Electrotechnische Vereeniging

Issue 20.1 | November 2016 | Delft

Maxwell

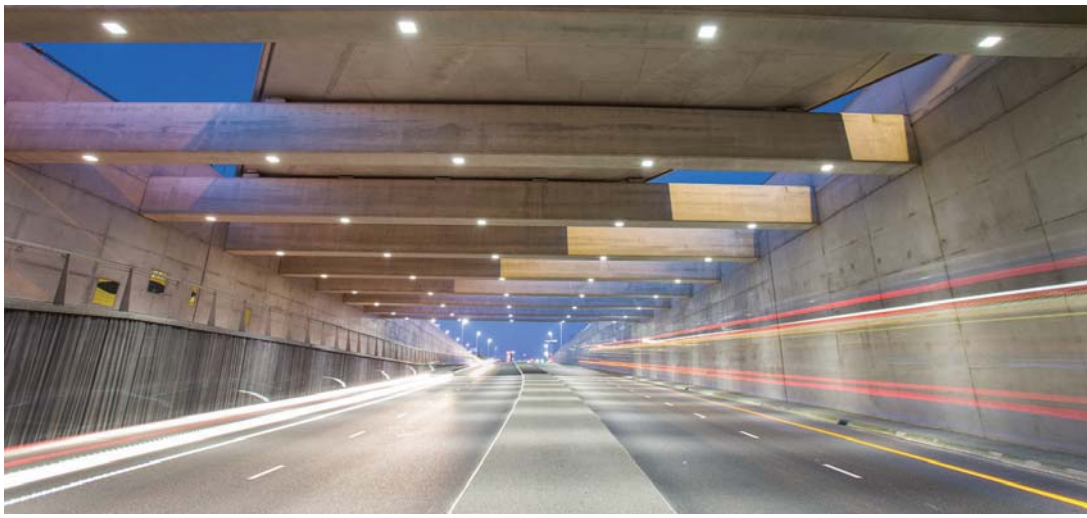
Underwater Exploration
Discovering the deep unknown

Floating Liquid Natural Gas Vessels
The electrical systems

Wave Power
The energy of the future?

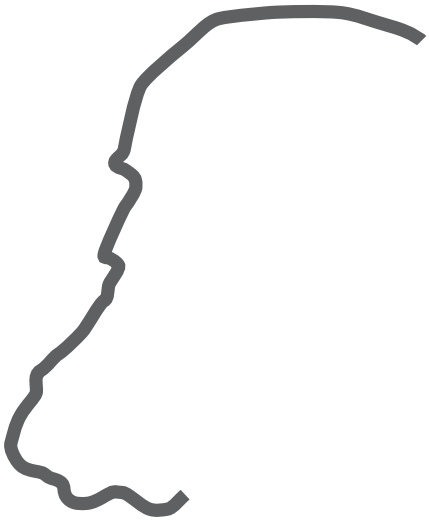
Witteveen + Bos

Ruimte voor talent en ambitie



INGENIEURSWERK MENSENWERK

Onze ingenieurs en adviseurs krijgen alle ruimte om het beste uit zichzelf te halen in projecten op het gebied van water, infrastructuur, milieu en bouw. Wat is jouw talent? **www.witteveenbos.nl > werken bij**



Editorial

As you may have noticed, unfortunately, the last edition of the 19th year has not been published. Fortunately during the holidays a new committee started making a whole new Maxwell, year 20! This is a Lustrum edition, so maybe one of the following issues will contain a little present.

This is not the only change made. Under the strict supervision of two Board members we made a new design for this year with each issue a new theme.

The theme of this issue is 'ocean'. Combining water and electricity might not be a smart idea. But in this issue you can read that electricity is necessary on sea for example on the vessels, but also in the water for localization or to produce energy. All these topics can be read in this issue, have fun reading!

Elke Salzmann

Colofon

Year 20, edition 1, November 2016
1440 copies

Editors
Martijn Hoogelander
Daniël Kappelle
Jelimo Maswan
Elke Salzmann
Tristan Wieffering

Contributors
Oliver Ashford, Lennart Boeke, Luc Enthoven, Philip van den Heuvel, William Hunter, Franck Kerkhof, Geert Leus, Maarten van der Meulen, Monty Montgomery, Hamid Ramezani, Elke Salzmann, Dick Simons, Mirjam Snellen, Ege Tansug, Scott Waters, Djurre Wikkerink

Advertisements
Inside cover front - Witteveen+Bos
Page 5 - Ricardo Rail
Back cover - Bakker Sliedrecht

Printing
Quantes, Rijswijk

Electrotechnische Vereeniging

The 145th board of the ETV
President: Philip van den Heuvel
Secretary: Roel de Rijk
Treasurer: Francesc Varkevisser
External Affairs: Declan Buist
Education: Luc Enthoven

Contact
Electrotechnische Vereeniging
Mekelweg 4
2628 CD Delft
The Netherlands

Phone number: +31 (0) 15 278 6189
E-mail: Board-ETV@tudelft.nl
Website: www.etv.tudelft.nl

Subscriptions
Non-members can receive the Maxwell four times a year, against a contribution of €10,- *per year*.

Change of address
Please send your changes to the address above, or use the website.

Ricardo Rail

Jouw frisse inbreng in onze vele projecten?

Wij zijn op zoek naar talenten voor onze vele projecten. Je komt terecht in een inspirerende omgeving met collega-professionals. Je gaat werken voor een open, informele organisatie waar flexibiliteit, uitdaging en ontwikkeling hoog in het vaandel staan. Een sterke organisatie met enthousiaste medewerkers en veel ruimte voor eigen initiatief.

Fabian Peek, Ricardo Rail, Ricardo Nederland B.V.,
Catharijnesingel 33, Postbus 2016, 3500 GA Utrecht,
T 030 7524 700, E nlrailrecruitment@ricardo.com

www.werkenbijricardorail.nl

From the Board

President Philip van den Heuvel
Secretary Roel de Rijk
Treasurer Francesc Varkevisser
External Affairs Declan Buist
Education & VP Lucas Enthoven

President

Dear Maxwell readers,

I am very excited to introduce the new Board of the ETV in this first edition of the Maxwell for the 2016-2017 academic year. Since the 13th of September, we have been responsible for all 1200 members of the Electrotechnische Vereeniging.

During the past couple of months, we have been very busy with the association wants and needs, as well as handling other ETV-related activities. As the president of the Board, I am not only in charge of my regular tasks for the ETV, but also involved in implementing our association's vision, which is to connect all Electrical Engineering students at TU Delft. Therefore, we believe a transition to a bilingual association is vital. Furthermore, we also hope to connect more alumni to our association. Alumni life stories can be extremely useful to our students, who luckily have a lot of choices for their future!

Lastly, I am always open to your advice and comments, and stand at your disposal for any questions or concerns. Feel free to contact me at *president-etv@tudelft.nl*! ■

From left to right: Declan, Roel, Philip, Francesc, Lucas

Commissioner of Education

Hello everyone! My name is Lucas Enthoven and I am the new Commissioner of Education. It is my honor to write the educational news update for the Maxwell. In this piece, I will give a short overview of educational affairs, lunch lectures and excursions.

The accreditation of a study program is what gives a diploma its value. It verifies that the quality of the study program is valid and that the level is appropriate for the title received. Since the current accreditations of the Electrical Engineering and Computer Engineering study programs are expiring, a new accreditation visitation was held on the 5th of October. Needless to say, the staff was very busy preparing for the visitation and even managed to do a trial visitation.

On an entirely different note, a LaTeX workshop was held on the 26th of September. This was a beginner workshop for master students to introduce them to LaTeX and show them what makes LaTeX useful. The workshop was a hugely successful and more than 80 students attended the workshop! Not able to make it but interested in the slides nevertheless? Then please visit the ETV blackboard page or send an email to *education-etv@tudelft.nl*.

Unfortunately, due to a change in ordering system at Pearson, certain books could not be delivered before the start of the academic year. As a result, first and second years students missed certain books. Pearson has been cooperative in providing online solutions to make sure that students were still able to attend lectures and study without delay. At the moment of writing, it is anticipated that the books should be delivered any minute now.

So far, two lunch lectures have been hosted, one by Alliander and one by Arcadis. Both lunch lectures were well attended and the free lunch provided at these lectures was definitely enjoyed by the students. Additionally, an excursion to ASML took place during the second week of October and this was also a great success. Interested in other excursions? Then please subscribe to the ETV Business Facebook page.
(*www.facebook.com/ETVextern*)

The Sustainable Energy Technology Master program has now officially been moved to the EEMCS Faculty. We are very happy to welcome all the new master students and wish them the best of luck with their studies!
If you have any questions or complaints regarding education, please send an email to *education-etv@tudelft.nl* or visit the board room. ■

Underwater Exploration

Communications and Localization

By Dr. Hamid Ramezani
& Prof.dr.ir. Geert Leus

The ultimate goal of modern telecommunication systems is to connect anything anytime anywhere. Due to the advancement of wireless networks, satellites and the Internet, this goal has been accomplished almost anywhere on land. However, we still have a long journey ahead of us to meet this goal underwater. Currently more than 95% of the ocean floor is unexplored, because of the challenging underwater medium.

First of all, the underwater pressure increases linearly with depth. The extreme pressure of the deep sea stops our best divers from exploring areas deeper than 60 meters. Such pressure also affects the cost of underwater devices and equipment working ultra-deep. In addition, high frequency radio signals such as those used in Wi-Fi and GPS (Global Positioning System) cannot penetrate more than a few meters in water. To overcome this hurdle, for long distances and telemetry applications, low-frequency acoustic signalling is the most versatile and widely used physical layer technology in an underwater environment. Still, this technology suffers from other characteristics of the underwater medium, namely the low propagation speed of sound (1550 m/s), variability of the sound speed, small communication bandwidth (i.e., low data-rate), multi-path (reflections from the sea-bed and surface), large Doppler spread, scattering, reverberation and coloured noise (e.g., human activities, ships, biological activities and so on).

Although the first observation of underwater sound propagation goes back to Aristotle's era over 2000 years ago, the first application, namely navigational safety and echo-ranging, emerged in the 18th century. The principle of this application was used during World War I (1914-1918) to detect submerged submarines and mines. Later, massive research was conducted during World War II which led to the development of several activities such as sound navigation and ranging systems (sonar, see Figure 1), the discovery of irregular acoustic propagation, the extension of underwater acoustic applications into marine biology, and the introduction of fish-finding sonars.

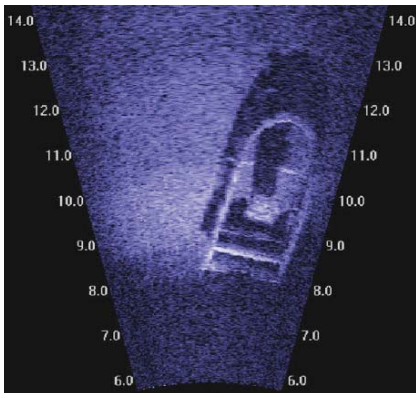


Figure 1: *An echo image of an underwater hull of a small boat from a sonar system (Image credit: Sound Metrics Corp)*

Currently, multiple research groups around the world are actively conducting experiments, and developing ideas to make the future of underwater acoustic networks more reliable and efficient. For instance, acoustically directed robots are replacing divers in maintaining underwater platforms (Figure 2). Further, the development of new computer vision (for sonar and optical images) and image processing algorithms is helping us to detect, categorize, and create 3D models of underwater objects rapidly and successfully. However, despite the great technological advances in underwater robotics, most of the applications still rely on human operators who can assess and interpret information gathered by the network elements, and who can remotely manoeuver the vehicles to fulfill a particular mission. The time inefficiency and prohibitive cost of training human operators encouraged the deployment of teams of autonomous underwater vehicles (AUVs) for underwater research. The target of such a network (as explained in the NOPTILUS[1] project) is

to fully autonomously take over real-life complex situation awareness operations such as environmental monitoring and clean-up operations, seafloor mapping, security and surveillance, inspection of underwater structures, and so on.

In order to accomplish this goal, a AUV should be well-equipped with several sensors and tools (see Figure 3). The inertial measurement unit (IMU) and Doppler velocity log (DVL) assist in the underwater navigation. Cameras and a multi-beam echo sounder can be used for exploration. Further, WiFi, GPS, GSM and Iridium used for communications and localization will be active only when the AUV surfaces. Finally, the acoustic transducer is employed for underwater communications (and also navigation). This transducer converts variations of the pressure (mechanical acoustic wave) into an electrical signal, and vice versa. The captured electrical

Figure 2: *A new humanoid robotic diver from Stanford, explores a 17th century shipwreck. (Image credit: Frederic Osada and Teddy Seguin/ DRASSM)*

signals are processed by the CPU to decode the communication messages.

Let us now focus in some more depth on the underwater communication system. At the transmitter side of the transducer, the communication messages can be

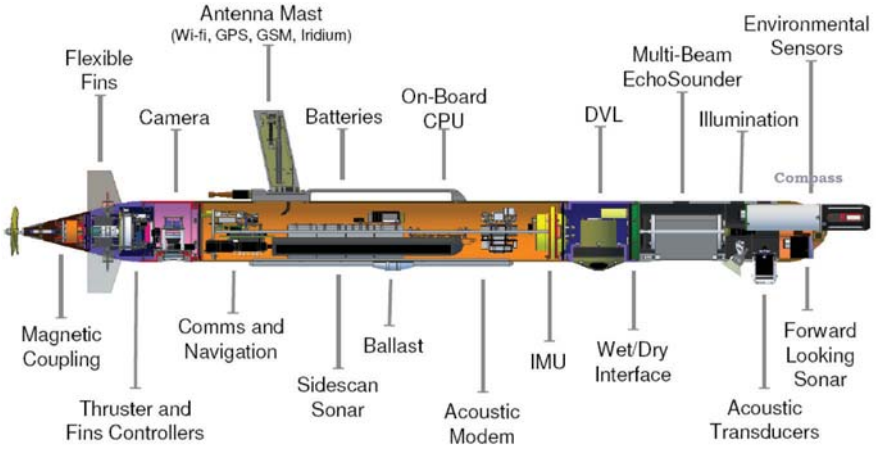


Figure 3: *System break-down structure of an autonomous underwater vehicle (Image credit: FP7 NOPTILUS project)*

electrically shaped either by analogue or digital modulation (for analogue or digital communication, respectively). From terrestrial wireless communications technology, it is well-known that digital modulation can transfer the data more efficiently than analogue modulation and hence also underwater communictions moved from analogue to digital modulation. It is claimed that the ping-based use of sonars during World-War II can be considered as the first appearance of underwater digital communications (transmission of binary data, a 0 or a 1); however, the general principle of digital signalling and digital modulation did not appear until the 1960s. At first, phase non-coherent modulations such as frequency-shift keying (FSK) and frequency hopping (FH) were the common ways to communicate, but the demand for higher data rates drew the attention towards phase-coherent modulations in the 1990s. At the same time, different companies such as Datasonics and Benthos were introducing new digital-based commercial acoustic modems. Up to very recently, single carrier coherent modulation techniques constituted the core of underwater digital communication systems. Such modulation techniques suffer from interference between successively transmitted symbols. As a result, a lot of effort was put into designing sophisticated channel equalizers and coding schemes in order to combat this so-called inter-symbol interference.

From an experiment conducted in the Mediterranean Sea in 2004, it was concluded that multi-carrier techniques can yield a good alternative to single-carrier communications. Multi-carrier techniques, such as orthogonal frequency division multiplexing (OFDM), which is also used in WiFi systems, do not suffer from inter-symbol interference and can thus simplify the implementation of an underwater communication system. The experiment of 2004 was followed by a great deal of research on OFDM-based underwater communication topics, such as channel coding, channel estimation, adaptive modulation and coding, ▶

[1] NOPTILUS is *funded by the European Community's Seventh Framework Programme ICT-FP7, Cognitive Systems and Robotics programme. NOPTILUS main objective is to determine – fully-autonomously & in real-time – the AUVs' trajectories/behaviour that maximize situation awareness subject to the severe communication, sensing & environmental limitations.*

sophisticated iterative detection algorithms, and the design of interleavers or waveforms for maximizing the frequency and time diversity.

Equally important as communications in underwater robotics is localization. In most of the underwater sensor network applications, the collected data has to be labeled by its position and time of measurement. Without a position label, the measured data is usually meaningless. For instance, the water temperature is a location-based phenomenon and in order to estimate the full temperature field from the scattered samples, the positions at which they are measured are required. In a few costly old underwater sensor networks the nodes are fixed and their locations are accurately determined before operating the network. In contrast, newly developed networks use ad-hoc deployable yet fixed bottom nodes, as well as mobile nodes which are moving in the operating area willingly or not (due to wind, waves, and underwater currents). Examples of mobile nodes are buoys, AUVs, and remotely operated vehicles (ROVs). For such networks, sensor localization is an important task, without which the operations might fail. In addition, knowing the position of the sensor nodes benefits other network tasks as well. For instance, more efficient routing algorithms for transferring data to the destination can be designed. The medium access control protocols can be designed to minimize the collision probability, and maximize the network throughput. Modulation schemes, coding methods and the transmission power can be adapted based on the nodes' positions, resulting in a higher network efficiency and longevity.

In order to determine the location of an object using a simple localization system, a sequence of actions is required. At first, the vehicle to be positioned transmits an acoustic pulse from its transducer. This pulse travels through the water and reaches some fixed anchor points. The anchors detect the signal and respond with a unique acoustic pulse. After the vehicle receives these pulses, it determines the round trip acoustic travel times (RTT) to each of the reference nodes. Then the RTT measurements are converted to distances using the speed of sound in the water. Finally, knowing the references' positions, and the distances to them, the location of the vehicle can be found through multilateration as shown in Figure 4.

The Future

Acoustic signals cannot propagate over long distances due to the high propagation attenuation. Furthermore, they cannot contain a lot of data due to their limited bandwidth (at most a few tens of kHz). Finally, due to the long propagation delay, they are not a good candidate for fast data exchanges. However, emerging underwater applications (such as the Internet of underwater things, underwater cities, etc.) require real-time massive data exchanges over large distances, which is not realizable via acoustic underwater signalling. For instance, it is still not possible to transmit live video between distant underwater nodes through acoustic signals, and it is very unlikely to happen in the future. Therefore, we have to devise new ways of data communications for underwater networks. One way is to build appropriate infrastructures similar

Figure 4: *Underwater localization of UAVs using only two fixed anchors (Porto harbour, NOPTILUS project)*

to what we have for terrestrial wireless networks, such as cellular systems with a wired backbone. In this way, each sensor node can communicate with its closest base station (within a short distance) at a much higher data rate, and a much lower delay (smaller propagation time). Furthermore, sensor nodes can be equipped with different types of wave generators such as optical, magnetic, and radio transmitters. If nodes are close enough to each other, they can communicate at higher data-rates through optical or even radio signals; otherwise, they can switch to acoustic reception/transmission to establish long-distance communications if they are located far away from each other. Finally, underwater communication systems are currently manufacturer-specific, following no particular international standard. As such, if we want different communication systems to be compatible with each other, standardization will have to become an integral part of future research on underwater networks. ■

Advertorial

Anjo Peeters graduated from Eindhoven University of Technology in 2015 with a master's degree in Electrical Engineering. Since March 2016 he is working at Witteveen+Bos at the office in Breda. Witteveen+Bos is part of the Dutch top 10 engineering and consultancy firms, with six offices in the Netherlands and several abroad. There is a great variety of projects in the fields of infrastructure, water, the environment, spatial development and construction.

Why did you choose for Witteveen+Bos?

I've performed my graduation project at Philips and during that time, I found out what aspects of the way of working there did and didn't suit me. So when I started looking for a job, I knew what was important to me. I was looking for a company with a really good atmosphere and nice colleagues with whom you can really work together on a project. Regarding the work itself, I liked to work on projects for an external customer. With these types of projects, you have to make a connection between what the customer says he wants and what the technical implications of are and how this can be realised. Furthermore, working for a customer triggers even more to work in a pragmatic manner and to always keep the goal of the customer in mind for the work you're doing.

After looking around at different companies, I received several job offers and it was time to make a decision. After some consideration I decided to choose for Witteveen+Bos since they best met my requirements. Especially the atmosphere was really nice; even in the job interview I didn't feel nervous or anything, it felt way more informal and was a nice and comfortable conversation. Although I've only started working several months ago, I already feel very much at home within Witteveen+Bos. The company is filled with enthusiastic people who are really interested in what you're working on and are very willing to help if you don't manage to figure something out on your own.

What do you do at Witteveen+Bos?

In the last few months I've been working on several different projects alongside each other. The benefit of this way of working is that it is more interactive, regarding both the subject of a project and the people with whom you work together. One of the projects I've been working on is for a water company. Amongst other things, they pump water from the municipalities towards the sewage treatment plant, where water will be cleaned for reuse. In this transport system a limited amount of sensors is present, which are used for the control mechanism to operate the water pumps correctly. This sensor data is possibly a huge information source about the performance of the system. Witteveen+Bos has been asked to investigate possible methods to use data for this purpose. With a better, real-time overview of the performance of the water transportation system, the company can gain better control of their assets. Using this information, maintenance and daily operations can be adapted to achieve a higher efficiency and cost reduction. Challenging in this project is to find a balance between on the one hand enough in-depth analysis of the sensor data and its relation to the physical system, and on the other hand a simple presentation of the data such that people with little knowledge about the system are still able to act upon this information.

What is your advice for job-seekers?

Get in touch with several companies. I've participated in multiple business courses and in-house days and I really enjoyed that. It is a very nice way to get a better idea about the possibilities and is also helps you to determine what type of company suits you. And if you're looking for a company with a good atmosphere, nice colleagues and interesting projects, Witteveen+Bos is definitely worth a visit.■

Floating Liquid Natural Gas

The electrical systems

By Ir. Lennart Boeke

One of the largest industries working on seas and oceans is the oil and gas industry, which is well known for its offshore platforms. Many different types of platforms are in existence, but what they all have in common is that the produced gas or oil is transported through a pipeline to shore for chemical processing in a chemical plant based on land.

Recent leaps in technology increasingly permit the combination of gas production with chemical treatment on the same vessel. A good example of this is Shell's Floating Liquid Natural Gas (FLNG) vessel. (figure 1) This kind of vessel is positioned above a gas reservoir and is designed for approximately 25 years of gas production, chemical treatment and liquefaction. This combination removes the need for an onshore chemical plant that separates pollutants from the gas and liquefies the gas for easier transport.

In terms of design and construction, every element of a conventional LNG facility needs to fit into roughly one quarter the standard area on the FLNG, whilst maintaining appropriate levels of safety and giving increased flexibility to LNG production. This requirement conflicts with the increased electrical power demand from approximately 70 MW to about 350 MW.

For safety purposes the electrical power system is restricted to the maximum allowed values of the short-circuit cur-

rents. An often used solution to decrease current levels is to increase the system voltage, which requires large and heavy transformers. While very cost-effective on land, the increased space and weight requirements inside the FLNG vessel makes this solution very inefficient for offshore projects. In the short term, alternative electrical power system designs are required that make use of fault current limiting equipment and custom designed generators to decrease the short-circuit current levels to acceptable levels. While these solutions significantly reduce the amount of required weight and space, the non-linear behaviour of fault current limiters may lead to operating scenarios where part of the load must be disconnected to ensure safe operation. In industrial facilities the disconnection of loads can have a large impact on production, so thorough modelling of this non-linear behaviour is necessary.

In the long run, two technologies may enable further reduction of space and weight of the electrical power system. Firstly, superconducting materials can be used in cryogenically cooled electric machines and transformers to decrease the size and weight of these devices as well as increasing their efficiency. A second developing technology is the increased use of power electronic converters as an alternative to bulky 50/60 Hz equipment. The power electronics could enable more optimal speed of operation of turbines and motors, easier connection of renewable energy sources and quicker isolation of electrical faults.

In summary, offshore projects continue to challenge electrical power engineers and significant changes to the electrical system design are possible in the near future thanks to the development of superconducting materials and power electronic converters. ■

Numbers

- **488 metres (1,601 ft) long, 74 metres (243 ft) wide, 93 metres high (305 feet) is the dimension of the vessel**
- **>600 engineers worked on the facility's design options**
- **>200km (125 miles) is the distance from the Prelude field to the nearest land**
- **4 soccer fields, laid end to end, would be shorter than the facility's deck**
- **175 Olympic-sized swimming pools could hold the same amount of liquid as the facility's storage tanks**
- 117% of Hong Kong's annual natural gas demand could be met by the facility's annual LNG production
- 5,3 million tonnes per year is the amount of production of liquids
- $ 10.8 billion to $ 12.6 billion is the investment in the world's first FLNG vessel

High bit rate audio sampling
Part III

By Monty Montgomery

Confirmation bias, the placebo effect, and double-blind

The number one comment I heard from believers in super high rate audio was (paraphrasing): "I've listened to high rate audio myself and the improvement is obvious. Are you seriously telling me not to trust my own ears?"

Of course you can trust your ears. It's brains that are gullible. I don't mean that flippantly; as human beings, we're all wired that way.

In any test where a listener can tell two choices apart via any means apart from listening, the results will usually be what the listener expected in advance; this is called confirmation bias and it's similar to the placebo effect. It means people 'hear' differences because of subconscious cues and preferences that have nothing to do with the audio, like preferring a more expensive (or more attractive) amplifier over a cheaper option.

The human brain is designed to notice patterns and differences, even where none exist. This tendency can't just be turned off when a person is asked to make objective decisions; it's completely subconscious. Nor can a bias be defeated by mere skepticism. Controlled experimentation shows that awareness of confirmation bias can increase rather than decreases the effect! A test that doesn't carefully eliminate confirmation bias is worthless.

In single-blind testing, a listener knows nothing in advance about the test choices, and receives no feedback during the course of the test. Single-blind testing is better than casual comparison, but it does not eliminate the experimenter's bias. The test administrator can easily inadvertently influence the test or transfer his own subconscious bias to the listener through inadvertent cues (e.g. "Are you sure that's what you're hearing?", body language indicating a 'wrong' choice, hesitating inadvertently, etc.). An experimenter's bias has also been experimentally proven to influence a test subject's results.

Double-blind listening tests are the gold standard; in these tests neither the test administrator nor the testee have any knowledge of the test contents or ongoing results. Computer-run ABX tests are the most famous example, and there are freely available tools for performing ABX tests on your own computer (see figure 10). ABX is considered a minimum bar for a listening test to be meaningful; reputable audio forums such as Hydrogen Audio often do not even allow discussion of listening results unless they meet this minimum objectivity requirement.

I personally don't do any quality comparison tests during development, no matter how casual, without an ABX tool. Science is science, no slacking.

Loudness tricks

The human ear can consciously discriminate amplitude differences of about 1 dB, and experiments show subconscious awareness of amplitude differences under 0.2 dB. Humans almost universally consider louder audio to sound better, and 0.2 dB is enough to establish this preference. Any comparison that fails to carefully amplitude-match the choices will see the louder choice preferred, even if the amplitude difference is too small to consciously notice. Stereo salesmen have known this trick for a long time.

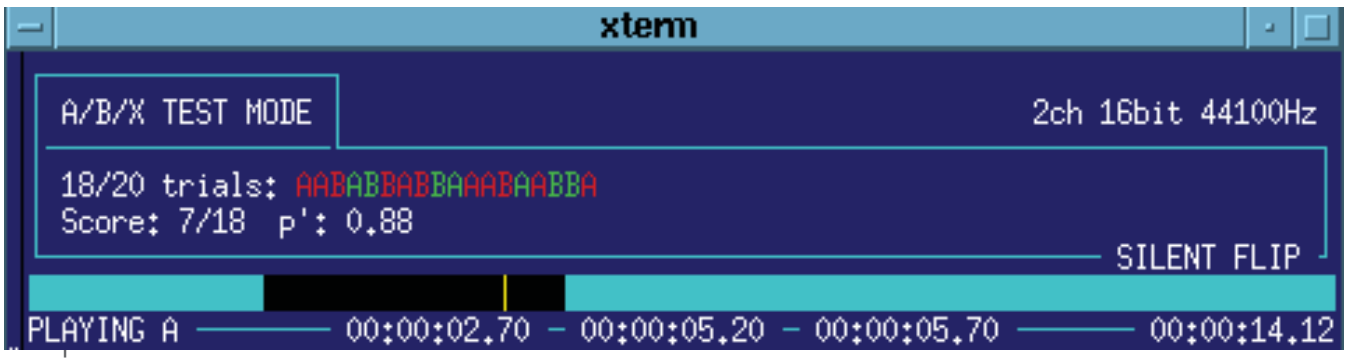


Figure 10: *Squishyball, a simple command-line ABX tool, running in an xterm*

The professional testing standard is to match sources to within 0.1dB or better. This often requires use of an oscilloscope or signal analyzer. Guessing by turning the knobs until two sources sound about the same is not good enough.

Clipping

Clipping is another easy mistake, sometimes obvious only in retrospect. Even a few clipped samples or their aftereffects are easy to hear compared to an unclipped signal.

The danger of clipping is especially pernicious in tests that create, resample, or otherwise manipulate digital signals on the fly. Suppose we want to compare the fidelity of 48 kHz sampling to a 192 kHz source sample. A typical way is to downsample from 192 kHz to 48 kHz, upsample it back to 192 kHz, and then compare it to the original 192 kHz sample in an ABX test. This arrangement allows us to eliminate any possibility of equipment variation or sample switching influencing the results; we can use the same DAC to play both samples and switch between without any hardware mode changes.

Unfortunately, most samples are mastered to use the full digital range. Naive resampling can and often will clip occasionally. It is necessary to either monitor for clipping (and discard clipped audio) or avoid clipping via some other means such as attenuation.

Inadvertent cues

Inadvertent audible cues are almost inescapable in older analog and hybrid digital/analog testing setups. Purely digital testing setups can completely eliminate the problem in some forms of testing, but also multiply the potential of complex software bugs. Such limitations and bugs have a long history of causing false-positive results in testing.

"The Digital Challenge - More on ABX Testing" tells a fascinating story of a specific listening test conducted in 1984 to rebut audiophile authorities of the time who asserted that CDs were inherently inferior to vinyl. The article is not concerned so much with the results of the test (which I suspect you'll be able to guess), but the processes and real-world messiness involved in conducting such a test. For example, an error on the part of the testers inadvertently revealed that an invited audiophile expert had not been making choices based on audio fidelity, but rather by listening to the slightly different clicks produced by the ABX switch's analog relays!

Anecdotes do not replace data, but this story is instructive of the ease with which undiscovered flaws can bias listening tests. Some of the audiophile beliefs discussed within are also highly entertaining; one hopes that some modern examples are considered just as silly 20 years from now.

Finally, the good news

What actually works to improve the quality of the digital audio to which we're listening?

Better headphones

The easiest fix isn't digital. The most dramatic possible fidelity improvement for the cost comes from a good pair of headphones. Over-ear, in ear, open or closed, it doesn't much matter. They don't even need to be expensive, though expensive headphones can be worth the money.

Keep in mind that some headphones are expensive because they're well made, durable and sound great. Others are expensive because they're $20 headphones under a several hundred dollar layer of styling, brand name, and marketing. I won't make specfic recommendations here, but I will say you're not likely to find good headphones in a big box store, even if it specializes in electronics or music. As in all other aspects of consumer hi-fi, do your research (and caveat emptor).

Lossless formats

It's true enough that a properly encoded Ogg-file (or MP3, or AAC file) will be indistinguishable from the original at a moderate bitrate. But what of badly encoded files?

Twenty years ago, all MP3 encoders were really bad by today's standards. Plenty of these old, bad encoders are still in use, presumably because the licenses are cheaper and most people can't tell or don't care about the difference anyway. Why would any company spend money to fix what it's completely unaware is broken?

Moving to a newer format like Vorbis or AAC doesn't necessarily help. ▶

For example, many companies and individuals used (and still use) FFmpeg's very-low-quality built-in Vorbis encoder because it was the default in FFmpeg and they were unaware how bad it was. AAC has an even longer history of widely-deployed, low-quality encoders; all mainstream lossy formats do.

Lossless formats like FLAC avoid any possibility of damaging audio fidelity with a poor quality lossy encoder, or even by a good lossy encoder used incorrectly.

A second reason to distribute lossless formats is to avoid generational loss. Each re-encode or transcode loses more data; even if the first encoding is transparent, it's very possible the second will have audible artifacts. This matters to anyone who might want to remix or sample from downloads. It especially matters to us codec researchers; we need clean audio to work with.

Better masters

The BAS test we talked about earlier mentions as an aside that the SACD version of a recording can sound substantially better than the CD release. It's not because of increased sample rate or depth but because the SACD used a higher-quality master. When bounced to a CD-R, the SACD version still sounds as good as the original SACD and better than the CD release because the original audio used to make the SACD was better. Good production and mastering obviously contribute to the final quality of the music.

The recent coverage of `Mastered for iTunes' and similar initiatives from other industry labels is somewhat encouraging. What remains to be seen is whether or not Apple and the others actually `get it' or if this is merely a hook for selling consumers yet another, more expensive copy of music they already own.

Surround

Another possible `sales hook', one I'd enthusiastically buy into myself, is surround recordings. Unfortunately, there's some technical peril here.

Old-style discrete surround with many channels (5.1, 7.1, etc.) is a technical relic dating back to the theaters of the 1960's. It is inefficient, using more channels than competing systems. The surround image is limited, and tends to collapse toward the nearer speakers when a listener sits or shifts out of position.

We can represent and encode excellent and robust localization with systems like Ambisonics. The problems are the cost of equipment for reproduction and the fact that something encoded for a natural sound field both sounds bad when mixed down to stereo, and can't be created artificially in a convincing way. It's hard to fake Ambisonics or holographic audio, sort of like how 3D video always seems to degenerate into a gaudy gimmick that reliably makes 5% of the population motion sick.

Binaural audio is similarly difficult. You can't simulate it because it works slightly differently in every person. It's a learned skill tuned to the self-assembling system of the pinnae, ear canals, and neural processing, and it never assembles exactly the same way in any two individuals. People also subconsciously shift their heads to enhance localization, and can't localize well unless they do. That's something that can't be captured in a binaural recording, though it can to an extent in fixed surround.

These are hardly impossible technical hurdles. Discrete surround has a proven following in the marketplace, and I'm personally especially excited by the possibilities offered by Ambisonics.

Outro

The point is enjoying the music, right? Modern playback fidelity is incomprehensibly better than the already excellent analog systems available a generation ago. Is the logical extreme any more than just another first world problem? Perhaps, but bad mixes and encodings do bother me; they distract me from the music, and I'm probably not alone.

Why push back against 24/192? Because it's a solution to a problem that doesn't exist, a business model based on willful ignorance and scamming people. The more that pseudoscience goes unchecked in the world at large, the harder it is for truth to overcome truthiness... even if this is a small and relatively insignificant example.

"*For me, it is far better to grasp the Universe as it really is than to persist in delusion, however satisfying and reassuring.*"
—Carl Sagan ■

Advertorial

Bakker Sliedrecht takes care of electrical system integration on board Damen's Service Operations Vessel

Damen Shipyards Group ordered Bakker Sliedrecht to supply and integrate all main electrical installations of the Damen Service Operations Vessel (SOV). It is the first vessel purpose-built for the transfer and accommodation of offshore personnel and aims to maximize working time and staff retention. In line with wind farms being constructed farther from shore, the SOV with walk-to-work access is able to remain at sea for periods up to one month. The design guarantees fast, safe and comfortable access to turbines, at lower cost.

Bibby Marine Services Limited, part of Bibby Line Group, signed a contract with the Damen Shipyards Group for delivery of its first Service Operations Vessel. The vessel, Bibby WaveMaster 1, will undertake offshore wind project work in the North Sea.

Responsible for all main electrical installations

Bakker Sliedrecht is responsible for the supply and integration of all main electrical installations of Damen's SOV. Key elements of this project are the design, fabrication, installation and commissioning of the main switchboard, two auxiliary switchboards and three drive systems. All drive systems will be equipped with an active filter that saves space on board and creates a clean power supply by eliminating harmonic distortion.

Bakker Sliedrecht will also take care of the design and installation of the complete cabling on board the SOV. We will commission the SOV's electrical installations at Damen Shipyards Galati in Romania.

BIMAC Vessel management system

The SOV will be equipped with Bakker Sliedrecht's Vessel management system BIMAC. Bakker Sliedrecht developed BIMAC especially for marine applications. The user friendly vessel management system manages all main and auxiliary functions of the SOV. ■

Impressions of Damen's Service Operations Vessel

Wave Power

An alternative renewable energy source

By Djurre Wikkerink

71% of the surface of our planet is covered by water which is constantly in motion. The oceans contain a huge, sometimes destructive, amount of energy. Due to the high energy density and predictability of waves, the ocean is a great potential source of renewable energy. In this article I will discuss the potential of wave power. I will show some of the designs of wave energy converters and explain their operating principle. The generator design of one of these devices, the Symphony, is part of my master thesis.

Introduction

Ocean waves are created by wind, which is in turn created by solar energy. As solar energy is converted to wave energy, its intensity is concentrated from typically 0.1-0.3 kW/m^2 horizontal surface of the earth to 2-3 kW/m^2 in the area perpendicular to the direction of wave propagation. The high energy density and an estimated worldwide power potential of around 1 TW makes wave power a considerable source of energy [2].

The idea of wave power is not new, the first known patent was filed in 1799. During the oil crisis in the 1970s the research in wave power was stimulated. Todays rising levels of greenhouse gases and climate changes makes wave power an important area of research again. Over the past centuries more than a thousand wave energy conversion techniques have been patented [3], yet wave power is still not applied on a large scale.

Some challenges arise when designing a wave energy converter. The ocean can be a hostile environment. Most of the time waves are in a normal state, but sometimes they can contain a destructive force which the device has to cope with. During a storm, survivability is a much more important issue than efficiency or even producing power at all. Also the salty water of the ocean can cause corrosion and maintenance should be kept to a minimum since offshore maintenance is expensive. Finally, finding investors is difficult since wave energy converters are not profitable yet.

Technologies

Unlike wind turbines, wave energy converters (WEC) come in a large variety of sizes and shapes. Due to placement

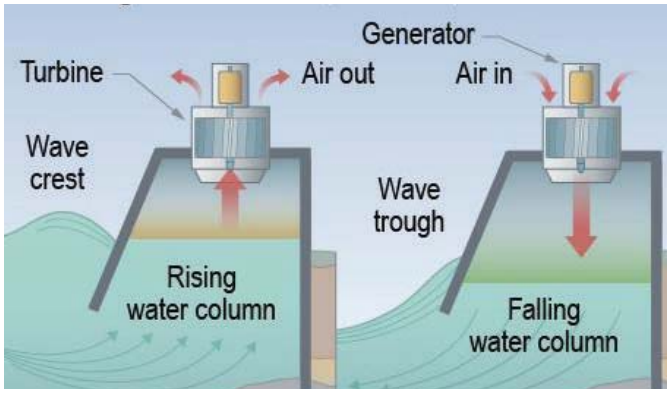


Figure 1: *Oscillating Water Column (terminators)*

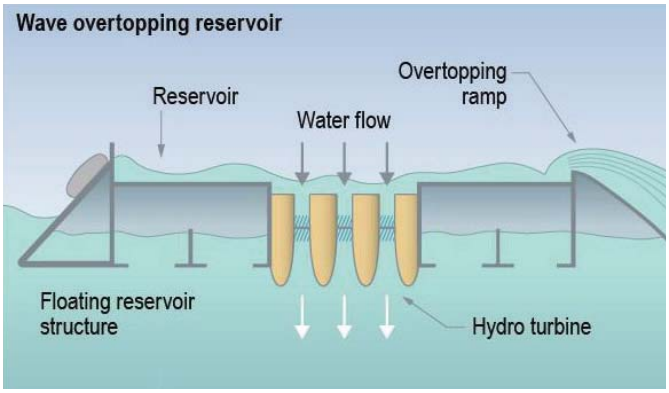


Figure 2: *Wave Overtopping Reservoir (terminators)*

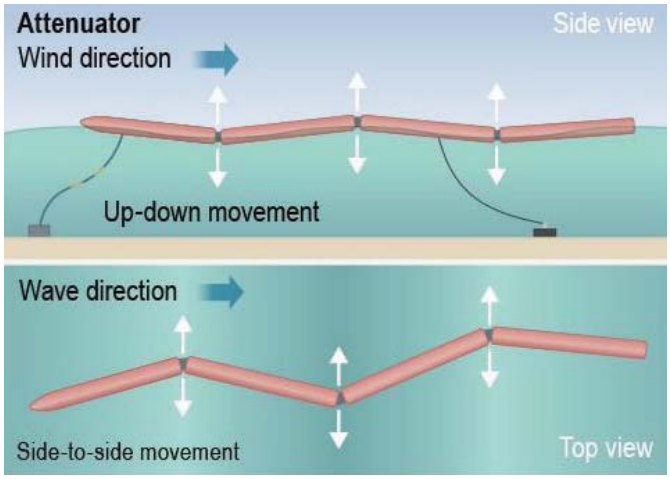


Figure 3: *Attenuators*

Figure 4: *Pelamis Prototype (attenuators)*

(shoreline, near-shore and offshore) and dependence on water depth, different approaches have been tested. At this moment around one hundred projects are at various stages of development [2]. While there is a large number of projects and huge variations in design, wave power devices can be categorized into three main categories [1].

Terminators

With its principle axis parallel to the wave front, a terminator device captures the wave. An example of this is the Oscillating Water Column (OWC) shown in figure 1. As the water level rises, pressure in the column builds up. The excess air can only leave through a turbine driving a generator. As the water level decreases, the process is reversed. One of the main advantages of this design is its robustness. An OWC is placed on or near the shore line and its chambre is made of concrete. Full size prototypes have already been built around the world and their power capacity is in the range of 60-500 kW. The largest ever built, a 2 MW nearshore plant named OSPREY, was destroyed by the sea shortly after being sunk into place near the Scottish coast [2].

Another way of capturing a wave is to use an overtopping reservoir seen in figure 2. In these devices, the wave fills a reservoir by overtopping a slope. The water in the reservoir is stored at a higher level than the surrounding sea. The potential energy can then be converted to electrical energy using a hydraulic turbine. An example of such a device is the Danish Wave Dragon.

Attenuators

"Riding" the waves, attenuators lie parallel to the predominant wave direction as seen in figure 3.

An example is the Pelamis developed in Scotland shown in figure 4. This 120m long device consists of four hollow steel floaters. The motion of the joints is resisted by rams pumping high pressure oil through a hydraulic motor which drives three generators. Each generator is rated 250kW. A set of three Pelamis WEC's with a total power capacity of 2.25 MW was installed near the Portuguese coast in 2008, making it the world's first grid connected wave farm [2].

Point Absorbers

A point absorber is small relative to the wavelength. Due to its small size, the direction of the waves is not important. It can float on the surface like a buoy or be submerged below sea level. An example of a submerged point absorber is the Symphony shown in figure 5.

The Symphony consists of a stationary part and a moving part called the hull. The top of the device is filled with air to create bouyancy. As the wave moves over the device, the hull gets pushed down by the water on top of it. A membrane filled with water slides down and decreases in volume. The contained water is forced out of the membrane through a turbine driving a generator. The water leaving the turbine enters an air filled chambre causing the pressure in this chambre to increase.▶

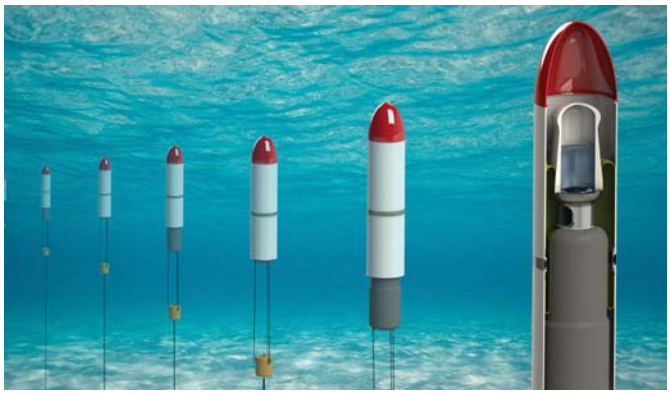


Figure 5: *Artistic impression (symphony)*

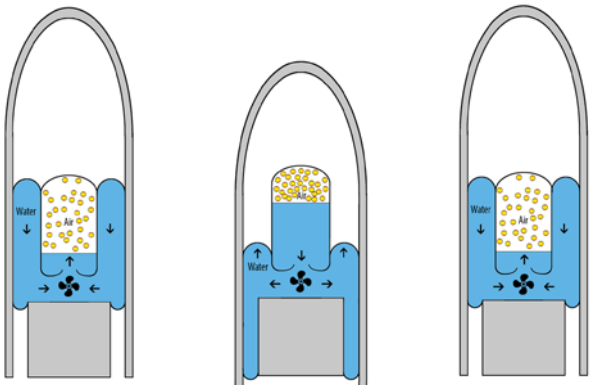


Figure 6: *Operating principle (symphony)*

As the wave passes by and less water is on top of the device, both bouyancy and the pressure in the air chambre will bring the hull back to its original position. Water flows back from the air chambre through the turbine to the membrane.

The combination of the mass of the hull and the pressure in the air chambre can be seen as a mass-spring system. By tuning the natural frequency of this system to be the same as the frequency of the incoming wave, the amplitude of the system will rise above the amplitude of the wave which is needed for optimal absorption of the wave power. The Symphony is still in the concept phase. A prototype will be built in the near future.

One of the predecessors of the symphony is the Archemedis Wave Swing (AWS). The mechanical operating principle of this device is very similar to that of the Symphony. A big difference is that the system does not use a rotary generator. Instead, the AWS can convert the vertical motion of the device directly into electricity using a permanent magnet linear generator so the use of a turbine is not necessary. One of the challenges is that the linear generator has to operate at a low speed [5].

Conclusion

The seas and oceans are an enormous source of untapped sustainable energy. Despite the hostile environment and commercial challenges, many different wave energy converters have been designed and tested. Wave power is still in a phase where a lot of creative and inventive projects are competing to achieve the highest efficiencies at the lowest costs. Eventually, the best designs will be distilled out and hopefully these will be profitable converters to make wave power a substantial part of our future energy mix.■

[1] Drew B, Plummer AR, Sahinkaya MN. A review of wave energy converter technology, Proc Inst Mech Eng Part A-J Power Energy 2010, 223:887-902.

[2] Falnes J. A review of wave-energy extraction, Marine Structures 20, 2007, 185-201.

[3] Clement A, McCullen P,Falcao A, Fiorentino A, Gardner F, Hammarlund K, Lemonis G, Lewis T, Nielsen K, Petroncini S, Pontes M, Schild B, Jöström P, Sresen H and Thorpe, T. Wave energy in Europe: current status and perspectives, Renew. Sust. Energy Rev., 2002, 6(5), 405-431.

[4] Falcao A. Wave energy utilization: A review of the technologies Renew. Sust. Energy Rev., 2010, 14(3), 899-918.

[5] Polinder H, Damen M, Gardner F. Linear PM Generator System for Wave Energy Conversion in the AWS IEEE Transactions on Energy Conversion, 2004, 19(3).

Advertorial

Big Brother in de trein?

By Martijn Janssen
Junior Consultant bij Ricardo Rail

Zondagmorgen in de trein: een dagje naar je ouders. Terwijl je onderweg rustig ontspant met een muziekje merk je er maar weinig van. Big Brother is watching your train!

Treinen zijn tegenwoordig rijdende computers. Tijdens jouw treinreis wordt er van alles geregistreerd. Denk hierbij aan operatie van de trein of gegevens over belangrijke componenten in de trein. Het is waardevol deze componenten continu in de gaten te houden. Hiermee krijg je zicht op hun gedrag tijdens gebruik.

Om dit voor elkaar te krijgen moet je meten. Je doet dit op meerdere punten in de trein en zo verzamel je voor de componenten data. Deze data bevat de informatie om het gedrag van deze componenten in de praktijk te vinden.

Om deze metingen uit te voeren heeft Ricardo Rail een meetsysteem met daarin zelf ontwikkelde meetapparatuur. Dit meetsysteem zit verwerkt in een koffer, ik houd hem vast in figuur 1. Met deze meetsystemen kun je meerdere kanalen tegelijk meten. Daarnaast kun je deze systemen op afstand uitlezen.

Deze metingen genereren een grote hoeveelheid data. Om een idee te geven, het gaat in sommige projecten om meer dan 1 TB per maand, gedurende een periode van meer dan een jaar. Om deze data te kunnen analyseren gebruik ik een server met 2 hexacore processors (type Intel X5650), totaal 12 cores, 60 GB RAM en 30 TB aan opslag.

Bij Ricardo Rail werk ik op kantoor meestal samen met collega's aan projecten waarbij ik dit soort datasets analyseer. Daarbij doe ik nieuwe inzichten op door data-analyse en simulaties. Daarnaast help ik buiten kantoor bij speciale treinritten om te kijken of een trein voldoet aan gestelde eisen. Wat ik zelf erg leuk vind is dat je zelf kan kijken welk type werk bij je past en daarmee kan bepalen op welk gebied je jezelf verder ontwikkelt. Daarbij krijg je veel ondersteuning in de vorm van coaching en trainingen. Ons kantoor zit bovenin Utrecht Centraal en is daardoor erg goed bereikbaar. Ook kan ik iedere middag tijdens de lunch met collega's een rondje door Utrecht lopen.

Ricardo Rail is een innovatief bedrijf dat altijd op zoek is naar technisch talent. En wij werken aan alle aspecten van een trein, het spoor en de interactie tussen deze. Een heel breed terrein dus!

Mocht je na het lezen van dit artikel vragen hebben, aarzel niet ze te stellen! ■

Figuur 1: *Martijn met een meetkoffer*

Localization of acoustic underwater sources

A global optimization approach

By Dr.ir. Mirjam Snellen & Prof. dr. Dick G. Simons
Section Aircraft Noise and Climate Effects, Delft University of Technology

One of the research themes within the section Aircraft Noise and Climate Effects (ANCE) is acoustic source localization using acoustic arrays. These arrays are used, for example, for measuring the noise of aircraft fly-overs, quantifying the noise from the various aircraft components such as flaps, slats, engines and landing gear, and in wind tunnel measurements. However, acoustic arrays are also used under water for source localization, for example with the goal of determining the position of a submarine. Although in many aspects similar, there are differences when considering acoustic source localization under water compared to the situation in air. The reason is that, especially in regions with shallow water, the propagation of sound from source to receiver is heavily affected by the interaction of sound with the sediment on the seafloor and by varying sound speeds in the water column. Not accounting for these propagation effects results in an erroneous localization.

A major problem is that although 70% of the earth is covered by water, the majority of underwater media are still unexplored, and consequently often both the sedi-

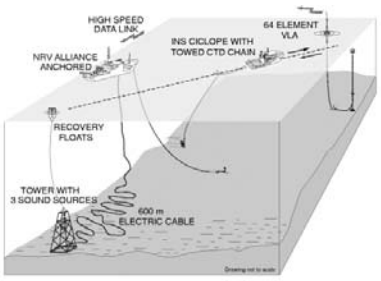


Figure 1: *Overview of the measurement configuration. The data are acquired on a 64 hydrophone vertical line array (VLA). A sound source was mounted on a tower placed on the bottom. A ship (INS Ciclope) was measuring the sound speeds in the water column with conductivity-temperature-depth (CTD) sensors.*

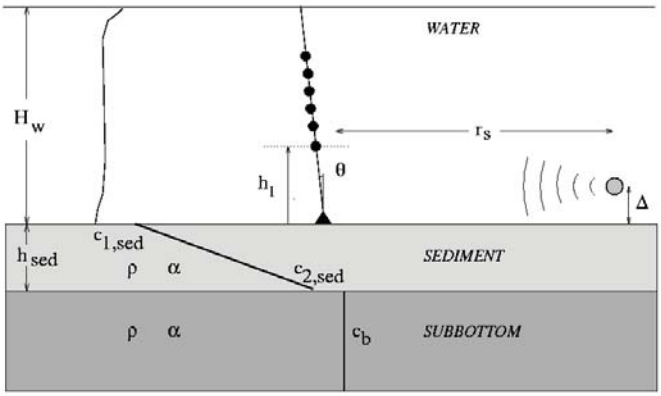


Figure 2: *The environment is assumed to consist of three layers, a water column of thickness H_w, a sediment layer of thickness h_{sed} and a subbottom. The acoustic source is located at a distance Δ from the sediment at a range r_s from the receiver. The receiver is a line array consisting of 64 hydrophones, with the lower hydrophone at a distance h_1 from the bottom and the array tilted at an angle θ. Sound speeds in the sediment and subbottom are $c_{1,sed}$, $c_{2,sed}$ and c_b, respectively. The density ρ and absorption coefficient α are assumed to be equal in sediment and subbottom.*

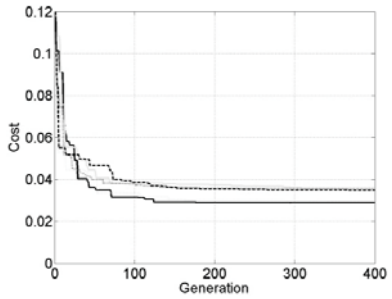


Figure 3: *Example of GA convergence behavior for 5 independent runs.*

ment characteristics and water column properties are unknown and therefore cannot be properly accounted for. To still allow for accurate source localization, the technique of matched field inversion, also called focalization, has been developed. The approach is to not only search for the unknown position of the source, but to also estimate all parameters of the environment that do affect the sound propagation but are not known. We will illustrate this idea by applying it to a dataset acquired in a configuration as shown in Figure 1. Figure 2 presents a schematic of the situation. All environmental parameters indicated are unknown and need to be determined to allow for localizing the acoustic source.

By using an appropriate acoustic propagation model that accounts for the effects of all above unknowns, the received signals are predicted for a large number of realizations of the unknown parameters. For every realization the agreement between measured and predicted acoustic pressure field is quantified through a cost function. Due to the huge number of possible combinations of values for all unknown parameters, an efficient optimization method is required to determine those values for the unknowns that provide a maximum agreement between measured and predicted pressure field. In addition, the optimization method needs to be capable of escaping local optima, i.e. combinations of values that provide good, but not the best agreement between measurements and predictions. For the application at hand a genetic algorithm (GA) has been used. The method works with populations of solutions and finds the global optimum by combining promising solutions in subsequent iterations. Figure 3 illustrates the convergence behavior of the algorithm. Since with these type of optimization methods there is always a possibility to end in a local optimum, five independent runs have been carried out. The resulting environmental parameters have been used for localizing both a source positioned at the bottom (see Figure 4), and the surface ship Ciclope (see Figure 5). For both acoustic sources the so-called ambiguity surfaces are shown. These quantify the agreement between the measured and modelled pressure fields for a grid of potential source positions. High levels, indicating good agreement between modelled and measured pressure fields, are indicated ▶

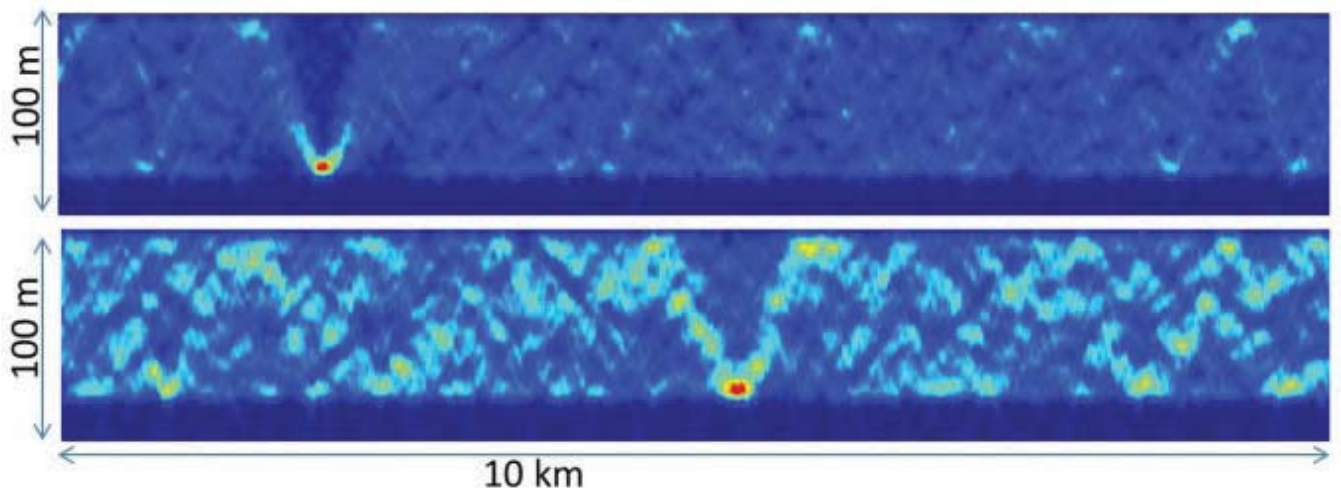


Figure 4: *Ambiguity surfaces for measurements with the acoustic source mounted at the bottom at 2 and 5 km distance from the array, respectively. The water depth is ~100 m.*

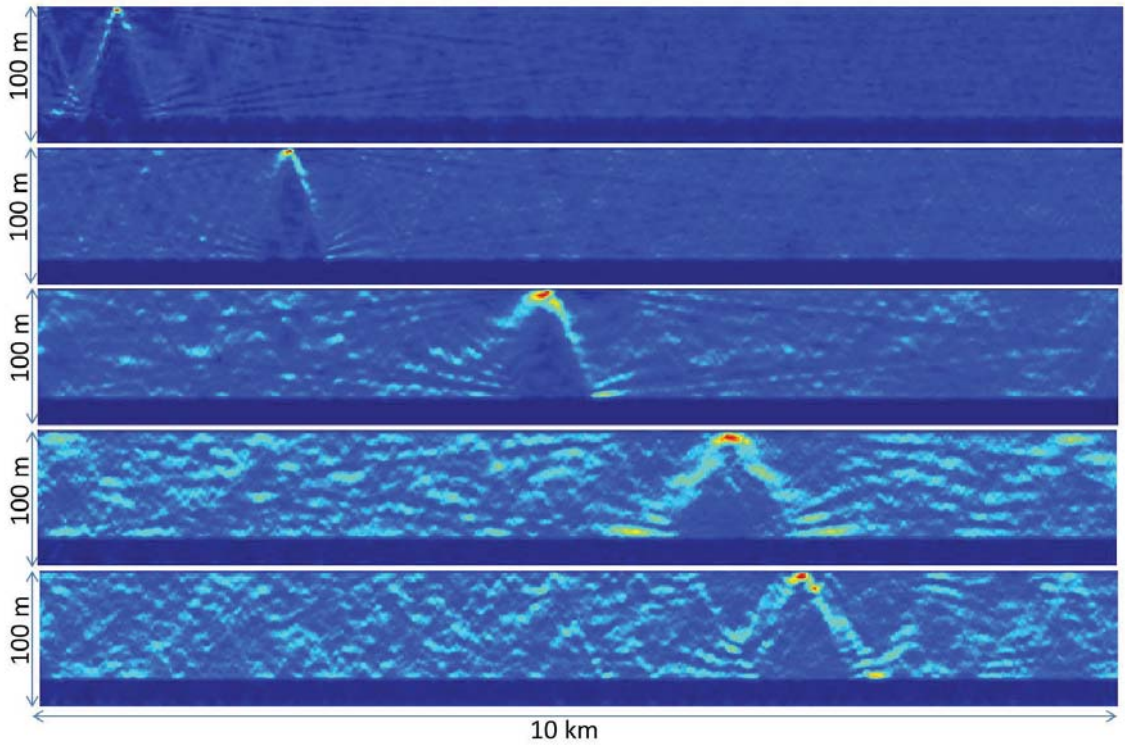


Figure 5: *Ambiguity surfaces indicating the location of the surface ship Ciclope at various times, corresponding to various distances of the Ciclope to the acoustic array.*

in red, whereas lower levels are shown in blue. Clearly, the estimates for the environmental parameters are accurate as the ambiguity surfaces indicate the presence of the source (red spots) at the correct positions.

Although started as a method for the localization of acoustic sources under water, nowadays the application has broadened towards also using the method for the assessment of the underwater environment. Applications requiring this information are manifold, and include for example the area of mine hunting where bottom information is essential, since mines behave differently for different types of bottoms. In a soft bottom, mines get buried in the bottom, whereas they stay on top of hard sea bottoms. Having information about the sediment properties is also an essential element for dredging, investigating the sea bottom for off-shore activities, e.g. when considering an airport on the sea, or tracing the sea bottom for certain types of material. ■

Changing the tide of high cost ocean exploration

By Scott Waters[1]

It's not every day that you meet a submarine designer in Kansas, a land-locked state in the middle of continental United States – about as far from the ocean as you can get. Yet that's exactly where you'll find Scott Waters pursuing his passion for refurbishing or building-from-scratch submarines that meet the highest standards for deep-sea research. When Scott reached out to me last year to serve as science advisor for his latest initiative – rebuilding the Cold War-era Pisces VI deep sea sub, I was intrigued, but naturally skeptical.

Through our subsequent conversations and meetings, however, I quickly developed enormous respect for him and the work of his team to make deep-sea research more affordable. I'm simply amazed at what they've accomplished, let alone in a region perhaps most recognized for its sepia-colored farmscapes in the Wizard of Oz. Scott is at the forefront of renewed interest in deep-sea research. With the ocean's role in regulating our climate and sustaining life on Earth gaining prominence in political and scientific debates, it's an exciting time to be an ocean explorer. Scott's ingenuity and drive to expand opportunities for cost-effective deep-sea exploration will open leagues of opportunity for all of us eager to unlock the ocean's mysteries so we can better manage its precious resources.

Exploration has always been an expensive endeavor, but the fuel of mankind's curiosity has always found ways to fund it. The noose of tightening budgets has made the depths of the ocean harder to reach than ever. It is for this reason that my team and I have set the goal of bringing a deep sea submarine available to the science community at a low cost.

When I was a young child I used to dream of exploring the depths of the ocean, outer space, and places humans have not been. I spent countless hours meticulously designing machines on scrap paper to take me there. I arranged on toys the likely locations of buttons and switches, and spent hours imagining in those mock-ups. To be honest, that part of my childhood was not that unique. The difference was getting scolded in school for not paying attention. However, being so immersed in my imagination never discouraged me, and when I set a goal I will not stop until I reached it.

Therefore, I made up my mind to build a craft that worked. I found a wooden spool used for power lines sitting in a field in my home state of Kansas and started building my first submarine. I sealed the cracks with silicon, installed Plexiglas for the viewports and valves for the ballast tanks. Neighbors made fun of me - someone even brought me a cardboard tube, laughing "here's a periscope for you." I inevitably realized that I possessed neither the skill set nor the materials required to complete this submarine. So I dove into research, getting every book I could on submarines, welding, engineering, etc.

Fast forward to my time in college. I never gave up on my dream to build a submarine, and by that time had spent ▶

[1]*Founder and President of Deep Water Research, LLC with introduction by Grace C. Young, PhD Candidate, University of Oxford's Ocean Research & Conservation Group, BSc, MIT Mechanical & Ocean Engineering, Aquanaut*

Figure 1: *Scott Waters on his first submarine, Trustworthy*

years researching and learning. I found the blue prints to a Kitteredge K-350 submarine on the Internet, bought them and started buying and making parts to build this amazing craft. I was really doing it! I saved every cent I could and put it all towards tools, parts, and everything else I needed to build the submarine. I often hit a roadblock where I didn't have the knowledge to do something and would have to stop to learn it before I could continue. In 2013 I launched my K-350 submarine and named it "Trustworthy." Amazingly, everything worked flawlessly! I spent the next few months improving the submarine, but quickly became depressed. I no longer had any goals I was working towards. No great challenge to fight against the odds with. I decided to learn how to fly by studying for a pilot's license, but it just wasn't the same. I had always wanted to build a submarine that could go really deep. The kind of deep that I used to dream about as a child, but everyone told me it would cost millions and was impossible for a private individual to do.

I simply wasn't going to be happy having the greatest accomplishment of my life (i.e., building Trustworthy) finished and over with. I began pouring myself again into learning about deep sea submarines. The more I learned, the more impossible this seemed. There are only 5 deep submarines currently operating in the world and they all cost several millions of dollars and operated by governments. Just building the personnel sphere would be a million dollars, making this project feel far out of reach. But when something seems impossible, either try harder or try a different approach. I started trying to track down other ways to build a deep submarine. I spent hours talking to people all over the world. After years of research and still not giving up, I caught a lucky break. I located a deep sea submarine called Pisces VI built by International Hydrodynamics Co. Ltd. (HYCO) in 1976. Her sister submarines Pisces IV and Pisces V are 2 of the 5 still in operation deep diving submarines in the world. I negotiated the price for 9 months with the owners until finally one cold winter day they agreed, and with the handshake agreement I would make her dive again!

In order to overcome what seemed impossible, I needed a crew of people who were experts in their fields. I searched the globe, finding each crewmember with a bit of luck and coincidence. It didn't take long and the Pisces VI crew was ready. We started working like a well oiled machine with each person focusing on their specialty. Pisces VI currently is part way through the build. The current goal is to have her completed and ready for service

in 2 years.

Pisces VI will have capabilities beyond any other privately owned submersible. She will be able to dive 2000 meters with one pilot and 3 observers. She will weigh only about 15,000 lbs, allowing for a significantly less expensive support ship. A unique trait of the Pisces VI system is that it fits inside a 20' shipping container. The container also holds extra parts and tools, and when the submarine is deployed, the container becomes the operations office and maintenance shop. The cost of shipping a container anywhere in the world is significantly less than shipping a submarine flat top on ship. Every aspect of the new Pisces VI is designed to meet or exceed every rule of safety while being very low cost.

The safety systems are redundant and exceed all requirements. She will have 120 hours of emergency life support for each person on board, totaling 480 man hours, whereas her closest equivalents have 72 hours per person. The submarine will have a built-in-breathing system (BIBs) and fire extinguishing system in case of fire or smoke. The submarine will also have powerful underwater and surface communications as well as locating beacons so the support ship will always know exactly what is going on with the vehicle. One of the crewmember's sole responsibility is safety and so with each dive there is a dive plan, emergency plan, brief, and rescue plan that will be set and ready. Pisces VI is tested and certified to the highest standards to allow insurance, which a lot of times can stop a project dead in its tracks.

The potential location of Pisces VI's home is still in the works, but she will specialize in getting to the dive site significantly less expensive than any other platform. She will primarily be used for the science and film industry, but will also be for hire by adventure tourists. You can follow the progress on www.piscessub.com and at some point in the next 2 years, an Internet series following the progress of the build and our mission to make deep sea exploration affordable and safe will be available. ■

Figure 2: *Scott Waters in front of deep-sea submarine Pisces VI during refurbishment*

Advertorial

The challenges of building an extra-large dredger

Two main engines, an auxiliary engine, six generators, five switchboards, the largest ultra-rapid circuit breaker available and 104km of power cable. These are just some of the critical elements of the electrical installation on board the AL BAHAR C/D HUTA 12, a 23,575kW diesel-electric powered cutter suction dredger (CSD) designed and built by Royal IHC

A CSD is a vessel used to excavate rocks and sand, mostly under water, and move the excavated material to a different location in order to deepen waterways, create new harbours or reclaim land. Royal IHC is a world-renowned Dutch company that designs, builds and maintains innovative equipment and vessels for the offshore, dredging and mining industries. IHC's subsidiary, IHC Drives & Automation in Sliedrecht, The Netherlands, specialises in providing innovative solutions for electrical power, automation, intelligent system integration and simulation.

High power, low voltage

In 2012, Huta Marine Works, the largest dredging contractor in Saudi Arabia, placed an order for a custom-built dredging vessel. Pieter Vos, Lead Engineer Electrical, and Paul Goos, Electrical Engineer at IHC Drives & Automation were involved in the design, implementation and commissioning of the electrical installation, and the control and automation system.

"Our customer already owned a couple of IHC CSDs, but this time they wanted an extra-large version," says Paul. In a dredging vessel most of the power goes to the propulsion system, dredge pumps, winches, the cutter system and a board net (400V).

"The challenge with a larger system is that you need a lot of power", adds Pieter. "However, our customer wanted a low-voltage system similar to the other vessels it operates. That meant in some cases even the largest components on the market, such as breakers (max. 6.3kA), wouldn't be able to handle the current that such a system requires. This meant we had to find workarounds to overcome these limitations."

Divide and conquer

IHC opted for a system in which each main engine drives two generators, instead of one. In this way, the power to the main switchboard is divided over two breakers, so that the largest breakers would be sufficient. In addition, special care was taken to make sure the generators were synchronised.

This solved one problem, but with vessels nothing is ever so straightforward. When a ship is out at sea, propulsion is a critical factor. "With dredgers, this also applies to the dredge pumps: they must never stop pumping in the event of a breakdown or an emergency," continues Paul. "The

dredged sand and other material is transported to a different location through pipes, sometimes across distances of up to 12km. If at any time the pumps stop working, the sediment settles in the pipes and needs to be removed manually. A hell of a job, with major implications for any project."

For this reason, there are always two main engines. "In case one fails, the other one will power the crucial elements," says Pieter. "The bus-tie connects the two busses, but that too has a maximum current of 6,300A. The power management system will ensure that the consumption matches the maximum allowed current to prevent a total shutdown of the ship."

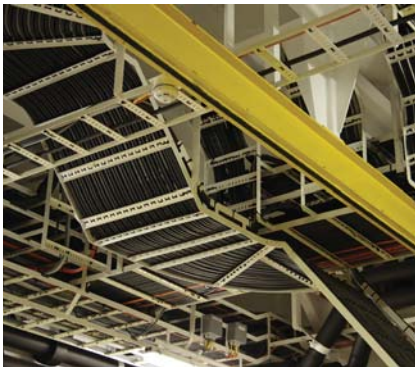
However, with the two busses being connected, the total short-circuit current would be too high even for the largest circuit breakers. The Schneider Electric Masterpact UR Ultra Rapid 6,000A circuit breaker, the fastest available, protects the system against high short-circuit current. If a short circuit occurs, it breaks the circuit so quickly that the high peak short-circuit current won't even have time to have an effect.

Connections

Another challenge lies in connecting all the critical elements, as space on board a vessel is limited. "You can't use very thick cables as we need to be able to manoeuvre them into place," says Pieter. "We are restricted to cables with a maximum diameter of 120mm², which can handle 270A. Our maximum current is 6,300A. So for just one connection we had to use 24 parallel cables. In total, we have used approximately 104km of power cable in the HUTA 12."

"It has been quite a challenge to make everything come together," concludes Paul. "So when it does, it is amazing!" Pieter is also full of admiration for the project: "Running at maximum capacity, this dredger uses as much power as 58,000 households. It seems incredible that this entire vessel can be brought to life by pushing a single button."

The AL BAHAR C/D HUTA 12 was handed over to Huta Marine Works in 2014 and has since been dredging the King Abdullah Port in Saudi Arabia.



Would you like to know more about Royal IHC, career opportunities and internships? Go to www.royalihc.com/careers. ■

A Storm of Science

By Oliver S. Ashford, Ocean Research and Conservation Group, Department of Zoology, University of Oxford, UK

Earlier this year I was given the fantastic opportunity to join the British Antarctic Survey 'SO-AntEco' (South Orkneys - State of the Antarctic Ecosystem) deep-sea research cruise. This cruise, aboard the RRS James Clark Ross (pictured) aimed to illuminate just what deep-sea organisms are found on the seabed around the South Orkney Islands in the Southern Ocean. I am proud to say that our findings are currently being used to re-draw the boundaries of the marine protected area in proximity to these chilly isles.

During the research cruise, I decided to write a number of blog articles to try and share some of my experiences with the world. In particular, it struck me that public understanding of deep-sea sampling methods is rather lacking – indeed the whole process of collecting data on deep-sea organisms probably seems highly mysterious to many! To try and put this right, I wrote the following piece, outlining a typical day of sampling during the SO-AntEco cruise.

Day 21 bobbing about on the Southern Ocean and, as gale-force winds whistle around the ship, bringing our work to a halt, I thought I'd use this opportunity to talk you through a typical day of science at sea.

My shift (day shift) is now working well as a team, and our sampling routine is becoming more and more fluid with every gear deployment. Our 12-hour shift begins at 7am, and we immediately take over tasks from the night shift. Because sample collection is a continuous 24-hour operation aboard the James Clark Ross, you never know quite what you will start the day doing, but sampling occurs in a circular manner, following a set sequence.

First comes a quick survey of the seabed

using the ship's sophisticated multi-beam sonar system. The beautiful high-resolution map that results is highly valuable in its own right, but it also helps us to pinpoint exactly where we'd like to collect physical samples from.

Once an appropriate site is chosen, the CTD (Conductivity, Temperature, Depth) is first to be lowered into the inky blackness. This cylindrical tubular metal frame is covered with numerous expensive-looking scientific instruments that measure almost everything you'd ever want to know about sea water – depth, temperature, salinity, oxygen concentration, and chlorophyll concentration, amongst others. Using a CTD helps to put our sampling in a broader environmental context.

Next follows the underwater camera system, which has the perhaps unfortunate acronym of SUCS (Shallow Underwater Camera System). SUCS is depth-rated to 1000 m and consists of a metal tripod frame with a downward-facing HD video mounted at the centre, flanked by two lights. The camera is towed slowly along a transect, descending to the seabed every 10 m for a photograph to be taken. Not only can these images be analysed scientifically, but they also offer a tantalising taster of what deep-sea animals we can expect to bring up in the following trawls.

We use an Agassiz Trawl (AGT) to sample the larger animals (more than about 2 cm) living on the seabed. The AGT is a simple

Figure 1: *Deploying the CTD*

piece of technology. It consists of a relatively small (1.5 m width) metal frame with sledge runners connected to a sack-like net that collects any large animals that pass through the mouth of the frame. The AGT is towed slowly (~0.5 mph) on the seabed for 10 minutes. Once back on deck, any animals collected in the net are quickly sorted into major groups, counted, weighed, given a unique identifier, and preserved for future, more detailed inspection.

Every third AGT, the Rauschert dredge is deployed alongside. This dredge is the little brother of the AGT, being about 10 times smaller in volume. It is used to sample the tiny animals living on and in the seabed, and so is equipped with a much finer net. There are usually too many small animals to individually process on the ship, so samples taken with this little dredge are preserved as a whole in alcohol to be looked at again at a later date.

Finally, at the end of the sampling sequence, the epi-benthic sledge (EBS) is lowered to the seafloor. This is the heaviest piece of equipment we use (about 550 kg), and consists of a long tubular metal frame with sledge runners and two fine mesh nets placed one on top of the other. The lower net collects animals from close to the seafloor, whilst the upper net ▶

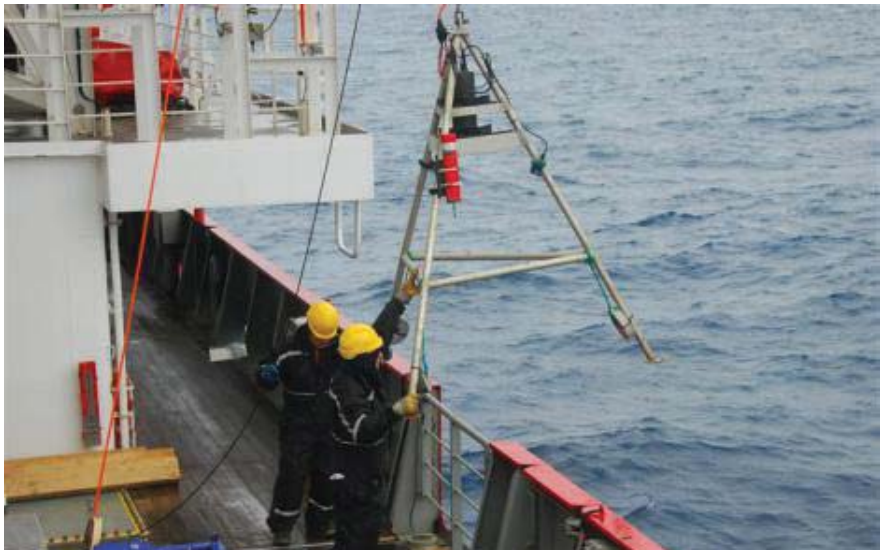


Figure 2: *Deploying SUCS*

Figure 3: *The Agassiz Trawl, surrounded by excited biologists*

takes animals from slightly higher in the water column. Like the little Rauschert dredge, the EBS is designed to sample the smaller animals that call the deep sea home, and, these being very numerous, the sample is usually quickly preserved in alcohol for future sorting.

It is impossible to escape the fact that there is an irony to deep-sea sampling. Other than the CTD, all the equipment that we lower onto the seafloor causes some amount of disturbance to the life there. This ranges in magnitude from small for the SUCS camera system, to relatively large for the Agassiz trawl. Yet, at present, these are the best methods we have of learning about what is living on the seabed below – from the very small to the very large. This disturbance is not without reason, however; the data collected by our sampling will be used as evidence to determine whether or not the areas we have examined require special protection from human activities. For a small amount of damage caused, we may be able to guarantee the long-term protection of an area. In fact, preliminary analyses of the camera images show that the majority of sites sampled so far are inhabited by relatively large abundances of animals deemed vulnerable to anthropogenic disturbance, and so may meet the criteria laid down by the 'Commission for the Conservation of Antarctic Marine Living Resources' to be worthy of protection. Real-world relevance and impact like this makes my work not only extremely exciting, but also very fulfilling. ■

If you'd like to read more blog posts from Oxford's Ocean Research and Conservation team, please check out https://oxford-oceanresearch.org/expedition-blog/.

Figure 4: *The Epi-Benthic Sledge, complete with compulsory iceberg*

Activities

Lustrum week 4

By William Hunter

In the first week of June, the fourth and last lustrum week was organized to celebrate the ETV's 110th birthday. It was a week full of fun activities and parties. Whereas the other three weeks began on Monday, the fourth began on Saturday with the Lustrum Rally. This two-day activity saw seven teams of competitors turn up with their cars early in the morning at the EEMCS faculty. Using cryptic instructions, each team had to go past certain checkpoints in the least amount of kilometers. From Delft the participants travelled to Moerdijk, Baarle-Nassau, Eindhoven and Limburg before ending the day just across the border in a German hostel. The next day, the route led people past Kloster Graefenthal (where the lustrum gala was held in March), through the Veluwe and past Baarn, finally finishing in Delft on Sunday evening.

On Monday participants were treated to a fun excursion to Tata Steel in IJmuiden, while on Tuesday it was time for the Lustrum Party at Area 015 in the centre of Delft. The theme being "You Only Live Onesie", lots of people turned up in their best animal outfits to celebrate the end of the lustrum year. Towards the end of the night, five men in black waistcoats marched into the bar: the Potential (now 145th) Board presented themselves with a fun movie, and were promptly congratulated by the party-goers.

Using cryptic instructions, each team had to go past certain checkpoints in the least amount of kilometers.

The following day, the lustrum reception took place behind the faculty. Guests from Delft and elsewhere in the Netherlands had the opportunity to congratulate the Board on the 110th birthday of the ETV and enjoy the free beer. It was great fun, just ask last year's Board ;)

On Thursday evening, the /pub was filled with people. The product of half a year's work by the yearbook committee was finally unveiled: the 57th yearbook of the ETV with the title Functie. Along with free beer, there were 57 pizzas for everyone to enjoy while they got their own copy of the book signed. As the evening progressed, the signing of yearbooks slowly made way for people singing their favourite songs at the annual karaoke.

Friday saw the week of festivities draw to a close. In the afternoon a delicious lunch was organized in the /Pub so that everyone could recover from a week of partying. This lunch had only just ended when at four o'clock the closing drink gave people the opportunity to end the week in a relaxed way. ■

Elektro Ontangst Weekend

By Maarten van der Meulen

The EOW is a weekend that most of the new electrical engineering students attend. The weekend started on Thursday when we arrived at the faculty. We were handed yellow coveralls and booklets. We also got a tour of the faculty, during which we were shown the high power lab and enjoyed the beautiful view from the roof of the building. In the evening we were dropped off in and around Delft and tasked with the goal of finding our way back to the faculty.

On Friday we went to the Staelduin campsite at Maasdijk by bike. At the camp we played a lot of icebreaker games to get to know each other. There was also an inflatable assault course at the campsite, and we were divided into two teams which were to compete on the course. The first person of each team had to drink a beer, complete the course and at the end dip his/her hand in a jar of hair gel and spin around 15 times. While still dizzy from the all the spinning, the person had to run back to the starting point and high-five the next person, who in turn had to do the whole course again. This naturally made for a good laugh, with people falling over, and we all had a fun time.

On Saturday we played even more games, among which was a game where we were handed a diode and had to trade it up for other items with the objective of recreating the faculty on a spot on the beach to the best of our abilities. Since we were on the beach anyway, we went for a swim afterwards.

Sunday arrived with us psyched for the "big hero's game", which had been hyped up during the entire weekend. The day started off with some gymnastics, after which we lined up for the big game. At the back of the booklets we were handed at the beginning of the weekend was a description of things we could do to get a head start. For example, you could spin around 34 times before the start of the game. We were then handed gar-

bage bags, and with the curiosity built up enough with us wondering what we were to do with the garbage bags, we got to play the "big hero's game": clean up the campsite! And that is how we ended an awesome weekend and headed back to campus. ■

Welcome Back Barbecue

By Ege Tansug

The first 2 weeks of classes were intense, but passed by quickly. Just like many other first-year students, I had the urge to simply kick back and relax on several occasions, which is what I did during the Welcome Back Barbecue that was held outside the faculty building. This was a great opportunity to hang out with other first-year electrical engineering students on a mild afternoon.

Standing in line while conversing with friends and waiting for the first burgers, I could already tell that people were enjoying the event as they listened to good music and chatted the afternoon away. I must say I was also quite excited to eat a delicious burger right off the grill.

As I carried on conversations with friends and enjoyed my burger, I noticed a line once more forming in front of the grill. What do you know? More food! Sweet words to a student's ears! There was beer too of course to go with the food.

Even as I headed home at the end of the day, I could not help but be amazed by how many first-year students showed up. That was probably the nicest thing about the event. It was definitely a day to remember. Needless to say, the pleasant sensation of being full probably contributed to making the event worth a 'VO! ■

IFF

By Franck Kerkhof

The IFF party took place on the 28th of September. This party is jointly organized by a number of study associations. One of these study associations is the ETV, which is how I got my ticket to the party. I could only begin to imagine the fun I would have at this party. I had heard good stories about this annual party from previous years, but in Dutch there's a saying: "Bij zijn is meemaken!". This means you should be present at the activity to experience the greatness of it. By actually experiencing it yourself, you are better placed to tell others why they should have been there. This was definitely true in my case! Before I went to the party I had a drink with some awesome people

In Dutch there's a saying: "Bij zijn is meemaken!"

and then we went to the party. The party not only had a very nice line up, but the excitement was visible on everyone's face. The atmosphere created by the party people was amazing, and I had a great time. I may have been one of the youngest present, but it certainly did not matter to me or the others. I partied like an animal, just like pretty much everyone else! The atmosphere was superb, everyone danced, had plenty to drink and had a wonderful time in general. IFF was an experience I won't forget, and it is a party which I will attend next year for sure. For anyone who couldn't make it this year, I most certainly recommend being present next year. ■

Ontwikkel jij jezelf verder bij Bakker Sliedrecht?

Bakker Sliedrecht is sinds 1919 een internationaal toonaangevende speler geworden op het gebied van elektrotechniek voor maritieme toepassingen. En voert als system integrator wereldwijd turn-key projecten uit in de sectoren offshore, baggeren, researchschepen, visserij, koopvaardij, marine en binnenvaart.

We zijn voortdurend op zoek naar de beste en innovatieve oplossingen, met behulp van zowel vernieuwende, als ook conventionele elektrische en mechanische technieken door het adviseren, ontwerpen en bouwen van:

- aandrijf- en besturingssystemen
- automatiseringssystemen
- schakelborden en MCC's
- besturingslessenaars
- elektromotoren en generatoren
- bekabeling/installatie
- projectmanagement

Bakker Sliedrecht als aantrekkelijke werkgever

Ben jij geïnteresseerd in elektrotechniek? Dan zijn wij voor jou de ideale werkgever. Bij ons heerst een informele sfeer waar de lijnen kort zijn en er veel ruimte is voor eigen inbreng en initiatief. Ben jij een enthousiaste WO-er met een Master Elektrotechniek? Of volg je momenteel nog een studie in deze richting? Dan krijg je bij ons volop de mogelijkheid je verder te ontwikkelen en door te groeien. Speciaal daarvoor beschikken wij over een eigen opleidingscentrum. Voor HBO/WO medewerkers is een Trainee programma ontwikkeld, waarmee je uitgebreid kennis maakt met ons bedrijf en diverse afdelingen. Maar ook voor de professionals bieden wij een ruim aanbod aan opleidingsmogelijkheden om je te blijven ontwikkelen en door te groeien!

Pon

Wij zijn een 100% dochteronderneming van Pon Holdings, één van Nederlands grootste familiebedrijven met wereldwijd bijna 13.000 medewerkers die werken in 80 bedrijven. Last but not least; Pon is in 2012, 2013 en 2014 gekozen tot Top Employer.

We take care of it!