â€˜Killerâ€™ AUV Sonar System

In January 2001, C&C Technologies (C&C), a company based in Lafayette (Louisiana, USA), introduced the first commercially successful autonomous underwater vehicle (AUV) to the offshore industry. The AUVâ€™s survey sensor suite, which included an EdgeTech side-scan sonar and sub-bottom profiler, performed well in the Gulf of Mexico and Brazilian offshore environments. However, West Africa proved more challenging â€“ particularly for the sub-bottom profiler. C&C soon began searching for alternative technologies to provide better sub-bottom profiler penetration and higher resolution side-scan sonar imaging.Jim Chance, C&C Technologies (USA) Art Kleiner, EdgeTech (USA)<P>

Narrator:

Fast forward to the early autumn of 2004… C&C is about to place an order for their second Kongsberg Maritime (KM) Hugin AUV. The company is searching for technology that will equip this AUV with cutting-edge sonar performance. C&C's intent is to provide better data to their customers and to sharpen their competitive edge.

Jim Chance, Vice President and Co-Founder of C&C, initiates e-mail correspondence with John Spruance of EdgeTech. As Jim sits at his computer keyboard, the story unfolds…

Subject: Sub-bottom penetration
Date: 19/08/2004
From: Jim Chance
John, your sub-bottom doesn't work… well, let me explain. It works fine in the Gulf of Mexico deep water, but off the coast of West Africa we were not getting any penetration.

What do you suggest?
Date: 19/08/2004
From: John Spruance
Hmm, let's try this on for an analogy... A tractor is a great vehicle for plowing fields. However, even though it 'works right' it probably has a poor chance of winning the Indianapolis 500 auto race.

The amount of penetration (performance) of a sub-bottom profiler depends on a number of controllable (and uncontrollable) parameters:
a) centre frequency of the pulse
b) bottom hardness
c) change in density
d) presence of biological.

Reprocessing the data or running 'raw' data through a different process is not going to improve the results if you have an issue (problem) with one or more of the items above.

Date 19/8/2004
From: Jim Chance
Thanks. I understand what you are saying, that physics is physics. I think an ocean bottom with a high absorption coefficient and no coherent strata probably causes the problem. However, I currently don't have the luxury of assuming this until the problem has been thoroughly beaten.
On the other hand, I doubt if you've done much testing with the 1–6kHz or 1–5kHz chirp, since you've just made them. What about the sub-bottom research work being done at Florida Atlantic University (FAU)? Would that help our cause?

Jim, the 3D sub-bottom scanning sonar is in development at FAU under Office of Naval Research funding. EdgeTech is the industrial partner. The sonar is designed to image buried objects up to 30° off-centre.

System features include:
1.a design using a 40-channel array of hydrophones that can be towed or mounted on an AUV or ROV
2.SAS processing for improved along-track resolution
3.frequency range: 3–19kHz
4.swath width: 60°
5.an omni-directional transmitter, illuminating all targets within the range of the sonar during each transmission event
6.the use of reflection tomography to construct the shape of the target from target echoes generated as the vehicle approaches and passes the target
7.a sonar range between 2 and 4 times vehicle height for targets buried deeper than 1 metre

8.detection of targets with shallower burial depths at sub-critical grazing angles providing significantly greater detection ranges (up to 10 times vehicle height).

I've attached a picture of a 20-year-old 20-inch buried pipeline (Figure 1). Depth of burial is 1+ metres.

Narrator:
Dialogue continues over the next several weeks about how to solve the sub-bottom profiler penetration issue. EdgeTech learns that C&C is considering integrating a Klein 5000 multi-beam side-scan sonar on the new AUV.

Thomas & Jim (Chance), let me throw you a curve ball. Enclosed is a brochure on a side-scan we are developing on the quiet. We would like to keep this as quiet as possible.
It is dynamically focused side-scan sonar. Here are some benefits for installation on the Hugin 4500:
1.about the same power consumption as the current 120/410kHz EdgeTech system on your current Hugin
2.an integrated chirp sub-bottom profiler without adding an additional computer
3.same form factor for the bottle of electronics (sub-bottom profiler and side-scan sonar) as the current version of the 120/410 on the Hugin
4.we have discussed this with Kongsberg in the past regarding interfacing with the Hugin AUV (size, weight, etc.)
5.real-time results of the focusing
6.virtually the same logical interface and data format interface as the existing 120/410 system.

John, this is very interesting, but now for the tough questions:
1.Has anyone successfully done this?
2.Will it work?
3.Will it work in the time frame we need (probably March at the latest)?
4.How sure are you of that last answer?
5.How sure is your technical guy of your last answer?
6.What if it doesn't work?

John, an additional question for you: on your spec. sheet you have a specification for resolution along track and across track. Please explain how these values are derived.

Gentlemen, I believe these are the outstanding questions from today's correspondence:

1. Question : Has anyone successfully done this?

Answer : This is standard in the ultrasound world. Reson SeaBat 8125-28, Knudsen DAISY, KM 3002 and Klein 5500 are dynamically focused sonars.
2. Question : Will it work?

Answer : FFI Norway has dynamically focused the EdgeTech 4400-SAS sub-element data with good success. An ideal dynamically focused array has pairs of elements that are asynchronous in length when compared with the other pairs. However, it is still possible to dynamically focus same-sized elements.

3. Question : Will it work in the time frame we need (probably March at the latest)?

Answer : Yes. April delivery as previously discussed.
4. Question : How sure are you of that last answer?

Answer : Very.
5. Question : How sure is your technical guy of your last answer?

Answer : Don't take my word for it, ask Steve Wright our head engineer! :-)
6. Question : What if it doesn't work?

Answer : It will work. We offer a no-cost loan of a 'conventional' chirp 120/410 should there be a delay.

Question : How are these resolution values derived?? Answer : Across track is based on the bandwidth of the pulse. The along-track specification depends on the frequency, the number of sub-elements and the length of the array. While the 4500-DF is based on 410kHz, we may want to go down a bit in frequency to achieve your requirement of 200+ metres a side. This, plus the maximum array length we can get on the Hugin, will indicate the resolution.

John, am I correct in thinking that this is a regular side-scan sonar with a long array using focusing to operate in the near field? Am I correct in thinking the data density will be no different than a conventional side-scan?

Yes and yes.

John,
1.Is the full array used for transmit?
2.Please provide background on your range estimate.

Jimmy,
1.The full array is used for transmission.

2.We do not publish our modelling information. However, in addition to the modelling work, our 270kHz 4300-MPX gets 250+ metres range in cold water. We have sonar data showing this and could show you if needed. This was with a system using our first-generation chirp electronics. The second-generation electronics are quieter.

The two-way transmission loss difference for 250m at the two frequencies of 270 and 220kHz is about 5dB, so this gives an additional margin.

Our rationale was to use the lowest frequency above the multi-beam sonar that gave us the range – and with the 78 inches to work with, gave us the 'less than 1-metre resolution' at the maximum range.

A final 'sales' pitch… On the 4500-DF, at no extra cost, we are going to segment the 410kHz array so that you will be able to operate it in - EdgeTech's multi-pulse mode. Via your command and control link, you will be able to switch between the standard 'high-definition mode' and the 'multi-pulse mode' for the 410kHz. We did not want to advertise this until we were sure that it would work.

Narrator:
At the end of January 2005, EdgeTech personnel travelled to C&C Technologies' office in Lafayette to discuss the proposed technology and to evaluate the development options. The resulting consensus is to integrate the dynamically focused side-scan sonar (deemed the 4500-DF) with an EdgeTech sub-bottom profiler specially engineered to C&C specifications with pulses and calibration to be done by Dr Steven Schock at FAU.

Gentlemen,
First, thank you very much for your hospitality during our recent visit.

For the 4500-DF, we have settled on the higher frequency (220kHz or even 230kHz). This will provide 250+ metres slant range. There are eight sub-elements in each array.

Once we have a purchase order in place, we will want the exact physical space (especially length) available for the arrays. We will design the arrays to fill the available space on the AUV and provide you the final specifications. We are now assuming a physical array size that is 78 inches long. As we discussed at the meeting, this configuration will provide around 0.7-metre resolution at 250 metres.

We will do all we can to improve on the delivery dates. However, as you know, the key lead-time items are the ceramics for the arrays.

John, I am in need of the following to be reflected in the quote:
1.system I electronics bottle populated
2.spare 'electronics bottle' populated (not just spare boards)
3.complete spare transducer for 4500-DF
4.same level of spares to be applied to sub-bottom.

Working on it…!

Some thoughts: the spares are 'full up spares'. For example, the spare bottle is a one-for-one replacement for the primary bottle. I did not charge full price for the bottle because you are bundling the purchase of the system and spares together. We generally do this for some of our better customers.

It is just somewhat confusing to me (and others) the way it is laid out. I want to make absolutely sure everyone is clear on what is being delivered.

I have no problem considering an acceptance clause in the terms as long as we agree on and have written acceptance criteria.

Agreed!?
Thomas & Jimmy, I want to let you both know we appreciate your order and continued confidence in EdgeTech. We will do our very best to meet your expectations and requirements for this system. Again, thanks!

Narrator:
After the C-Surveyor III enters service, Jim Chance sits at his computer again and reviews AUV sub-bottom profiler and side-scan sonar data collected during two different mapping campaigns off the coast of West Africa. He quickly realises that this team effort has paid big dividends. C&C's twin goals of better customer data and staying several steps ahead of its competition have succeeded. He muses to himself, "My next idea is…"

Epilogue
Since the deployment of the new AUV (C-Surveyor III), both the side-scan sonar and sub-bottom profiler continue to meet expectations. On a number of occasions, side-by-side comparisons can be made between data taken with the first EdgeTech AUV sonars and the dynamically focused 4500-DF and custom sub-bottom profiler.?

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