CHRISTMAS PARTY

COMBINED DRINK OF 2 DEPARTMENTS BIG SUCCESS

New Year speaches | Early **BEP** project | Team

FAST | **DIES** Thor | **PhD** research | **Column**

What a year full of changes we had in 2015. Also in 2016 we have started with a big change for our department. We have said goodbye to our 'running' dean Ton Backx, who will take up the new challenge of starting up the Institute of Integrated Nanophotonics, and we have welcomed our new dean Bart Smolders. We wish them both success in their new challenge!

If you are looking for inspiration for an internship abroad, please have a look at the article by René Baelemans about his internship Down Under, or have a look at internship of Glen Bergmans at ARM. Further, we bring an article written by Gijs Dubbelman about the huge i-Cave project that gives us a view into the Future of Driving. Of course, one of the big events for our students in the past period was the Dies of Thor. Read everything about the Dies on page 20.

We take the opportunity here to introduce and welcome Mohsin Siraj as a new editorial-board member. Moshin is also known for his nice columns in Cursor, so we are very happy to include him in our editorial board. At the same time, we have said goodbye to Edgar van Megen. Edgar, thank you for your contributions to the Connecthor over the years. It was great to have you in the editorial board!

Are you up for a new challenge and would you like to contribute to our magazine? We are looking for new members of the editorial board and we are especially inviting employees of the EE department to respond. As always, we will be glad to receive your suggestions and ideas for upcoming editions and you can contact us via connecthor@tue.nl.

We hope you will enjoy reading this new edition of the Connecthor!

The Connecthor editorial board ∎

58th Dies Natalis of Thor
Thor's birthday was celebrated with a week full of activities and a lot of pie. Read more about it on page 20.

Whose desk is this?
Another employee reveals what is on his desk. Read it on page 10.

Internship Down Under
Read about Renés internship Down Under on page 26.

Excursion Allseas
Thor visited the largest ship in the world, at the Tweede Maasvlakte in Rotterdam. Read all about it on page 11.

Board Issues

By: Ton Backx and Bart Smolders

Speech of our former Dean, Ton Backx

Ladies and gentlemen,

I wish all of you a Happy New Year. May all your wishes come true in 2016, but above all I wish you good health!

This will be my final speech to you as dean of our beautiful faculty. In a moment I will hand over responsibilities to Bart Smolders. Together with Bart, I agreed to split our New Year's speech in two parts. In my part I will look back at the things we achieved in the past years. Bart will look forward to the coming years.

Although I look back at a marvelous period with many highlights for our faculty, we also had some extremely negative experiences. I want to memorize the three professors we lost during the period I was dean of the faculty:

André Vandenput in 2008, Wil Kling and Harm Dorren both in March 2015. We also had the tragic death of Juan E. Lopez Carcelen – one of our PDEng students – in April 2014 and of one of our foreign students last year. The loss of these people has had a huge impact on all of us. Our thoughts are with their relatives and families.

As I mentioned, we had many highlights during my almost ten years as dean of Electrical Engineering. A couple of these highlights I want to reflect upon.

At my appointment the faculty was facing several problems. We had a relatively poor financial position. The number of students starting our Bachelor program was historically low with only 60 first-year Bachelor students. Dropout in the first half year was high with approximately 50% leaving before the end of January. The curriculum was considered too heavy to finish the program nominally. Actually, the average time to finish the Bachelor was close to 5 years.

Financially, the faculty was doing poorly at that time with very significant budget overrun especially in the energy groups and only two groups performing well: the ECO group and the ES group. Furthermore, the faculty was facing strong internal competition between groups and coherence in research was lacking.

I am very proud of the turnaround we realized together. A major step we made by defining three strategic research themes for our faculty:

• Connecting the world

• Care and Cure

• Smart and sustainable Society

These themes and the centers we created helped us getting coherence throughout the faculty. It also brought a team spirit in our faculty where we established strong collaborations between groups throughout our faculty. Instead of spending energy in internal competition we started focusing on strengthening our ties with industry and external parties. The solid relationships and established collaborations enabled us to improve our financial viability. Financially, we became very healthy and strong. Even during the economic recession we continued to grow our activities and we further improved our performance. We became the robustly performing and healthy faculty we are today.

To solve the problems of our students we severely revised our curriculum. We introduced three tracks in the Bachelor's curriculum which created choices without affecting the high-quality and broad base content. Our students very much appreciated the changes we made. We also started an intensive coaching program for our Bachelor students during the first half year. The study results improved gradually with more students studying nominally and a severe reduction of the dropout rate. The decision we took to start an Automotive track in our Bachelor turned out to be a good choice as well. We established a steady growth in the number of students starting in our Bachelor's program, where we passed the limit of 100 students in 2011, 150 students in 2013, and almost 300 students in 2015.

Since 2006, we initiated a program to attract more foreign students for our EE Master's programs. With the initiatives we took, we were able to initiate a steady flow of foreign students. Especially the tight relationship we built up with Zhejiang University worked out very well. The Brainbridge program we initiated together with Philips enables us to attract top Chinese students of which many remain in our region or take PhD positions in our faculty. At the same time our Bachelor's programs also attract foreign students.

I am also very pleased to see that the number of female students we attract is increasing. The gender balance has been a major point of concern and although we still have a long way to go, we see a steady growth in female students.

I am proud of everything we achieved together. I want to thank everyone for the very pleasant cooperation during all these years. I very much enjoyed working closely with you building the strong faculty that we are at this moment. With Bart we have a dean who will continue to work closely with all of us to further strengthen and grow our faculty. I am confident that we keep our winning team spirit and further strengthen both our national and international reputation with Bart as our new dean. With confidence and with pleasure I hand over the chair of our faculty to Bart and together with you I congratulate Bart in his new role.

I look forward to work together with several of you in building up a strong Photonics Institute and a Photonic ecosystem in our region that will be a leading global center of many future innovations in Photonics.

Speech of our new Dean, Bart Smolders

First of all, I would like to thank Ton Backx for all the effort that he has put in our department in the past ten years. Our department has been transformed from a relatively small department in terms of number of students, budget and research output to the largest department of our university with almost 300 first-year students and about 230 PhD/PDEng students.

Since our department is in good shape, it will become an easy job for me! So what is left for me to do?

First of all, the total number of students in our department will continue to grow, quite rapidly. From the 280 first-year students that started in September 2015, we expect that about 20% will drop out in the first year. This means that in four years from now about 220 students of this cohort will try to find a graduation project in one of our capacity groups. We have nine of them. With an uniform distribution over the groups, this would imply that each group has to supervise about 25 Master students, and, of course, an equal amount of Bachelor End Project students; and an equal amount of internship students. On a yearly basis, this means that every scientific staff member has to supervise about 12 students per year on average. Next to this, we have our regular courses, labs and OGO projects, each with a growing number of students as well. It is clear that we have to come up with a solid plan to cope with this. This plan should include the following elements:

• Ways to divide the students more equally over our capacity groups

• Ways to reduce the work-load of our staff members by hiring extra staff and/or by recruiting more support staff e.g. support in writing project proposals or using more teaching assistants.

The good news is that the increasing number of students will provide us with an increase of our financial budget (part of the budget that we receive each year from the university). It is my intention to use this increase in budget to reduce the workload of our staff in the upcoming years. As a first step, in 2016, we will hire six additional scientific staff members. In addition, extra budget is reserved for teaching assistants and for hiring supporting project officers.

Next to this, several of our senior scientific staff members are going to retire in the upcoming three to five years. These positions need to be replaced. In total we expect to recruit more than 40 scientific staff members in the next five years.

In conclusion, hiring talented scientific staff will be one of our main challenges in the next years. We have to compete with local industry and with other national and international universities. By hiring new staff we will also have the opportunity to start activities in new domains within Electrical Engineering (e.g. sensors/radar). Your input is essential here. So please provide me with your ideas.

I would like to use the next six months to define, together with you, the new strategy of our department in terms of future research directions and related financial strategy. As a kick-off of this process, I will visit all capacity groups in the upcoming month. The final plans should be ready before the summer holiday. ∎

Innovate at Vanderlande

By: Martijn Roza

VANDERLANDE

Mechanical Development Engineer Martijn Roza works in the Research and Development department at Veghel. He joined Vanderlande as a master's degree student of industrial design from the University of Technology in Eindhoven. The main topic of his final year project was to generate an adaptive working environment that could respond to operator behaviour.

"This is an interesting and different approach to increasing operator productivity and satisfaction," says Martijn. He has also been involved in the standardisation of the TRAYSORTER workstation. "While our customers might have very different wishes, needs and logistical processes, we aim to provide the best suitable solution. Standardizing the possibilities means we will be better at helping customers throughout the sales and development process."

From investigation to conceptual design

"Within Vanderlande, there is wide variation in workstations and interactions that people have to perform with material handling solutions. We want to avoid reinventing the wheel over and over again. So I look at what lessons can be learned from the past, the insights gained from using installed systems, and how we can improve on the initial design. Then it's possible to innovate and optimise the workstations that Vanderlande provides."

"The challenging aspect of my job is getting the right information from the right people. This allows me to formulate design propositions that genuinely fulfill the needs of our customers' operators. What I find most interesting is the combination and transition of investigation to conceptual design."

Not afraid to innovate

"One of my greatest achievements to date at Vanderlande was seeing the demonstration model of the TRAYSORTER come alive for the first time at LogiMAT 2015. It looked exactly as we had envisioned, and the overwhelmingly positive responses from customers and colleagues alike were very satisfying. The collaborative efforts of everyone involved made it a proud moment."

"I enjoy working at Vanderlande because it is not afraid to innovate and it has a strong focus on people. There are many opportunities for employees to develop their skills and knowledge through a variety of courses at the Vanderlande Academy. And the high level of cooperation between the company and its customers means there is always an ambition to deliver the best solution."

"As part of my role at Vanderlande, I aim to create usable and motivating workstations that allow operators to achieve higher levels of productivity. That's why I closely identify with the company's core value of 'every day better'. By working closely with customers and users, I intend to innovate the workplace to a higher standard. On a more personal level, I believe that people are a valuable asset, who you can learn from, both within and outside the organisation." ■

Innovative with a strong people focus

From the President

By: Daan Daverveld

Another Connecthor, another word from the President. The last time I wrote for the Connecthor, I talked about our installation as 59th Board of Thor. Now we are already the Board for some time and everything is going fine. Of course there are always things to improve, but overall we are still really enjoying our time. We even have some time to study left.

What can be seen is that after the Christmas break, as a Board member, we are adjusted to every standard task that we need to do. This results in working more efficient and being able to focus on more specific things that we want to accomplish this year. These things include having a better reciprocity between students of different study years for example. We see a need for this because of the big growth of students.

A couple weeks back there was another Information Day. We could see that there is a drastic growth of people interested in our wonderful studies Electrical Engineering and Automotive. Over two whole days, a lot of parents and coming students visited our Faculty to ask questions and visit a practical demonstration. It is convenient that we, as a study association, are present as well, so we can tell the potential students and their parents a lot about what Thor does as a study association. Many times people do not even know what all the things are that we do, so here is a short list. As Thor we provide study books, lunch lectures, excursions, exam practises, hardware, study trips, mentors, an introduction week and student instructors. Beside these educational things, we also provide a lot of relaxing activities, because we think that besides studying a student also needs some fun in their free time. By offering activities, as well as providing the platform to organize those, Thor offers its members the opportunity to acquire skills they would not develop within the regular curriculum of their studies.

Because we have some more time now for other things we also like to meet some honorable members. Not too long ago we met with an old President: Guy Kerpen. We had lunch with him and talked about the differences and similarities back in his days and now. It is fun to see how the things change over time. He told us that in his time the student associations just moved to the 'Bunker', where one could also find the housing agency now known as Vestide, as well as a really cheap restaurant for students where they could buy dinner for only five 'guilder'. Now, Vestide has its own big buildings and has become a really large company. Also, the restaurant is not there anymore, but there are plans for making less expensive restaurants for students to make Eindhoven more attractive for studying.

Next we went to the Philips museum, as Guy works at that company. He organized that the museum was open especially for the six of us. We were overjoyed, especially when our guide told us, after a small introduction from Guy about our association, that he, Jan Kamp, had been President of Thor in 1966-1967. We had good laughs and a great tour, learning a lot about Philips. I would recommend going there sometime. I know that I will be back at least once because Thor recently made a new yearbook and Jan really would like to have one. As a President, I am not against making a small trip to an old Board member, especially for an old President.

Veel gedonder!

Daan Daverveld ■

Introducing...

Hello! My name is Dhruv Khandelwal. I am 24 years old and I am about to start a PhD in the Control Systems group. I grew up in the large but quaint city of Kolkata in India, where I spent eighteen years of my life. I then pursued a Bachelor's degree in Electrical and Electronic Engineering at VIT University, located in Southern India. I have now been living in Eindhoven for the past two and a half years, having completed my Master's degree also at Eindhoven University of Technology.

I am an avid music enthusiast, and I like to spend most of my free time with my guitar and mandolin. I also like to swim, and play squash and tennis whenever possible. Despite my underwhelming cooking skills, I do like to experiment a bit in the kitchen. I usually make spontaneous travel plans, and I hope I get several opportunities to do so in the coming years.

My past two years in Eindhoven have been quite eventful, and I've been lucky to come across countless interesting people. I hope that the coming four years prove to be even more exciting. I look forward to learning as much as I possibly can, both within and outside the realm of academics. ∎

Hello everyone, let me grab this opportunity and briefly introduce myself. My name is Rogier Wildeboer and I just moved to Eindhoven to join the SPS group as a PhD candidate. For the past six years I lived in the far-away city Enschede, being a student at the beautiful University of Twente. A few years ago I obtained my bachelor's degree in Biomedical Engineering and last September I graduated in both Biomedical Engineering and Applied Physics.

Of course I really enjoyed student life back in Twente; going out with friends, being actively involved in study and cultural associations, but also organizing more serious events together with Studium Generale and assisting in a great deal of courses. Now I am up for the next challenge here at the TU/e. Being originally from Rotterdam, I am also looking forward to explore the southern way of life. In my spare time I like to play the piano, compose some music, write and, of course, have fun. I am sure I am going to have a great time here at the TU/e.

The coming years I will work in close collaboration with Philips and the Jeroen Bosch Hospital, studying the imaging and diagnosis of prostate cancer; a somewhat more masculine subject after focussing on the diagnosis and treatment of breast cancer for my Master thesis. Since I will be around for a few years, I will surely meet most of you some time in the corridors. See you then! ∎

New employees

Name	Research group	Function	Starting date
A.W. Burstein	EES	PhD	1-11-2015
R.R. Wildeboer	SPS	PhD	1-11-2015
W.J.S. Wessels	EPE	Education/Research Officer	2-11-2015
M. Fadaeinia	SPS	PDEng	1-12-2015
H. Gao	MsM	Assistant professor	1-1-2016
Y.C. Gultekin	SPS	PhD	4-1-2016
D. Khandelwal	CS	PhD	4-1-2016
M.A. Mohammad	ECO	PhD	4-1-2016
M. Spiegelberg	PhI	PhD	5-1-2016
G. Papini	SPS	PhD	1-2-2016

Cum Laude promotion Kevin Pluk

Kevin Pluk, from the Electromechanics and Power electronics group of the faculty of Electrical Engineering, was cum laude promoted on the 23rd of November 2015. The title of his thesis is: Hybrid 3-D Electromagnetic Modeling; The Challenge of Magnetic Shielding of a Planar Actuator. His promotors from the EPE group were Professor E.A. Lomonova and Dr. J.W Jansen.
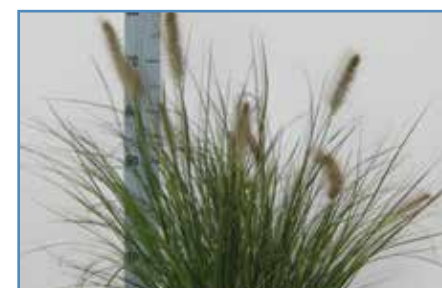
Edgar leaving editorial board

For several years, Edgar van Megen has been one of the layout editors of Connecthors. After the December edition, Edgar decided to step down from the editorial board. We would like to thank Edgar for his contributions to the Connecthor.

Farewell reception Matti Herben

On Wednesday, December 9, 2015 Dr.ir. M.H.A.J. Herben had his farewell reception. Matti started in the Electrical Engineering department in 1978 and worked as an associate professor in the electromagnetics group. We wish him and his family all the best in the future.

Cum Laude promotion Marco Altini

Marco Altini was promoted cum laude for elaborating on various original personalized approaches for unobstructive energy expenditure (EE) and cardiorespiratory fitness (CRF) estimation.

Marco did all this work in about 3 ½ years. Moreover, in parallel to the final phase of this work he has led the data science activities of start-up company Bloom Technologies based in San Francisco, USA.

No trees in the oasis of Flux

In contrast to earlier announcements no trees will be placed on the roof terrace on floor 6. Trees turn out to be too heavy for the roof terrace construction. The announced grass will be planted and will be approximately 80 cm high. In the boxes in which the trees would be placed there will also be grass planted. When this greenery will be placed is still unknown.

Fire in the lab

On Friday November 13, 2015, a fire with heavy smoke in Spectrum completely destroyed one of the labs, occupied by Richard Engeln and his co-workers. We wish Richard and his team good luck in rebuilding the lab.

Best Poster Award

Elles Raaijmakers (Electromagnetics group) won the Best Poster Award at the URSI-NARF-IEEE Benelux Meeting on 7 December 2015.

Solar Team Eindhoven honored

A couple of months following the victory in the Cruiser Class of the World Solar Challenge 2015 in Australia, Solar Team Eindhoven and its solar-powered car Stella Lux are back in the Netherlands. During the New Year's reception 'The New Horizon' on January 5 in the Evoluon in Eindhoven, the team was once again put in the spotlight as it was honored by Jan Mengelers and mayor Rob van Gijzel.

Picture by Bart van Overbeeke Photography

Whose desk is this?

By: Mircea Lazar

My name is Mircea Lazar and I have been working in the Electrical Engineering department since September 2002, when I began my PhD in the Control Systems Group. Back then I had a desk in the 4th floor of the Potential building, facing Kennedylaan, which I shared with one colleague only.

It was very nice to see how the trees by the Dommel are changing their color following the seasons. So, moving to Flux was a big change, as the windows of my desk now face in the opposite direction and I share the office with 4 colleagues. An interesting coincidence is that in both offices my desk was located near a pillar that provides resistance to the building. This pillar somehow gives a feeling of shelter, like I have my own distinctive corner in the big office.

If you look at my desk you probably first see the big smiling flower. I followed the advice of my wife and took this flower in the office so that students would not be scared of me when they walk in. I think that students are only scared of subjects that they do not understand very easily, and dynamical systems and the math behind is sometimes difficult to digest. Together with my colleagues at the Control Systems group we are doing our best in several courses to convey students the joy of understanding dynamical systems and control.

As usual, my desk is a mess and in my defense, they asked me not to clean it for the picture. What usually lies on my desk are papers that I have to review or read, theses of students, plenty of yellow sticky notes to write down stuff, a bottle of water, a coffee mug and some personal items to cheer me up. Headphones and music play a very important role in being relaxed and focused in a shared working space. In the desktop picture you can see the Atlantic Ocean meeting the Indian Ocean at the Cape of Good Hope in South Africa, where we were attending a conference.

Having a shared office also has its benefits: you can always interrupt and tease your office mates to chase away the feeling of loneliness and you can always get a partner for coffee talks which lead to very interesting and often entertaining discussions.

I am therefore looking forward to spending quality time behind my new desk on the 5th floor in the Flux building, together with my office mates, watching the sun and the rain changing intermittently, drinking coffee, listening to good music and do some research as well. ◾

Lunch lecture Sioux

By: Loy Rovers

Hi, my name is Loy Rovers and I am working as mechatronics system designer at CCM (part of technology company Sioux). On the 25th of September I had the pleasure of giving a lunch lecture about the 'Generic Substrate Carrier' which is developed and produced on site at CCM.

CCM specializes in the field of mechatronic systems, ranging from initial design concept to final products. As part of the Sioux Group, we support leading high tech companies in the development and manufacturing of their products.

Generic substrate carrier

One of our own products is the generic substrate carrier (GSC). The GSC is a module that can be used in large industrial inkjet printers. It transfers substrates with high velocity and high precision at the same time through the printer. The GSC uses a unique concept by temporarily fixing the substrate to a very accurately running metal conveyer belt. This allows for handling both flexible substrates such as foils (e.g. labels for exclusive wine bottles) as well as stiff substrates like solar panels. High precision is obtained by running the belt over segmented rollers, which can be deformed using custom designed actuators.

Complex challenges

The extreme accuracy our customers are requiring is really challenging. Approaching the issue from merely an electronics point of view will become increasingly complex since the effect of consecutive fine-tuning steps will become smaller and smaller. During my presentation I focused on how to succeed in such a complex situation.

Multidisciplinary

At CCM we are spoiled in the sense that communication lines are short and cooperation with other disciplines is promoted. For example, cooperation with mechanical experts resulted in the selection of different sensor locations that made measurements less sensitive to vibrations and resulted in a major reduction of tracking error. In addition, complex calibration and several learning algorithms were developed in discussion with mathematicians to compensate for repetitive errors.

I really enjoyed being back at my former college, TU/e, and want to thank everyone for the great interaction during the presentation. At the end some tough questions were asked that even pointed towards challenges that we only observed during a later phase of the project. This made the interaction also very interesting for us as GSC team. Thanks! ◾

Excursion Allseas

By: Ralph Roetman

Together with our neighbors from Gemini, Simon Stevin, we went to the largest ship in the world, the Pioneering Spirit, on the Maasvlakte. Once there, we were transported by two small boats to the boat of AllSeas. After a small journey we arrived at the Pioneering Spirit. After a huge climb, we were welcomed at the fanciest part of the ship: the special guest dinner location, with coffee, tea and cake.

After a small wait, we were separated in several groups and got a tour around the ship. We first went to the first control room, where you had an amazing view of all the controls, and continued to the second control room, which is a mirror of the first, but in the opposite direction. Afterwards we saw the bottom of the ship where all the pipes are welded together. After walking some time below decks, we did not know where we were once we climbed up, because the ship was simply too big.

After the tour we went back to the dining room. There we got served some pizza, other snacks and tax free drinks. This was the end of the excursion, we left the huge boat and returned to Eindhoven. ◾

Excursion TenneT

By: Brian Kuijsters

To start the new year in a good way a TenneT day was organized by Thor and Waldur on January 6. The day was divided into a midday program, which was an excursion to the 380kV substation Eindhoven, and an evening program, consisting out of a lecture followed by a dinner.

For the excursion some preparation was required as everyone had to pass a small safety test. This is in line with what we heard throughout the rest of the day: safety is very important for TenneT. The excursion started with a brief introduction on what TenneT does and where it is responsible for, which is maintaining the high voltage grid of the Netherlands and a part of Germany. We then got a brief tour by Roel van Hees throughout the 380kV station. There we could see the incoming 380kV fields with components like circuit breakers, disconnectors, earthing rods and voltage and current transformers.

We also saw the differences between newer and older transformers, where the main noticeable difference was the size; the more modern transformers are much smaller. Also much smaller, compared to the 380kV equipment, are the 150kV fields. They consist out of the same components but due to lower voltage they can be made much smaller taking up less space.

Around 17:00h the lecture from Sander Franken started. The topic was about operational challenges in the transmission system, which included all sorts of factors that can influence the behavior of the high voltage grid. An important topic for the near future was the increasing renewable energy usage (wind, solar power), as those forms of energy generation are different in many ways compared to what is used today and in the past. TenneT needs to anticipate on these changes fast and in a smart way as it can take many years to increase or expand grid capacity, which is needed to remain there 99.9996% grid availability.

After the presentation there was time for questions and dinner was waiting for everyone that joined this day. ◾

i-CAVE and the Future of Driving

By: Gijs Dubbelman

The Dutch technology foundation STW is making 4 million euros available for the i-CAVE research program coordinated by Eindhoven University of Technology. i-CAVE is an acronym for *Integrated Cooperative Automated Vehicles* and the program, existing of seven projects, researches all the key aspects of the self-driving car. The project consortium embodies, amongst others, all our sister universities of 3TU, companies like DAF, NXP, TomTom and Ford, as well as parties such as ANWB, TNO, AutomotiveNL and the Ministry of Infrastructure and the Environment. Together they will develop vehicles that are able to drive autonomously on private roads, such as our campus, and cooperatively on public roads.

Integrated scalable approach: from fleet management mobility services to cooperative vehicle control, including research on fault-tolerant software.

Realistic step-by-step approach: manual to cooperative automated driving, precise vehicle localization by vehicle sensors and scalable Highly Automated Driving (HAD) maps.

Focus on human factors: interaction with vulnerable road users and non-equipped vehicles.

How can the technological aspects of cooperative automated driving be combined with the human factor aspects whilst guaranteeing efficient, safe and acceptable cooperative automated driving.

The Research Program

The i-CAVE research program addresses current transportation challenges regarding throughput and safety with an integrated approach to automated and cooperative driving. In i-CAVE, a Cooperative Dual Mode Automated Transport (C-DMAT) system is researched and designed, consisting of dual mode vehicles which can be driven automatically and manually to allow maximum flexibility. The programme integrates technological roadmaps for automated and cooperative driving, accelerating the development of novel transportation systems addressing today's and future mobility demands. Besides these enabling technologies, focus is put on fault tolerance and fail safety, wireless communications, human factors and others

Figure 1: The i-CAVE consortium covering the complete automotive value chain and governmental stakeholders

addressing transition of control between manual and automated driving and response of other road users.

i-CAVE tackles the main challenges of automated driving, i.e., achieving high levels of safety and reliability through rigorous technological design, combined with seamless integration between automated and manual driving to obtain maximum flexibility and user acceptance. A living-lab will be used for the integration and evaluation of accurate vision-based mapping and localization techniques, distributed cooperative vehicle control algorithms and fleet management methods. In addition it allows for a close-to-market transport system, which can be commercialized by the transport industry, specifically leading automotive tiers in the Netherlands, by applying the results in their roadmaps.

The uniqueness of i-CAVE is that it takes an integrated scalable approach: from fleet management and mobility services to cooperative vehicle control, including research on fault tolerant software. At the same time, it takes a realistic step-by-step approach: manual to cooperative automated driving, precise vehicle localisation by vehicle sensors and scalable Highly Automated Driving (HAD) maps. Last but not least, it puts a strong focus on human factors: interaction with vulnerable road users and non-equipped vehicles.

Research challenges

The central research question of the i-CAVE programme is: how can the technological aspects of cooperative automated driving be combined with the human factor aspects whilst guaranteeing efficient, safe and acceptable cooperative automated driving? The innovative character of this programme lies in the coherent and integrated setup of its projects, which shows an internationally unique multidisciplinary approach, solving the fundamental challenge of advancing and integrating different enabling technologies with human factors in an integral mobility concept. The main scientific challenges which will be addressed are: How can we

1. Design intrinsically safe and efficient Cooperative Dual Mode Automated Transport services for goods and people with a maximum level of comfort in urban type environments?

2. Design highly reliable, accurate, and scalable digital video-based sensing, mapping, and localization technologies that support cooperative and automated driving?

3. Control individual cooperative vehicles taking into account vehicle dynamics, longitudinal and lateral string stability,

and human behavior, including how to obtain a sufficient level of fail safety and fault tolerance?

4. Manage (dispatch, route and reposition) a fleet of cooperative autonomous vehicles for passenger and cargo transport in an efficient and cooperative way, taking into account longitudinal and lateral string stability and cooperation between multiple strings of vehicles?

5. Obtain an intrinsically fail-safe, fault tolerance system of Vehicle-to-Vehicle (V2V) communication to support cooperative driving?

6. Take human factor issues into account for drivers, as well as guarantee the safe interaction with other road users including vulnerable road users?

7. Design and evaluate the functional architecture and quality model of autonomous and cooperative vehicles software?

These activities combined will lead to a tightly integrated programme, solving the fundamental challenge of advancing and integrating different enabling technologies with human factors in an integral mobility concept.

The seven projects

To ensure the programme reaches its objective, seven individual but intertwined projects are set up in which all scientific challenges are represented.

Project 1: Sensing, mapping & localization focuses on sensing related challenges in automated driving. In this project research and development is focused on 1) self-learning computer vision technologies (detectors and classifiers) that allow the vehicle to better perceive its surroundings, reducing its dependency on HAD maps 2) real-time computer vision technologies for accurate localization in HAD maps under all weather conditions and 3) developing distributed computer vision technologies for crowd sourcing the information required to (partially) create and update HAD maps, thereby improving the scalability of HAD maps.

Project 2: Cooperative vehicle control focuses on designing an experimental evaluation of distributed controllers for cooperative and automated manoeuvring. Global and

local control algorithm concepts and implementations will be researched and evaluated that ensure longitudinal and lateral string stability of platoons of vehicles.

Project 3: Dynamic fleet management focuses on developing fleet management (FM) methods taking into account uncertainty in demands and dynamic situations. Fundamental research will lead to practical approaches for scheduling, repositioning, and optimal parking. Extensive experience with FM strategies for fleets of port-based automated guided vehicles (AGVs) for cargo transport, and strategies for coordination of fleets for inter terminal transport and routing of airplanes will form the basis for addressing these challenges.

Project 4: Communication focuses on RADAR-based communication. This project aims at 1) exploiting ADAS RADAR front-ends as a means for (radio) communication and 2) levering existing WiFi-P protocols for RADAR-based communication. Special focus will be on tight integration of both communication modalities, with the aim to develop highly robust multi-modal communication technologies, protocols, and standards for V2V communication domain. ▶
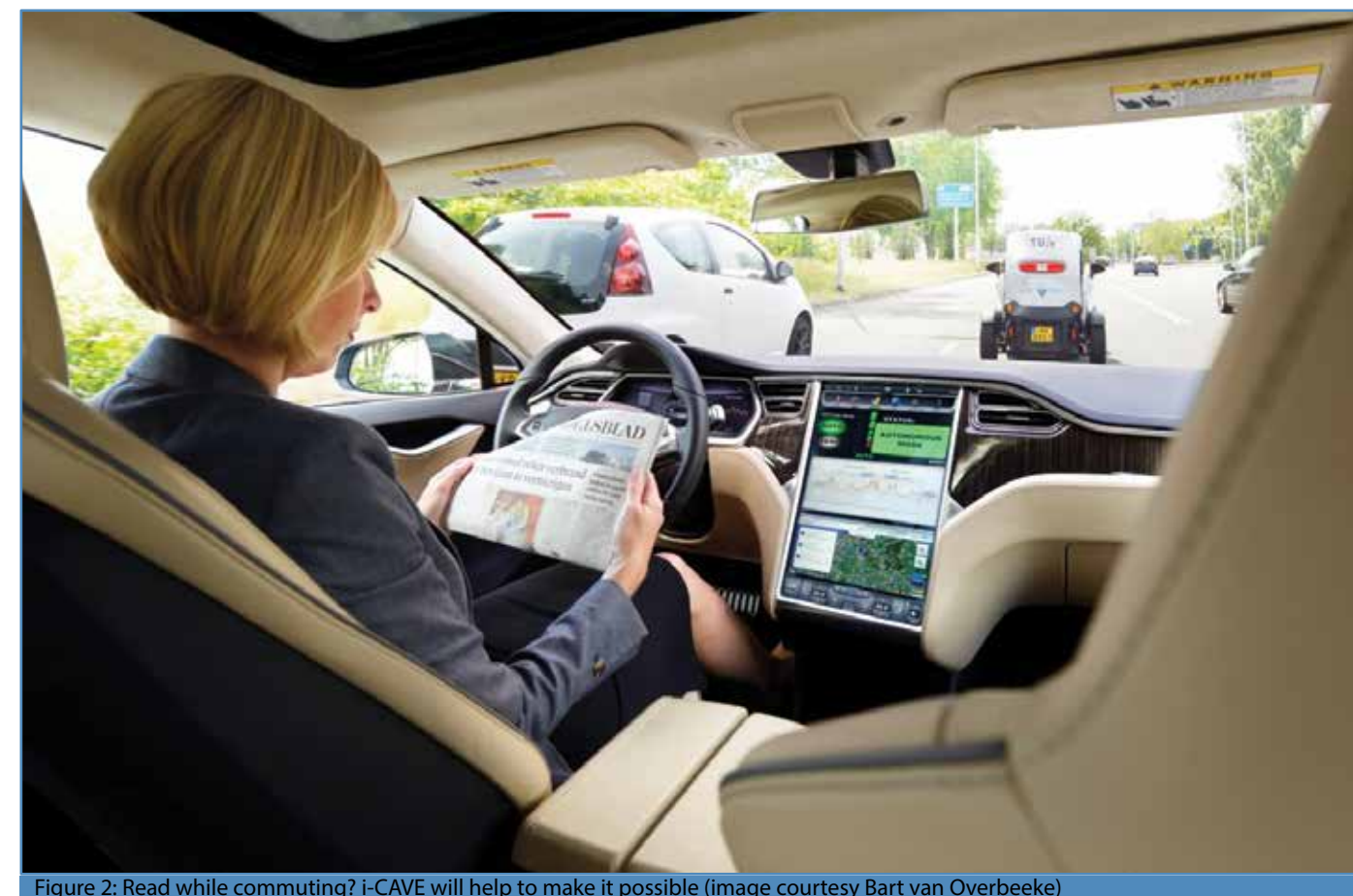

Figure 2: Read while commuting? i-CAVE will help to make it possible (image courtesy Bart van Overbeeke)

These protocols and standards also involve high-level mechanisms for sharing crowd sourced data between vehicles (RADAR-based) and traffic management systems (WiFi-P based).

Project 5: Human factors focuses on configuring a fail-safe human-vehicle symbiosis in which the driver knows exactly what the vehicle will do under what circumstances, and in which other road users interact with the vehicle in a natural and self-explaining manner. Questions that need to be answered are: How to safely design for dual-mode transitions? How to design an intuitive HMI for dual-mode vehicles? How should the C-DMAT 'behave' so the driver does not overrule the system, and how do drivers respond to (apparent) vehicle failures or limitations? How do other road users respond to and interact with (partially) automated vehicles?

Project 6: Architecture & functional safety focuses on design and evaluation of the functional architecture and quality model of autonomous and cooperative vehicles software. An integrated quality model will be researched, which can be used at all stages – from architectural design to implementation – by extending the Hazard Assessment by Risk Analysis. It will be evaluated by running scenarios from Architecture Tradeoff Analysis Method (ATAM) on the Living-lab demonstrator system.

Project 7: Demonstrator platform covers all key enabling technologies for sensing, system integration and communication architecture including dynamic fleet management, handling of HF and functional safety for technology demonstration in a living-lab environment. Results and deliverables of projects P1 to P6 are combined and in project P7 this will be integrated into a demonstrator, consisting of 4 to 5 dual mode automated vehicles, operating in a concerted mobility system in which transport demands by end-users is matched with vehicle availability. HF are fully integrated in the transport concept, resulting in an intuitive and safe user experience and avoids accidents in the entire system.

Levels of automation

i-CAVE takes a pragmatic approach, by considering the cooperative and automated dual-mode principle. With this we recognize that the ultimate goal is full automation (SAE level 5, see Figure 3) but that many societal goals can already be achieved with lower levels of automation. Our integrated research lines therefore specially consider vehicle automation technology that can be introduced step-by-step and that allows for seamlessly switching between human-controlled driving and cooperative automated driving, i.e. dual-mode driving, when possible and when wished for. While other international research initiatives focus on either cooperative driving, automated driving, or dual-mode driving, i-CAVE uniquely addresses all three simultaneously.

i-CAVE @ TU/e

A considerable part of i-CAVE will be located at our university. In total we will house seven PhDs, three post-docs, and 2 PDEngs. They will be spread out over our faculties of Electrical Engineering, Mechanical Engineering, and Industrial Design. This gives unique opportunities for cross-faculty interdisciplinary research. i-CAVE is planned to start at the end of 2016 and its total duration will be five years - very exciting five years surely! ∎

Figure 3: Levels of vehicle automation as defined by SAE international (image courtesy SAE International and J3016)

Transcranial Magnetic Stimulation

By: Linda Janssen
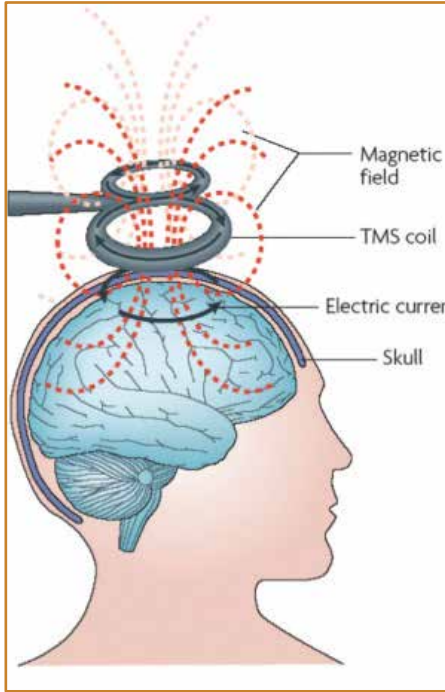
Usually, in the third quartile of your third academic year you begin to spend half a year working on your Bachelor End Project (BEP). Nonetheless, sometimes you take a little detour and end up starting your BEP in the first quartile of your fifth academic year. Also, usually, you receive a large stack of projects from which you choose one that interests you. However, this was a much smaller round with limited choices. After following the course Cognitive Neuroscience last year and learning all about cognitive functions and the human brain, I felt inspired to learn more about this subject. I decided to be bold and ask my former professor if there was any way he could help me acquiring a BEP. He initialized this and a few meetings later, a project description was available, so I had my BEP project and no less than three supervisors.

My project was about Transcranial Magnetic Stimulation, or TMS for short. TMS is a treatment where a coil, powered by a pulse generator, is held above the scalp and generates a magnetic field. This magnetic field then activates a certain part of the brain, which can help with several diseases and problems. Some examples are migraine, stroke, depression, multiple sclerosis and epilepsy, and it is suggested that it might even help with certain symptoms of schizophrenia.

For my specific part in TMS I was tasked to program a model that could calculate the magnetic fields induced by TMS coils. The result is a model, called the Biot-Savart model, programmed in Matlab with two functions. First, you can design your own TMS coil. There are ten different variables that you can alter to ensure your coil has the right specifications. If you don't know what coil you want to design you can choose from one of the preprogrammed ones and alter those. When you are pleased with your design you can then simulate the resulting magnetic field. Because the system is quasi-static the magnetic field is calculated by means of the law of Biot-Savart.

The model then had to be verified. This was done with a commercially available electromagnetic solver. The Biot-Savart model had a maximum error percentage of 15%. However, the Biot-Savart model can do in five and a halve minutes for which the commercial program takes up to 6 hours. After this further verification was done by performing measurements with a hall sensor on a handwound coil. Winding my own coils was a good experience, however some concerns arose with the measurement. The coils heated up to a point where I thought they would melt the frame on which they were wound. In the end, no coil, table, or measurement equipment was harmed in the making of my BEP.
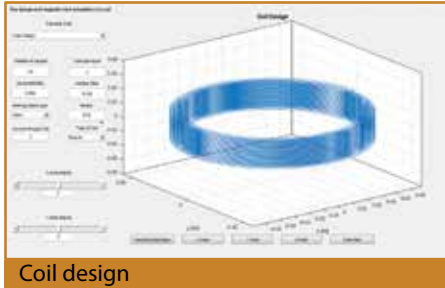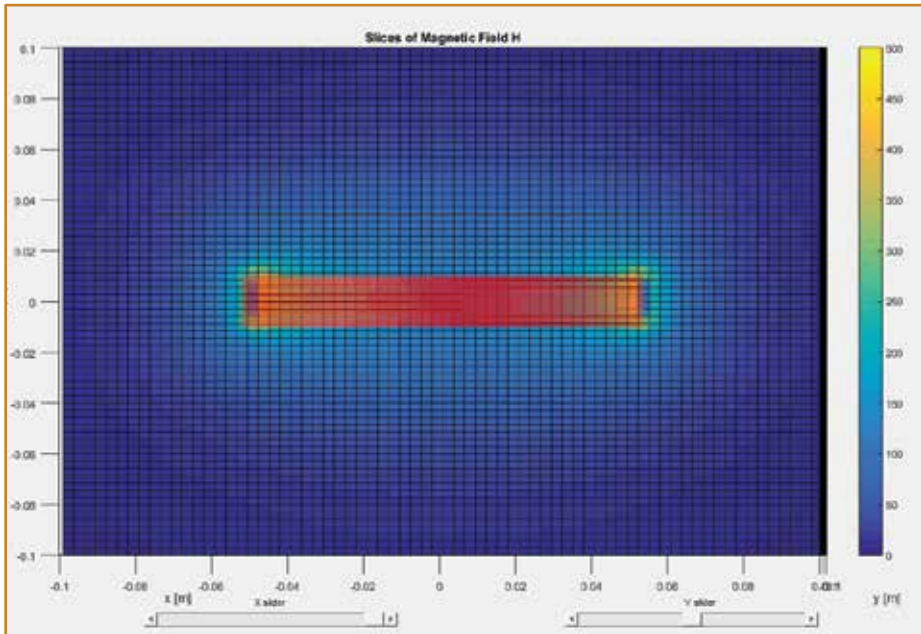

Coil design
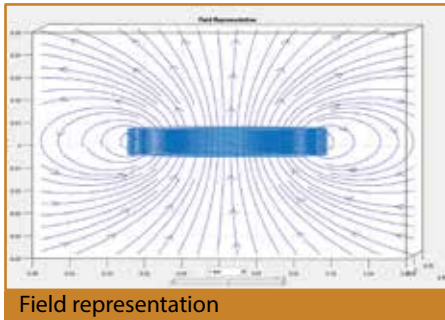
Field representation

At the moment of writing this article, I have not yet had my final presentation and thus don't know yet whether I have passed my project. However, I do know that I really enjoyed my time. Working on something for half a year is a lot more enjoyable when it's about something that interests you. ∎

Slices of Magnetic Field H
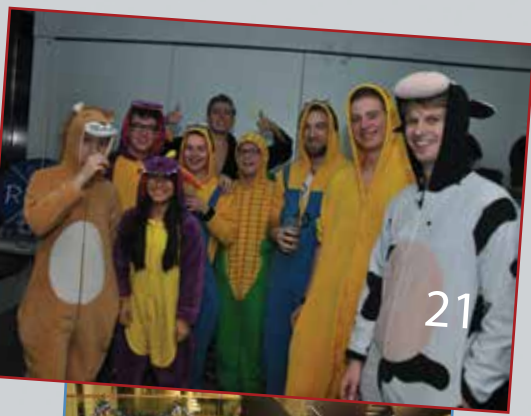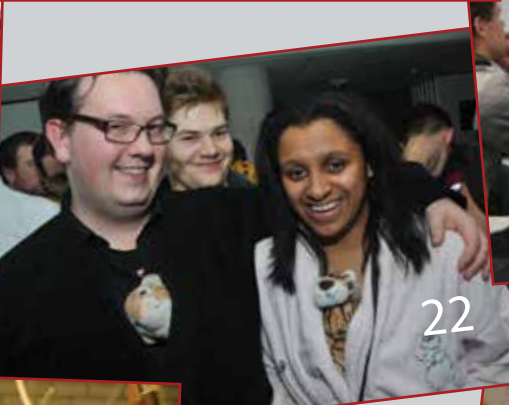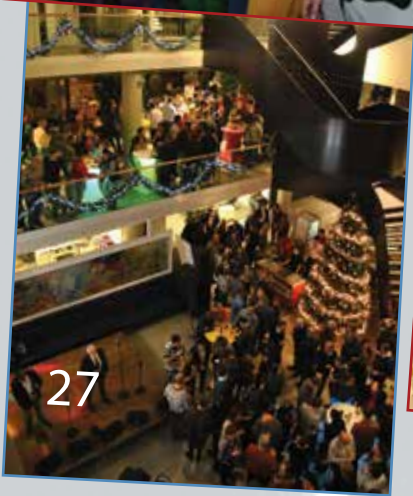
1 & 2. TV Deco

3. Centhorion

4 - 6. ACCI Party

7 & 8. DIES pie opening

9. DIES Cantus

10. DIES Cartoon drawing

11. DIES Shell excursion

12 & 13. DIES Archery Clinic

14. DIES Party

15. DIES Oude Bokken Borrel

16 & 17. DIES Dinner

18. Volundr PCB Design workshop

19 & 20. SinThorklaas

21 & 22. Ivaldi Party

23. ACCI LAN

24 - 26. Tennet excursion and lecture

27 - 29. Christmas party Flux

Going FAST with Formic Acid

By: Birgit van Huijgevoort and Mitch Winkens
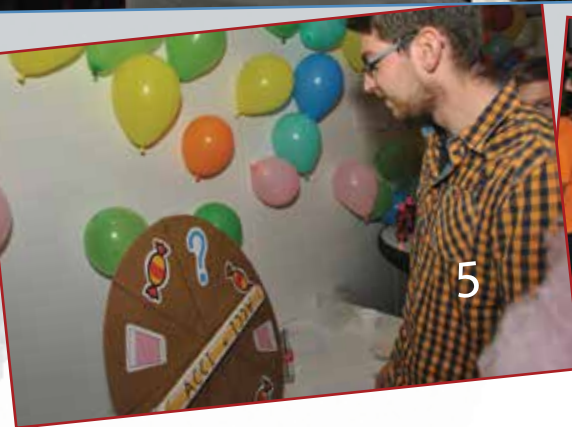
What started as just an Honors project has since managed to become an innovation that caught the attention of students, professionals and companies alike, and secured the DLL Duurzaamheidsprijs at the 2015 BrainsAward competition and one of the STW open mind subsidies. We are talking, of course, about the Formauto of the recently formed Team FAST (Formic Acid Sustainable Transport). While 'fast' is not exactly a description that fits the prototype yet, it is certainly able to move using only Formic Acid for fuel. Want to know how? Just keep reading!

The concept of the Formauto was born when our group of students participating in the honors program (energy transition track) contacted Georgy Filolenko to talk about his new catalyst. This catalyst was able to convert carbon dioxide and hydrogen to Formic Acid and vice-versa, with the downside that the catalyst becomes inactive when exposed to oxygen. Maybe we could think of some application for it?

Formauto Pico

Formauto Junior (image courtesy BvOF)

Looking at the reactants, it quickly became obvious that there would be potential to 'store' hydrogen in liquid form by converting it to Formic Acid, essentially using Formic Acid as a hydrogen carrier (i.e. a compound from which hydrogen can be obtained). This is very interesting, as one of the usual downsides of hydrogen as an energy source is its low energy density, volume-wise. This is usually solved by compressing hydrogen; for example, a Toyota Mirai stores hydrogen under a pressure of approximately 700 bar to increase its volumetric energy density. However, compressing hydrogen like this results in a need for elaborate safety measures, and even then it is like you are driving a bomb. By converting the hydrogen to Formic Acid first, it becomes possible to store the hydrogen in liquid form without increasing its pressure. That all sounds nice in theory, but that

By converting the hydrogen to Formic Acid first, it becomes possible to store the hydrogen in liquid form without increasing its pressure.

does not necessarily mean it works. To test our concept, we started doing experiments on a small reactor to measure the behavior of the catalyst at various temperatures and

concentrations. Results were promising, so we tried to connect the reactor outlet to a model hydrogen car. After increasing the amount of catalyst a bit, we were delighted to see that the wheels of the model car started turning.
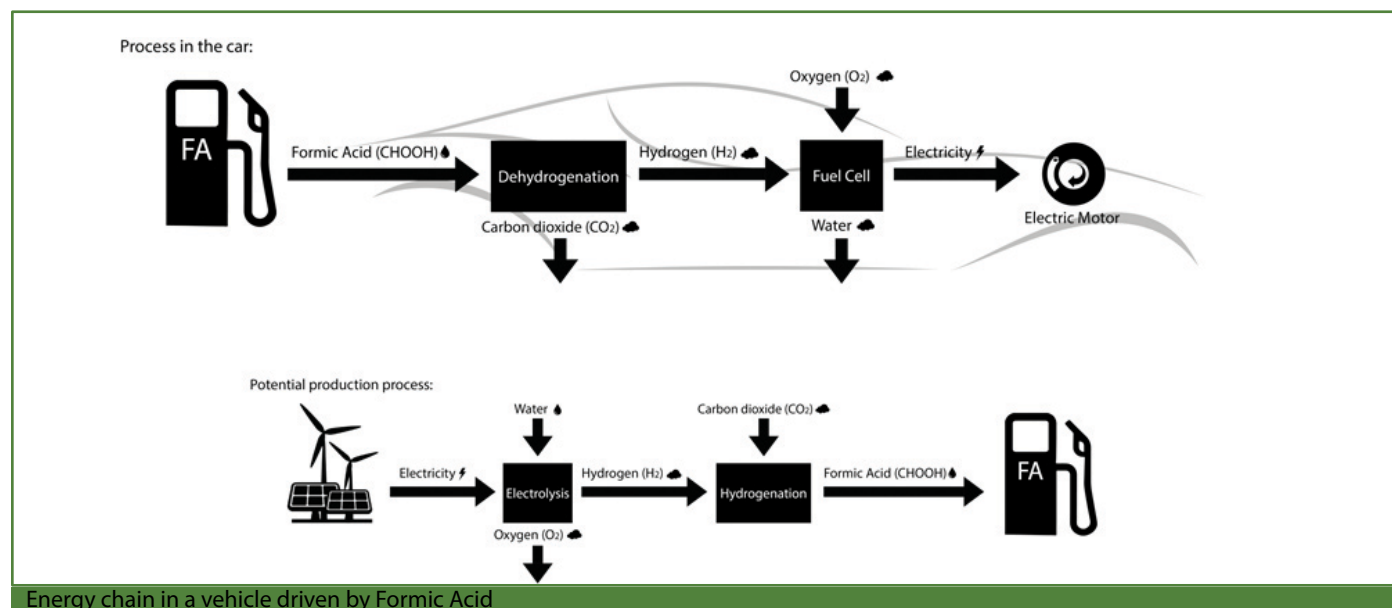
Energy chain in a vehicle driven by Formic Acid
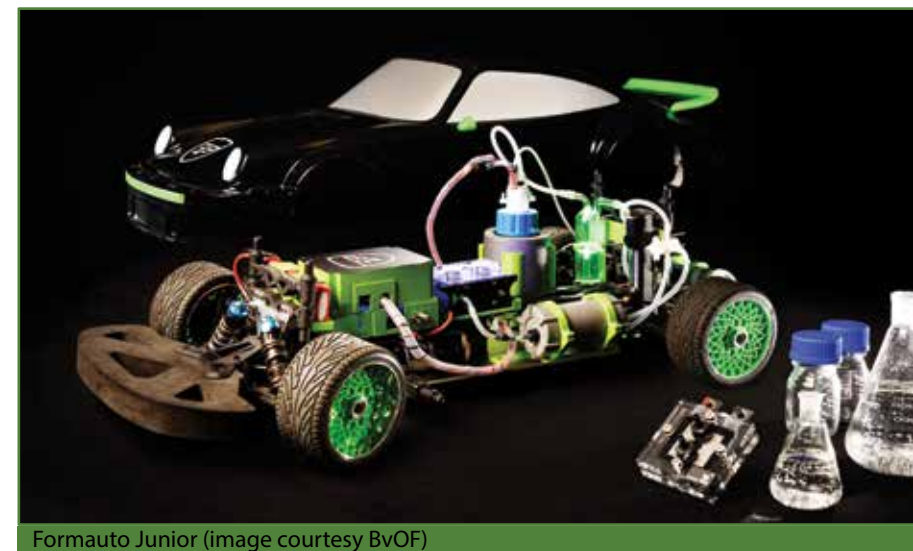
Formauto Junior (image courtesy BvOF)

For our proof of concept, all that remained was to show we could implement the reactor on the car in such a way that is was able to move. It was at this point that we decided to order parts to build our custom reactor, rather than to continue working with the makeshift experimental reactor. It was important that this new reactor would be airtight, as we could not flush it with argon as we did with the experimental setup. In the end, we were able to keep the prototype simple, using a glass jar and an airtight cap to seal it, with 4 ports that could be used to inject or remove chemicals from the jar. Again, tests proved successful when our model car was racing along a desk in the lab with a breakneck speed of about 1 km/h. Now that we had our proof of concept, dreams began to take shape of building an actual car that drives on Formic Acid. To accomplish this, a lot of work would need to be done, more than the ten of us could do in less than half a year.

The decision was made to become a student team at the university's strategic area 'energy', posing ourselves the challenge of building world's first Formic Acid car that we would then be able to drive across Europe, visiting universities in multiple countries. This would hopefully provide us with the manpower and time required to bring about the world's first Formic Acid car. The time that remained us before team FAST activities would start in September could then be spent writing a feasibility study, arranging our subscription

as a student team, optimizing our computer model of the car and reactor and, last but not least, to try and get someone to sponsor us a hydrogen car. Because our innovation is actually an adaption to an ordinary hydrogen car,

Now that we had our proof of concept, dreams began to take shape of building an actual car that drives on Formic Acid.

we thought it would save us a lot of time if we do not need to build the entire car ourselves.

Let's be honest: the prototype doesn't look like much. We figured we would need to show something better before we could convince someone to sponsor us something as big as

a hydrogen or electric car, so that's what we are working on at the moment. The second version of the Formauto, Formauto Junior is bigger than the first one; it is a model car with a length of about one meter. It is remote controlled and looks more streamlined than the prototype. By showcasing this new, more elaborate model car we hope that we can find a sponsor willing to provide us with a car we can then modify.

The innovation of this car is the use of Formic Acid, which makes it a chemical challenge, however the electronics are very important as well; if the reactor becomes too hot, the reaction will not be very efficient. In addition, the energy management of the car is important since you don't want to charge your battery for 100% disabling the chance of getting back some energy from regenerative braking. Another challenge is measuring the fluid level of the tank filled with Formic Acid. Most of the sensors cannot stand Formic Acid, so measuring from the outside of the tank will be necessarily, however, this will impose some challenges as well.

If you would like to help us build the world's first Formic Acid car, give us a shout! We could still use some additional members on our team. As a member of team FAST you will work in a multidisciplinary environment; members are spread among almost all different faculties of the TU/e. When everyone makes his/her own unique contribution to the process, one really learns to appreciate what others have to offer.

For more information, you can visit our website: www.teamfast.nl ∎

Team FAST (image courtesy BvOF)

58th Dies Natalis of Thor

By: Niels Vertegaal

Thor was founded on the 28th of November 1957. This year we turned 58 years old, which had to be celebrated accordingly with a week full of activities. As every year, there was a Pie Reception on Monday to open the festive week of the 58th Dies of e.t.s.v. Thor, with over 50 pies, ranging from fruit to chocolate. All the staff of the department and all the members were invited to get a piece of pie and coffee or tea. The rest of the week was filled with various and diverse activities.

[ACCI] Tag

After the great speech by the chairman of the Dies committee, it was time for the ACCI to start the ACCI TAG, also known as the Thor Assassination Game, in which each player has to 'kill' his target: a fellow TAG participant, who is assigned by a card with the name and picture on it provided by the ACCI. By hitting your target with your weapon you earn points and you take over his target card. Where previous years there were two teams containing all TAG participants and everyone had to work on their own target card individually, this year it was all different. New building, new ACCI, new rules, new weapons! Everyone had to enroll in pairs and each pair got a sword and a bow, but still only one target card. Since in Flux there are quite some non-shooting zones because of openness of the building, this would make it more fun. The battle kept on going for the whole week in hallways and lecture rooms, with thankfully Het Walhalla and the Board room as safe zones. The winners received a special limited edition TAG Walhalla beer card to celebrate their victory.

Cantus

Everyone remembers their Freshman Weekend at Thor, which starts with an amazing cantus. That's why also this Monday evening was filled with a cantus. With our great 'praesidium', consisting of John van Weerdenburg, Manon Eijsvogel, and Thomas Woudsma, it was a great evening. This year they had the very hard task to lead the cantus and maintain order in the corona. This succeeded with enough, very original, punishments, some bad enough not to be discussed here. With a constant singing and enthusiasm the evening came to an end. Everyone had a lot of fun and had certainly wet their whistle.

Heimdall Movie Presentation

And then it was Tuesday, the second day of the Dies week, which started in Het Walhalla with the movie presentation of Heimdall. This committee was set up a few years ago to film the life of Thor in our old building Potentiaal, so the later generations can see how Thor lived in in the old building. Of course it was fun for everyone to see the best moments of the previous year.

With some popcorn, chips and a free drink for everyone, the movie began, with fragments ranging from the candidate board getting thrown into the water to seeing the old brown dark Walhalla in the basement. Everything was there and the reactions were very positive. When it is exported completely, it will become available for everyone who missed the presentation. So don't worry!

Cartoon Drawing Workshop

After seeing how a 'professional' movie is made, it was time to make some professional cartoons. With a small group of around 10 people including 2 people of the EM capacity group, it was time to get drawing. Our own Elles Raaijmakers stood in front of the class explaining concepts, how to get creative and how to do the drawing itself, after which it was time for us to start working ourselves. Quickly it became clear who already had some experience and which people had no idea what to do. The latter group needed more time, but in the end everyone was completely busy. All kind of jokes were transformed into cartoons. Where the secretaries made jokes around words, the other people were busy with inside jokes.

Shell

At the crack of dawn, around 15 students left for the excursion to Shell at Moerdijk on wednesday. After a short nap in our comfortable bus, we arrived at Shell and were greeted warmly. After a thorough instruction of the safety procedures, the presentations started. The informative presentations were about functions within Shell, building a career and the application procedure for students. During lunch we had the possibility to have informal conversations with employees about their experiences. After lunch, it was time for the most exciting part of the day, the tour around the plant! In our cool safety uniforms we visited the control room of one of the plants and went into a plant. Everything was so gigantic! At the end of the day, we drove around the whole terrain and we even saw the destroyed reactor that exploded last year. The trip to Shell was definitely a great success!

Archery Clinic

With the ACCI TAG coming to an end, there was a possibility to practice your bow-and-arrow skills during the archery clinic organized by E.S.H. Da Vinci. It started off as a competition between the participants in which the losers had the possibility to shoot balloons. The popping balloons had to distract the participants, which did not work unfortunately. The winner of the tournament received a self-brewed E.S.H. Da Vinci beer.

Dies Party

One of the biggest events of the week is of course the Dies party. Het Walhalla was completely filled with people and with every hour a free keg of beer the party was really great. This year the theme was 'Cartoons', so the committee was dressed as Popeye, Olive, and Totally Spies. The President being dressed as a Vampire was quite a fun surprise to our managing director, as well as the music, which came from cartoons that were over 20 years old. The committee, consisting of members of the previous Board, traditionally arranged shots in their Board colors, and with a mobile snack bar outside there was also enough to eat for everyone who wanted to stick to the party to the very end. Of course in this new building it was also possible to go to the Spar, if the snack bar was not healthy enough.

Hangover Breakfast

Friday morning, it was very quiet at floor six of Flux. Everyone was still sleeping with the feeling of having had a great party in their head and stomach. Not only the Dies Party, but also the after party in the o-so-famous Santé had taken their toll. Of course the ACCI was already awake and busy preparing a delicious hangover breakfast. This year there were not only fried eggs, juice, bacon, cheese and jam, but also pancakes! Delicious brown pieces of baked dough, great choice. People coming to the hangover breakfast were visibly 'damaged', but after the great hangover breakfast they left full of energy.

Oude Bokkenborrel & Dies Dinner

The week had to end somewhere and what better moment than a Friday evening! Starting off in Het Walhalla, with a free keg beer during the 'Oude Bokkenborrel'. Former Board members and (former) active members visited Het Walhalla to congratulate the new Board with Thor's birthday. For most of them it was a new experience: Flux, Het Walhalla again, and the new Board room.

After the clock hit 7:15h and the bus finally arrived, we drove off to 't Boshuys. After the bus driver drove past the location and had to turn around, we could enter the restaurant. The restaurant was fully capable of handling the more than 80 people that enrolled. There were not only older people, as also some first and second year students enrolled! During the dinner, one of the older Board members was getting sleepy and after falling asleep, face first, in his food, he was brought home to get some rest.

After the speeches, the dessert, and the many bottles of wine, it was time for the final part of the night: we ended our week of festivities at some drinks and some dancing at De Vooruitgang. After all it was a great week, with many great activities. As chairman of the organizing committee, I would like to thank all the participants and hope that everyone had a great week. ∎

Het NS Techniek Traineeship

Door: Felix Corbeij

Toen ik na mijn opleiding ging solliciteren had ik drie wensen: ten eerste wilde ik in mijn baan met elektrotechniek bezig blijven, daarnaast leek het me vanwege eigen interesse erg leuk om bij een spoorgerelateerd bedrijf te werken en tot slot wilde ik graag bij een groot bedrijf werken vanwege de vele mogelijkheden die dit biedt. NS sloot perfect aan op deze drie wensen en daarom heb ik hier via de website werkenbijns.nl gesolliciteerd voor het Techniek Traineeship.

Het Traineeship

Als techniektrainee kom je op een technische functie terecht die goed bij je past. Meestal is dit bij het deelbedrijf van NS, NedTrain. Dit is het onderdeel van NS dat verantwoordelijk is voor het onderhoud, de reparatie en de revisie van het rollend materieel. Vanwege mijn elektrotechnische achtergrond kwam ik hier terecht op de afdeling die technisch advies geeft op elektrotechnisch, werktuigbouwkundig en pneumatisch gebied. Meestal betreft het een advies over de hele vlootbreedte. Een fictief voorbeeld hiervan: wanneer treintype x met een bepaalde snelheid rijdt zijn er veel meldingen van een brommend geluid in de omroepinstallatie. Wat is hier de oorzaak van en hoe kan dit worden verholpen?

Je krijgt dan de kans om diep in de systemen te duiken, metingen te doen, contact te zoeken met leveranciers, na te denken over verschillende oplossingsrichtingen en de oplossingen in de praktijk in het materieel op de proef te stellen.

Theorie en Praktijk

Ik vind de combinatie tussen theorie en praktijk erg leuk. Ik ben niet iemand die de hele week op kantoor wil zitten. Het is leuk om de ene dag op kantoor een complex vraagstuk uit te werken, zoals hoe een oude analoge regeling omgezet kan worden in een digitale regeling, terwijl je de volgende dag in de werkplaats zit om metingen te doen aan deze analoge regeling. Ook heb ik regelmatig contact met monteurs om te bespreken hoe zij een systeem gebruiken en wat ze ervan verwachten. Het leukste moment is aangebroken als je na een hele tijd hard werken zelf een prototype van je eigen product kunt gaan testen in de werkplaats.

Een Gevarieerd Bedrijf

NS is een mooi bedrijf om voor te werken. Persoonlijk vind ik de enorme verscheidenheid aan werkvelden erg leuk. Ondanks dat ik er niet direct mee bezig ben, kom je er bijvoorbeeld al snel achter hoe complex het is om alles logistiek te regelen. Niet alleen de dienstregeling van de treinen, maar bijvoorbeeld ook de goederenstroom met alle onderdelen.

Tijdens het traineeship krijg je de kans om bij allerlei bedrijfsonderdelen mee te kijken. Je kan bijvoorbeeld een kijkje nemen bij de materieelbijsturing, een dag meelopen met een monteur en een conducteur of reizigers een dag te woord staan op Schiphol.

Ook niet onbelangrijk is dat er prima secundaire arbeidsvoorwaarden zijn, zoals vrij reizen in Nederland en heel goedkoop in de rest van Europa.

Persoonlijke Ontwikkeling

Er is veel aandacht voor persoonlijke ontwikkeling binnen het traineeship. Een aantal keer per jaar is er een cursusdag, gegeven door een externe organisatie gespecialiseerd in trainingen, waarbij onderwerpen als presenteren of overtuigen aan bod komen. Deze cursusdagen zijn heel goed georganiseerd. Hetzelfde bedrijf organiseert ook een aantal intervisiebijeenkomsten waar je een casus met andere trainees kan bespreken. Daarnaast heb je regelmatig een gesprek met je leidinggevende over je voortgang en krijg je twee maal per jaar een beoordeling waardoor je snel feedback krijgt op je functioneren en daar ook gericht mee aan de slag kunt. Tot slot krijg je een mentor. Dit is een manager van een heel ander bedrijfsonderdeel, waarmee je alles in vertrouwen kunt bespreken.

Het Selectietraject

Als je wil solliciteren, moet je als kandidaat enkele stappen doorlopen. Te beginnen met je CV en motivatiebrief, gevolgd door een online assessment en – mits deze positief is beoordeeld – een eerste sollicitatiegesprek. Hierna volgt nog de selectiedag. Nadat je alle stappen met een positieve beoordeling hebt doorlopen, kun je aan de slag als techniektrainee! ∎

Hybrid 3D Electromagnetic Modeling

By: Kevin Pluk

In the constant urge of obtaining more accurate high-precision systems, dual-stage positioning systems are the state-of-the-art. These dual-stage systems consists of two movement stages, one for the large movements and another one used for obtaining the desired accuracy. Ideally, these two stages can operate independently, however, the magnetic fields that are used in both stages are interconnected, resulting in an undesired coupling between the two stages, and consequently, a reduced accuracy of the dual-stage system. The electromagnetic coupling between the two stages is significantly reduced by applying magnetic shielding. However, the predictability of the magnetic fields inside the full system is significantly reduced as well. A novel electromagnetic modeling method for a fast calculation of the magnetic fields present in a shielded dual-stage positioning system was therefore investigated.

Introduction

In the Electromechanics and Power Electronics group, a very broad knowledge of various analytical and numerical electromagnetic modeling methods is present. Therefore, it is not a surprise that ASML contacted the group in light of its challenges of the electromagnetic field modeling of their shielded dual-stage positioning system. In the lithographic machines of ASML, a dual-stage positioning concept is applied to ensure the large movements of the wafer underneath the lens, with the required accuracy. The large movements in the system are supplied by a moving-coil planar actuator with six degrees of freedom. The planar actuator consists of large permanent magnet Halbach array, above which, based on repulsive forces, a set of coils is floating. The movement range of this long-stroke planar actuator is approximately 1.5 m, while the required accuracy for the lithographic process is within 10 nm. As you can imagine, it is very difficult to obtain this range of movement with this accuracy in a single stage. Therefore, a set of short-stroke actuators is placed on top of the moving coil array of the planar motor. These short-stroke actuators are intended for only a mm stroke, while their controllability and predictability are designed for an accuracy in the order of one nm. An illustration of the full system is given in Fig 1.
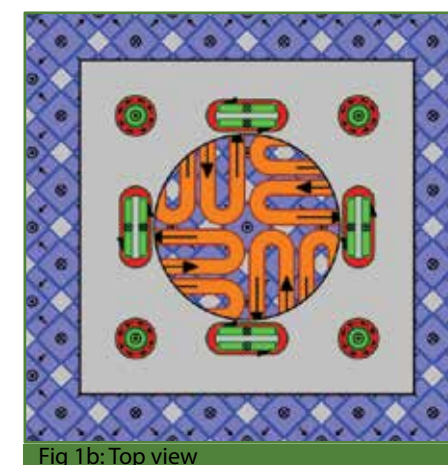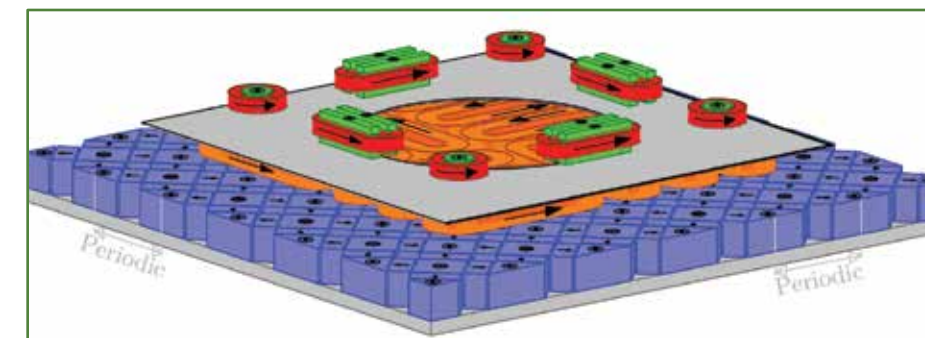

Fig 1a: Example of a shielded dual-stage planar positioning system. (a) 3-D view

The working principle of the long-stroke actuator is based on a nice sinusoidally shaped magnetic flux density that is originating from the permanent-magnet plate. Unfortunately, this sinusoidally shaped magnetic field is completely unbounded (in space) and is, therewith, not confined to the volume of the long-stroke actuator itself. A decent amount of magnetic stray-field that is originating from the long-stroke actuator (both the permanent magnet plate and the coil array) is present at the location of the short-stroke actuators. Consequently, the performance of the short-stroke actuators is significantly influenced by this magnetic stray-field.

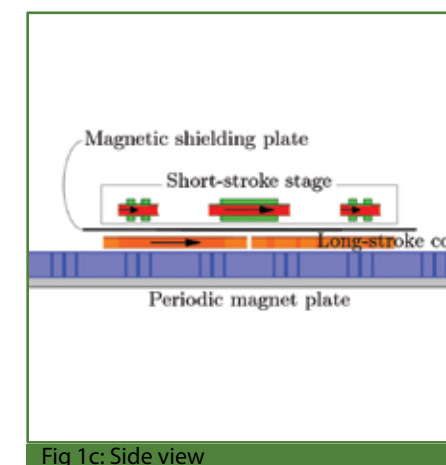To reduce the influence of the magnetic stray-field on the performance of the short-stroke actuators, only two considerable options remain: either predict the influence of the magnetic stray-field, or reduce the magnetic stray-field itself. In principle, it is possible to predict the magnetic stray-field at the location of the short-stroke actuators using a conventional numerical method (i.e. finite element analysis), and afterwards, compensate this influence with your short-stroke actuators. However, for an accurate prediction, the full system should be taken into account (the complete wafer positioning module) for each possible combination of positioning of the long-stroke and the short-stroke stage, and for all possible current combinations in the long-stroke coil array. This option would be too time consuming, especially in the light of the very long calculation times required for the numerical 3-D analysis of this system. In light of the second option (i.e. reducing the magnetic stray-field itself), the easiest solution would be to add a magnetic shield in-between the two stages and, therewith, reduce the coupling between these two stages. Unfortunately, the presence of additional high-permeable material (the material used for the magnetic shielding) has a significant influence of the magnetic field shapes and strengths of both the long-stroke and the short-stroke actuators. Asides, the ideal magnetic shielding (a thick, solid piece of high-permeable material) cannot be applied, since there are cable entries necessary in the shielding, and the full weight of the shielding (and its attraction force towards the permanent magnet plate) should be carried and compensated by ▶

Fig 1b: Top view

Fig 1c: Side view

the coil array of the long-stroke. In the current lithographic machines applied by ASML, a thin sheet of high-permeable material is present between the two positioning stages to reduce the magnetic coupling between these stages (see Fig 1). The application of the magnetic shielding has two down-sides: the predictability of the magnetic fields is significantly reduced (in general, the amplitude is reduced, however, the direction and local magnetic field strength are difficult to predict), and the time required for magnetic field calculations using numerical 3-D analysis is even further increased.

Magnetic field modeling

Ideally, a modeling method should be found, formulated or created that is significantly faster (over four times) than the currently applied numerical 3-D Finite Element Analysis models, while the modeling can cope with the complexity of the shielded dual-stage planar actuator structure. From a short exploration of various analytical and numerical modeling methods, no modeling method was found that could full-fill both requirements. Based on the analytical basis of the Fourier modeling method and the strong periodic structure of the permanent-magnet plate, this method gave the most promising results of the reviewed methods and it was decided to dive more deeply into this modeling principle.

Within Fourier modeling, the magnetic flux density is described based on a superposition of various spatial harmonics. Due to the presence of a periodicity in the modeled structure, only the fundamental spatial harmonic that complies with the periodicity and its higher harmonics are required for an accurate description of the magnetic field. By calculating the right amplitude for the various frequencies (with their corresponding exponential increase
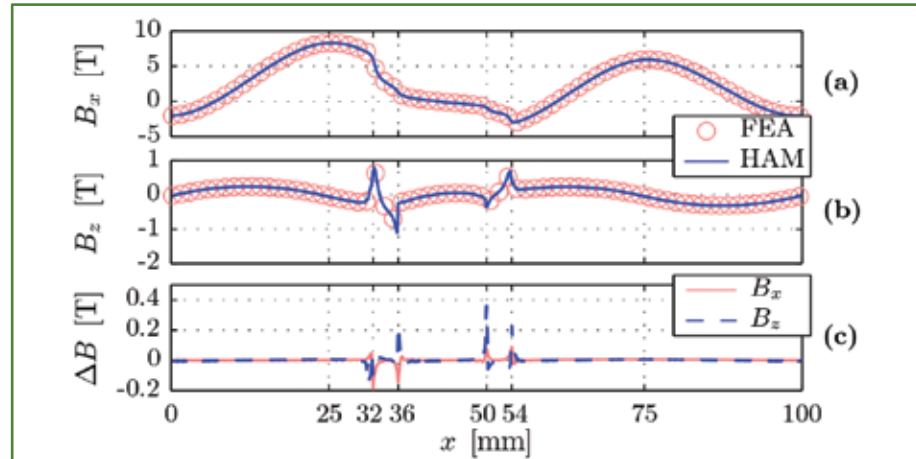

Fig 3: Magnetic-flux density in the middle of the shield of the situation shown in Fig 2, calculated with the analytical model and the finite element model (FEA)

or decrease in the non-periodic direction) the total magnetic flux density distribution in the structure is given.

To get an idea of the complexity of the modeling and the possibilities, the Fourier modeling method was firstly applied for two-dimensional situations. The first results of this modeling methods were already obtained in the first few months of the research. Unfortunately, to comply with the complexity of the shielded dual-stage planar actuator, the modeling method should be able to incorporate pieces of material that are differently sized compared to the periodicity in the structure. To allow for this option, the Fourier modeling method was extended with the mode-matching principle.

By including mode-matching into the Fourier modeling, the various regions with a different fundamental spatial frequency are combined. In principle, the magnetic flux density distribution that is calculated on the boundary of region 1 is described by the superposition of the fundamental (and higher-order) spatial frequency of

region 2. By matching these descriptions on the boundary between the regions, the magnetic flux density distributions in both regions are connected.

With the application of the mode-matching algorithm, and investing quite some time in optimizing this modeling method, various 2-D electromagnetic structures were calculated (see Fig 2 and 3). Unfortunately, at a certain point it was realized that a 2-D description, was far from sufficient to describe the 3-D electromagnetic fields of the planar actuator. Even tricks like superimposing various 2-D models or applying 2.5-D modeling did not give the required results. The only plausible option is to extend the Fourier modeling with the mode-matching into a 3-D modeling itself. Even though the Fourier modeling is extendible to a 3-D modeling, the 3-D mode-matching algorithm has such a significant influence on the magnetic-flux-density distribution, that an accurate description of a shielded dual-stage planar actuator is far from possible.

"Realizing after more than two years into your PhD that you spent the last two years wandering on a path that has a dead end, is a serious throw-back for your motivation and inspiration. However, looking back, I really needed the experience of the first two years of my PhD to obtain the results with which I finalized my PhD. Both from modeling and from personal point of view."

Being back at square one, still the Fourier 3-D modeling was the best suited candidate. However, an alternative modeling method for describing the small pieces of high-permeable material should be found. By combining the 3-D Fourier modeling with 3-D magnetic equivalent circuit modeling, a novel 3-D Hybrid Analytical Modeling (HAM) method was formulated. The experiences gained
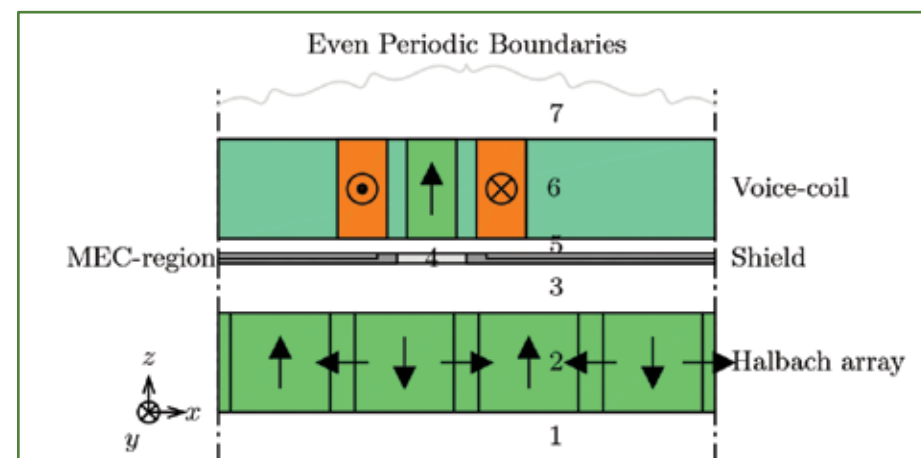

Fig 2: Outline of a 2-D geometry calculated with Fourier modeling extended with mode-matching
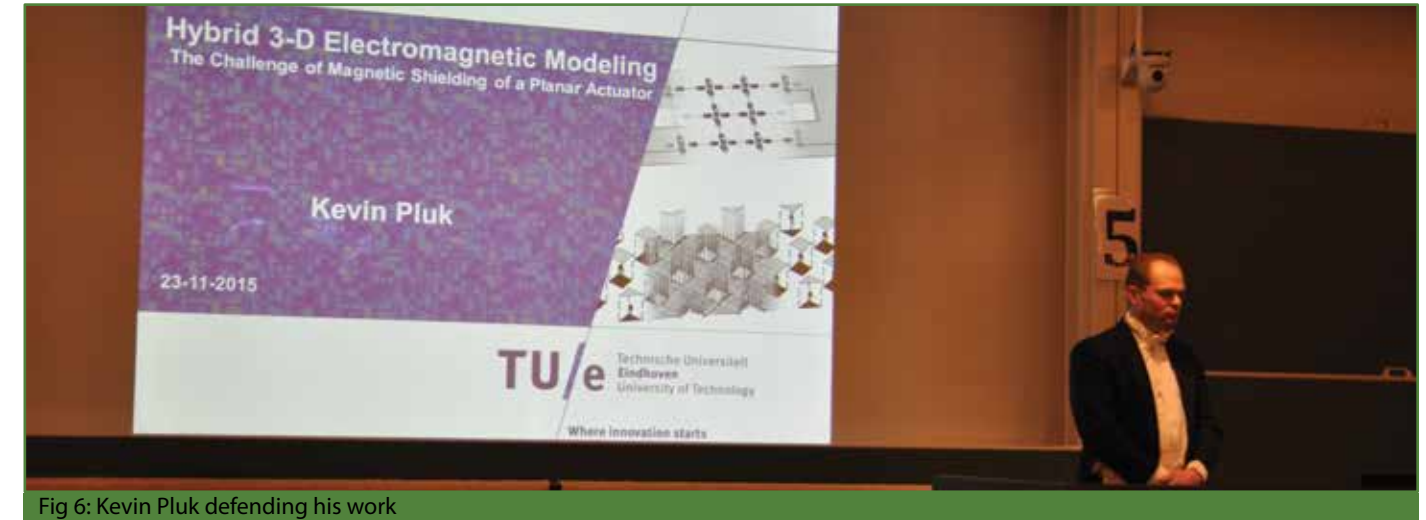

Fig 6: Kevin Pluk defending his work

with the Fourier modeling from the first two years were put into practice, resulting in only a short lead-time till the conceived modeling method was working.

Results

The 3-D HAM method allowed for a fast and thorough prediction of the magnetic flux density distribution in various situations. The ultimate test was formulated to compare measurement results on a test-bench present within ASML with the obtained modeling results. Within this test-bench it was possible to measure the forces on a part of the short-stroke actuator due to the presence of the long-stroke magnet plate and due to the currents in the long-stroke coil array. The situation used in the measurements is illustrated in Fig 4, for which the magnetic-flux-density distribution has been calculated using the novel 3-D HAM.

In the performed force measurements on the supplied test-bench, two large deviations where found between the developed model and the measurements. First of all, in certain measurements a large deviation (>100 %) was visible. This deviation was caused by
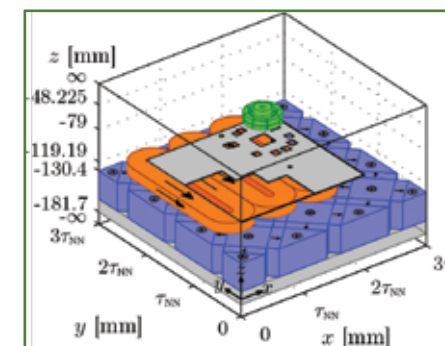
the (undocumented) presence of a shell of magnetic material around the measured object.

"The first challenge in comparing a model with a measurement, is to determine what the actual topology is that you are actually measuring, especially if you did not design the test-bench yourself. For me, this resulted in many headaches, and finally it required initiating new tests on a different (self-designed) test-bench during the finalization of my thesis."

Secondly, the saturation of the magnetic shielding plate has not been included in the modeling, while this is significantly influencing the measurement results. As can be seen from Fig 5, the force obtained with the 3-D HAM are accurately followed by the results of the 3-D FEA with linear shielding material. Asides, the force of the measurements is precisely described by the 3-D FEA with nonlinear shielding material.

Despite of the deviations found, the 3-D HAM model results in an accurate prediction of the amplitude of the disturbance forces (≤ 10 %

deviation) on the short-stroke actuator with respect to the measurements. A significant reduction of the calculation times is found by applying the 3-D HAM instead of the conventional numerical 3-D modeling, a reduction of 10-20 times has been obtained.

Closing

The scientific work has resulted in a novel class of 3-D electromagnetic modeling methods, with a great potential in various applications. The modeling proved itself on the complex structures of a shielded dual-stage planar actuator of ASML with more than a factor of ten reduction in calculation time and was defended cum laude on November 23, 2015 (see Fig 6).

"In retrospect to my PhD-research there are so many things I learned the past four years. Aside of the obvious learning points with the knowledge of the modeling and the experience with the implementation and measuring, especially the change in personality and the way to tackle the next challenges are the learning points that I deem the most important." ∎

Fig 4: Full measurement situation with the permanent-magnet array, coil triplet, shielding plate with square holes and the short-stroke actuator
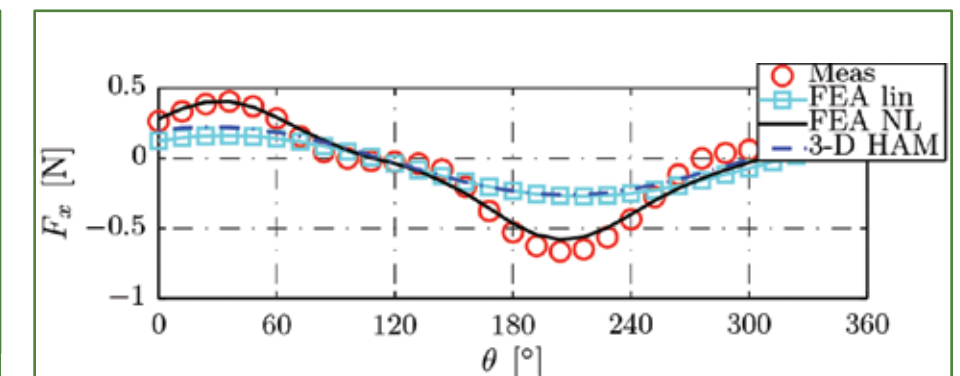

Fig 5: Force on the moving part of the short-stroke actuator, for a variation of the current phase in the coil triplet

Internship Down Under

By: René Baelemans

Like many students before me, I also decided to do my internship abroad and decided to go to Perth in Australia. After a 24-hour-long trip, I arrived completely alone at the other side of the world and was feeling equally nervous and excited for my adventure to come. Let me share my story with you.

The city of Perth

Perth is the capital of Western Australia and has about two million inhabitants, making it the fourth largest city of Australia and by far the biggest city of the west coast. Since it has a lot of suburbs and only a small densely populated city center, Perth does not have a big-city feel. It is known to be one of the most isolated cities in the world. Although this may seem like a disadvantage at first, it means that Perth has nearly everything to offer one can ask for, almost being a small country in itself. The very mild Mediterranean climate made my stay very pleasant, even during winter time at the southern hemisphere.

History

Dirk Hartog and later Willem de Vlamingh, both employed by the Dutch East India Company (VOC), were the first Europeans to explore and charter the Australian west coast, which they named 'Nova Hollandia'. Part of this Dutch connection can still be found in present-day Western Australia. Rottnest Island was for example named by Willem de Vlamingh, who called it 'Rotte nest', Old Dutch for rat's nest, after its quokka population. These quokka are a real tourist attraction, and also I couldn't resist to leave Rottnest with a 'quokka selfie'. Several other landmarks of Western Australia still have got a distinct Dutch name. The shipwreck of possibly the most famous Dutch vessel, the Batavia, can be found in a West-Australian
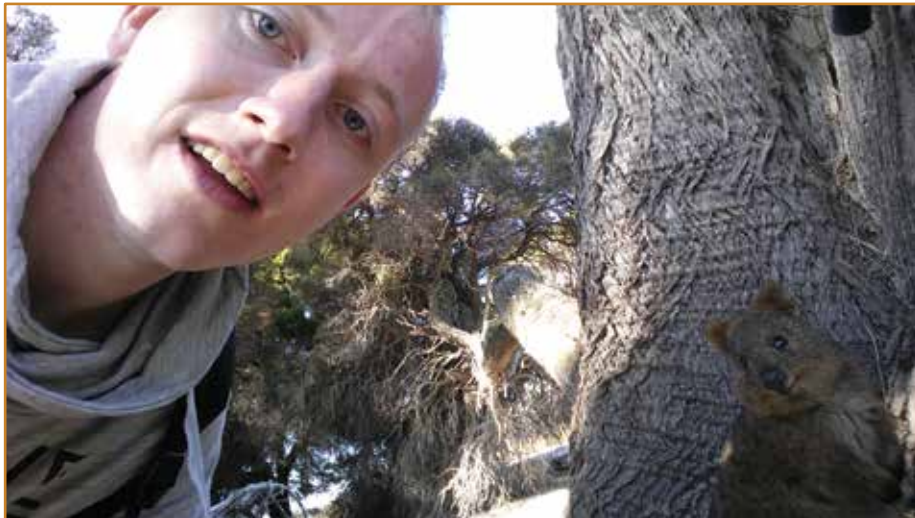
Museum and a replica of another Dutch ship, the Duyfken, can be found in Perth's harbor port of Fremantle.

My internship at Curtin University

I did my internship at the Curtin-University node of the International Centre for Radio Astronomy Research (ICRAR). Curtin University is a big university with almost 50,000 students divided over several campuses, but the institute I was working for was much smaller. ICRAR employs both engineers and astronomers, which allowed me to pick up the basic principles of (radio) astronomy throughout the different lunch lectures, colloquia, and even a conference.

The goal of my internship assignment was to model and understand the polarization properties of a certain type of antenna, the so-called dual-polarized inverted-V antenna, which is commonly used in phased-array radio telescopes. A phased-array-based telescope is made up of a large number of antennas. The response of each of these individual antennas is combined and weighed such that the radiation from only a single point in the sky constructive adds up. Although the assignment was a bit challenging at first, I have managed to get some interesting results out of my internship. My work was part of the international effort to

create the world largest radio telescope, the so-called Square Kilometre Array (SKA) (www.skatelescope.org).

I have had the opportunity to spend a week at the Murchison Radio Observatory (MRO), situated in the middle of the West-Australian desert. The MRO is home to the ASKAP and MWA telescopes and will also host the low-frequency part of the SKA telescope in the future. The MRO is part of the Murchison shire, a region the size of the Netherlands while it has only 114 inhabitants. I was lucky enough to go to the MRO during winter time when the temperature there was still very pleasant. This deserted region is also ideal for star gazing. Unfortunately, I only had one unclouded night to watch the stars, but it was certainly worth it.

Easy living

The general lifestyle in Perth is more relaxed compared to the lifestyle in the Netherlands. People don't seem as rushed as people in the Netherlands are and are easy to say 'no worries mate'. This can be very pleasant but also be very annoying, for example when you have to travel by public transport and your bus once again doesn't show up. People in Perth are very friendly and eager to help out someone who is new to the city. It also surprised me how early people normally wake up and go to bed; the city center could feel completely deserted after 9pm on a weekday, which is however greatly compensated during the weekends. People wake up so early because it is the only time of the day to go outside during the mid-summer heat.

Exploring the scenery

During my six months stay I have had plenty of time to explore the city and its surroundings. Perth itself has several big parks of which Kings Park is the biggest and most popular
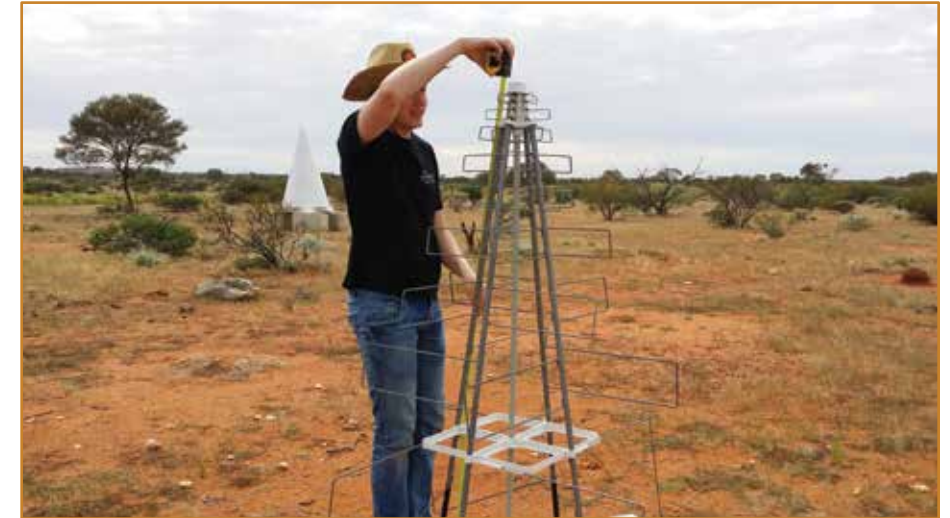
one. Almost every city park has free to use barbecues such that people can have their beloved Sunday-afternoon 'barbie'. The wildlife parks outside Perth are ideal for longer walks and/or hikes and give you an occasional run-in with a kangaroo. Having seen tons of beaches during my time in Western Australia, I am now convinced that every part of its coastline is a deserted white-sand beach with clear blue water.

I also made a longer trip to the south together with an intern from the University of Twente and a Dutch colleague. During this trip we went for a whale-watching tour and managed to see a few of them up close. We visited Leeuwin-Naturliste National Park including two of its famous caves; Mammoth Cave and Jewel Cave. Another trip took us up north where we visited the Pinnacles, limestone formations found in the desert near Cervantes, and to the sand dunes of Lancelin.

I have already mentioned seeing kangaroos, quokka's and even whales during my time in Australia. Maybe the most famous animal of

Western Australia is the black swan, which can be found on the state flag and can be seen in the Swan River, which runs through the middle of the city. I once even saw some dolphins swimming by while I was biking along this river, and was able to get within a few meter of them. My relation with the birds wasn't as good as with the other animals, whether it was being attacked by a breeding Magpie or getting awakened early in the morning by an Australian crow or a Kookaburra. They weren't fond of me, and this feeling was soon mutual.

A great experience

In the end, I spent an unforgettable half year full of new experiences on the other side of the world. I even liked it so much that I will return to Perth for another three months this year. For those still in doubt whether or not they should do an internship abroad, like I was in doubt before I did mine, I would always advise to seize this opportunity to travel and gain new experiences. ■

An internship at ARM

By: Glenn Bergmans

Spend 5 minutes telling a professor you're looking for an internship, and three months later you're on your way. I got an offer to do my internship at a research group of ARM in Cambridge. Needless to say I was rather excited. I started my internship at ARM last November and it's been quite a ride.

Even though the flight is shorter than the train to Utrecht, Cambridge feels like a different world. Cambridge is a beautiful city, about half the size of Eindhoven, which is primarily dominated by the university, about twice the size of the Eindhoven University of Technology. It has a lovely city centre, with more coffee houses, luxury shops and Subways than you'd expect given the size.

The first weeks

People that know me a little, will agree that I tend to have quite tight schedules. Naturally the start of my internship was no exception. Where I was still emptying my room in Eindhoven on Saturday, I arrived in Cambridge on Sunday morning. After an extensive walk around in Cambridge, I spent the night at a hostel, just so I could show up at ARM the next morning. This was not my official start, but I did do quick introductions with the team. The rest of Monday I spent looking for housing, which I miraculously found and moved into Monday evening. Tuesday I had my first full working day at the office, which was only 5 days after signing the contract. Fortunately I had Tuesday evening off and I'm glad that it all worked out pretty well.
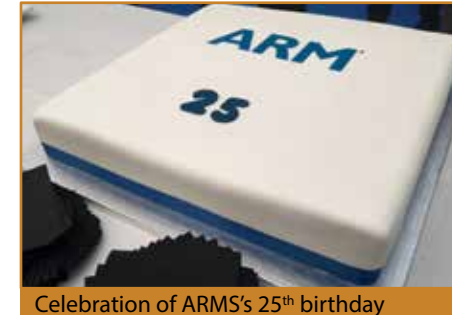
It soon turned out that I had chosen one of the best moments to join ARM imaginable. Within two weeks of my start, ARM turned 25

years old and this was well celebrated. Not only did everybody at ARM get a full day off from work, there also was a party, fireworks and a bottle of champagne for everyone. Hardly weeks after these festivities, there was a huge Christmas party, themed 'The Seven Wonders Of The World', with different styles of music, dance and entertainment in every one of the seven different gigantic rooms.

My assignment

ARM is well known for their processor designs, however they make and sell more designs, like memories and GPUs. My initial assignment at ARM involves an open source hardware simulator: GEM5. Unlike most simulators, this simulator is not aimed at very detailed models of hardware components. GEM5 is used to run full system simulations in order to identify bottlenecks and point out improvements for the entire system. This way they know where to place caches, how to dimension memory busses, what improvements a certain GPU gives the entire system, et cetera.

GEM5 is able to simulate full systems and as such the simulated system runs Linux (including GUI) and Android. The problem here is, that the Linux kernel somehow needs to know what hardware it is running on. For these systems it used to be that if the hardware changed, the kernel needed to be recompiled with the headers that add support for that hardware. However, modern kernels can be equipped with something called a 'Device Tree Blob'. This is basically a flattened tree structure, a list if you will, of all devices in the system and what they look like.

Running simulations on different systems, say adding extra CPUs or changing the memory sizes, is a tedious process. Each time the system changes, the device tree has to be rewritten in accordance with the changes. I was asked to equip the simulator with the ability to automatically generate the device tree blobs, so that this takes out a tedious step in the simulation process. At the time of writing this, the code is already in final stages of review. In the mean time I started to rewrite the configuration and system specification code, making them more easy and more versatile to use. After that, I am going to use both of these systems in order to do some simulations on power usage versus performance analysis in new, cutting edge ARM system designs.

My stay here is of course not only about work. Cambridge has lots of pubs and restaurants, ARM has an excellent free 24/7 gym, London is around the corner and I have a weekend trip booked to Edinburgh. ARM also allows me to do a volunteering project on Social Innovation with the Cambridge University, which I'm really looking forward to. There certainly is enough to do here. Fortunately, I still have a few weeks to do everything that I'm hoping to do here. ∎

Celebration of ARMS's 25th birthday

Christmas party

Welcome gift

Spectrum of EE

By: Marieke van Beurden

The course Spectrum provides electrical engineering students with an opportunity to interview an expert and write an article about new arising technologies, sky-high ambitions of companies, and career dreams of graduate electrical engineers. This course shows first-year students what the current and future concerns of electrical engineers are. A broad overview is given of electronic technologies and their impact on the three faculty-research directions: Care & Cure, Connected World, and Smart & Sustainable Society.

Not only does the course offer the technical perspective of electrical engineering, it also focuses on soft skills, which are highly important for an engineer in the future. That is why several skills trainings, such as interviewing and writing articles, are included in the course to help students to conduct a good interview and write an article about it. One of the intermediate examinations of Spectrum is to write an article based on the interview with a young

professional, an engineer, most probably a graduate from our department. The best articles compete in a contest for the first prize.

Friday the 15th of January was the closing date of the Spectrum course. A jury selected the 13 best articles. The jury, chaired by Jan Blom, applied four criteria to the articles: content and structure of the article, lay-out and attractiveness to read, originality and attention to the interviewee's career.

Three of those articles were outstanding. The article by Panteleimon Katsis (3rd place) describes the career of dr. Gaxiola and the different paths that gave him new experiences in several fields of electrical engineering. The article by Ferenc Kandi (2nd place) stood out because of its original structure, as he writes about Huawei and focuses on the interviewee (dr. ir. Bas Huiszoon), the job, the company, and the product. The article by Robin van Steen (1st place) is about ir. Niek Eck working as a Research & Development manager for FEI. It exceeds the others because of the good storyline; that is, content-wise it is very

informative. Robin describes the company, the technology and places both in a good context. In addition, he gives insight into the career development of Niek Eck illustrated by personal quotes. That makes him the winner of the contest. He finishes his article with a conclusion that could be the conclusion of every electrical engineering student about the Spectrum course: "Seeing these pictures and walking around those big electronic microscopes really makes you think about how amazing it is how such a big machine can make such small things visible, it really makes you think about how amazing electrical engineering actually is."

The best articles have been published on http://5xea0.tue.nl. ∎

A new vector network analyzer

By: Ad Reniers

Today's keyword for new innovative communication is 'wireless', implemented in devices like your mobile phone, laptop, and even your car. With wireless communication we are able to set up an internet connection and retrieve data from satellites to determine our position. To be able to establish a reliable wireless link, new antenna concepts are necessary. These antennas need to be measured to determine

if they perform as designed. For measuring and characterizing antennas special measurement equipment is needed.

As shown in Fig. 1, a new vector network analyzer (VNA) was purchased and since this year implemented in the antenna-measurement facility on the 8th floor of the Flux building, room 8.077. The VNA works as follows. It generates a sinusoidal electromagnetic signal at port one with a specific chosen frequency between 0.01 GHz and 50 GHz. The signal is transported via cables into the anechoic chamber shown in Fig. 2, where both the antenna probe and antenna under test – a satellite dish – are situated. The antenna probe generates an electromagnetic wave that is partially received by the designed antenna under test and then transported back via the cables to port two of the VNA. It compares the received and transmitted signals and derives conclusions from the measured data. The gray pyramidal structures are absorbers to prevent reflections from the
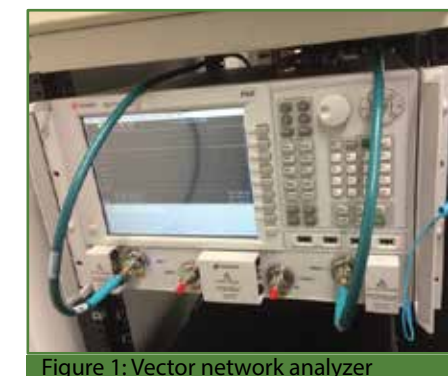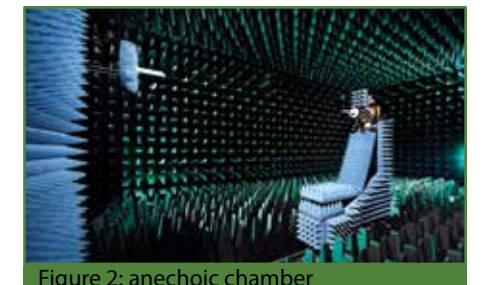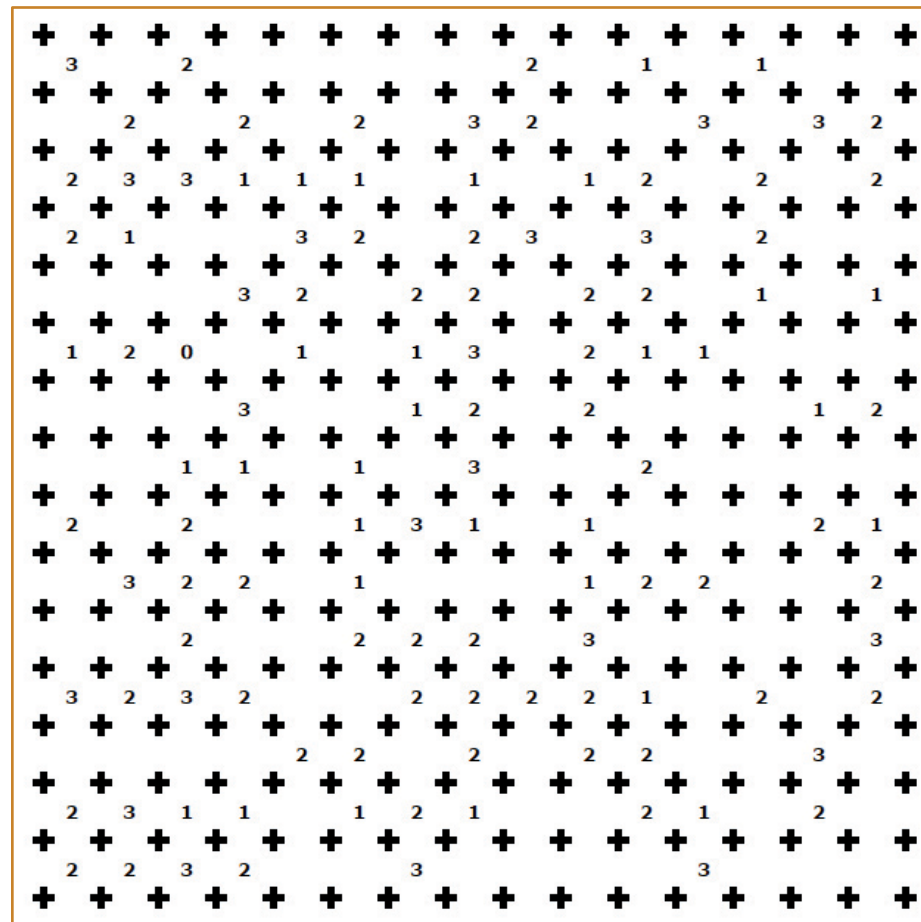

Figure 2: anechoic chamber

environment so only the direct communication between the antennas is registered by the VNA.

To be able to measure a variety of antenna designs for previously mentioned applications, this new system needs to cover the frequency range, but also provide enough sensitivity to be able to measure small signal levels. Preliminary measurements were successful and showed highly accurate measured information. With this new VNA we are prepared for future research into innovative antenna concepts. ∎

Figure 1: Vector network analyzer

Puzzle

Previous puzzle
The winner of the previous puzzle is Alec van der Linden.

Puzzle solution September edition (Connecthor 31)
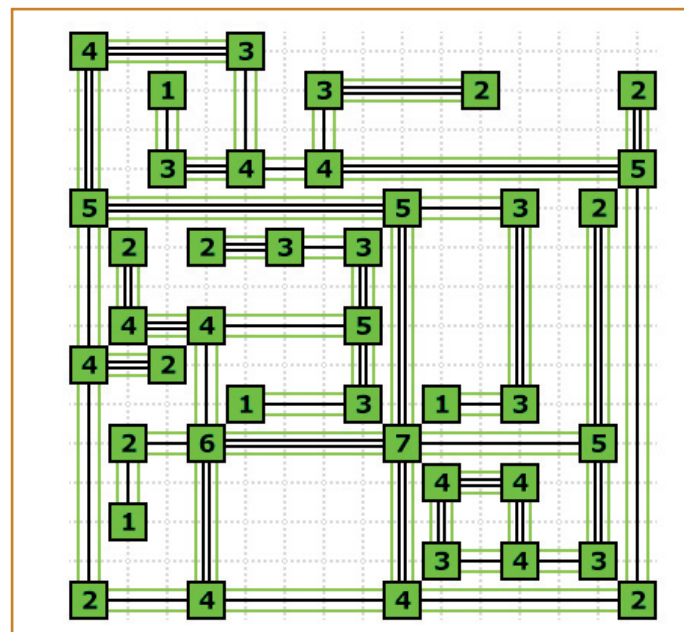
Puzzle solution December edition (Connecthor 32)

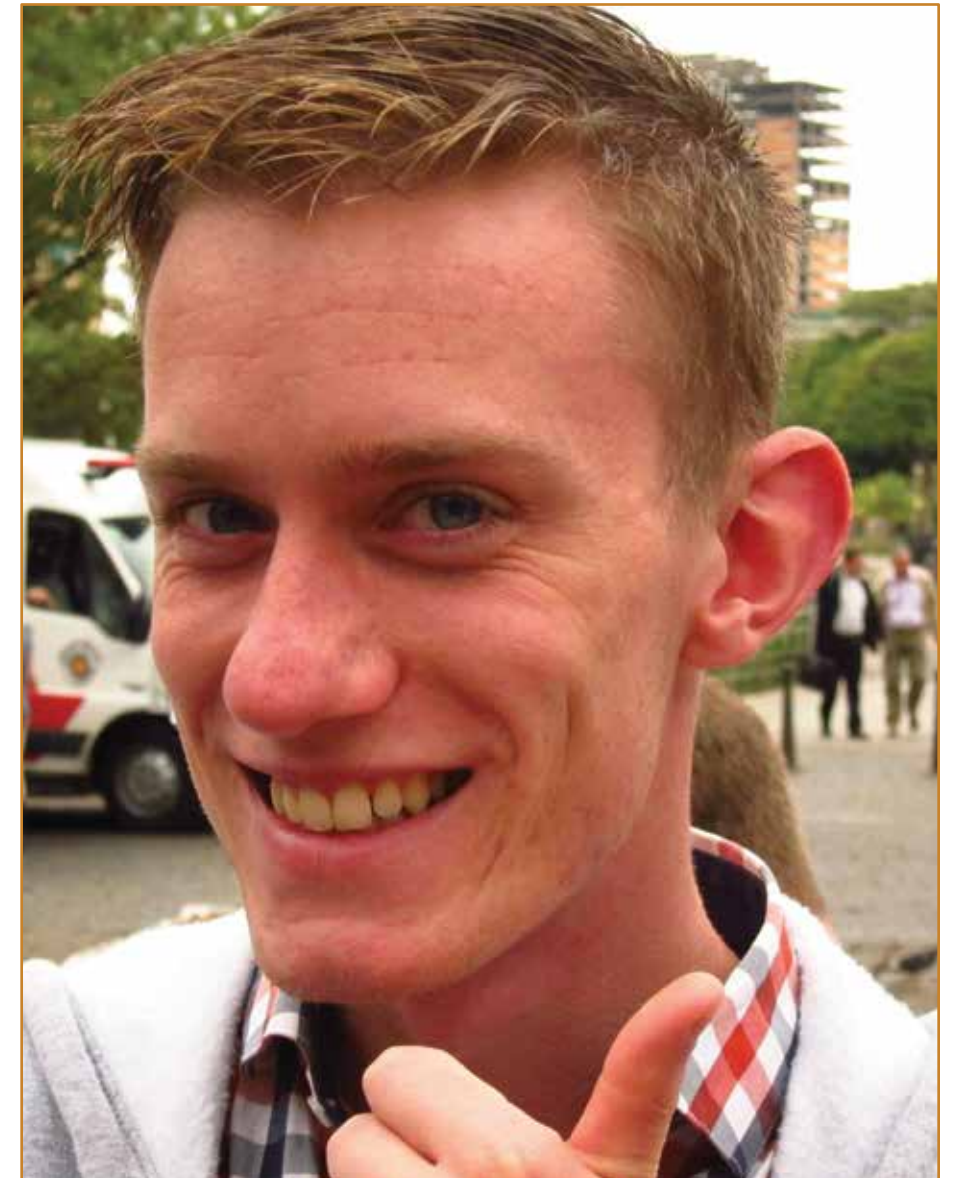# Last seen in person

By: Tom van Nunen

A little while ago, a good friend of mine said something quite interesting. It was Saturday evening and just before going to bed, he asked himself: "why don't I turn off the internet on my cellphone tomorrow?" Before I could respond, he went to sleep, so I wasn't able to make a bet. My proposal was: if he would succeed, I would buy him a beer in Het Walhalla, else he had to buy me one. He was lucky that he didn't read my message, because the next morning it quickly became clear that he would have had to buy me a beer!

Although it's just a nugatory thing, it still got me thinking. It are often the small things that make me think a lot. First of all, I started thinking about why he would even suggest such a thing. Why does he feel it's necessary to even consider switching off his phone? And is he overreacting, or is this something more people should consider doing?

During the following days, I was still thinking about the suggestion my friend made. Subconsciously I started paying attention to the cellphone use of the people around me and the people on the street. Also, I got more aware of my own cellphone use. The more people I saw, and the longer I paid attention to myself, the more it became clear to me. For many, the cellphone has become a necessary item. I even dare to state that some are unable to function properly without having their cellphone within reach.

In the train I noticed something funny. A guy was sitting in front of me and I was able to clearly see everything he was doing on his cellphone, without me having to change position or act strange. This guy obviously had a very hard time entertaining himself. After he finished checking Facebook and that kind of things, he was bored. One way or another, he felt like the only thing that he could possibly be doing in the train, was using his cellphone, so he did something remarkable; he opened a photo, start zooming in on random parts, opened the next photo and repeated this until he had to get off the train. Even today I'm still astonished by the fact that he felt like the only possible way to entertain himself was by using his cellphone.

This phenomenon can be found in social situations in a slightly different way. Whether it's during a professional discussion or informal in a bar, there are always people who, as soon as they receive a message or an e-mail, can't resist grabbing their phone right away. Some of them even pretend that they are perfectly able to continue following the conversation while they're reading from their screen. To me, assuming the phone has no influence on their capacity to follow the conversation, it still appears simply as if they don't find it interesting enough to listen to me or something like that.

I must admit that, from time to time, I'm guilty myself as well. I too experience difficulties sometimes. When I receive a message on my phone, and I'm pretty sure it's worth watching, I tend to open it on the spot. Now that I think about it, maybe this behavior is triggered by the fact that, when we send messages to people, we expect them to reply as soon as possible, preferably right away. I recognize this from one of my roommates: he tends to reply several days later, or not at all, and it can drive me crazy!

From now on, I think I will put my cellphone away from time to time, and I encourage you to do the same. I will also try to care less about delayed replies, and use face-to-face situations what they're meant for: talking to each other. ∎