thing on the upper echo gram showing a transect into a largely unvegetated area. And from that area we look down and this is essentially an oscilloscope return where on the lower left graph the vertical axis essentially represents time or depth and the horizontal axis represents amplitude of the signal. So you have the typical near surface return. You have a quiet zone and in this case you have a sharp rise when the bottom occurs of a very short duration.

Courtney Chambers: Excuse me Bruce. I'm sorry to interrupt again. I just would like to ask our participants to double check that they're on mute. We're getting intermittent background noise. If you don't mind. Thank you. Sorry Bruce.

Bruce Sabol: Okay. Farther on the right here we're into the vegetation and again you see the surface noise and ringing, again a quite zone. And then it rises with a much more extensive return before it falls back to the noise level. So these are some of the characteristics that are typical of return. And these are used in the processing.

Now I'm going to let you absorb this for a minute and then we'll go through it in detail. Really the good news is we're not going to go through it in detail.

My primary purpose in showing this is that between the previous slide that showed you some of the features and the next slide which shows you the output, there is a significant amount of digital signal processing that was developed to exploit that and convert data into information.

And this particular graphic is known - this particular code is known as the submerged aquatic vegetation early warning system or SAVEWS. If anybody's interested in that it's described elsewhere and I'd be glad to provide you links to that. Okay.

This is essentially a cartoonized version of what you get. Here we have a boat running a transect. We have the position data coming in typically at a slow rate - one or - typically around 1 Hz. And the ping - the acoustics are pinging at a much faster rate, in this particular case about ten pings per second.

And what you get out of this is every ping is characterized in terms of if you detect vegetation and if so, how tall it is. So when you're going and you encounter the first position you summarize the ensemble of pings between that and the second position.

In this case four out of ten of the pings had detected vegetation resulting in roughly a 40% coverage estimate. And of the pings that had plants average height was 15 cm. And we also report out the position as the midpoint of the two GPS reports.

This is a little bit exaggerated because the boat at 1 Hz, one report per cycle, and typically five knots, that's only 2-1/2 meters. So it's really much denser than is indicated by the cartoon here.

What the output of - and this again we're still talking about SAVEWS which is the existing technology, is position referenced depth of the bottom below vegetation, plant cover height and again with the idea that this was really intended to detect low density vegetation early in the growth season.

What you do not get out of this is there is no species discrimination from this. We have looked at this and pretty well concluded that there's just too much overlap between species and that simply wouldn't be possible to do. In the upper right here this is a section of St. Andrews Bay in Panama City. It's about a 35 (hector) area. You can see the transects that we ran into and out of shore and we processed that to generate the underlying bisymmetry and we colorized the plants used to indicate vegetation presence or greater than 15% and vegetation absence or less than 15%.

And you see it follows pretty dramatically the symmetry. This was about a two hour survey in the processing and field. The graphics at the bottom represents a 500 plus acre lake up in Wisconsin that we surveyed numerous times roughly at about a 50 meter transect spacing. And that was immediately before and then four weeks and eight weeks after a chemical application intended to control your Asian water (milfoil).

This is what's flatter is percent coverage unlike the upper right where we just show the transects here we've done interpolation and mapping and made a color isopleth map just showing the coverage.

And this is what this shows - just how the coverage decreases through time following the treatment. One thing to remember is that with the amount of time taken you're generating thousands or in some cases tens of thousands of output points. So you have a really data rich situation to analyze and look at whereas for instance if you were doing diving in the same time you might get maybe a couple of dozen samples. So one of the things you can do, and we've done a show - the next couple of slides there are some examples of that.

This first one we bend the reports into half foot depth increments and just took the average of the coverage by each of those increments. And it shows quite clearly that prior to the treatment you had a very well developed canopy in the six to ten foot depth.

Following the treatment the coverage goes down but certainly the plants haven't gone anywhere, just a reduction in coverage. This is the same sort of thing but half with (unintelligible) but we're looking at effective canopy height. That's the ECH.

And here it's much more dramatic. You see what actually happens is the height of the canopy just collapses rather quickly. And by eight weeks we're down to an average of less than half a foot.

So control was certainly effective and you can see some of the depth distribution of that control. I'm sorry. I hit the wrong thing. I'll try again. Okay. Another thing to remember is once you interpolate things you effectively have a two dimensional array of numbers.

And in the top here we have done that. This is canopy height with the brighter red being the taller canopy. So we have the canopy height prior to treatment four weeks and eight weeks after treatment.

But what you can do is since these are essentially just a range of numbers, you can do some matrix subtraction. And we have done that here, taking the four week and subtracting it from the (pre). And I do apologize for the color selection I used here.

On the lower graph we're looking at change in canopy height and the red represents a loss of height. The blue represents an increase of height and it's unrelated to the red in the graphic above. But you see a very large decrease in the height of the coverage during the first four weeks after treatment. And afterwards again, from the second four weeks you see a much smaller spatial distribution of the reduction of height, again showing you what the previous graphic did in a non spatial sense. Okay. Here's a more traditional way of just looking at multi temporal (unintelligible).

This is a June and August survey of Lake Sinclair about a mile and a quarter transect showing the solid line represents the bottom and the dash line represents the canopy top at June and August and you can quite clearly see the increase in canopy height. Also note this August survey was considerably rougher conditions.

Here is another graphic. Now what we have here - this is a section of the St. John's River in Florida. The solid colors represent classified aerial photography. The blue, the red and the dark red are essentially in the water. And the bright red represents a low density area or (tape) grass. The dark red represents a thicker (tape) grass. The colors to the left on the land we're not concerned.

At about the same time we were out there with the equipment and we did a zigzagging transect where we would go in until we found the vegetation zigzag out so it would enable us to very precisely find the edge of the vegetation.

And what I was able to get out of this is that the photography is essentially underestimating by a considerable amount the depth of the vegetation. I've seen this at multiple places. Of course the St. John's River is a very dark (tannin) colored body of water. So anything optically is typically underestimated.

Okay, that's everything, that's where we are operationally. That's stuff that we have done. SAVEWS was completed and patented in '98. It was licensed to BioSonics in 2001. They have been marketing it since as EcoSAV. And they have told me there are approximately 70 users on the system worldwide and there are some 20 plus publications out describing its use or using it as a tool in other things. And only a few of them were by me.

The limiting factor has been the cost of the hardware. Now when we first developed this the BioSonics DTX system was the only thing out there that - data was in a form we could use directly without having to get any shortcut design or so forth.

So naturally we used it. It's been quite successful and it has pretty well established performance levels with it. What's happened since then is the technology has caught up and now you have sound or GPS systems that by all appearance generate some similar data but at a greatly reduced price.

So ERDC, through the aquatic plant control research program, undertook the task of adapting that to the new available low cost systems with the idea that it would be much more widely available to folks who might need this type of data. So what we did an initial survey and we decided that although (Rant)'s HDS system was the way to go and looking at the system and this system is around $2500 worth of equipment compared to the DTX, obviously there are differences and frequency (beam) width and so forth.

The ones that are really important are the lower three. What you get out of this is the BioSonics is a scientific grade calibrated system. You get 22 bit digital data calibrated.

The low (Rant)'s essentially makes a pretty 8 bit picture, not quite the same, also there's considerable digital pre-filtering with the BioSonics very nice signal, not so much so with the low (Rant)'s requiring that certain types of software processing be adapted.

Here is an echo gram of the low (Rant)s. Again it's pretty much seeing the same sort of features. The surface noise, the quiet zone, typically a strong return from the bottom and the vegetation coming up from the bottom, and again considerable reverberation again.

But noting that really it's just reverberation, nothing is down there to be able to extract information from. And it's a typical ping so what we have here is the time or essentially depth of the return and the 8 bit amplitude of the return.

Again no physical meaning, just an 8 bit number. And the structure of it is quite similar to a calibrated system. Again with the quiet zone you typically have a sharp rise and you can identify the amplitude of the rise and the depth of the rise, the peaks and so forth.

So these again are the types of features that are used in the algorithm that has been developed. And in fact it's quite a different - it's a very different algorithm than the original SAVEWS which again we didn't realize it would be so different. But there's enough differences that require that we do that.

Okay, a very simplified version of what's involved reading the file, reading the file and picking a configuration file that sells the algorithm, how you set thresholds and these sorts of things. A data cleanup phase that involves some despeckling, (splicing) and smoothing, feature extraction, getting the features we need from each ping, decision logic and output. So again this is a fairly simple version of what is done. But the outputs again are pretty similar. Depth, location, coverage, canopy height and you can get the depths of the canopy top and also (fugacity) which is kind of a freebie but it's for instance, if you want to do coral reefs, (fugacity) is a measure of interest.

Okay, now here is a typical output from this. Starting in the upper left again we have the colorized echo gram. But if you can note the black dots represent the declared bottom and the red dots represent the canopy height in areas where canopy was detected.

Below that is just the scatter plot of percent cover and mean canopy height. And the part that you would use beyond this of course is an ASCII file that contains the same information. From that you can put that into your favorite statistics or mapping package and do analysis from there.

We don't attempt to get into that area. Now where we are or where we did from the end of last season we have looked at - we've been to a number of places and looked at a number of species, certainly a long, long way from all of them.

But we have sampled enough things of enough different morphology types to convince ourselves it is probably going to work rather well. We've got some data on sea grasses both the diminutive halodule and the more robust (sastera). We have more species to get but typically they look like one or the other so we would expect performance similar.

We had data from the Wisconsin/Michigan area looking at some of the freshwater species - (mariophilum), (potomagetum) and again they have found detection performance to be generally good.

We will be looking at additional data as it comes in and trying to make sure that it works for all of the conditions we’re liable to encounter. Now the validation, again, this is essentially a remote sensing system, and you want to make sure that what's coming out can be verified and validated.

What we have in progress right now is we have looked at simultaneous transects with BioSonics and the Lowrance to compare the outputs, using the BioSonics (SBUs) as the standard, since it's a fairly well characterized system. We have looked at underwater video from Wisconsin, looking at some diver data, and we'll be getting more diver data in (Florida). So by the time this is fully released we should have a reasonable body of data showing the validity. Okay, what I've got here, this is just a single transect done in some of the New Jersey's (ASTRA), the upper graphic being the BioSonics, again, with the color scheme you saw, and the lower being the Lowrance, in which case we also have the bottom detection and the canopy heights show in there. Just to illustrate the similarity of the two signals, in actuality the BioSonics is a 420 kilohertz, and the Lowrance is 800.

Okay, the nature of this algorithm is if you can successfully find the bottom beneath the canopy, everything else is easy, and here's a plot of the bottom section for the previous graphic, again, showing general agreement.

We're actually coming in from the - compared to the previous graphic, we're coming in on the right from deep water into the shallow, and just plotting that in terms of longitude. This is somewhat of an older graphic, and we've actually gotten the Lowrance much more stable through some additional processing. So that's somewhat dated, but what I get out of that, it tracks the BioSonics fairly well.

Okay, canopy heights, again, coming in from the deep water on the right, and finding generally similar canopy heights, percent coverage, not quite so much so. We get a very good agreement. Of course when you get into canopy we're getting slightly higher estimates with the Lowrance.

This doesn't particularly trouble me, because work with BioSonics and the videography has shown that the BioSonics was a little bit lower than the videography. So to have a slightly higher output, we hopefully we get some videography data to compare with, but I think that indicates a reasonable output.

All right, now where we are, we're getting close to the end here. On the overall project schedule, we have essentially completed the software development. We're still doing some testing and cleaning it up prior to release. We have a user manual that we expect to release in July that covers equipment needed, how to assemble it, how to use it, how to process the data.

We also, in July, will be releasing the software to those who are interested, and we're going to consider that a beta release. Then we'll be looking at that data to make improvements until we have to freeze the software in September. And we have one hands-on training class planned for the New England area at the end of July.

Okay, products available, the equipment is the responsibility of the user. We're not handing out hardware. And let me answer a question that hasn't been asked, but I know it will be. Can we make this work - if you, for instance, have a, say, a Humminbird transducer, can we make this work on there?

And the answer is of course, yes, but it may take a couple of months of software development testing that could easily be in the excess of $20,000. So I think the best answer is it’s really not economically feasible to use anything at the moment but the Lowrance.

Okay, we'll have the software, planning on releasing that at no cost to users, compiled version, user manual, same thing. We have a training class up in New England District. It's in the Boston office, and we'll be planning on operating both in estuarine environments and freshwater. There may be slots available, and if you're interested, let me know and I'll put you in touch with who's keeping the master list on that.

And we also will provide telephone tech support to users who get the software and would like to use it, to try and make sure you have a successful result. We have funding on this through the end of September. So I can't guarantee what happens beyond that point, but the point is we should be able to help you get going.

Okay, contact information, if any of this sounds of interest and you'd like to do this, send me an email or call me. I'll make sure you're on the distribution list and get it, which will be sometime this month. And expectedly we're going to be sending some files back and forth, typically the SL2 files from the Lowrance that we may want to process here and help you develop a configuration file, the correct configuration file.

And we'll be using the AMRDEC safe program, which allows government and non-government transfer of files. So don't worry about scribbling this down rapidly. This information will be available on the archived presentation. Okay, well that's really all I had. We'll stop here. And this is a real live picture taken somewhere down in South America. That's the best I can tell you, but it's part of the 70 worldwide users.

So I'm going to stop here. If there are questions I could answer, I'd be happy to do so.

Courtney Chambers: Great, thank you very much, Bruce, for sharing this new tool and capability that's available to us. Remember that if you're going to ask a question verbally, to take your phone off of mute so we can hear you first, and if you have a question that you'd like to type, please send it to everyone so that we can see it. Thanks.

(Bruce): Well, I'll take silence to be assent. If anybody needs any more information, like I say, just contact me. I'll be happy to answer any questions I can. So I guess no questions.

Courtney Chambers: Well, let's give them just a few more minutes. Sometimes it takes a few minutes to get your thoughts together.

Robert Kipker: This is Rob Kipker with the Florida Fish and Wildlife Conservation Commission. Bruce, are you aware of private companies providing this type of analysis? (C.I. Biopace) is one that we've dealt with.

(Bruce): Yes, I'm aware of them. It's - like I say, it's a slightly different approach. I'll be talking with them more at the upcoming Aquatic Plant Management Society Meeting, but yes, we're aware of them. There is commercial - there are commercially available systems for doing similar things. We haven't had a chance to do any comparison, but short answer to your question is yes.

Robert Kipker: Okay. Is it your intent to compare yours with them, or is that something that would be...

(Bruce): That's something that could be done. We haven't made arrangements to do so. My initial intent is just to go ahead and complete and publish the validation of what the output is versus what, you know, higher resolution sampling techniques would show, that we may want, if there's an interest on their part, we may want to do some study that involves some physical ground-truth. There are some upcoming opportunities to do that.

Robert Kipker: I guess what I was wondering is, we're currently collecting data with a Lowrance HDS system that we are running through the Bio Basics algorithms. Could we run that - those same transects through yours?

(Bruce): Do you use the structure scan?

Robert Kipker: Yes, we are. For most of them we are. We're trying it both ways.

(Bruce): I think the tentative answer is, probably, but I need I can get you a draft copy of the manual that has the configuration you need to generate the file. We're set to operate with the 800 kilohertz with a certain group of settings. So if - you know, which may or may not be what you're doing right now. But if you want to just send me an email, I will respond by getting you the draft, the current draft of the manual that tells you what the settings are.

Robert Kipker: Okay, thank you very much, (Bruce).

James Kannenberg: (Bruce), Jim Kannenberg with Marine Biochemists.

(Bruce): Jim, how are you?

James Kannenberg: Good, how about yourself?

(Bruce): Good.

James Kannenberg: The output on this, is this going to be fairly similar to what (Aquaset) puts out?

(Bruce): Quite, yes. The only thing that we're doing extra is we're looking at the heighth to the first encounter, which the (Ecosav) doesn't do. Essentially what that is, what that means is if you have a very dense canopy growth, such as a millefoile, where you simply can't see the bottom, this will tell you the heighth of what's out there, and you could deduce the plant growth based on a bathymetry map that you took at another time. Plus we'll do the rugosity, which, you know, may or not be of interest to you.

Martin Curran: (Bruce), Marty Curran from Hopkinton Dam.

(Bruce): Yes sir.

Martin Curran: (Bruce), you mentioned the training in New England in July, at the end of July and August. Do you know where the training is going to take place, and is there a charge for the training?

(Bruce): There's no planned charge. Of course the charge would be you getting up there and hotel and that sort of stuff. We're going to give preference to Corps of Engineer folks, which were naturally - the folks that pay the bills.

But I would say there may be space available, and it would be worth asking. It is Bill Hubbard, up at New England District, setting that up, and if you just want to send me an email, I'll pass that name and contact information along to you.

Martin Curran: Yes, I work for the Corps. So I have Bill's - yes.

(Bruce): Okay, you're in.

Martin Curran: Okay, thank you very much.

(Bruce): Sure.

Courtney Chambers: (Bruce), we had a question typed in the chat feature. It said, "Can you manually adjust the bottom to visually match the echogram after the initial processing?"

(Bruce): Yes. There are number of configuration parameters used in automatically detecting the bottom. Now we do not do any manual overwrite to, you know, trace the bottom as you might do with a pencil. Everything is done in an automated mode, but there are enough parameters that go into that that give you pretty good flexibility as to how the bottom is defined.

The philosophy we took is this needs to be a completely objective repeatable process without, you know, without subjective valuation of what things are or where they are, and that we have tried to stick to that. So I think the answer is a qualified yes.

Courtney Chambers: Great, thank you. Any other questions at this time?

Dean Jones: Hi, (Bruce), this is Dean Jones, University of Florida.

(Bruce): Hi, Dean.

Dean Jones: Can you clarify what exactly your output is?

(Bruce): Yes, let me - (Courtney), do I still have control?

(Courtney): Actually I took it back so I could go to your contact page, but I can give it back. Just one second.

(Bruce): Okay, I'll page back to that and just spend a little more time on it.

(Courtney): There you go. You should be able to now.

(Bruce): Okay. This may be a little difficult to see this. Let me get my cursor back here - okay, looking at the ASCI output, again, longitude, latitude, time, center ping, the bottom depth, canopy heighth, percent cover. It's pretty much the same set of outputs that, again, we're associating with the (Ecosav).

There is a preprocess - there's a post-processing piece - separate piece of software that we'll be putting out there, and it's described in the manual, that also allows you to convert (lat/long), any State Plane Coordinate, and also corrects for the transducer depth and tide, if you have a tide file. So again, that was - those are all the capabilities that were with the earlier (SBUs). So that will be there, but it's - that's basically the output. Did that cover your question?

Dean Jones: Well, the follow-up would be has this gone through the algorithm processing at this point?

(Bruce): I'm sorry, has what gone through the algorithm processing?

Dean Jones: Your ASCI data file. Is that...

(Bruce): Well I mean this is the output of the processor right here.

Dean Jones: Okay.

(Bruce): I mean, you know, the input are just 8- bit echo returns, and we've processed that to put that out in terms of mapping information. So yes, that is the output and that's essentially as far as the output goes, except for the post-processing correction that I just mentioned.

Dean Jones: Okay, thank you.

Courtney Chambers: We have time for more questions, if anyone has anything else. All right, if you're still thinking, that's fine. You can chime in if you have a question. But I did want to call attention - I posted a link to the Web site where this archived meeting will be posted once it's been edited and we've received the transcript. So if you would like to reference this at a later time, save this link, or if you follow that link now you'll see our past meetings that are posted there. Any other questions?

(Bruce): If you have some thoughts later, don't hesitate to call or drop me an email. I'll do what I can to get you an answer.

Courtney Chambers: All right, great, and likewise, if they'd like to participate in that training in Boston, they can also contact you for further information. Correct?

(Bruce): Yes, that's correct.

Courtney Chambers: Okay, well that sounded like a great opportunity to get early access or get a jump on it here soon. Okay, well if there are no other questions, I want to thank you very much, (Bruce), for sharing this new capability and application with us today.

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