MAXWELL

Data Collection

Display technology
On the history of displaying decimal numbers

Aquatic autonomous robots
Improving water quality with robotics

Sexually transgressive behaviour at TU Delft
Interviews with the ETV Board and the EDIT

Upcoming activities
For members of the Electrotechnische Vereeniging

Batavierenrace

The batavierenrace is an annual event where teams of 25 run from Nijmegen to Enschede in 25 shifts of around 8 kilometres each. A lot of student and study associations participate in this event. At the end of the race the batavierenrace ends with the biggest student party of the Benelux!

When: April 29
**Where:** Gelderland, Overijssel
Price: Sold out

Lustrum Gala

To celebrate the association's 115th birthday, the 23rd Lustrum, there will be a Lustrum Gala in Kasteel Maurick in Vught. The party will include a live band and two DJ's, all drinks are included aswell. So put on your dress, suit or prom dress and dance the night away!

When: May 5
Where: Kasteel Maurick
Price: €90,- (duo ticket)
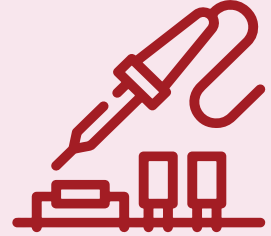
Parents' Day

On Parents' day, the parents of our members get the chance to see the faculty where their children work and study. They can also get a taste of Electrical Engineering by making a small device themselves! The day will end with some drinks in our own /Pub.

When: May 8
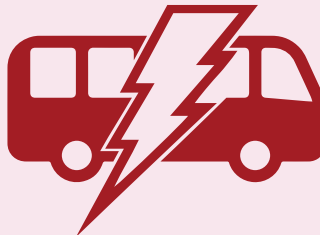**Where:** Faculty of EEMCS
Price: Free

Honorary Members Installment

For the first time in six years, we will welcome two new honorary members to our association. The men that will be installed are Prof. Dr. Ir. Arno Smets and Dr. Ir. Jaap Haartsen. It will be a very special event.

When: May 12
Where: /Pub
Price: Free

Electrip

Are you interested in working abroad? Do you want to know what happens behind the closed doors of companies? Then join the Electrip 2022! This year we are travelling to Stuttgart from the 22nd until the 25th of May, to take a look at the workplace of high-end companies! Signing up can be done at the ETV front desk. Full = full so be quick!

When: May 22 till May 25
Where: Stuttgart
Price: €120,-

DIES

The ETV has turned 1 year older once again, so it is time for the DIES week! From the 30th of May until the 3rd of June each day of the week is filled to the brim with fun activities and workshops! Signing up is separate for each activity, so make sure to keep an eye out on our social media for when you can buy your tickets!

When: May 30 till June 3
Where: TBA
Price: Activity dependent

From the Board

Dear readers,

When I got the opportunity to write a piece for the Maxwell I knew I had to write something about my fellow board member and one of my dearest friends Jorrit.

Jorrit and I both lived in Almere and started our college journey in Delft together. We bonded a lot starting from the first time we met and now that we are both doing a board year, we have become even closer. Jorrit is the commissioner of education of the ETV. He loves to remind us, due to the nature of his function, that our association is a study association and not just a normal student association. Maybe this is not true, but what is true is that the association would not be the same without Jorrit.

Jorrit is always excited about everything. When someone wants to talk, he is always there for them. When you don't feel very great, he is there to cheer you up. This year I also found out that Jorrit is a hard worker and he wants the best for everyone, that is what makes him such a great commissioner of education. He has the perfect balance between working seriously and having fun.
I look forward to working with him — but of course also with the rest of my board — for another half year. I can say with all my heart that Jorrit is a friend for life and I look forward to where the future will lead us.

With Magnifying regards,

Mark Imhof
President of the 150th Board of
the Electrotechnische Vereeniging

Jorrit van Drie
Commissioner of Education

Dear readers,

I would like to introduce you to the secretary of the 150th board of the Electrotechnische Vereeniging, Maarten Groen. Maarten has a lot of characteristics that make him instantly recognisable once you come by to have a chat with us in the Boardroom. For instance, there is nobody in the world I know that gets affected as quickly by caffeine. A cup or two and Maarten is bouncing around in the boardroom, which is always very amusing to me and my fellow Board members.
Maarten also likes to play volleyball in his free time. I've yet to watch a game from him, but I'm sure he's great at it since he loves to talk about it.

Maarten is certainly no digital illiterate. Even though we all are studying a technical study he has a special interest for managing the ETV website and other technical problems with our server. He is also relatively proficient at using InDesign, which is why everyone always asks him how the program works, since nobody really wants to learn it.
All these things make him a very unique secretary and I wouldn't want to miss him for the world. I cherish positive expectations that you got to know him a little better and I will see you in the Boardroom!

With Magnifying regards,

Niels van Duivendijk
Treasurer of the 150th Board of
the Electrotechnische Vereeniging

Maarten Groen
Secretary

Colophon

Editorial

Dear readers,

The willingness to innovate is probably the reason why you are here right now, reading the Maxwell, staying up to date with all the exciting and amazing developments in the electrical engineering world. What would life be if everything were to stay the same even though we know we could do better? Innovation, however, would not exist without information, and information itself would not exist without data.

In this edition we present you different aspects to the collection of data, ranging from the tools required for the collection and display of data, to robots designed for data collection in hard to get to places. In addition to exhibiting this wonderful technical content we would also like to use this special edtion to do our part in spreading awareness of sexual harassment, and harassment in general. As many of you will know, the 20th of January this year, BOOS presented a broadcast about sexually transgressive behaviour behind the scenes at the television program 'The Voice'. This has inspired us to organise and include interviews with both the board of the ETV and the EEMCS Diversity & Inclusion Team (EDIT) to gain some meaningful insights on the magnitude of this problem within our faculty, and the measures that are being put into place to prevent and combat such behaviour.

Special thanks to all contributors without whom we could not have created this special edition. We dearly hope that you stay happy and informed, and we wish you a pleasant reading experience.

Kees Broek

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Sexually transgressive behaviour at TU Delft

Interviews with the ETV Board &
EDIT (EMMCS Diversity & Inclusion Team)

Kees Broek & Arman van Dijk

January 20th 2022. More than 7 million people were watching the television program BOOS about 'The Voice of Holland' presented by Tim Hofman. Victims of sexually transgressive behaviour explained their personal experience with abuse behind the scenes of the famous television show. They accused Jeroen Rietbergen of sexual harassment, Marco Borsato of sexual assault towards children and Ali B of rape.

The show has since both reached and affected the majority of the Dutch population. It has allowed and empowered more and more victims to speak up about their own experience. The wave of awareness has also inspired us to include this very section about transgressive behaviour at the TU Delft. For this, interviews were conducted with Mark Imhof, president of the Electrotechnische Vereeniging (ETV), and Jorge Martinez and Tina Nane of the EEMC Diversity and Inclusion Team (EDIT). The discussion content ranges from personal experiences with sexually transgressive behaviour to the measures that are being taken to prevent and combat both general harrassment and transgressive behaviour.

For those of you that have been affected by sexually transgressive behaviour, or have had any other troubling experience, contact information of counsellors has been provided at the end of the section. Please do not hesitate to contact them; they are more than willing to be there for you.

Figure 1. *Youtube thumbnail of the aforementioned BOOS episode. The video has, as of writing of this article, been viewed almost 11 million times. If you would like to watch the video yourself, you can find it at the BOOS YouTube channel.*

Interview with Mark Imhof, president of the ETV

Are you familiar with the BOOS broadcast about sexually transgressive behaviour?
"Definitely, it was quite a shock, especially because you see those people as your role models, and when you suddenly hear that one of those greats has been making such utterly wrong and disgusting decisions, it is just appalling. Even more so because I, as president, also have to be a role model at times."

So it has been quite the eye opener?
"Most certainly, the stories about Marco had been known to the public for quite a while, but I have met Ali B in person, and I did not know anything about it. As you can imagine, that was quite shocking indeed."

What is your personal experience with transgressive behaviour?
"I can recall from way back in the day, when I was really young, that boys and girls were separated from eachother, and at some point there comes a moment when that gap starts to close. The problem then is that, at that age, you are not really sure about how you should behave towards the opposite gender, and then stuff like that can also happen. This manifests itself mostly in bringing others down mentally, and that is what I have been really noticing, but I have never actually witnessed or experienced anything remotely severe with regards to transgressive behaviour. From my own experience, it is just that a lot of boys do not know or understand how they should behave around girls. Of course, when you are in the club, for example, and there are things being done in your vicinity that are leaning towards sexual assault, that is just absolutely wrong."

What efforts are being made by the board to combat and improve the overall situation surrounding transgressive behaviour?
"After the broadcast we immediately thought that the overall message should be brought to the attention of the members. The last thing that we want is something similar happening within the association, and the broadcast has also made it very clear that there were a lot of people that were not aware that this was happening, even though some of these people were higher-ups. We as the board are also higher-ups, but we often do not have even the slightest clue of what goes down among the members when we are not around. In a certain way that is also a good thing, because I would not like to know everything, but it is important that there are people who you can talk to. That is why our association has appointed two counsellors, who will be there for someone if they need it. They have also been trained by the TU Delft specifically for this function. We have also sent around a message to all cohorts and groups to notify everyone that these counsellors exist and are willing to be there for anyone. Additionally, we emphasized that it is important to pay attention to how those around you are feeling. It is these small things, we feel like, that are really important."

Do you think that the relatively skewed gender distribution within Electrical Engineering plays a significant role in transgressive behaviour within the faculty and study association?
"I feel like most guys within Electrical Engineering are, if you can put it that way, quite nice and sweet, or they might a bit shy or inconspicuous. The latter, perhaps, at times causing them to either be or appear to be rather uncomfortable around women, but not in an intimidating way. There are, of course, quite a lot more men than women within our study programme, and even though 12% is female at the moment, it might still happen quite frequently that those women feel intimidated by the sheer amount of men that they are surrounded by. It is probably also for this reason that they often try to find each other and stay together, and that is why we have created a group with all women that study Electrical Engineering. Together they organise things like dinners and informational events, to learn more about what other women do in the engineering world or to just have fun together. I think that this especially is of major importance, as it is vital for everyone to have them find and form their own circles, even more so for women in engineering. The end goal would

of course be to have no artificial separation with everyone being able to have a good time with each other. It is most definitely something we strive for, but that is also why we have the EDIT (EEMCS Diversity & Inclusion Team). It is important to make it known, and tell each other: it is for everyone, everyone is welcome, and everyone has the capacity to do it."

Have you considered organising an informational event, for example, to make male students more aware of their behaviour towards women? Or do you have other ideas on how to tackle the roots of the problem?

"We have kept similar things in mind, as it is just not feasible to tell women to 'talk more about it'. It might for example be very difficult or embarrassing to share such things with a peer. It is definitely important that boys are also educated properly with the general idea that certain behaviour is just not nice, and that some things are just not done. Treat each other equally, that is the most important thing in our eyes. The only thing is that it can prove to be quite difficult to share this message from our position, because you also would not like to attack those guys. Personally, I do think that you would have to start a lot sooner with preventing such behaviour, like during elementary school or high school. These are the times when you are really developing on a personal level, and in later years you just do not do that as much."

Has the current board itself had to deal with any cases of transgressive behaviour?

"Not yet, fortunately. Of course I cannot be completely sure about it, but I notice that a lot of guys within Electrical Engineering are relatively well-behaved and they are disgusted by such behaviour. That is, of course, quite nice to see."

You mentioned earlier that, in clubs for example, you have noticed some cases that were leaning towards transgressive behaviour.

> *"It is important to make it known, and tell each other: it is for everyone, everyone is welcome, and everyone can do it."*

From your personal experience, you say that most guys within Electrical Engineering are relatively well-behaved, and you have not experienced any cases of transgressive behaviour within the study programme. Do you think that, because you do not see it happening, that it does not happen within our study programme?

"Purely speculative, but I do think so, yes. From my own perspective I can see that the situation is not that bad here. In the /Pub (the faculty pub shared by Electrical Engineering and Computer Science) there always seems to be a great atmosphere, but I indeed do not, and cannot, see everything. I cannot be totally sure for this reason. If there is one thing that I have learned from the episode of BOOS, it is: 'Wow, I think that there is a lot that I do not see or have not seen yet.'. In the end, you should not immediately assume the worst, but think to yourself: 'Okay, it might look all fun and well, but there might still be something wrong'. So do still look carefully, and do not immediately think that everything is just fun and well. At the start of my board year I did not really pay attention to this, but I have actually started to do so more and more, so it is quite a good thing that that episode has been broadcast. I do truly think that it has been a wake-up call for a lot of people."

Is there something that you would like to tell everyone regarding this subject?

"I think that the most important thing is that if something happens, please share it. Keep in mind that there are counsellors who are always willing to help you if you have anything bothering you. Even though you might not have a problem with somebody else, please share it. As a study association, we dearly want everyone to be at home in our association. If you do not feel like that, please approach a person whom you feel safe to talk with, be it a counsellor, a peer or anybody else. For those that are having a great time, do enjoy it, but also pay attention to your fellow students and others in your surroundings."

Interview with dr. ir. Tina Nane and dr. Jorge Martinez from EDIT
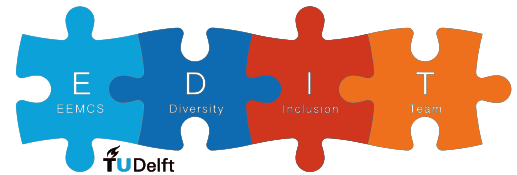
Could you give a short introduction about what EDIT is and what it does?
Tina:
"EDIT stands for the faculty's (EEMCS: Electrical Engineering, Mathematics and Computer Science) Diversity and Inclusion Team. It is a team of colleagues, so academic and support staff, focusing on diversity and inclusion aspects at our faculty. This includes how to improve those aspects in order to create a more inclusive environment. As you might know, it could be that things do not go as expected; it is important to identify and to talk about problems, so we can find out how to mitigate those problems and find solutions."

How many years has EDIT been active up till now?
Tina:
"I think EDIT became active around 2017, so it has been about four years since it has started functioning. It is also worth mentioning that it was the first diversity group in the whole university."

What was the motivation to create this group? Was there perhaps some kind of catalyst, or was there just a general idea for its creation?
Tina:
"There were multiple people, but I remember that there was one specific former colleague. She wanted to draw attention to gender diversity, and that was basically the driver. She, together with other colleagues, approached the dean with the proposition of creating a group. Additionally they got the university to make a change in the policy, so now women can have a longer tenure track period if they have children during the tenure track. That might have definitely been a trigger for starting the group, but we are not only limited to just this aspect of diversity. We do also take diversity in its broader spectrum into account."

What has EDIT's experience and response been regarding the situation that was presented during the BOOS broadcast?
Tina:
"I think that it is horrific what is happening, but it is great to have people talking about it, because not talking about it does not mean that it does not exist. It means that it is simply not talked about, so I think it is great to take this momentum and to start talking even more.
This is definitely not the first time that we have been exposed to such a situation. As an example, in 2019, we, as EDIT, have been exposed to many different situations, especially pertaining to colleagues, such as researchers being exposed to harassment. We also have a survey among employees, which suggested that harassment happens at every level, and all aspects of harassment are

present, whether it is gossiping or sexually transgressive behaviour. Before the broadcast we were already concerned indeed, and we also had some activities. The main thing that we have noticed after the broadcast is that we do now hear from more instances. Not just colleagues or general things that are already known, but students have also been reaching out. I think that this is critical momentum, in the sense that we are now aware of the overall situation, which is great, but now we should also act on it.

Jorge:
In my opinion, the biggest problem with harassment in general, and all other kinds of problems that people could have to deal with in an organisation, is that it can be very difficult to personally draw a line towards what is still acceptable or tolerable, and what is not. Harassment is normally characterised by not just being one incident, but by being something that happens all the time. Little things, different kinds of things that together, at a certain point, make it not bearable anymore. People find it very difficult to, first of all, be very conscious that they are being subjected to harassment, and second, to also actually be able to say it. Once you are like: "Okay, this is not tolerable anymore, so I will make a point of it.", then you will be confronted with what is going to happen afterwards. Additionally, many people are concerned about what that could mean for their careers or their studies, or whether or not it could backfire anyway. It is pretty much taboo right now, and the common consensus is that if you complain, it is only going to backfire on you. This is very difficult, and like Tina mentioned, in recent times, we have seen that much more people, in all kinds of settings, are now willing to speak up about their experiences; they are willing to complain or at least say something. In the last six months I have been in all kinds of roundtables, meeting sessions, interviews, and every single time that harassment, not explicitly sexual, but harassment in general is mentioned, there is always someone that says "Yeah, me too", always. That already, for me, has been a real eye-opener that we are really only just seeing, or uncovering, the tip of the iceberg

Tina:
Also, like Jorge said, it backfires, so people do not react because they are afraid. Especially those who are in vulnerable positions. We are very worried, because what we also notice is that, at times, it is not acted upon. So suppose that I am not in a vulnerable position, but still I see that nothing happens, nothing really changes. Not only do I think that this is the worst possible outcome, but it is the case that when nothing happens, it really just transmits a message to me as the victim saying that it is

> *"Harassment is normally characterised by not just being one incident, but by being something that happens all the time. Little things, different kinds of things that together, at a certain point, make it not bearable anymore."*

useless to talk about it, because, ultimately, nothing will change. So with this the momentum can be changed; we can switch the narrative, and make it so that it is safe for people to say that it is fine to speak up. Hopefully, there will be more thought about what can, and will happen. Regarding the concrete steps that are being taken right now, I think that, so far, there is not really a policy in place yet, so one of the main goals of the diversity board is to really get that policy in place. A policy that pertains to what will happen if something bad happens. It should be a policy that is set in stone, rather than a general effort of trying something and hoping that it will have a net positive effect. We hope that such a policy will empower more people to speak up, and that it will make it really clear what is, and what is not acceptable. How it is treated right now, I think, is that everything is still being put on the victim; the burden of any effect, or any action, is still on the victim and that, I think, is really a terrible thing to happen.

So most of the changes that EDIT has been working on are reactive rather than preventive? Could you explain why there has been more focus on incentivising victims to speak up instead of attempting to prevent cases from happening in the first place? Additionally, regarding this context, what are EDIT's resources?

Tina:
Our resources are rather limited, especially our time, which is limited because of our jobs, but we do have some extra time dedicated to it.

Jorge:
There was or there still is budget assigned to us, and well, it seems like we can use that budget, but it is still very limited.

Tina:
Regarding the first part of the question, the focus has been more on awareness, so not only empowering people to speak up, but also providing a safe environment for people to speak up. Additionally, when talking about awareness, it also includes raising awareness among the culprits that are causing the damage. Trainings are one such example of concrete plans that have been and are being implemented, and at the department of Applied Mathematics there are concrete plans for awareness trainings, as well as meetings with a professional listener.
There also was a Delta article in which a student from Computer Science was saying that she experienced a certain consensus that girls cannot code and that she would

not really contribute to anything significantly, except from making things prettier. The article caused a stir, and more women stepped forward with their experiences of inappropriate behaviour. The aim is to really make it clear, at the beginning of a course or a programme, that certain behaviour is absolutely not okay. More recent actions include training teaching assistants to enforce this idea, not only among themselves, but also among students. It should really be reiterated over, and over, and over again that certain behaviour is unacceptable. It was actually quite shocking to me to realize that stating the obvious — in my opinion — could be so empowering. The victim, or someone who is supposedly a victim, could recall and relate to this message. Even this very tiny example shows how useful it can be to reinforce those ideas in such a way that it becomes normal to speak up. These are small steps, but I think that they are quite helpful in the general picture.

Taking the fact that you have very limited resources into account, what is your vision for the near future? What are some of the goals that you would like to attain?
Jorge:
In the end we would like to make a change, that is for sure. We would like to be able to look back in a couple of years, and say that people are more aware at that moment. We also would like people to be more informed about what their options are when they are dealing with problems. Regarding the future of EDIT, there will probably be an EDIT for as long as there will be problems, but it might undergo a name change in the future. The important thing is that we should keep doing it together, because it is also cultural, and for as long as we can provide a change there will be something to win on the mission that we have.

Tina:
I completely agree. I think that the awareness is the first step, but then actions should also be taken afterwards. The actions can be, as previously mentioned, quite small, but we should definitely keep reinforcing those actions, and keep pushing for improvement. What these years have taught us is that no matter what list we make, no matter what plans we make, there will always be unexpected things that come up. I think that that is great, as it shows that there is more work to do. It is like Jorge said, we do not really work on a daily basis using a clear agenda.

Jorge:
It might be nice to look at what EDIT has done in the past to paint a more concrete picture. Recently we have established quite a decent contact network with many instances that relate to both diversity and inclusion. Not only do we have access to the central

diversity office via Tina, but also the integrity board, Delft Design for Values, Delft Women in Science, study associations, the student council, and Tina is also the diversity officer of mathematics. We are also trying to reach out to instances outside of the university like the Dutch network for specialisation of women in engineering, the beta field and STEM (Science, Technology, Engineering and Mathematics), and the national network of Dutch female professors. We have been talking to those contacts; we talk to the other diversity groups of the faculty and with the confidential advisors, for example. That is already there, even though we are still working on reinforcing that network. Now we would also like to reach the public, to reach both students and colleagues to tell them what they need to do if they want more information. You can always come to us if things are not clear, and we would like to keep spreading the word through events, through interviews like this one, et cetera. After that, other initiatives can come. Sometimes opportunities are presented to you, and you ask yourself if you would you like to do that. If so, then you should go for it.

As far as we know, events that are not mandatory do not have a high attendance rate among students, so are there maybe any plans to implement mandatory awareness lectures for example, or do you have any other ideas on how to approach this situation?
Tina:
Yes, that is indeed the plan, and if we follow the discussion from the Delta article, that indeed seems to be the case for the Computer Science programme at the bachelor level. I am not completely sure about Electrical Engineering, but I think that the idea is to implement introductory lectures during the introduction week. Additionally, I think that it is important that this is not only done for the students, but also for teachers in their teaching qualifications, so to have diversity and inclusion as a key component or mandatory part of the qualifications. We are definitely not there yet, but that is indeed the plan.

Jorge:
The important point here is that the dean is well aware of the situation and is willing to make a change. Education and student affairs are also contributing, and then there also are the initiatives that are already in place, like the one that was started in Computer Science. I am certain that other departments will also follow, and if not, then we, as EDIT, can at least try to push them in the right direction. This could include reaching out to the directors of studies to ask them what is happening and if they have any plans. If they do not have any, then we can always suggest some actions, of which we know that they can always be taken. That is everything with regards to actions and initiatives pertaining to awareness. Then there is also the

> *"When nothing happens, it is really just transmitting a message to the victim that it is useless to talk about it, because, ultimately, nothing will change."*

aspect of qualifications, because like Tina mentioned, we are all people who are involved in education, so staff members, professors, et cetera. They need to be qualified via what is called the UTQ, or the university teaching programme, which is standardised for all the technical universities. The ones in the Netherlands at least. Recently, in November, I also heard that diversity and inclusion is going to be included as part of the training, so there are some things being done that are very important to get us moving in the right direction.

Does EDIT also provide support to victims directly, or are they referred to someone else? What happens, in general, to victims after they have reported something?
Tina:
The one victim of harassment that I was in contact with unfortunately had already left Delft at the time we got in touch. Generally, our policy is not to interfere, and it is not our responsibility to act on the consequences. We definitely support them, and I think that anytime we have had a chance we mention the following: if people are willing to reach out to us, then that is great already. The idea is not to be saying that they have to talk to someone, rather it is to be there when people need you to be there for them. Of course, action should then also be taken, but for that we direct them to other people, such as counsellors.

Jorge:
The one thing that is important is that people should know that they are not prohibited from talking to other people, and in that respect, when people are exercising that right, we at EDIT will always be open for people who need help or have problems. We know the policy and we try to keep ourselves updated on the policies. We know about cases and we know about what has happened in the past, and what the intention is for the system in the future, so we can tell people what the options are. In the end it is not that we are not going to offer support; if someone really needs more help than just advice, a good talk, or a friendly hug, then we will refer them to the to the official channels that are more suited for that. Sometimes we might also refer them to those channels, just for those channels to know that there are things happening.

"We are here to make a change, and the change starts with us; if we do not do it, then no one ever will."

"Change can always come, and in the end it does not matter when; there is no timestamp for change. Do not think that, if some time has passed, you cannot talk about it anymore. You can always talk about it. You can always raise awareness."

We provide advice, but we do not do anything official or anything with legal matters. We are just your colleagues and your friends.

Do you, perhaps, have some words of wisdom for the readers?
Tina:
I would say that it is never too late to speak up. The takeaway message from all of this is that change can always come, and in the end it does not matter when; there is no timestamp for change. Do not think that, if some time has passed, you cannot talk about it anymore. You can always talk about it. You can always raise awareness. The more you talk about it, the more awareness is raised, and the better the situation becomes. A path to success, or a potential solution might appear.

Jorge:
I totally agree with that. I think we are here to make a change, and the change starts with us; if we do not do it, then no one ever will. It is especially important for the next generations to come. Now is the time to be pioneering the change. It is logical that we are in uncharted territory, but we should not be afraid of that. We owe it to the next generations.
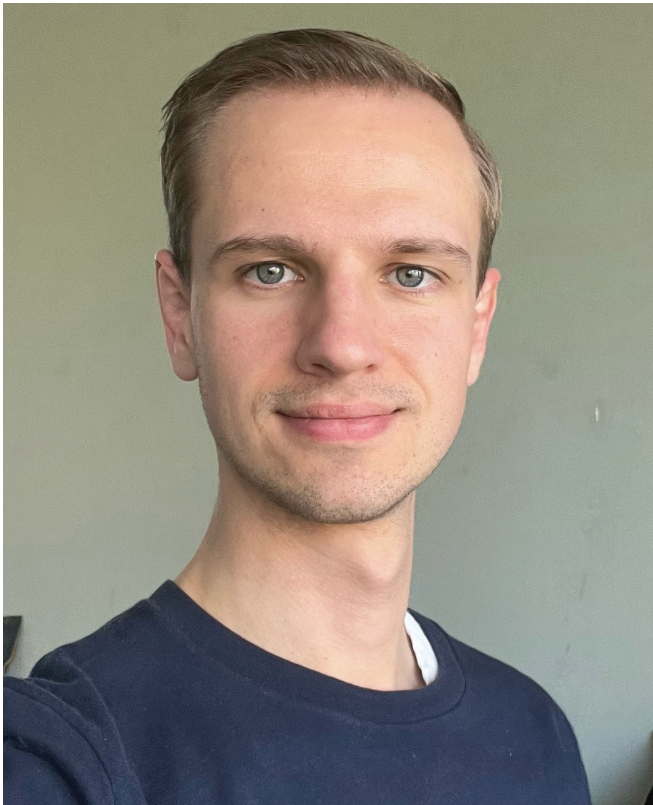
Tina:
And we also are role models of some sorts. The question is what kind of role models we would like to be. We should be proactive.

Contact Information

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edit-EEMCS@tudelft.nl

Anonymous suggestion padlet
https://padlet.com/fgrazian/zgdtm0ag2tq6ejyy

The Tektronix 7250 Transient

Pushing analogue oscilloscope techniques to their limits

Recently, an interesting and rather heavy (60 kg!) oscilloscope-like instrument (Figure 1) was donated to the Historic Collection of the Faculty of EEMCS by the Reactor Institute Delft. Though the instrument looks like an "overweighted" digital oscilloscope, it appeared to be an instrument hiding a remarkably interesting component, namely a scan-converter tube. In this contribution we will discuss this device in more detail, in particular in relation to the physical limitations faced by traditional oscilloscopes.

Conventional CRT oscilloscope high frequency limitations

The basic analogue oscilloscope consists of a Cathode Ray Tube (CRT), a linear time base (sweep) generator and a signal amplifier (Figure 2). The electron gun (cathode) of the CRT emits electrons. These electrons are accelerated and focused on a phosphoric screen, thereby producing a small visible spot. The time base, or sweep generator, is connected to the horizontal deflection plates causing the electron beam to move linearly with time from left to right. In contrast, the signal under study, after being properly amplified, is fed to the vertical deflection plates. The trigger system takes care of the synchrony between the waveform under study and the start of the sweeps. In this way the waveform of the signal is displayed on the screen.

Figure 1. *The Tektronix 7250 Transient Digitizing Oscilloscope*

The central part of an oscilloscope is the CRT deflection system, of which the bandwidth is limited. At very high frequencies (> 100 MHz) the electric field between the deflection plates changes while the electrons are still passing through that field. The net deflection of the electrons is therefore reduced, and this reduction increases as the frequency of the voltage applied to the deflection plates increases. This effect could be reduced by increasing the speed of the electrons, which would decrease the time during which the electrons are influenced by the deflection plates.

Increasing the speed of the electrons can be accomplished by increasing the voltage of the accelerating electrode. Doing this introduces some new problems, however, such as higher demands on the insulation both outside and inside the tube. Furthermore, when the speed of the electrons is increased, the time that they are under the influence of the deflecting electric field is reduced, which leads to reduced vertical deflection sensitivity and, in turn, to higher demands on the vertical amplifier. In this article we will discuss two interesting developments that led to significant improvements.
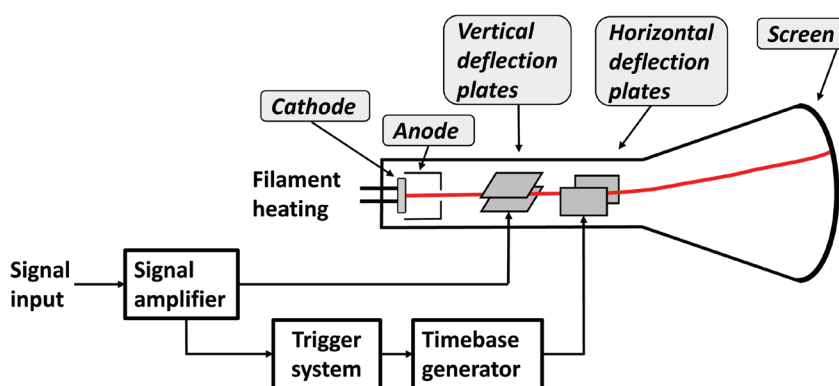

Figure 2. *The Tektronix 7250 Transient Digitizing Oscilloscope*

Digitizing Oscilloscope

Otto Rompelman

Distributed deflection

As has been mentioned above, changes in the electric field of the deflection plates during the passage of electrons leads to a reduction of the bandwidth. This problem was significantly reduced by the development of the so-called distributed deflection assembly [1][2], as illustrated in Figure 3. The basic idea is to split up the deflection plates into a number of smaller segments. Within the tube these segments are interconnected through delaying circuits. The delay per segment is such that it matches with the travelling time of the electrons passing through that segment. The net result is that, during passage, the electrons are subject to the same phase of the deflection voltage. The introduced delay line has to be terminated properly (i.e., by Z in Figure 3) as to avoid unwanted reflections.

This leads to a low impedance as seen by the deflection amplifier, which was problematic with vacuum tube amplifiers. Distributed amplifiers were used to solve this problem, however at some expense (namely some vacuum tubes). Distributed deflection plates were amongst others introduced in the Tektronix 580-series oscilloscopes [4] in the late 1950's with 100 MHz bandwidth and the Tektronix model 454 [5] in 1967 with 150 MHz bandwidth.
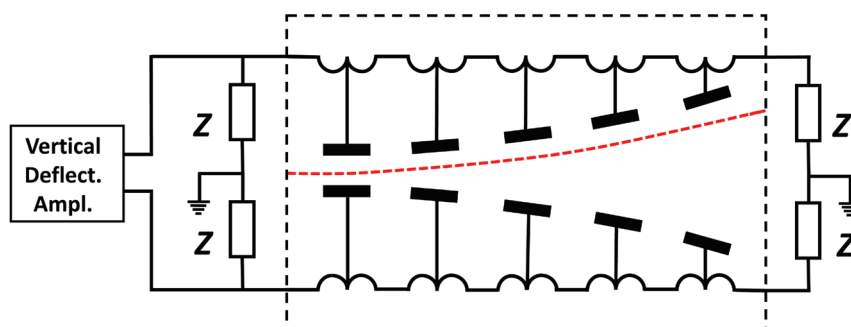

Figure 3. *Distributed deflection assembly; the configuration is 'seen' as a transmission line by the vertical amplifier [2]*

Microchannel plate technology

When increasing the bandwidth of an oscilloscope a new problem arises. High frequency demands lead to high sweep rates and, consequently, to reduced exposure times of the phosphoric screen. The net result is a low light output. To overcome this problem, Tektronix introduced the microchannel plate technology [2][3] in the late seventies of the past century. A microplate acts as an electron multiplier based on secondary emission and is positioned a few millimeters before the phosphoric screen (Figure 4). The microchannel plate consists of a large number of parallel channels at a slight angle with respect to the electron beam. The channel walls are semiconducting, which allows charge replenishment from an external voltage source. Each channel can therefore be considered to be a continuous dynode structure which acts as its own dynode resistor chain. An acceleration voltage of about 1000 V is applied across both sides of the plate. Electrons entering a channel will hit the channel walls and release a cascade of secondary electrons: this process is repeated a number of times, resulting in an enhanced number of accelerated electrons leaving the plate. Finally, an acceleration voltage V_a (10-50 kV) propels the electrons to the phosphor coated screen. The diameter δ of the channels is 25 μm and therefore, the resulting diameter of the micro channel place is about 5 cm.

This technology, in combination with further developments in distributed deflection technology (both horizontal and vertical) and special electron optics, has allowed the bandwidth of the CRT to be increased to about 1 GHz. The CRT at issue was the Tektronix T7100 [6], which was used in the Tektronix 7104 1 GHz oscilloscope, introduced in 1978 [7].
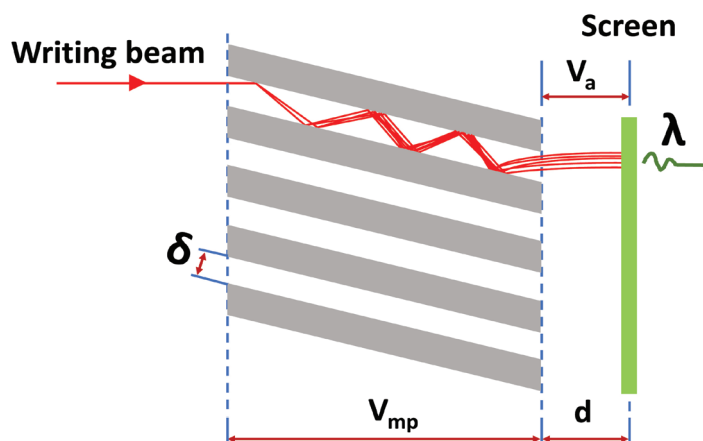

Figure 4. *The microchannel plate: the electron beam is enhanced by repetitive secondary emissions before hitting the phosphoric screen (d ≈ 3 mm)*

Transient recording by means of scan converter technology.

An ordinary oscilloscope is intended to show repetitive waveforms that, when displayed on the screen, are 'fused' by our eyes to a stable image. However, if we are faced with a low duty cycle and single event phenomena, we would need some way of storing the image. This need can be fulfilled by a storage oscilloscope or a transient recorder. When dealing with very rapid phenomena, we have to combine the technologies, as described earlier, with some storage function. In the Tektronix 7250 transient digitizer a so-called scan-converted is used for recording very fast phenomena. The scan-converter at issue is in fact a combination of two vacuum tubes, namely an extremely fast writing tube (including distributed deflection and a microchannel plate) and a reading tube similar to a Vidicon as was used in video cameras [8]. Its principle is illustrated in Figure 5. First the signal under study is applied directly to the vertical plates of the CRT-part (not shown in the figure). To achieve maximum bandwidth, no vertical amplifier is used, resulting in a vertical sensitivity of 5 V full scale.

It should be noted that the introduction of the microplate in fact implies a digitizing process. The number of microplate channels leads to a resolution of 2048 points vertically (11 bits) and 512 points horizontally (9 bits).
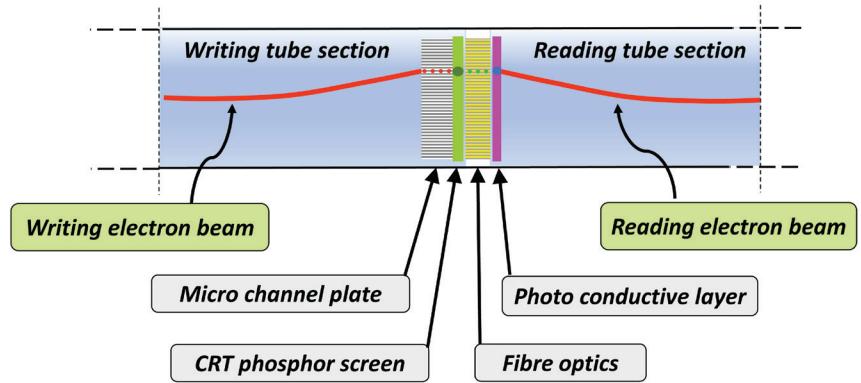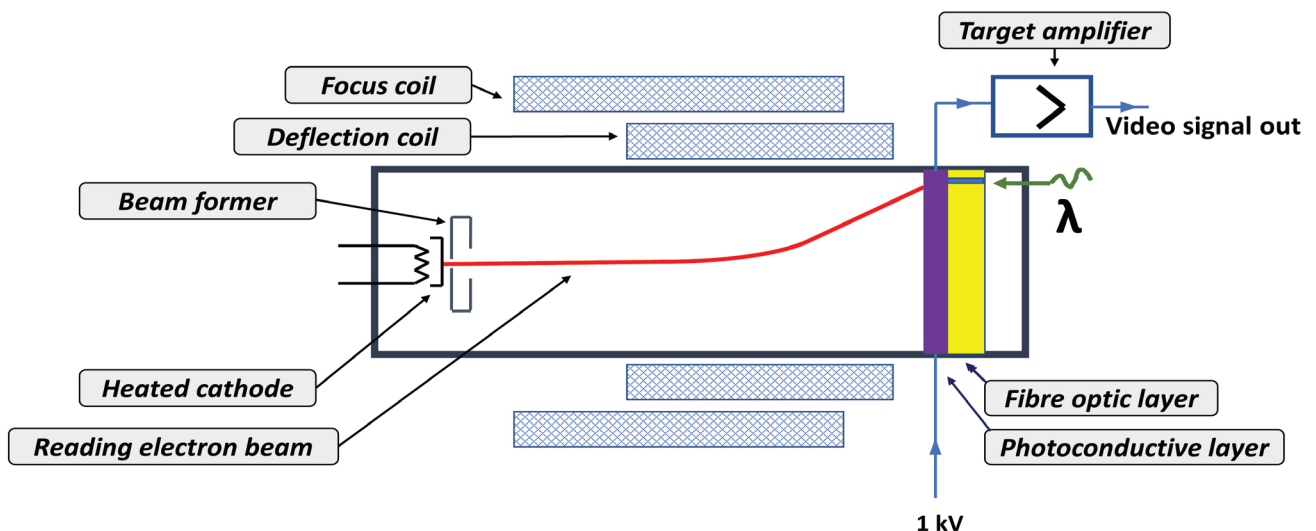

Figure 5. *Basic configuration of the scan-converter tube (deflection system not shown)*

The phosphoric screen, when hit by fast electrons, emits photons which are consequently transported through a fibre optic disc to the photoconductive screen of the reading tube (camera) section of the scan-converter (Figure 6).

In the camera section the photons emitted by the CRT-section hit the photoconductive layer, which releases electrons and leaves a positive charge at that point. The net result is a positive charge image corresponding to the image on the CRT-screen. This image can now be scanned by a reading electron beam. This scanning beam is focused and deflected with magnetic coils, similar to the usual scanning procedure in TV-systems. The photoconductive layer is connected to a high voltage source. Once the scanning electrons hit a charged area of the layer, an electrical signal is generated in the circuit of the conductive layer. After amplification, the signal is converted into a standard pulse which is fed into one location in a digital memory, the location being determined by the deflection information of the reading electron beam (Figure 7).

The memory is made up of CMOS static RAM. These chips were introduced in the mid '70s of the past century. The data can be stored for up to two years using a built-in battery backup. The memory size for one scan corresponds to the physical resolution of the system as discussed before, namely horizontal (time axis) 9 bits and vertical (signal amplitude) 11 bits. The actual memory size is a multiple of this value, enabling the storage of multiple waveforms.

Figure 6. *The camera section of the scan-converter tube; (this section is mirrored when compared to the overall view of figure 5)*
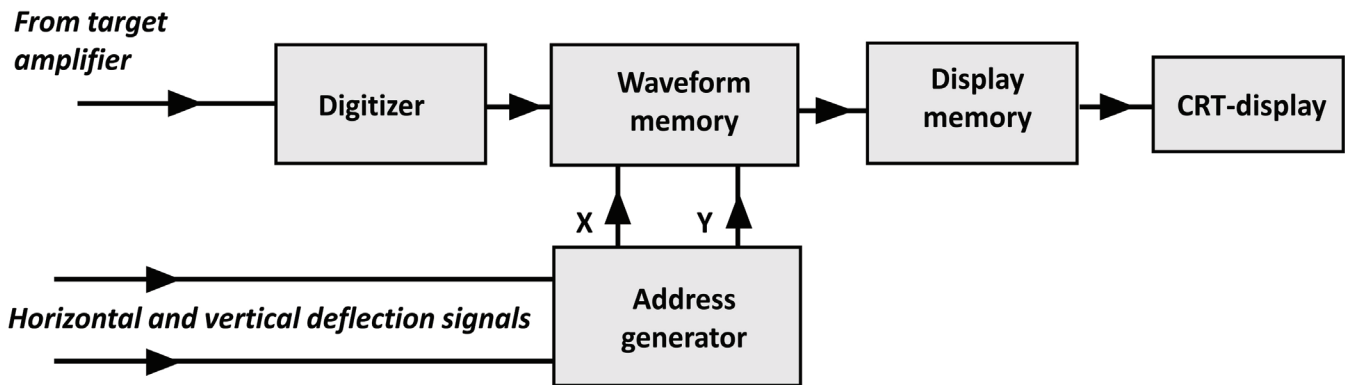
Figure 7. *Data storage and display*

Concluding remarks

The application of the scan converter technology in the Tektronix 7250 has led to an instrument with a bandwidth of 6 GHz enabling the recording of 50 ps rise-time phenomena. The absence of vertical amplifiers leads to a sensitivity of 5 V full scale. Because of the absence of a vertical amplifier and due to the delay line character of the vertical deflection system, the input impedance is 50 Ω. The input connectors are located at the rear side of the instrument. Sweep rates range from 1 μs to 50 ps per division. The instrument is suited for analysing both single shot and repetitive signals. An external trigger signal is required. The sweep delay (delay between trigger signal and actual start of the time base generator) is widely programmable.
Obviously, the use of a digital

memory enables detailed data analysis options such as cursor-controlled measurement of signal values. Also, automatic rise time (10% - 90 %), peak-to-peak time and delay times can be assessed. All results are shown numerically displayed on the screen. The stored waveform has a much higher resolution that can then be displayed on the screen. This allows zooming in on details of the stored waveform. Finally, the memory contents may be read out on a plotter or can be transferred to other equipment with the at that time usual GPIB-protocol. Further details can be found in the instrument leaflet [9] and the VintageTek website [10].

Interestingly, the 7250 was originally developed by the French company Intertechnique (Division Systèmes

Militaires et Transmissions) and introduced around 1985 as the IN7000 Oscilloscope Numérique. In the Tektronix 7250 service manual it is mentioned, that occasionally within the instrument texts are in French [11]. Furthermore, various parts (e.g., printed circuit boards) are provided with French inscriptions. The instrument was rebranded by Tektronix for sale in the USA.

Now that sampling devices with over 1 G-samples/sec have become available (see e.g. [12]), instruments like this have become obsolete.

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An interesting original 'promotion video' on the 7250 can be found at:
https://www.youtube.com/watch?v=fS6WOx5X8zM
or by scanning the QR-code.

Displaying decimal numbers

Kees Pronk

With the advent of digital measuring equipment around 1960, the need arose to display decimal numbers on the front panel of instruments. In those years, providing a numeric readout was really a problem requiring much inventiveness from engineers. This article discusses several solutions to the display problem as they have been developed from the very beginning of the technology. The examples given are all available in the Historic Collection of EEMCS in Delft.

Figure 1. *Hycon VTVM 615*

Digital measurement equipment

The first example given here is not a digital meter at all. This Hycon Model 615 VTVM (Vacuum Tube VoltMeter, Figure 1) is an analogue voltmeter equipped with a mechanical counter driven by a servo system. This development shows the need for easy to read digital readouts instead of difficult to read needle pointers on an analogue scale.

Digital counters and digital voltmeters

The first digital voltmeter (DVM) was designed by Andrew Kay in 1954 [1]. The oldest digital frequency counter we have in the Historic Collection is a Hewlett-Packard HP-524A (Figure 2). This 8-digit counter measured frequencies up to 10 MHz; it was introduced in 1952. This impressive machine (55 x 71 x 36 cm) was used for two main purposes: measuring the transmitted frequencies of radio stations, and research in nuclear technology. Regarding the latter, please remember that these were the years during which nuclear energy and atomic bombs were developed.
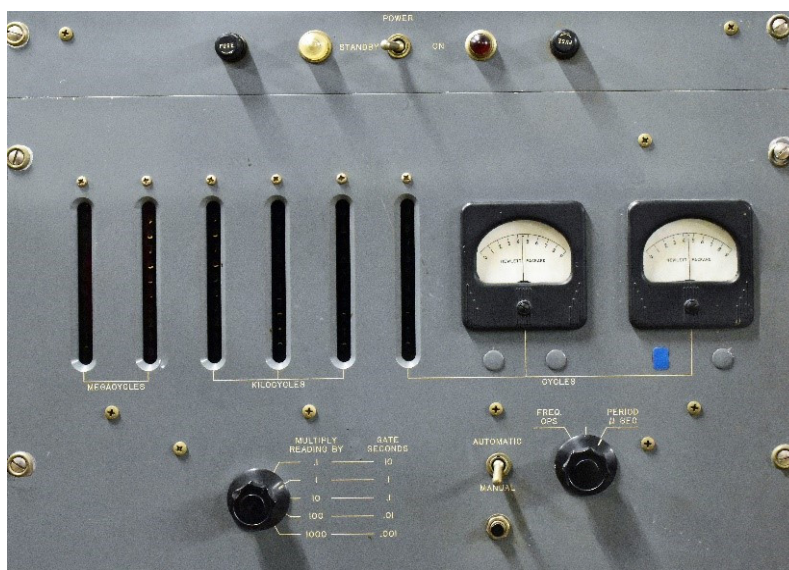
Figure 2. *HP 524A Electronic counter (detail)*

The digital/counting part of these DVMs and frequency counters always includes a series of decade-counters. Each decade-counter consists of four flip-flops. Figure 5 gives the block diagram of such a frequency counter. Basically, such a counter counts pulses. By providing a time base of one second, the counter will display the frequency of the input signal in Hertz.

Construction of a decade counter unit

In those days decade counters were constructed using four vacuum double triodes (e.g., 5693, ECC82, etc.). These triodes were specially developed for on-off control applications involving long periods of operation under cut-off conditions.
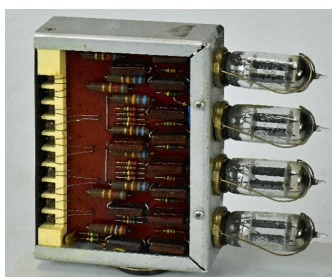

Figure 3. *Decade counter built using four double triodes*

Figure 4. *Front view of that decade counter showing the digits*

A decade counter produces a 4-bit BCD (Binary-Coded Decimal) value. This code has to be converted into signals, suited for the decimal display device. This includes both the signal itself and its voltage level. This latter is relevant, because of the high voltage used in vacuum tube technology and the voltage needed by the display device.

Figures 3 and 4 show a decade counter type HP-AC-4A from Hewlett-Packard with four double triodes. Instead of the usual 1-2-4-8 coding, this counter uses a 1-2-2-4 coding to ease the design of the decoder. The display uses 10 small neon bulbs of type NE-2, one of them being lit. The anode voltage of the triodes is either 70 Volt (logic 0) or about 200 Volt (logic 1). The neon bulbs are so-called cold cathode tubes having a low pressurized gas inside and using an unheated cathode. Electrons are emitted from the cathode and ignite the gas. These tubes require approximately 70 Volt on the anode to ignite. After ignition the voltage over the neon tube drops to about 30 Volt. The current through the neon bulb must be limited by a series resistor, sometimes external to, sometimes built into the bulb.
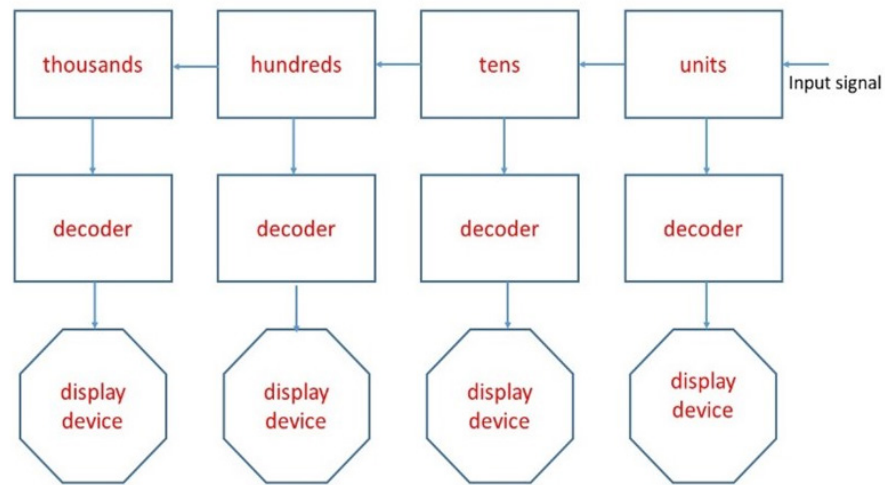

Figure 5. *Block diagram of a frequency counter*

Units like these have been built around 1956 by Hewlett Packard to include in their HP 524A electronic counter (Figure 2) and have also been sold separately [2]. More information regarding this counter can be found in volume 4 of the HP-Journal [3].

The Van Der Heem electronic counter
Regarding display technology an interesting device was produced by the Dutch firm Van der Heem. The electronic counter type 9908 in figure 6 dates back to approximately 1960.

This counter has a freqency range of 10 Hz up to 1 MHz. This counter was already transistorized, but, as the designers had no low voltage display devices available, they used six analog moving coil meters to display the results of the measurements. The decoder they designed was a kind of digital to analog converter. More details of this frequency counter are available in the *Tijdschrift van het Nederlands Radio Genootschap* [4].

Figure 6. *Transistorized counter by Van Der Heem using analogue meters for display*

The Philips E1T electronic counter and display
Around 1953 Philips designed a very ingenious vacuum tube to enable both counting and display of one digit. By electrostatic deflection a small electron beam is projected onto specific locations on one of two horizontal lines of fluorescent material. The number counted is made visible on the outside of the tube. The input to the tube is a negative pulse signal; the tube also provides a carry output to trigger the next decade.

This tube was suitable for applications requiring small dimensions, high counting rates (100 kHz, which was high at the time) and reliability of operations. These tubes have been used extensively in the control console of the former nuclear reactor in Delft (Figure 7). This console is now in our Historic Collection in Delft. Nice demonstrations of this special tube are available on the internet [5] [6]. The design of this very interesting tube as shown in Figure 8 has been described in a Philips Technical Review [7].

Figure 7. *E1T based counter from the console of the former nuclear reactor*

Figure 8. E1T-tube from our collection

The Philps Indicator Tube ZM 550
When counter circuits became transistorized, the low voltage design of the counter did not match with standard neon indicators. Around 1958 Philips therefore developed the ZM 550, (a.k.a. ZM 1050) an integrated counter and indicator tube. In essence, this tube comprises ten neon bulbs in one glass envelope but now running on low voltage. This display device could be developed thanks to the knowledge Philips had on tubes and special gasses. The device has been used in the Philips Scaler PM 4231, a high frequency counter (Figures 9 and 10). A neon glow appears behind the activated digit. This device, sometimes called a Dekatron, is not always easily readable.

A wonderful overview of the research leading to the development of this tube has been given by Ronald Dekker [8]. In particular, the lab reports from Philips Natlab are worth reading (these have been written in Dutch, however).

The Nixie tube
Nixie-tubes have been developed around 1955 by a small firm, later bought by Burroughs. The name "Nixie" was supposedly derived from "NIX I", an abbreviation of "Numeric Indicator eXperimental No. 1". Nixie tubes are cold cathode tubes filled with gas; much like the neon bulbs described before. There is one wire mesh anode and there are ten (sometimes more) wire mesh cathodes being shaped as digits [9]. Jelle Boelen, our student member of the Historic Collection, developed a digital clock using old Russian Nixie tubes as shown in Figure 11. The internal design of this clock uses modern digital integrated circuits for the counting and driving the Nixies. It can be easily seen that the designers mounted an upside-down digit of '2' to be used as a '5'.

Figure 9. *Philips Scaler 4231 using this special ZM 550 tube*

Figure 10. *One decade of this counter*

Seven segment indicators
Seven segment indicators started appearing already around 1900 [10]. They were first built using filament lamps, but became popular when LED (Light Emitting Diodes) came to the market; later followed by Liquid Crystal Display (LCD) indicators. Figure 12 shows a part of the Casio FR 310 printing calculator. In order to reduce the wiring count between the calulation part of the calculator and the display, the various segments as given in Figure 13 are usually not fully "on", but are subject to a scanning regime. A particular pass-time in schools was to invent number sequences that showed up as characters when viewed upside down (try 07734 in seven segment form).

A variant of the seven segment indicator was the Hewlett Packard digital numeric indicator using a 4 by 7 dot matrix of leds called the: HP 5082-7300 series (Figure 14). These small (10 x 14 mm) displays were DTL/TTL compatible. This device was somewhat more readable than the seven segment indicator and - depending upon the type - allowed the display of hexadecimal numbers. It could be mounted in a standard DIP-socket. It is worth mentioning, as it was used in the authors' thesis work back in 1976 [11].

Figure 11. *Electronic clock, which uses Nixie-tubes, displaying '19:00:50'*

A modern digital clock
Ronnald Lokker from the Historic Collection was so kind to show us a much more modern kind of digital clock. This clock uses LED´s with programmable colors to create digital numbers on ten layers of polycarbonate. The clock is driven by a programmable microprocessor and is able to display not only time but a multitude of formats (Figure 15).

Two invitations
This brief overview does not to do justice to all developments and developers of the decimal display technologies. The interested reader is welcome to consult the references below and to visit the Historic Collection to have a look at these and many more intruments. The exposition is opened each Monday from 10 AM in the cellar of the low-rise building of EWI.

Figure 12. *Casio FR 310 Printing Calculator using seven-segment indicators*

Schematics for driving these display devices are available from the internet. The Historic Collection would love to have a demonstration setup where these devices can be shown in working condition. In the past, the volunteers of the Historic Collection enjoyed the cooperation of two students. As these students have now finalized their studies, they will soon leave Delft. New student members are very welcome.

The author whishes to thank Kees Wissenburgh, Ronald Lokker, Piet Trimp, Otto Rompelman and Jelle Boele for their help in preparing this paper.
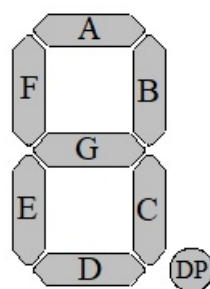
Figure 13. *Standardized ordering of the seven segments and the decimal point*

Figure 14. *HP 5082-7340 4 by 7 led dot hexadecimal indicator (not to scale)*

Figure 15. *Modern numeric display device using LEDs*

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An interdisciplinary robotics community

Mateusz Mazurkiewicz

Figure 1. *Borrel in the RoboHouse attic*

An animated discussion about Reinforcement Learning is taking place, master and bachelor students across all TU Delft faculties surrounding a robot on the table. They talk over the laughter and ping-pong tournament in the background. Every other week the RoboHouse attic is full of life and boasts an impressive amount of robotics expertise per meter squared of surface, as roboticists of Delft gather for the borrel of the Robotics Student Association.

The RSA is a relatively new association, currently going through its third year. Nevertheless, the students have managed to do quite a lot towards the association's goal of supporting the robotics community in Delft and providing opportunities to TU Delft students interested in robotics. RSA is a space for both robotics newbies, who can receive guidance or mentorship from other members, engineering students wanting to apply their skills, who can join any of the association's or affiliated projects, and experienced roboticists and PhDs, who connect with the highly motivated students eager to contribute to their work and learn while doing so.

The Robotics Association, an organization largely formed throughout the pandemic, needed to explore different forms of activities as the restrictions came and left. How to facilitate engineering collaboration when in-person events are sometimes impossible, and half the student body is scattered across the world, following their study remotely? What activities can future-proof the community, connect the roboticists of Delft and encourage them to start projects together, and how to engage busy students to develop their skills and build networks, while not disturbing their studies?

Supporting robotics in Delft
The basic activity to which one can always default is a lunch lecture, possible to be held over an online video meeting. But one shouldn't underestimate its utility. They do quite a good job of broadening participant's horizons and provide a great overview of robotics work and research done in Delft. It's remarkable how easy it is to be oblivious to a Dream Team or a local company that works on topics exactly in someone's interest. A step further than the lunch lecture is a presentation at the beginning of the

borrel: the usual slides or the robot demonstration is followed by a party in the RoboHouse attic, and members discuss the presentation over drinks, approaching the companies or researchers with questions. Often they join the presented projects afterwards.

The Robotics Association also boasts a collection of its own and affiliated projects. In particular, an important theme is reusability and a positive feedback loop of the projects augmenting the association capabilities. An example would be a Package Allocation Lifter project (formerly Package Delivery Robot Project), whose members work on an autonomous vehicle navigating around the building, delivering packages to organizations based in the RoboHouse, including the RSA. Another project fitting that category would be a robot arm, designed and constructed as a platform for further use in RSA projects, in particular Reinforcement Learning projects for robot arm manipulation. First and foremost though, the RSA members are developing skills which they later use in further projects, share in RSA masterclasses or mentorship program, and give back in situations

Figure 2. *Project MARCH lunch lecture*

as trivial as discussions during an attic party.

A lot of opportunities and expertise within the association comes from the affiliated projects. Krill is a robotics team developing autonomous swarm solutions to measure and improve water quality, and the Lobster team develops a scalable underwater robot system to make the famously difficult environment of deep sea accessible. Even more than the actual affiliation, what contributes the most to the association is the fact that many of the affiliated project highly-skilled members are simultaneously members of the RSA, participating in its regular activities. RSA members who want to join the affiliated projects already know some of their team members, and are better aware of the projects' work, atmosphere, ambitions and opportunities for contributing to them.

Importance of the interdisciplinary community

During the last three years the association brought some first-hand insights into organizing engineering collaboration. The social events in an open, interdisciplinary community provide a forum for information exchange regarding developments in robotics, particularly in the local Delft projects, and an opportunity to make friends with students specializing in very different disciplines. The latter is very important for robotics: a robot has to have functional mechanics, electronics, software and design, and a robot designed by students of any given faculty will usually fare worse than a robot designed by an interdisciplinary team. A robotic swarm developed by brilliant computer scientists that developed a genius distributed algorithm for task distribution and path planning

might easily improve if an electrical engineer takes a look at the motors used, and with a seemingly minor replacement causes the performance to skyrocket.

It is important to be able to ask for help when struggling with some aspect of the robotic system. Every student has an immediate group of friends in their faculty. Friends in that group know someone in another faculty, who knows someone who has the exact knowledge required to solve the problem. An interdisciplinary community acts like a short circuit in that graph structure. Immediate links in the robotics association are already scattered across faculties, projects and groups, with a remarkable coverage. This ensures that seeked knowledge is just a text message or one mention away.

The diversity of backgrounds proves advantageous in not only technical challenges, but also personal ones. This is true in particular for undergraduate students talking with masters students, who already might have work experience, have dealt with technical interviews and can share some tips, and perhaps figured out some problems in work-life balance or lifestyle. Some fields of engineering are interconnected in most unexpected ways, and it is useful both in strictly technical problems, as well as in career choices or at other cross-roads we face, to have guidance in navigating the wide web of engineering knowledge.

Figure 3. *'Unstoppable Tank' hackathon*

Learning by doing

Systems engineering for the deep sea

Arthur Admiraal

Figure 1. *Design Evolution*

As with any modern tech start-up, data is very important to ocean exploration technology company Lobster Robotics. Every bit of collected data can provide new insights about the underwater world and thus directly improves the end product for the customer. However, there is a kind of data that is even more important: the lessons learnt form past systems engineering tests.

An old joke states that you can recognise a programmer by a deep-rooted fear of time zones. Though it is difficult to find a direct analogy in electrical engineering, there is no denying that an engineer is only as good as their level of experience. However, it can be easy to forget that experience is usually earned through making mistakes.

Lobster started out as a group of TU Delft students with a background in electrical, mechanical, and software
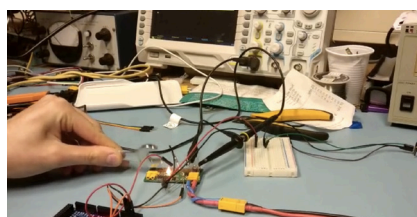
**Figure 2.** *Board blowing up*

engineering. However, no one had any experience in building underwater robots. As such, it took going down quite a few dead ends to get that experience.

But not all dead ends are created equal. Nobody likes their board to blow up in testing, but a solution can usually be found in a matter of weeks. There is a type of mistake that is far more painful though: mistakes in systems engineering. When you take a wrong turn at the system level, no amount of work in the detailed engineering can truly fix it.

Here are two examples of the hard-earned lessons in systems engineering from the history of Lobster, so that you can hopefully avoid them.

The protoype without a power switch

Lobster's initial engineering process resulted in an idea for a system architecture. To test some of the ideas and control methods behind it, a simple prototype was built. It was called the PTV for Propulsion Test Vessel and it had 6 thrusters, an on-board computer, some batteries, and even some battery protection. It worked quite well, moving through the water nicely in pool tests.
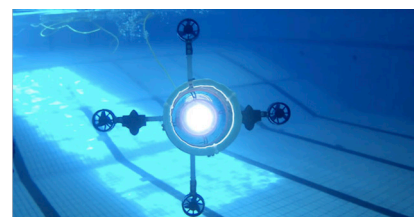
Figure 3. *Everything but a power button*

There was one thing it did not have, however: a power button. Why is that?
It is because of a common system engineering mistake: converging too quickly. It was not that the process of using the robot had never been considered, but never in a more detailed way than the rather vague 'pre- dive initialisation'. One of the goals of the design was to make repair and upgrades straightforward, so the insides could be pulled out and the batteries disconnected. This meant there was a way to power the robot up and down, but having to assemble a robot at every test location is not very convenient.

Had the functional flow of working with the robot been more closely considered up front, the problem would have been designed and a power button could have been added at design time.
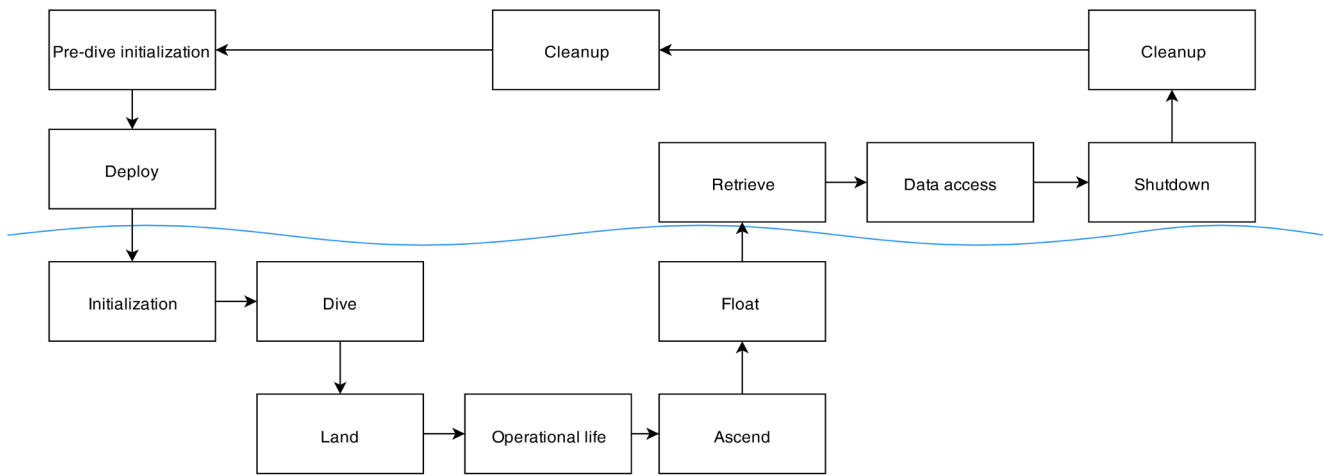
Figure 4. *An early functional flow chart shows only vague 'pre-dive initialisation'*

Forgetting a power button may sound really silly, but it is far more difficult to spot while in the middle of a project. It probably will not be a power button for you, but without properly thinking through how your system is going to be used, making these types of silly mistakes is a near certainty. That is why it is essential to test your approach so you can identify blind spots in your thinking.

Since learning that more detailed was needed, dedicated user stories are used to identify each and every accessory and subsystem the user interacts with. Since then, these types of problems have all but vanished.

Spaghetti at the system level
But a power button was one of the smaller learnings. A far bigger lesson was that the chosen system architecture was the systems engineering equivalent of painting yourself into

the corner. Though this did not result in any problems with the PTV, when the time came to build a deep-sea capable robot in the form of the Lobster Explorer, it would prove to be much more impactful.

Flexibility was a key goal of the design, so in the front of the robot was a removable sled in which computing upgrades, network infrastructure or even co-processing for advanced sensors could be placed. It was easy to work with, having cartridge-like slots for placing the computing systems. It connected to the rest of the robot using 200 spring-loaded pins and neatly organised cables via a collection of connectors mounted to a tightly weight-optimised flange.

The thing is, upgrading the capabilities of an underwater robot nearly always requires changes on the outside. Increasing the speed of the

robot requires adding thrusters in the seawater. But measuring anything requires sensors, which should also be placed in the seawater. Hence, all of the modularity on the inside was not contributing to flexibility. What was worse, if anything did need to change on the outside, 200 spring-loaded pins had to be redesigned, along with many cables having to be rearranged, and an additional connector having to be squeezed into what must have been one of the most complicated parts in the robot.

Though having a design that is difficult to change is not inherently a problem, here there was simply too little room for the amount of uncertainty that was still in the project. When the time came to make a change, the only way to fix the problem was to retrace the steps leading up to the design and use the gained
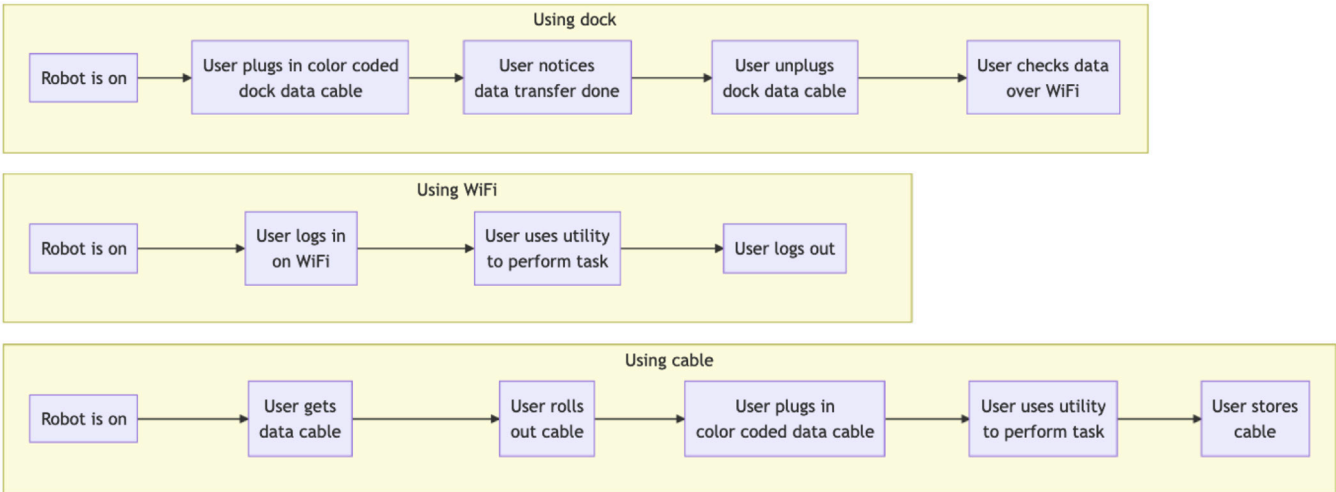

Figure 5. *The newly adopted use of detailed stories for every aspect of operating the robot after developing the PTV*

experience to find a better solution. The next and current robot would see a different approach. Instead of being modular only on the inside, the Lobster Scout has fully modular hull segments. That means that it can be upgraded within 5 minutes by slotting in a new module, or replacing an existing one. Better yet, the modules can be developed independently of each other, so that development can be parallelised. So far, it seems that this was the missing puzzle piece needed to find a good path ahead.

Conclusion

Late last year, Lobster was asked to measure the magnetic fields of sub-sea power cables in offshore wind farms. Thanks to what was learnt from what was tried in the past, the robot was successfully deployed at the IJsselmeer just a couple months later and brought back beautiful data to a very excited customer.

Systems engineering is often seen as boring paperwork that is of little added value, but nothing could be further from the truth. If you do not pay close attention to your design on a system level, implementing your design can feel like a constant uphill battle. What's more, ignoring systems engineering may lead to all of your detailed design effort being wasted in hindsight. Hence, testing the system level design before going to a more detailed implementation is indispensable.

On the flipside, though putting in the effort to do systems engineering takes time in the short term, it can save a lot of effort in the long term with designs coming together like a satisfying jigsaw puzzle. But more important is that once you start viewing your designs through its lens you get to learn from your mistakes. After all, there is one thing that is better than learning from mistakes, and it is having learnt enough not to make them.

Figure 6. *Building a robot capable of operating in the IJsselmeer would never have been possible without making some mistakes along the way*

A swarm of autonomous robots

Measure, Model and Improve water quality..

Calvin Terpstra

Figure 1. *Project Krill*

Krill is a startup that provides the next generation of water quality measurements and improvements. We do this by combining big data and a swarm robotics framework. Krill will detect and tackle water quality issues at the source using a broad and adaptable toolkit of measurement and improvement methods. This is important for the Netherlands which is a densely populated river delta, where water plays a fundamental role in the health of the country. The health of this water is affected by pollution, as the world is engulfed in a climate crisis.

WWF states: "Water is essential to life. It need not be spelt out exactly how important it is. Yet water pollution is one of the most serious ecological threats we face today". All beings on earth are directly or indirectly affected by water pollution. Our team is united through the shared ambition to find a sustainable and technological solution to combat water pollution. One aspect of this is helping meet the standards of

the water framework directive, an initiative that has been put in place to try to regulate water quality. We are strategically partnered with SAS Advanced Analytics and Deltares, to work together to provide cutting-edge technology to improve water quality. In order to tackle the whole problem of water quality, we will deploy a circular operation consisting of three stages. Measuring the water parameters, modeling the results and improving water quality.

Water quality analysis today is highly manual and is built from low-density data. Many issues relating to water quality are complex, resulting in solutions requiring targeted, large-scale and expensive operations. Often, problems are more costly to solve than to ignore.

Krill is a collection of modular robots that can collectively monitor water quality and collect debris in surface water bodies. It is our aim to simplify the individual robots as much as possible while increasing the overall complexity and performance. The robots can work together to measure various water quality parameters, share data to develop innovative models, and collect debris. Using our swarm robotics framework, Krill can revolutionize the field of water quality due to the framework's unique combination of advantages. A swarm is modular, which means that components can be separated, specialized and easily replaced, allowing for high adaptability. A swarm is reliable since it can be highly redundant.

Figure 2. *Krill robots*

As a consequence, the points of failure are isolated, the system remains functional and even adapts to the failure. Swarming also allows for parallelization of tasks, since many robots work together. Another advantage of the swam format is that it is scalable since more agents can be added to handle more throughput of a specific task. When zooming in on the swarm, each individual robot is designed to be cheap with only the absolutely necessary functions to perform the task, while many components of the swarm do not need to be duplicated. With all the mentioned advantages we believe our system achieves a self-sufficient and efficient solution to efficiently monitor and tackle the problem of water pollution. Our solution balances the simplicity of the individual with the complexity achieved by swarm intelligence algorithms. This allows tackling bigger challenges more efficiently. Moreover, we will be using Artificial Intelligence algorithms in the execution of different tasks such as operation planning, waste detection, automated charging, etc.

Krill is developing four main types of robots: continuous measurement, static measurement, multi-sampling, and collection agents:

1) The **continuous measurement agent** allows for the collection of more data than what was possible before. With continuous measurement, various water quality parameters are measured around once every second as a robot traverses a body of water, mapping the area with continuous data. Using the big data we generate we make novel models of the water bodies to help draw insightful conclusions.

2) The **static measurement agent** collects vast amounts of data, similar to the continuous measurement agent. However, in this case, it does so at one, static, location and measures continuously over time. The goal of these agents is to gather information over longer periods of time, such as to capture the day-night cycles.

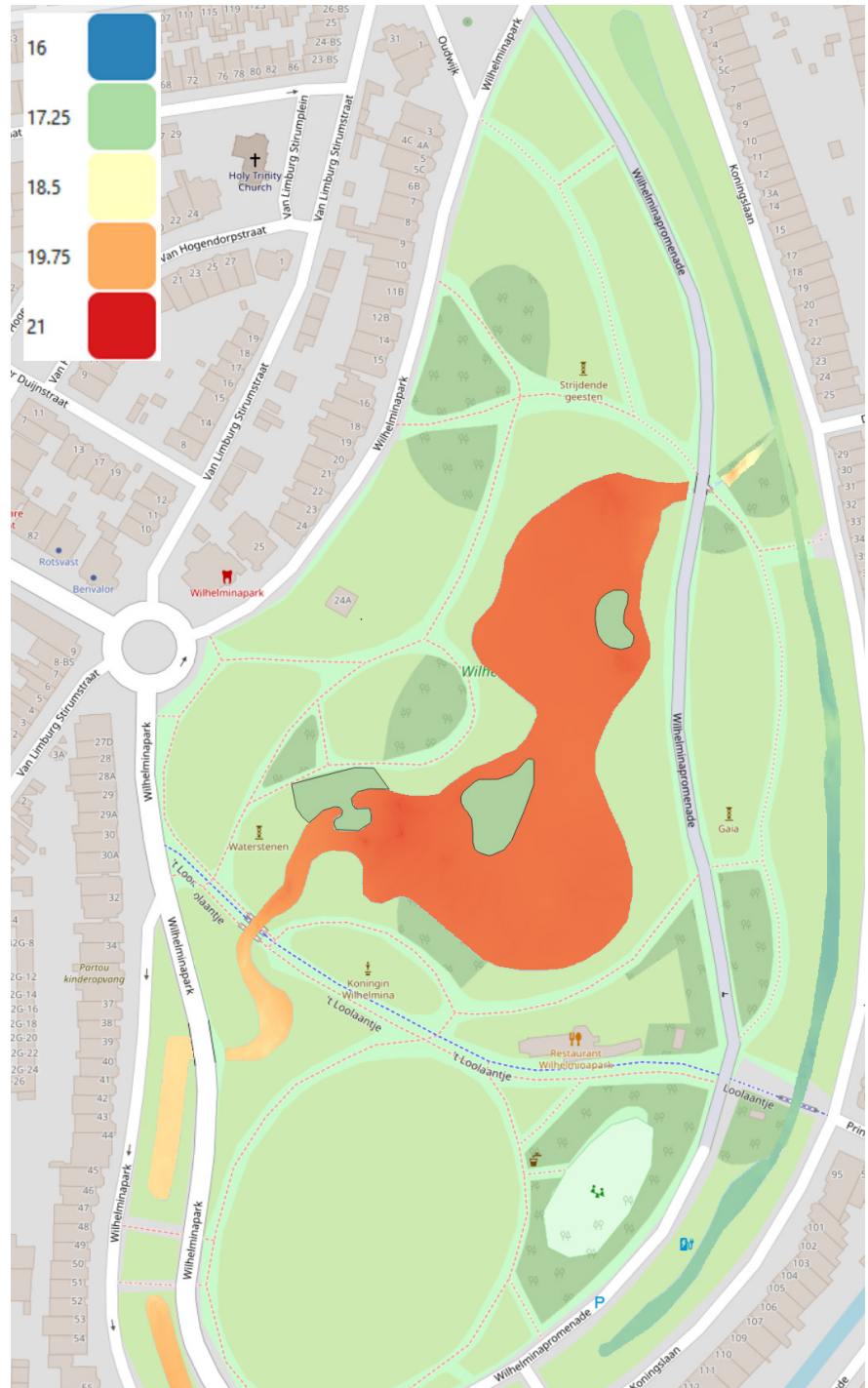3) The **multi-sampling agent** is a robot that expands the types of

Figure 3. *Measurement data from Krill robots*

water quality parameters that can be analyzed. Not all parameters can be measured in-situ, and therefore have to be subject to analysis in a lab. The multi-sampling robot takes samples of the water to be used in such lab analysis. The main focus of these robots will be to take samples to analyze the nutrient concentrations.

4) The **collection agent** collects data to get a better understanding of water quality, we also aim to actively improve it. To combat pollution,

collector robots can be deployed to collect various types of debris such as duckweed, blue-green algae, and plastics.

As of today, we have successfully completed our first pilot in Utrecht, thereby validating our solution of continuous measurement. We are in contact with various other water boards and municipalities and plan to perform more pilot operations in the future.

V.O. Patents and Trademarks

To patent or not to patent..

Jasper Groot Koerkamp

To patent or not to patent - that is a question a technology company will ask at least once. Some will ask that question only once and will respond with a single, definitive and negative answer. And some will ask that question many times, each time they have a new invention. Sometimes the answer will be positive, sometimes negative. And even though a patent is by many considered as the holy grail of innovation, sometimes the decision not to apply for a patent may be in the company's best interest. But if applying for a patent may not always be a decision in the best interest of a company, why would it be that holy grail?

A patent grants the party that has applied for a patent and got the patent granted a right to exclude others to use that technology. As such, a patent grants the company holding the patent absolute control over use of the invention, like a monopoly to build a business around an invention. Customers looking for the specific patented feature for use in their products can only buy from the patent holder. This allows the patent holder to decide who they sell to or not. And it allows the patent holder to set the price they want for the product. But applying for a patent comes at a price - and may not always result in a patent, even if the price has been paid.

The application for a patent and the granting of the patent is a deal between the inventor and society: the inventor makes the invention available to the public, such that any engineer with average knowledge of the technology can reproduce the invention. In return, the inventor receives a monopoly. There are, however two further conditions: the invention as described in the patent application is to be novel and technical parts of the invention are non-obvious to the average engineer. And whether or not that invention is novel and non-obvious, is assessed by the government.

Firstly, for some inventions, it is best they are kept secret. Because the fine details of the invention can be kept secret for a long time, even if the product is out to the public. The best-known example of this is the secret recipe of Coca Cola - but it applies to the recipe Pepsi as well, of course.

Second, governments set high standards for inventions to be granted patents, for novelty and non-obviousness in particular. The basis of the assessment is broad: information about the invention should not be available prior to the filing of the patent application, irrespective of the language or the way the information

is made available. Even if someone on the other side of the world came up with the same invention twenty years ago and has never made any business of the invention outside his small village, nobody will ever be able to get a valid patent on that technology.

Similar standards apply to the non-obviousness of the technical features of the invention. However, the line is a bit less strict on this matter: with respect to inventive step, there is often room for debate - Unless the invention has no new technical features. In such case, it will be impossible to argue that the invention has non-obvious techni-cal features. And in that case, not applying for a patent is usually the best option: irrespective of how in-novative a new business model may be, irrespective of how creative new rules of playing a card game are: they are not technical and therefore not patentable.
And for a lot of innovation of tech-nology companies, providing benefit to individual companies and society as a whole, patent protection is a proper solution to take control over the use of the invention. If you are a start-up, you want to make sure the ground breaking invention that is the basis for future growth of your company is yours alone. For larger companies, for example in the field of telecommunication, there is no other option to use your technology other than by using technologies of other companies as well. The other companies may ask you money to use their technology - or permission to use your technology. In this way,

your patents can bring in money or save money by allowing others to use your technology.

It may be difficult to argue why your technology provides that new and surprising effect that is not obvious to an average engineer. Arguing that an invention meets the standards requires technical and legal acumen, making drafting, prosecuting and enforcing of patent rights specialised work. What makes the difference between the invention and the state of the art and how does that achieve that great new effect? And how to argue this before the patent office or the court, taking into account legislation?
This is the work I have been doing for over twenty years now. As an engineer in the semiconductor indus-try, I was looking for an intellectual challenge in my job - without losing touch with my technology back-ground. I started my patent career with Philips Electronics and NXP. There, I supported the business by drafting patent applications. And I negotiated agreements for projects in which patents play a large role with other technology giants like Texas Instruments and Intel. To ensure return on investment in R&D and to achieve the best possible implemen-tation of the technology.
Thirteen years ago, I moved to a patent law firm; an office with only patent attorneys that offer service to a wide variety of companies. Instead of one client, I now serve over 150 clients and in addition to semiconductor and telecommunica-tion technology, I also work in the technical field of power electronics,

user interfaces, medical equipment and power distribution.
For our clients, I set up patent strat-egies to provide coherent protection for their technology, draft patent applications and address use of tech-nology of my client by their compet-itors. And in case necessary, we sue them - though an amicable solution is possible in most cases. And yes, also my clients receive such letters from competitors that we have to attend to. With this variety in work and high stakes with our clients, we set high standards to our own work and to our colleagues.
This allows us to provide your com-pany with support with the proper protection for your R&D in accor-dance with these high standards. In case you are interested, we are ready to discuss with you how we can help you control the results of your innovation in a way that serves your interest best. You can contact us via *https://www.vo.eu/en/* for an appoint-ment at your place or an office near you for a conversation without any obligations.

In case you are interested to become a patent attorney, you are invited to contact us for an informal inter-view any time that suits you, at an office location near you. We expect graduates and others new to the pro-fession to attend the regular external professional education programme, as well as our additional internal programme. In return, we offer an informal working atmosphere, career perspective and good benefits. You can find more information at *www.vo.eu/career/*.

Patents & Trademarks

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