



New year's **speech** | **BEP** project | DIES Thor |
Symposium Electrical Engineering | URE | **Column**

Connecthor

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Art in front of Flux, called 'Leap into the deep'.
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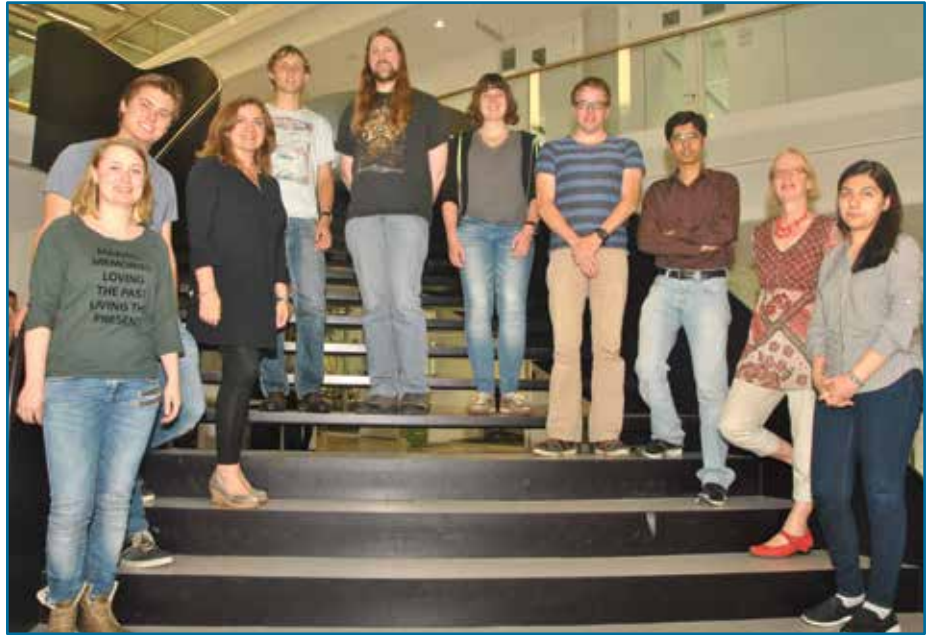
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We are already a couple of months into 2017. Even though a lot has happened in this short period of time, for instance the Symposium 2050 that was held on January 19th, we also look back at some events and happenings that took place at the end of last year. All this can be read in this brand new edition of the Connecthor Magazine.

In this magazine we remember Barbara Cornelissen, who sadly enough passed away on November 6th, when she and her husband were on holiday in Australia. Our thoughts are with her family and relatives.

During the New Year's Speech, our dean Bart Smolders talked about the highs and lows of 2016. You can read more on what he had to say on page 7.

Our vice-dean Ton Koonen is looking back on how things went globally in the domain of electrical engineering and is looking forward towards the many new challenges ahead of us. Read more about it in the Board issues.

Last year Thor organized a new event: the Fluxcursions. Three students wrote about their experiences on how it helped them choosing a research group for their Master Electrical Engineering.

We hereby take the opportunity to introduce and welcome Jan Vleeshouwers as a new editorial-board member.

Finally, the Connecthor editorial board has positions open for creative and enthusiastic (scientific) employees of the Department of Electrical Engineering who are interested in joining us to make the Connecthor magazine. Up for a new challenge? Please contact us!! If you have ideas for upcoming editions, please contact us via connecthor@tue.nl.

We hope that these teasers have triggered you to open the magazine and read the articles.

Enjoy reading this new edition.

The Connecthor editorial board ■



Mythology: Grettis Saga

Read a comical viking tale on page 34



New Year's Speech 2017

Dit you mis the New Year's Speech, or do you want to read it over? It is possible on page 8.



University Racing Eindhoven

URE talks about their car on page 14.



Whose desk is this?

Harald van den Meerendonk shows his workplace on page 11.

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Board issues

By: Ton Koonen



At the start of a new calendar year, looking back and looking forward is a good and frequently-practiced habit. Looking back on how things went globally in the domain of electrical engineering, we have witnessed how it has continued to evolve and to impact our society. Next-generation even more powerful smartphones were introduced (although some of them explode...), next steps in autonomic fully-electrical cars were taken, as well as in medical robots, in even larger and higher-resolution video screens, etc., etc. Photonic technologies are making great steps forward; they are entering new application areas and new ways to complement electronic technologies. The Institute for Photonic Integration (IPI) was inaugurated at TU/e last year, superseding COBRA in multi-disciplinary research by the PhI and ECO groups together with several groups in the Applied Physics department. IPI is also embarking on higher Technology Readiness Levels (TRLs), by extending its activities into prototype development work in the Technology Centers foreseen. Our EE department received increased interest from industry for cooperation, which resulted in many joint projects with NXP, Prodrive, etc., and thus in great opportunities for our PhD students to explore the valorisation of their research. A good thing was also that the visibility of our research for the general public was increased, amongst others by the television interviews about 5G network technologies and the nice demonstrations at GLOW of amongst others the longest lightning discharge arc.

Looking forward, starting this new year brings again many new challenges. Our department's research themes Connected World, Care and Cure, and Smart Sustainable Society continue to be highly current and relevant. To keep the EE evolution going, new ideas and new collaborations need to be developed, together with creative ways to get the funding for those. The competition for acquiring funding remains fierce, the success ratio for national and European programs is often only 10% or less. Therefore, in order to save precious effort and time of our staff, ways to improve this ratio are sought, such as additional support by project officers for establishing and coordinating cooperation with industry. In the midterm 3TU EE Research Review of the activities done in the period 2011-2014, which was held in 2015, we were praised for the fruitful cooperation we have with industry. In autumn 2017 there will be the EE Research Review over the full period 2011-2016, again together with the EE colleagues from TU Delft and University of Twente. At the midterm review, we got some wise recommendations from the reviewers. Overall, we were encouraged to think out-of-the-box for new research directions, for which amongst others the initiative to build a vision "EE in 2050" is taken. We were also advised to grab every opportunity to further increase the visibility of electrical engineering and the good things it brings to our society. We should closely work together as 3TU EE community and promote electrical engineering towards the politicians and decision makers. As also recently articulated

by the new Nobel laureate Ben Feringa, our Dutch government should make more funding available for doing research in exact sciences; without any additional funding means, we are getting seriously behind the major economies. And that certainly holds for the domain of electrical engineering. Funding programs, national ones as well as European ones, are more and more requiring multidisciplinary research and a clear description of the potential impact of the proposed research. Our Centers are well positioned for this. Recently, the 3TU alliance has been enlarged to a 4TU alliance with Wageningen University and Research; this opens new options for multidisciplinary research, e.g. in micro-agriculture with its intense ICT needs. Next to multi-partner cooperation projects, the opportunities for Personal Grant project proposals are very attractive, particularly for TRL 1-2 research. NWO Vernieuwingsimpuls programs (VENI, VIDI, VICI) and the European Research Council's personal grant programs (Starting Grant, Consolidator Grant, Advanced Grant) give plenty of freedom to further develop your own research profile, and thus to build a strong CV. This is helpful in getting access to more funding, expanding your research network, and further enhancing the profile of our EE faculty. Moreover, and last but not least, a Personal Grant enables you to define and realise your own research plans, be personally responsible for it and steer it, which is great fun!

Ton Koonen
vice-dean EE ■

From the President

By: Lester Manders



When I look at the world, I can see that many things are happening. Donald Trump becomes president of the USA, there are bombings in a variety of countries almost every day, the Netherlands is going to host elections again and the sale of alcohol-free beer continues to rise. Unfortunately, not all things going on in the world are positive. People have to deal with an enormous amount of problems and not everyone can solve them properly. Therefore, I am very glad to tell you that Thor is one of the things you do not have to worry about.

Last time, I told you about us being the new Board of our association. I told you about the GMM where I was handed my medal, Mjölir-hammer, one-liter tankard, and a lot of responsibilities. I also told you about our happiness: we could not stop saying "Guys, we are the new BOARD!". Next, the first GMM took place where I could actually be the President from the beginning until the end of the meeting. I can say without a doubt that a feeling like that is great. This GMM we were able to not only present our Board policy but also to review and evaluate it. We have learned a lot since the beginning of our year and we are, as promised, still having fun. The experience we have gained is incredible, but we will not

stop learning. Thor is still growing, students want to join all different kind of committees and our members make sure we are being kept busy. A lot has already been done but there is still much to do, for example solving the problem of our Coca-Cola cans. Since this is fortunately one of our biggest problems, I think I can say that all other things are going quite well.

Our Board is very happy about the current state of Thor. Our first, second, third, fourth, fifth, sixth etc. year students are still active within the association, especially in committees. Activities from Ivaldi and the ACCI are still greatly being organised and the other committees are doing great as well. Activities like the Christmas Drink, the TesLAN, a pub lecture, the Promotion Market and the Winter BBQ made me very happy. People are having fun and enjoy themselves. This is one of the things an awesome association should provide. Soon we will have the Open House Day where all parents are able to see what their son or daughter is actually doing here at the TU/e. We also have the first party of one of our newest committees, the FeestCo, which will organise the Masquerade Party. This summer Thor will visit Russia and South

Korea with the SPARK study tour. As President, I am very proud that all these things are being organised by our members.

Since an association cannot exist without a Board, we have to make sure that we have successors. One the most awesome times you have as Board is the time before you actually are the Board. When you are a candidate the Board tries to prepare you to make sure you can follow in their footsteps. When you finally are the Board, you realise how much you actually are able to learn and have to learn to run Thor.

Happily, the change of Boards is still far away and we are not nearly done with all our plans for Thor. We are at the middle of our year and until now it has been really great. I can honestly say that I expect the following half year to be as great or even better than the past half year. As President Trump tries to run the USA, me and my Board will try to run Thor. At the end of the year we will see who did the better job.

Veel gedonder!
Lester Manders
President of Thor ■

In Memoriam

Barbara Cornelissen-Milner



On Sunday 6 November we were shocked by the news that our colleague Barbara Cornelissen-Milner had suddenly passed away during a vacation in Australia.

Since 37 years, Barbara was working as secretary of the Control Systems (CS) group within the department of Electrical Engineering of our university.

During those many years of work, she has become the constant and stable factor in the group, having witnessed many changes over a long range of years. When she started at our university ("Technische Hogeschool") in 1979 the group was called "Meten en Regelen" (ER), that in 1996 changed name as part of a larger group "Meet- en Besturingssystemen" (MBS), to finally evolve into the current setting. She served as group secretary for many different professors and staff, and saw the university change from a complete Dutch to a highly international environment. With her roots in the United Kingdom, she enjoyed the contacts with the international visitors and colleagues. And all the changes that she witnessed, she approached with a very flexible mind.

With her warm personality, and her supportive and caring attitude, she was a great help for all colleagues and students in our group. Her strong professional support reached out to many colleagues in the department, and with her native English language skills she was often helping out with translation requests. Within the group she felt responsible for a smooth organization, and she was enthusiastic about bringing people together. The numerous social activities that were organized by her were always a great success.

We have lost a great and highly committed colleague and a person who was dear to so many, who intensely feel the grief of her husband Henk and sons James and Niels, and their close relatives.

On behalf of the colleagues of the group Control Systems and the department Electrical Engineering of the Eindhoven University of Technology.

Prof.dr.ir. Bart Smolders,

Dean

Drs. Jolie van Wevelingen,

Managing director

Prof.dr.ir. Paul Van den Hof,

Chair CS ■



First place Chester Sall Awards for former PhD student SPS-VCA

Dr. Onno Eerenberg, former PhD student at the SPS-VCA research group, has won the first place for the Chester Sall Awards at the IEEE International Conference on Consumer Electronics 2017. It was awarded on January 9th, 2017 at the IEEE congress in Las Vegas, USA. Onno was awarded for the best IEEE Transactions paper of all CE section entries from 2015. His paper concerns a new search method in MPEG-based video using sound fragments in addition to video fragments. The co-authors of the article were prof.dr. Peter H.N. de With (SPS-VCA, promotor, left) and prof.dr. Ronald M. Aarts (SPS, right).



The vlaai

The vlaai of this Connecthor goes to Niels Vertegaal. Niels has broken his collar bone during a snowboarding course.



Weiming Yao gains his PhD cum laude

Weiming Yao of the Department of Electrical Engineering has gained his PhD cum laude. He defended his PhD thesis, about new components for future photonic integrated circuits, Thursday January 12th in the Auditorium building of the university.



Information Days – January 13th and 14th

The Information Days were very well visited. Even though the weather forecast gave a so-called 'code orange' warning, 2200 pupils found their way to our campus, while in January 2016 this were 1976 pupils.



Memorial tree Harm Dorren

On December 7th, 2016, a memorial tree was planted, in honor of Prof. Harm Dorren, who passed away on March 30th, 2015.



Memorial tree Will Kling

On December 21st, 2016, a memorial tree was planted, in honor of prof. Will Kling, who passed away on March 14th, 2015.



Memorial tree Professor Vandenput

On February 2nd, a memorial tree was planted in honor of prof. A.J.A. Vandenput, former chair of the Electromechanics and Power Electronics group from 1911-2008.



Renovation of EE labs on 10th floor

New furniture and appliances have been placed and installed in EE labs 10.070 and 10.072.



New Year's Speech 2017

By: Bart Smolders



First of all, I would like to wish you and your loved ones, a Happy New Year. But above all, I wish you good health! This will be my first speech to you as Dean of our department. Despite the growing work load in our department, I hope that you will all continue to enjoy working in our nice Flux building. If not, please let me know.

2016 low and high-lights

Let me first look back at the year 2016. Despite the many highlights in our department (I will come back on this in a moment), we again

had to cope with some very sad experiences. In March 2015, we lost two professors: Will Kling and Harm Dorren. In 2016, we again had to face two terrible losses. Let me first memorize Barbara Cornelissen. Barbara suddenly passed away on November 6, during a well-deserved holiday in Australia. Barbara had been working for 37 years in the Control Systems group as a secretary. We all remember Barbara as a very warm personality who was always very supportive towards staff and students, for example to help out in translating Dutch text to English. Sadly, also our

emeritus professor Ralph Otten passed away early October. He was involved in a terrible accident in Georgia, where he slipped and fell into a fast-flowing river and disappeared. Only a few days later his dead body was found. Ralph was our former program director and leader of the Electronic Systems group. The loss of Barbara and Ralph had a major impact on all of us. Our thoughts are with their relatives and families.

We had several highlights last year. Again the intake of first year students was very high (250 in total). We expect to maintain this level in the upcoming years, since we observe a growing interest of secondary school students for our open-days and "meeloopdagen". In addition, the number of international students will steadily grow as well. Another highlight was the Bachelor and Master program assessment in October, which was very positive. The committee was impressed by the improvements that have been realized in the past years, the popularity of our program and the quality of our graduates. Of course, there were also recommendations for further improvement.

In 2016, we were again very successful in acquiring new research funding. In particular, I would like to mention the three personal research grants that were obtained in 2016:

- A VIDI grant for Rob Maaskant in the EM group.
- ERC Advanced Grant for Paul van den Hof





- ERC Starting Grant for Roland Toth

Both Paul and Roland are from the CS group

We also had the kick-off of the new Institute for Photonic Integration (IPI) headed by Ton Backx. The ambition is to bring the photonic activities in the Brainport region to a next level, so to maintain and, preferable, further expand our leading position world-wide.

And last but not least, we have invested in our staff. In total we hired nine new scientific staff members in 2016, partly to replace retirements and partly new hires.

2017 Outlook

Our financial situation for 2017 looks very solid. We have an overall budget of 30 million euro of which about 10 million euro is direct funding (1st money stream which we get

from our government) and 20 million euro is funding that we have acquired via 2nd or 3rd money-stream projects (STW, EU funding and bilateral contracts with companies). Although we will see a further increase of our 1st money-stream budget in the upcoming years due to the strong increase of the number of students, we need to make sure that we remain successful in the acquisition of new research projects. Therefore, we will further strengthen our centers. Next to this, we have a challenge in managing the increase of the number of students. This year we have reserved additional budget for teaching assistants and for hiring new scientific staff members. Hiring talented staff will be one of our main challenges in the next years.

An important activity this year is the research assessment of our department. This is organized together with our colleagues from Delft and Twente and will take place in October 2017. The preparations for the assessment will start soon and all groups will be asked for input. Please take this very seriously, it is very important for our future. As part of the preparation, we will organize a unique event (Title: Electrical Engineering in 2050) on January 19 in our Flux building. Together with Delft, Twente and IEEE, we will explore the future of Electrical Engineering.

To summarize: thanks again for all your efforts and let us toast to a fantastic 2017! ■



Introducing...

Hello everyone! My name is Maikel Klerx and I am 22 years old. I grew up in the beautiful town of Rijen, right in-between the cities Breda and Tilburg. After receiving my BSc degree in Electrical

Engineering at the TU/e, I decided to enroll in the Sustainable Energy Technology MSc program. This summer I graduated with a research on a forecasting method to support capacity planning in residential low-voltage

distribution grids at Enduris, the Distribution System Operator (DSO) in the province of Zeeland.

This October I started my PhD project on condition assessment of the low-voltage grid in the Netherlands. The project is carried out in close collaboration with the three largest DSOs in the Netherlands. The low-voltage area is becoming increasingly important in the energy transition, but little is known about the condition of the components. This project aims to assist the DSOs in choosing the right strategies. As I enjoyed working with DSOs in my graduation project, it is a great opportunity for me to continue in this area for the coming years.

In my spare time I am an avid football enthusiast, spending my time with playing and watching football. Furthermore I like to ride my road or mountain bike and enjoy great moments with friends. My music taste will most likely differ from most of you, as I am quite into Dutch music. I hope you enjoyed this introduction and maybe we will meet in the coming four years! ■



Hello everyone! My name is Samuil Aleksandrov (or just Sam) and I moved to Eindhoven half a year ago to join the EPE group as a PhD candidate. I was born and grew up in the capital of Bulgaria, Sofia. I received my BSc and MSc diploma from Technical University of Sofia, Electrical Machines Chair. I prepared my BSc final project in Universidad Publica de Navarra (UPNA), Pamplona, Spain, where I graduated as Erasmus student.

In my free time, alongside technical stuff, I like to play and watch football, tennis and extreme sports. I also like to travel a lot, to discover different places and cultures, and I'm particularly interested in the variety of architectural styles across the world. One of my recent hobbies became photography, which

is coupled perfectly with exploring new places. For the next four years, I'll be working at the university, which due to its location is perfect for weekend (or even week) trips to North and Western Europe. I'm looking forward to meet and work with a lot of new and amazing people at the TU/e! ■

From more professional point of view, I carried out an internship followed by a one-year full time position as design engineer at a Bulgarian factory for induction motors "ELPROM Harmanli". Shortly after that I spent two years in the R&D division of "Hyundai Heavy Industries", located at Sofia, Bulgaria.

Then I moved to The Netherlands, where I'm currently working on a PhD project about linear machines in collaboration with "Tecnotion". I recently joined Tech United's team, working on their service robots, which participated successfully in the @Home world competition of RoboCup.



Whose desk is this?

By: Harald van den Meerendonk

Showing here... the desk of the new study advisor for the master students and pre-master students of Electrical Engineering. I started in July 2016, and as study advisor, I deal with all sorts of questions from students and teachers, regarding study programs, curriculum, courses, internships and graduation. Students can also come to me if they experience problems with their study, or in case of personal problems.

I have quite some history at TU/e: I was a master student of Electrical Engineering back in 1991 and after my graduation, I continued as a PDEng student. After obtaining the PDEng degree, I did not want to leave the faculty so I continued as a researcher in the SPS group. In 2002, I started working with the newly founded company Medecs, a spin-off of the TU/e, which core business is a medical decision support system to aid doctors and nurses in their daily care for their patients. Although we officially had a room in the Multimedia Paviljoen at the TU/e-campus, we were allowed to stay within the SPS group. In 2010, we (four people in the meantime) moved to the Twinning Center, also located on the TU/e-campus (a special location for small ICT companies). Last year, I got the opportunity to return to the faculty and



become the new study advisor of the master students. And as from July, I have returned to the place where I belong and where I have always felt at home.

The desk looks quite empty: next to the standard features as a phone and the laptop (very handy for meetings by the way), you can also find my booklet and pen, a coffee mug and some papers dealing with actual questions. You can recognise me by my mug, showing my name and also my favourite recipe for my coffee: only milk, no sugar. This mug was given to me by my sister when I started this

job, hoping that people would get me my coffee. The booklet is used during meetings with students to make notes and to remember everyone who visits me.

You can find me in room Flux 0.123, close to the stairs, purple chairs and long table. I share the room with my colleagues Lies and Martine, the two other study advisors of Electrical Engineering and Automotive. I am sitting closest to the door, ready to invite you in for any questions you might have. So please, drop by if you want to see me or for the occasional chat: the door is always open. ■

Excursion Ellips

By: Renate Debets

On the 20th of december, about fifteen students gathered with their bikes in front of flux, underneath "the new work of what seems to be art" (quoting the Commissioner of Public Relations) after the break. We were about to be received by the company Ellips after half an hour of cycling, a company specialized in designing and selling fruit sorting machines. As usual, we were welcomed with coffee, tea, a presentation and cookies, after which the group was split in two to visit the offices and the machine test/showroom.

The machines Ellips designs are capable of scanning and analyzing a continuous stream of fruit, and sort it based on either internal quality, color, size, or you name it. In order to make this magic happen, they have, among other things, written their own operating system. An important role is fulfilled by extremely high-end cameras which they test

for hours by aiming them at a wall covered with fruit stickers. Image processing techniques are experimented with constantly, to find new ways to detect whether the fruit passing by on the assembly line is ripe thoroughly. Many of the desks were decorated with at least one camera aimed at a tablet displaying an animated flow of fruit passing by, used for testing software.



Experimental set-up to sort fruit and vegetables by visual inspection.

Next, we were shown how effective the machines really are in the showroom. Their functioning was demonstrated using potatoes and several other types of fruit and somewhat sphere-shaped objects. Remarkable and satisfying for the neurotic ones among us was the fact that they built a fully functioning example dedicated to sorting M&M's.

The two groups were merged again to have a drink together at the bar and socialize with the employees, getting to know more about their previous education and how they experience working for Ellips. It turned out that several of them ended up there after talking to other employees in Het Walhalla. This style of recruiting new employees fits in perfectly with the relaxed and informal atmosphere in the offices. In my eyes, Ellips presented itself as a very enjoyable place to work where your skills are pleasantly challenged. ■



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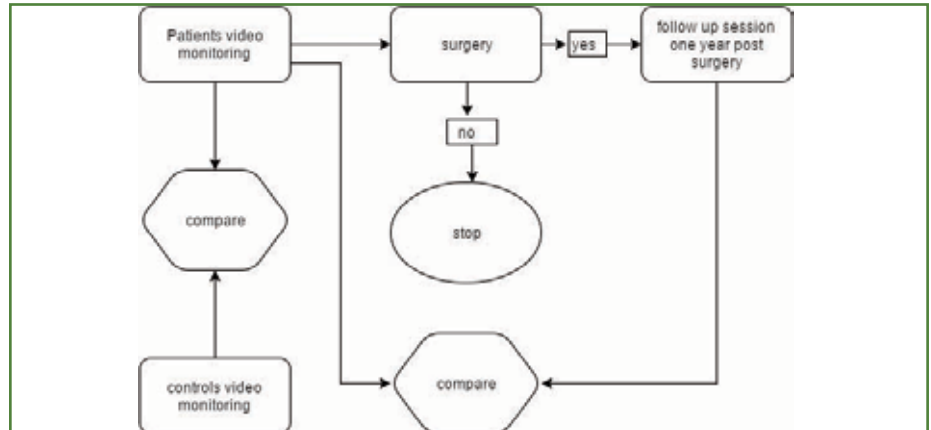
Final Bachelor Project: EEG analysis

By: Esmee Huismans

At the end of the bachelor each student has to do an individual project. This project relates to one of the following tracks: Connected World, Smart and Sustainable Society, Care and Cure or Automotive. I chose to do my project within the Care and Cure track. I had the opportunity to do my project in collaboration with Kempenhaeghe, as part of a bigger ongoing project.

The main goal of my project was to develop a method for quantitative EEG analysis, related to a project at Kempenhaeghe. The overall project focusses on the difference in emotion and mood of patients with severe types of epilepsy, both pre- and post-surgery. In order to see if there is any difference in emotion and mood, the patients are shown 36 one-minute film clips linked to a certain emotion before and after surgery. Also a number of control subjects will be evaluated to compare with the patients before surgery. My contribution to this project is EEG analysis and parameter extraction for those 36 one-minute film clips.

For my project I received unprocessed EEG data from several recordings. Enclosed in the data were the time stamps of the different film clips and visually identified artefacts. The first step was to match the EEG data to the correct film clip. The next step was to process the visually identified artefacts, e.g. movement or muscle artefacts. The data relating to the artefacts was marked as 'not reliable'. In order to do EEG analysis, the data from the film clips had to be segmented. The data of each film clip was segmented into overlapping parts of two seconds. So the first segment is from 0–2 seconds, the second from 1–3 seconds,



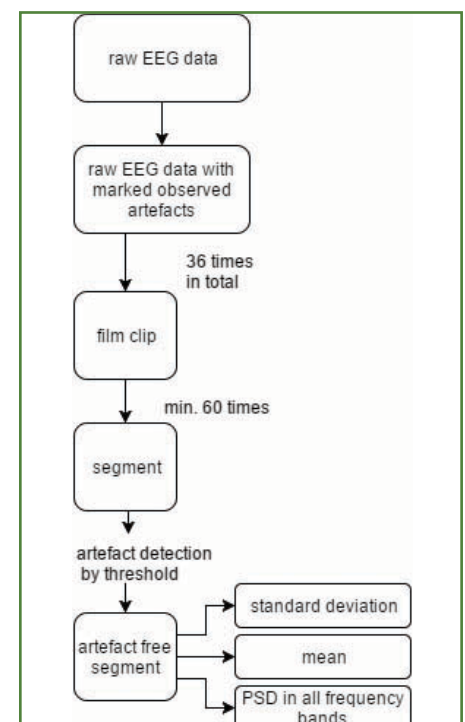
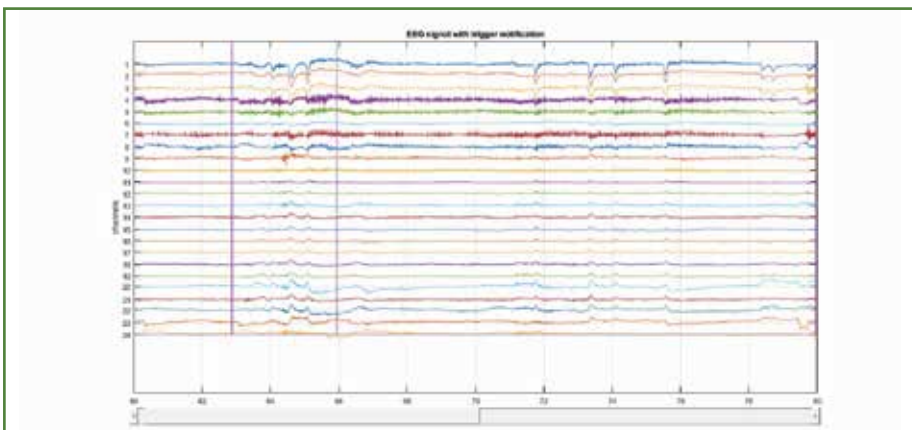
etc. The reason for overlapping segments is to gain as much artefact-free segments as possible.

After the segmentation, the segments have to be classified as reliable or non-reliable. That means artefact detection has to be carried out. I did the artefact detection by setting a threshold. This is done in the following way: the reliable EEG data will have a lower peak-to-peak amplitude than artefacts such as eye blinking or electrode movement. The EEG recording consisted of 24 channels. Because the segment contains data from 24 channels, it is only classified as reliable if the threshold is not exceeded in all channels.

The next step is to extract certain parameters from the artefact free segments. First the standard deviation and the average is extracted. Next, the absolute and relative power spectral density (PSD) in the delta, theta, alpha, beta and gamma frequency bands have to be extracted. In order to extract the PSD parameters, the artefact-free segments are analyzed by the Fast Fourier Transform. Lastly, all the

extracted parameters are saved in a certain format for further statistical analysis that allows a comparison between the pre-surgical EEG-recordings from patients and control subjects, and a post-surgical comparison from the patients' EEG-recording. The overview of the complete implementation can be seen in the flowchart diagram.

In the end I delivered an EEG analysis, specific to the overall project, that provides data reduction and parameter extraction, which allow further statistical analysis. I enjoyed working on an individual project. Another aspect that I liked about my project is that it has a contribution to a bigger project. ■



University Racing Eindhoven

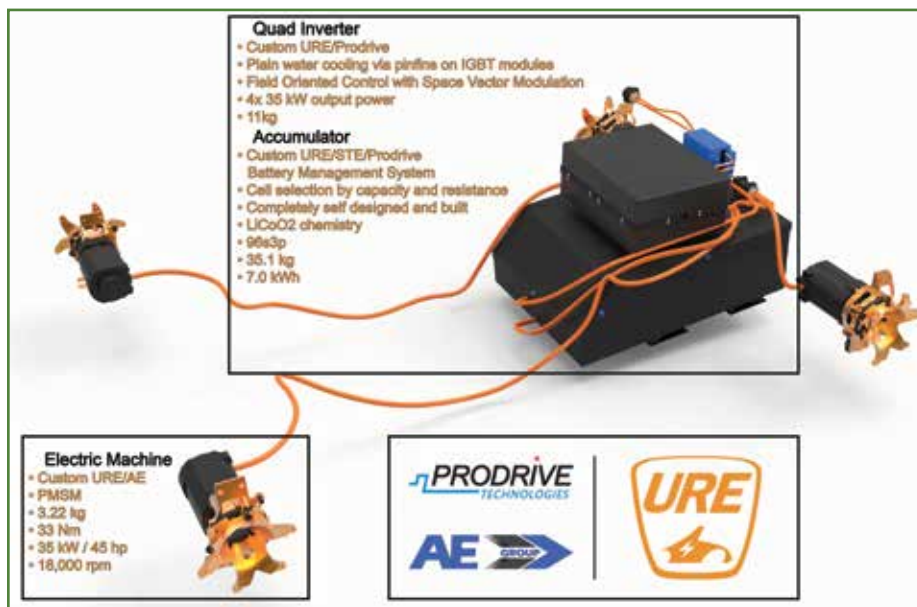
By: Jacky Pang

Would you believe a group of TU/e students have built an electric car that accelerates faster than a Tesla Model S, Bugatti Veyron and any other production car?

Meet University Racing Eindhoven (URE). We are a student team consisting of 50 passionate students from Eindhoven University of Technology and Fontys University of Applied Sciences. As the oldest automotive student team from Eindhoven we have over a decade of experience in completely developing and building racing cars from scratch, with the most recent one being the URE11 and the URE12 currently in production.

Formula Student

As the world's largest engineering competition with nearly 600 teams participating, Formula Student has grown from its first event in 1978 in the USA to multiple events on Formula 1 circuits all over the world. In the past we participated in Europe's four biggest events each summer, being in England (Silverstone Circuit), Austria (Red Bull Ring), Germany (Hockenheimring) and Spain (Circuit de Barcelona-Catalunya). This year England will be replaced by Formula Student Netherlands, which will be held for the first time at the TT Circuit Assen. At these events we compete with Europe's top universities. Recently one of our competitors broke the world record acceleration from 0-100 km/h for electric vehicles with a time of 1.513 seconds! The car is taken to its absolute limits at the competition's dynamic events; acceleration, skidpad, autocross, efficiency and endurance. At the acceleration event the car has to drive for 75 meters straight as fast as possible, at the skidpad a figure 8 has to be driven to test its cornering abilities, at the autocross the car has to drive one lap as fast as possible and at the endurance the car's durability is tested



by a 22km long race, while simultaneously points are scored for efficiency by consuming less energy.

Whilst the dynamic events are the absolute pinnacle of the competition, perhaps the static events are even more important. These events include cost, business and engineering design. At the cost event every single bolt has to be documented, and it has to be shown that the car is not only fast but also cheap. The business event consists of convincing potential investors by presenting your plan to sell the car to the public. Finally the main static event is engineering design. At this event experienced engineers from the automotive industry (including Formula 1) have to be convinced that your design is the best.

URE11

The URE11 is the 12th car (7th electric) completely developed and built by URE. What sets us apart from other teams is that our powertrain is also completely self-developed by students.

This starts from the accumulator from which only the battery cells themselves are bought. The cells are tested and sorted by their capacity and internal resistance. In total the URE11 features 288 lithium battery cells which have an energy density of 200Wh/kg. With a total capacity of 7.0kWh the total weight from the cells comes down to only 35.1kg. This capacity was chosen after optimisation for the endurance event, which is the longest distance the car has to be able to drive. These cells are put in a 96s3p configuration, which results in maximum 400V and are further divided into six battery modules, such that working on the accumulator can happen in a safe manner.



The accumulator has a battery management system, or BMS in short, self-developed by students in cooperation with Prodrive Technologies. The BMS keeps track of the cells such that they are not taken outside of the boundaries of their specifications such as current and temperature, where 94% of the cells are monitored for their temperature. The BMS consists of a main module and



a slave board at each module. Furthermore it has an integrated battery balancing function. Housed together with the BMS is a self-developed 300W dual active bridge DC/DC converter to supply the low-voltage system of the car through the high-voltage battery, this saves weight due to not needing a separate low-voltage battery. The other advantage is that this converter has an efficiency of over 94%, which is more than the commercial solutions.

From the battery the next part is the inverter/motor controller, which is also self-developed in cooperation with our main partner Prodrive Technologies. Since the car is a four-wheel drive, this means a quad inverter is used. It is water-cooled together with the electric machines and is housed in a carbon fibre casing. The inverter makes use of field-oriented control, which gives full control of the motor's torque and internal flux.

The final parts of the powertrain are the electric machines themselves. The URE11 features four in-wheel motors which have been self-developed together with AEGROUP. They are permanent magnet synchronous machines which have the advantage that they are very efficient and require little maintenance compared to DC machines with brushes. The machines run up to 18,000rpm and have



a final drive reduction of 12:1. In total this results in a power output of 180hp whilst the car itself also weighs 180kg, giving a 1:1 horsepower to kilogram ratio.

Electronics

The wiring harness is the biggest electronic part of the car as it connects every electronic device in the car to the ECU. Communication is done through the use of two CAN buses, one for the powertrain and one for the sensors and actuators. This reduces the busload on each CAN bus and prevents messages getting lost.

All the electronic devices in the car are connected to the central ECU. In order to save weight this is done through the use of so called 'IO Nodes' which are located near each wheel, they are able to convert both A/D and D/A signals. This significantly reduces the required wiring thus also weight and complexity. These IO Nodes are connected to the central ECU via a CAN bus. For the ECU the dSPACE MicroAutoBox is used, which is one of the few components which are actually not self-developed and/or self-produced. The MicroAutoBox is Simulink programmable, which enables our entire vehicle software

model to be created by engineers with little programming knowledge and reduces possible errors. Since making changes to the vehicle software model can be done quickly through Simulink, this greatly reduces testing time.

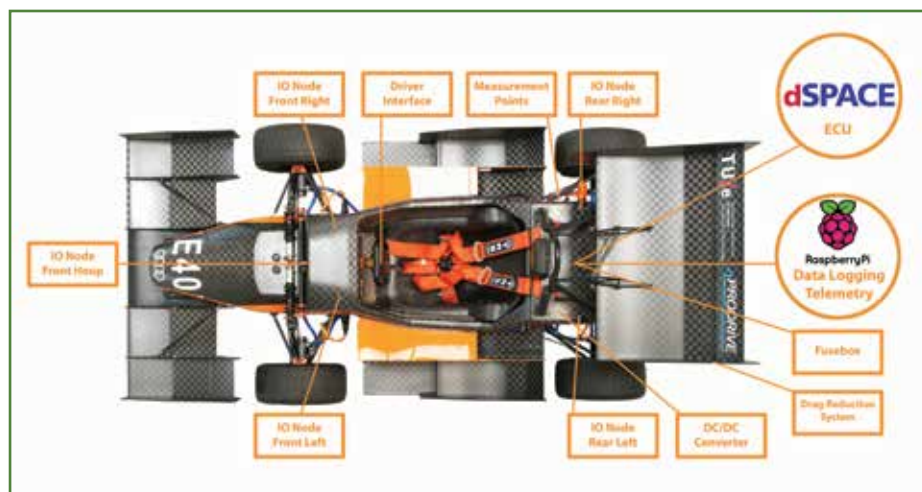
The display of data is done through two ways. First the steering wheel is self-designed in order to house a display which supplies the driver with crucial information such as battery charge and temperature. This display communicates through the CAN bus and thus allows the driver to change settings such as the torque limit on the ECU through the steering wheel. The other way is on the laptop, which is done through the use of data logging with a Raspberry Pi and telemetry. Together with McCoy & Partners a digital real-time dashboard has been created based on a SAP backend. With this dashboard data from the car can be read real-time on any computer from the cloud.

Challenge

Are you looking for a challenge? Enthusiastic Electrical Engineering and Automotive students from all years are always welcome to help push the boundaries of engineering! As most of our team members are part time, the team consists of a variety of students from all years and different disciplines.

Opportunities exist in the form of part-time assignments, end projects and sometimes even internships. Do you want to challenge yourself and gain valuable practical experience? Visit our website at www.universityracing.nl or contact us through universityracing@tue.nl.

Do you want to see the URE12 in action? We will participate in Formula Student Netherlands which will be held on the TT Circuit in Assen. The event is held between the 17th and the 20th of July in 2017 and is open for visitors! ■



MRI compatible TMS system

By: Vadim Fomichev

“There are no negatives in life, only challenges to overcome that will make you stronger.” I think this citation of Eric Bates perfectly describes the way of thinking that I developed working at the Eindhoven University of Technology. My name is Vadim Fomichev and I am currently finishing the PDEng program of the ICT track in the Electromechanics and Power Electronics (EPE) group of prof. dr. Elena Lomonova under the supervision of dr.ir. Helm Jansen. During past two years I was involved in the EU project that is coordinated by Philips Healthcare and named DeNeCoR. The acronym means Devices for Neuro Control and Rehabilitation. As seen from the name, the project is related to the medical systems. Indeed, the main mission is to demonstrate the coexistence between modern neuromodulation techniques and conventional diagnosis systems like MRI and EEG. However, the challenges that I have worked on do not have a medical nature. As a member of the EPE group, I have been solving electromechanical problems that arise in the MRI-compatible TMS system.

The Transcranial Magnetic Stimulation (TMS) system is a noninvasive neuromodulation technique based upon the principle of electromagnetic induction. A stimulation coil produces a pulsed magnetic field in the brain, which induces an electric field in conducting tissue. The induced electric field can be of sufficient amplitude to alter the neuronal membrane potential, and if this exceeds the critical threshold, depolarization potential of the neuron, it leads to a self-propagating action along the neuron's axon. TMS is becoming established as a promising investigative technique and therapeutic tool.

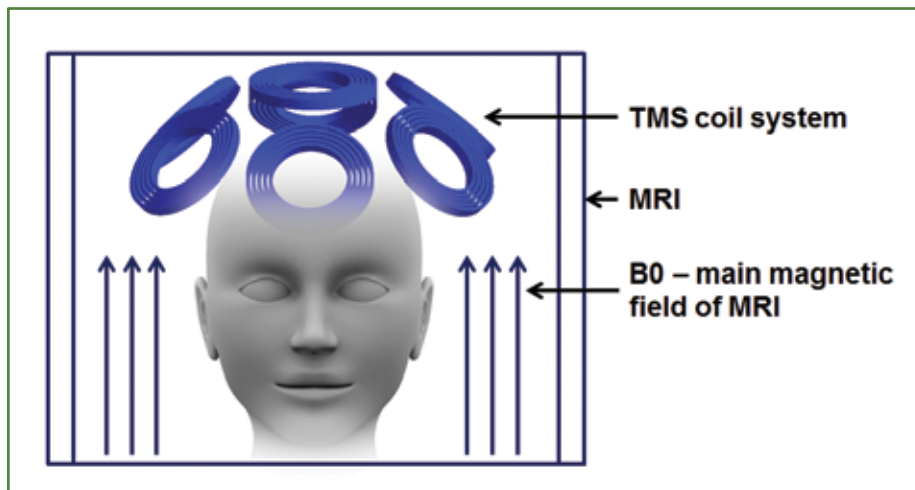


Figure: 1 MRI-compatible TMS system

It has recently been investigated for its effect on Parkinson's disease patients and in cognitive neuroscience studies. Earlier studies have used the technique to stimulate the motor cortex to assess the conductivity of corticospinal motor pathways. Unlike other methods of neural stimulation, TMS does not require invasive surgery and can provide some degree of localization of the stimulation.

A realization of TMS followed by functional magnetic resonance imaging (fMRI) is a perspective idea that has appeared recently (Figure 1). This would allow researchers to monitor the changes in brain activity during TMS by detection of subsequent blood flow in the brain using fMRI. This capability would greatly improve understanding of the effects of TMS on the brain, enhance the usefulness of TMS, and provide the necessary treatment guidance.

The problems of the implementation of the MRI-compatible TMS system arise due to various engineering issues. While being in the common electromagnetic environment of the MRI, the TMS system is exposed to the interactions with MRI electromagnetic fields that are produced by different types of coils and characterized by different values of parameters such as amplitude, frequency and duration.

The main barrier that prevents this system from being implemented and then introduced on the market is related to the mechanical safety of the TMS coil in the MRI environment. As a current-carrying coil system, the TMS structure interacts with the main magnetic field of the MRI (B_0). This interaction leads to a high electromagnetic force acting on the TMS coils. It causes the mechanical deformation of the coils and can sequentially result in the failure of the TMS system.

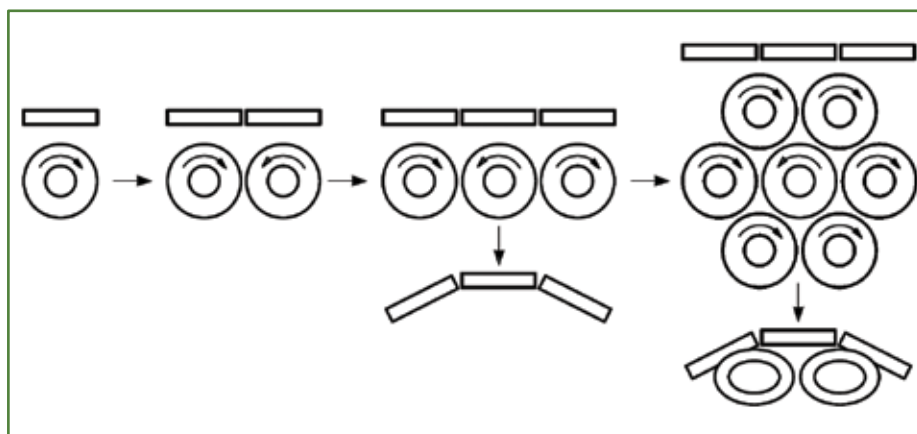


Figure: 2 Evolution of the TMS system

Levels of current flowing inside the TMS coil are higher than 1 kA and values of the magnetic field produced by the superconducting electromagnet are equal to 1.5 and 3 T in my investigations. Based on this data, values and distribution of the electromagnetic forces acting on the TMS system have been defined. Further, these results have been used to estimate the mechanical stresses and deformations. Finally, predictions of the mechanical strength of the TMS coil have been made.

The analysis of the TMS system employs the superposition principle. The advanced coil topology is constructed as a combination of

simple round coils (Figure 2). The resulting full structure consists of several round TMS coils placed and tilted in space in a variety of ways in order to form a helmet configuration. While making these sequential modifications of the structure, the corresponding changes in magnetic fields, forces and deformations have been observed. The magnetic field in each coil element included in the entire system is calculated as the sum of its own magnetic field, the external magnetic field of the MRI and the magnetic field of adjacent coil elements.

The advantage of the helmet structure is that it provides good spatial brain coverage without the movement of the entire system by robotics or expensive manipulators. Analysis of such a system was the main task of my project.

The helmet concept presumes that coils are located in various positions inside the MRI at various angles with respect to the direction of the static magnetic field of the MRI (B_0). The distinction in the location of the TMS coils included in the helmet causes the difference in mechanical loads experienced by each coil. Therefore, various positions of the coil together with various values of magnetic fields and currents have been investigated in mechanical simulations in order to define limitations on usage of TMS coils inside MRI and to suggest possible solutions to MRI compatibility problems.

Results of my investigations show that the superposition of TMS coils leads to only small changes in stresses and deformations (about 2-3%). It means that each round coil of the helmet can be investigated individually without taking into account distortions of the parameters caused by mutual effects.

Tilted lateral TMS coils of the helmet structure experience increased stress levels and deformations in the MRI. Bending of these lateral coils in the MRI environment causes elastic deformations of up to 0.6 mm (Figure 3). Consequently, the extra protection is required.

The selection of the appropriate material plays an important role in the mechanical protection of the TMS device. Therefore, the TMS coil inside the MRI has been investigated in the wide range of parameters and different materials. As discovered in material investigations, the stiffness of the coil system is mostly defined by the stiffness of the insulator since usage of different aluminum and copper alloys as a material for the coil does not change the level of deformations significantly

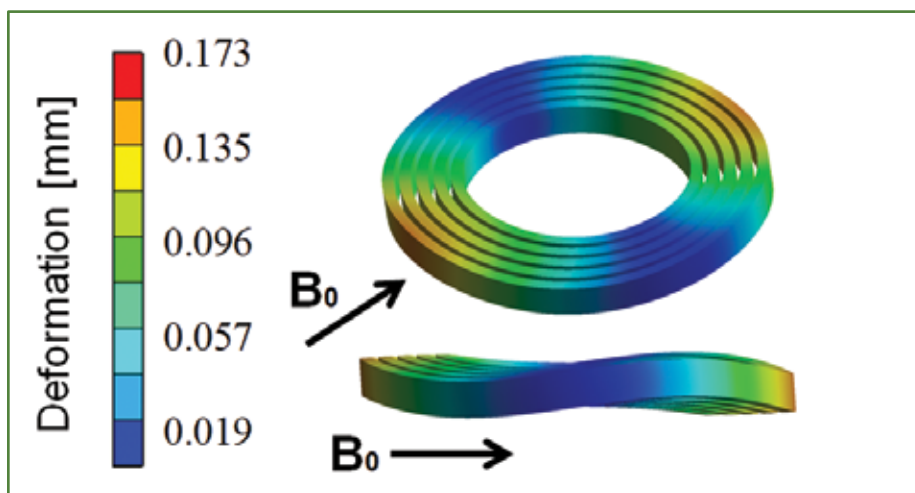


Figure 3: Deformation of TMS coil element

(about 5%). The insulation material performs a supporting function and the safety of the full TMS system depends on the properties of this material. The process of the material selection and verification had a high priority and was conducted with all necessary precautions. Eventually, the epoxy resin – glass fabric substrate composite G-11 has been accepted as the insulation material and the mechanical support for the TMS system due to compatible mechanical, electrical and thermal properties. The outcome of this insulation material choice is the double reduction of the deformation in the TMS system.

According to the lifetime estimations, the TMS coil with G-11 supporting material is able to work for about 330 TMS sessions of 10 minutes each. The compatibility of this material with the MRI has been proved in measurements. The scanning of G-11 material in the MRI scanner has not revealed any contribution of this material into the underlying signal of interest in the MRI. The quality of the MRI image remains at the same level.

Further protection of the TMS structure against excessive deformations can be provided by the system of reinforcement bars as shown in Figure 4. These bars are used to hold coil and insulation parts together and provide the additional level of the stiffness.

They are inserted into the system through holes drilled in the coil. Reinforcement bars are made of the non-magnetic steel and they do not result in the distortion of the magnetic field pattern for the TMS coil. According to the simulations, deformations are reduced by a factor nine in case of using these bars.

Minimization of deformation values is the key to prevent premature failure and prolong the lifetime of the TMS coil inside MRI. A concept of the TMS coil reinforced by system of bars has been proposed as a solution of the TMS-MRI mechanical deformation problem. The specification of the possible structure has been made as well.

To prove the compatibility of the TMS device with the MRI, predictions and simulations have to be verified by means of fatigue tests with TMS coils. Magnitudes and directions of stresses obtained in calculations can be used as input for these tests. Results of these tests should give the final verdict regarding the mechanical safety of the TMS coil in the MRI.

As my time at TU/e comes to an end, I would like to thank the EPE group and specially prof. dr. Elena Lomonova for giving me the opportunity to take part in such a nice and challenging project. ■



Figure 4: Reinforced structure of the TMS element

"Futuristic technology – that really is my thing!"

By: Francesco Esposto

TNO innovates with impact. By bringing together a wide range of disciplines in two areas of expertise and thereby tackling societal challenges within five current themes. Innovator Francesco Esposto works at TNO and is developing ground-breaking technology, which will be part of our everyday lives in a few years' time.

As an innovator on the Co-operative Mobility programme, Francesco is working on technology to enable self-driving cars to communicate with each other and with the infrastructure around them. "My main focus is the safety system, which ensures that the technology works in dangerous situations on the road. Another project I'm involved in, this time in Automotive, is the construction of a simulator to test self-driving cars. It's fantastic to be working on all this – we have so much to look forward to when it comes to self-driving cars. Some vehicles already have autonomous functions, but they're going to develop enormously over the next few years. So-called co-operative driving, especially, is really important for safety and traffic flows. That's the main thing we in Co-operative Mobility are working on. For most people this is very futuristic, but we're already developing the technology and we can see that it works."

Futuristic technology

"I studied Electrical Engineering at the university and I have a passion for cars. My thesis was about technology to repel intrusive or hostile drones. Futuristic technology – that really is my thing! After graduating, I chose TNO because I knew what brilliant things they do here, certainly in Automotive. In so many technologies, hardly anyone else is as far advanced as TNO. Here I can keep building my own body of knowledge, and make myself useful by putting it into practice straight away", Francesco explains.

Future project manager

For TNO innovation means demonstrating how significant knowledge is for society. Working at TNO means working in teams on inspiring assignments for multinationals, SMEs and government. You contribute directly to innovation and the ongoing development and application of knowledge. The assignments range from contract research to consultancy, from policy studies to testing. Francesco tells: "You never run out of things to learn here. We work on big projects involving a lot of people, who have to collaborate effectively to make real progress. Even though I'm still relatively new here, I'm already encountering many aspects of project management. That's important to me, because it's the direction I want to move in. Right now, some colleagues and I are working on a bid for a major European tender procedure. For that I have to consult with our consortium partners and come up with solid proposals."

The people of TNO

TNO employs around 3000 people with all kinds of backgrounds, qualities and interests. This multidisciplinary aspect is essential to be able to innovate. We combine the right, existing and newly acquired expertise from different disciplines to get the optimum results. Together with universities and top technology institutes we develop knowledge that is closely aligned with the latest international trends and developments.



Ambitious starter?

Are you interested in getting a flying start at TNO? There are many different options within our organisation. Whether you want to be a top researcher, consultant, project leader or business developer. Once you join us, you will have the freedom and responsibility for shaping your own career path.

Discover your possibilities at: www.tno.nl/career ■

TNO

TU/e Lustrum gala 2016

By: Marcella Gunther

Being a student from generation 2012 I had just missed the previous lustrum of our university and therefore its lustrum gala. In 2014 I already started looking for a date because "it's only two years until the next TU/e gala". At the end of 2015 it became clear that the 60th anniversary would be celebrated with the Dream and Dare festival. No lustrum gala at all. Since I am a huge fan of galas, and because I was looking forward to it for years, I was of course very disappointed when I heard that there would not be a lustrum gala. In my (very conservative) opinion a lustrum simply has to be celebrated with a gala as well. Luckily some fellow students of rethoricadispuut Tau shared my opinion and they decided to organize the gala for the 12th lustrum.

On December 16th the doors of a magnificent auditorium were opened for the party of the year. Expectations were not that high beforehand. After all most of us were used to fancy locations ranging from castles to the town hall of Eindhoven (that is where the gala of the 11th lustrum took place). How could the Auditorium compete with that? Well, you start with some nice lighting at the outside of the building, together with a red carpet. Then, when your guests enter the building you give them the opportunity to pose in front of a wall with sponsors, which will give them the feeling as if they are celebrities. Next, when they enter the main hall, you amuse them

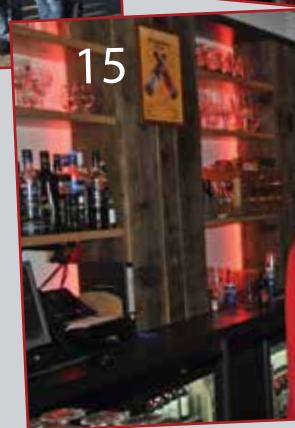


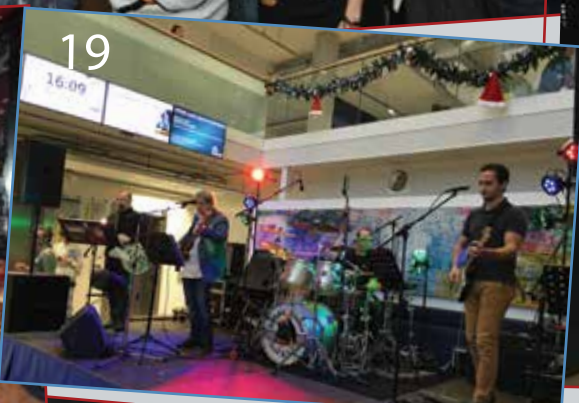
with Studentproof and Quadrivium playing on a huge podium in front of the Blauwe Zaal. Finally, when they look up they will see a beautiful large chandelier companioned by banners of the associations giving them the feeling that we are all part of one big community. And that is how the lustrum gala of the 12th lustrum began.

The party was officially opened by Jan Mengelers, who traditionally performed the opening dance. And when the funky disco band Mr. Nice started to play the rest of the hall started to dance as well. If you needed a break from dancing, you had the opportunity to take another drink (unlimited drinks were included after all), you could grab some culinary delights in the back or you could go to one of the three (!) photo boots to make a nice picture (see some of the results around this text). After the funky beats of Mr. Nice there was a very nice areal silk performance, which you just should have seen. And in case you were pleasantly surprised by the first band, the Hermes House Band also blew you away. The party even continued after 2:00!

Looking back to this gala it exceeded my expectations and I had a lovely evening. At the moment of writing my feet still hurt from my 'touch of dare'. It is also worth noting that surprisingly many people actually came with a touch of dare, ranging from yellow bow ties till blinking led corsages. Anyways, I will probably wear more comfortable shoes at future a gala. And those who pay attention will know that I will not have to wait that long this time, because in 2017 Thor will celebrate its 60th anniversary! ■







1. ACCI Pre-winterweekend
2. DIES Opening
3. DIES Cantus
- 4 & 5. DIES Excursion IHC Merwede
6. DIES BowTieTyingCourse
7. DIES Party
8. DIES Oude Bokkenborrel
9. DIES Dinner
10. CenThorion
11. SinThorklaas
12. Volundr Soldering workshop

- 13 & 14. Christmas gathering EM
15. Feutenfeest
16. Prodrive pub lecture
17. Excursion Ellips
18. Thor christmas drink
19. Department new years drink
- 20 & 21. TesLAN LAN party
22. Witteveen+Bos pub lecture
23. Information days TU/e
24. ACCI WinterBBQ

Icons of EE: John Bardeen

By: Matthijs van Oort

For many engineers John Bardeen will not sound very familiar, because he is not quite as famous as for example Tesla, Maxwell and Marconi. However, he did have a major impact on the way we live nowadays. He worked on the basic principles of transistors and successfully created the first solid-state transistor. Transistors are the most basic parts of digitally processing and therefore very important in engineering. In fact I could not have written this article about him without the research he has done.

John started his career in a financial depression, which means that it was hard for him to find a good job which fit his interest. He started working for Gulf Oil as a geophysicist, which gave him a quite good salary of \$3000,- during the depression. This job did not really fit his interests however, so he started with the graduate program in mathematics at Princeton University. Here he ended up writing his thesis on solid-state physics. Even before finishing this thesis, he was offered to work at a junior position at Harvard. At

The first attempts by applying an external electrical field on the semiconductor led to no results.

John Bardeen was born in Madison in 1908. He grew up in a quite wealthy family with his father Charles Russel Bardeen being the dean of the University of Wisconsin and his mother Althea Harmer being a teacher. The little John's intelligence was already visible at an early age, which led to jumping from the third grade to junior high school. Eventually he enrolled at the University of Wisconsin for a major in Engineering at the age of 15, and did a master in Electrical Engineering at the same university afterwards.



The first transistor build by Bardeen

Harvard he spent his time working on problems in cohesion and electrical conduction in metals.

In 1945 Bardeen began to work for Bell Labs as a member of the Solid State Physics Group. He worked in this group with William Shockley, Stanley Morgan, Walter Brattain and Gerald Pearson. The long term goal of this research group was to find a robust alternative for the glass vacuum tube amplifiers. The first attempts by applying an external electrical field on the semiconductor led to no results. After this the group had a big breakthrough due to one of Bardeen's theories. Bardeen stated that invoked surface states would prevent the electrical field from penetrating the semiconductor. The whole group focused on these surface states after getting some good results. In the end of 1946 Bardeen gathered enough results to publish his paper on surface states.

Not much later, in 1947, Bardeen and Brattain succeeded in creating the first point-contact transistor. Despite the fact that Bardeen and Brattain worked without the help of Shockley, they were nearly getting no credit for their invention, while Shockley got all the public credit. This led to a breakup in the group, as Bardeen and Brattain did not want to work with Shockley again.

After he invented the field-affected transistor, he focused his further studies in the field of superconductivity. In 1957 Bardeen presented the Bardeen-Cooper-Schrieffer theory, which is also known as the BCS-theory, with his



John Bardeen

colleague Leon Cooper and his student Robert Schrieffer. This theory describes that electrons near the Fermi surface become unstable against the formation of Cooper pairs, which is a binding between an electron and a positive charge due to an attractive potential.

In his entire life John obtained several awards, but the most notable awards were his two Nobel prizes in physics. The first one was in 1956 for his work in the research of the transistor effect, which he had to share with Shockley and Brattain. The second Nobel Prize was for his developed theory in superconductivity, which he had to share with Cooper and Schrieffer. Because of this second prize, John became the first person to win two Nobel prizes in the same area of research.

To wrap things up, John Bardeen's work has had a big impact on the way we work and live nowadays, as he stood at the foundation of the transistor. Today we cannot think of a world without transistors since they are the most fundamental building block of digital electronics. Next to this he brought us a bit further in the research of superconductivity with his Nobel Prize worthy BCS- theory. That is why John Bardeen is an icon of Electrical Engineering. ■

Find your dream job via Thor

By: Jasper Sleumer

Numerous career events are being organized on and outside the campus of the TU/e. How do you filter out the appropriate event for you as an Electrical Engineering or Automotive student? And why should you attend these events in the first place? Using your time outside the lecture room for studying is more important, right? During your time at the university, you will also receive lots of information of companies via magazines, flyers, Facebook, email and more. "Spam?" "Not at all!" Even better, it can help you find out what you want to do after you graduate, where you want to go to and how you can get there

After you graduate as an Electrical Engineering student, more than ten companies are eager to hire you. "Wow that's great! I will certainly get a job to pay all my study debts back!" This is certainly true, but wouldn't you prefer a profession that suits you, where you arrive every morning with a smile on your face?

You probably know that Thor organizes all kind of career-oriented events. These range from excursions and lectures to workshops and trainings. Besides, you might find an email in your mailbox with information about companies to notify you that they organize an in-house day for example, find leaflets in the Board room, read an advertorial in this magazine or find a post of a company on the Thor Facebook page. This is a lot of information which is not brought to you to spam you, but to inform you about what is out there in the abundant world.

Our study association aims to prepare you as a member for your future career. The Commissioner of Public Relation visits companies and discusses what the company and Thor can do together in a form of cooperation. We give you the chance to gather information about the job market: what it is offering, what you do and do not want to become, and, also very important, how do you get in?

Our study association aims to prepare you as a member for your future career.

been working on? You can experience the ambiance of a company during its visit, get to know it and find out if you see yourself working here later. During lunch and pub lectures (you'll receive a free lunch or free

drinks/snacks!), the company tells you what it is about, what it does and highlights some of its products or services in detail. Are you further in your studies? We organize trainings and workshops too, where companies check and reflects upon your CV and LinkedIn profile, tell you how job interviews go and how to prepare yourself for these. This is not always easy and straightforward! You might underestimate the importance of these aspects.

The Kvasir committee makes sure that the events are organized. Promotion and information can be found on the website of Thor, on Thor's Facebook page, on the flyers we distribute in the first week of every new quartile during lectures, and the poster screens in the Flux building. Participation is totally free. This can't get any better: get to know companies for free, your later career goal, where you want to go and how you get there.

Do you want more information about Thor's career-oriented activities or companies, contact the Commissioner of Public Relations (externebetrekkingen@thor.edu). See you next time during a company visit, lunch lecture, or pub lecture! Good luck with finding the right career path! ■



A company visit where you can see the theory in practice



Find out more about a company during a lunchlecture

Designing the Brains of Complex Manufacturing Systems

By: Bram van der Sanden

Efficient manufacturing of products has become more important than ever in our global society. Have you ever thought about how these systems themselves are designed? Manufacturing systems that produce these products are becoming increasingly complex. They need to be flexible, in order to quickly adapt to changing market demands. Products need to be produced faster, while ensuring their quality. All these constraints make the design of present-day manufacturing systems a true challenge.

Achieving the economic and quality goals of manufacturing requires the use of a sophisticated controller that directs the scheduling of operations in the system and handles on-line changes in the production process. The controller in a sense functions as the brains of the system, and controls its behavior. In this article, we describe how these controllers can be automatically generated from domain-specific models that specify the system and its requirements.

Domain-Specific Models

To make a good controller design, we first have to know the manufacturing system for which we are designing a controller. The behavior of these systems becomes so complex, that it cannot be totally understood by a single system designer or operator. To deal with the complexity, we use model-based engineering, where we create formal and executable models of the system. These models describe precisely the possible system behavior, i.e. what the system can do, and the requirements, i.e. what the system should do. In the end, the complete model is composed of many building blocks. To understand the full system behavior, we need to understand the individual parts and how they interact.

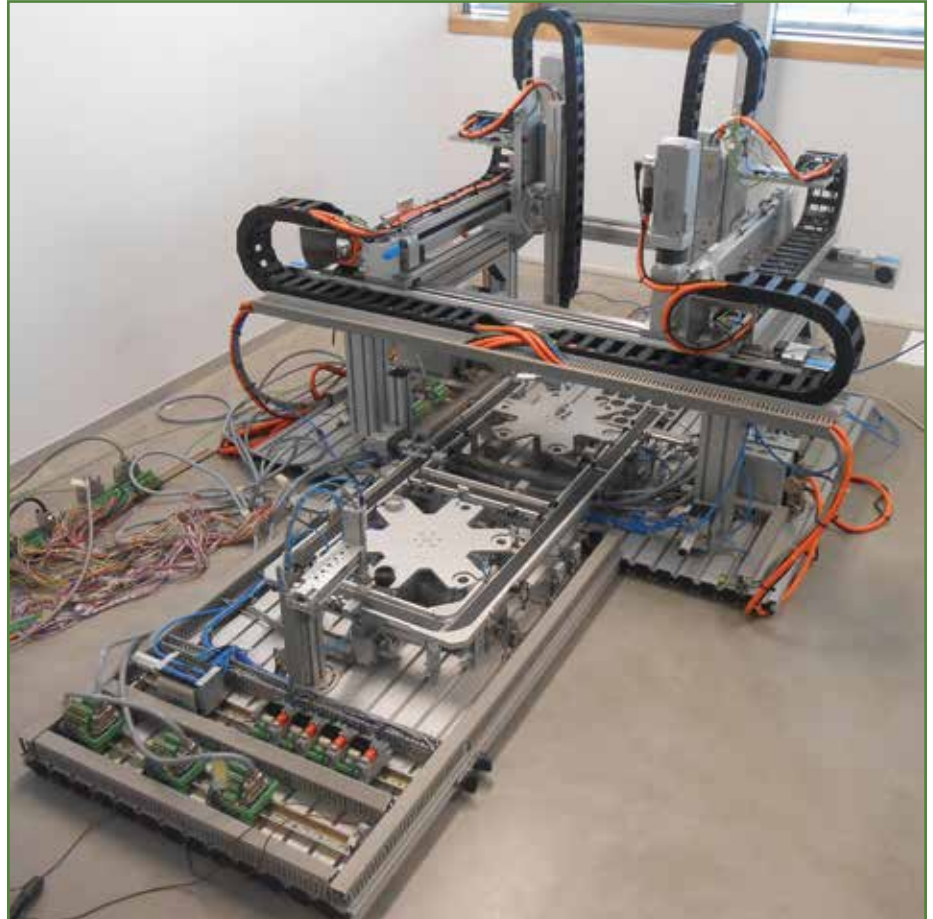


Figure 2: xCPS platform, a small-scale machine mimicking a production line to assemble and disassemble objects.

Then we can study the complete behavior using computer simulations and interactive visualizations.

The models are used throughout the development process of the controller. Since the models are formal, we can provide guarantees on functionality and performance if the system is built accordingly. After specifying the possible system behavior and the

requirements, we can automatically generate a controller that enforces all requirements upon the system. After including timing details of the operations, we can also optimize this controller according to one or more performance indicators. For example throughput, which is an indicator that specifies how many products per time unit are produced. Figure 1 shows this work flow.

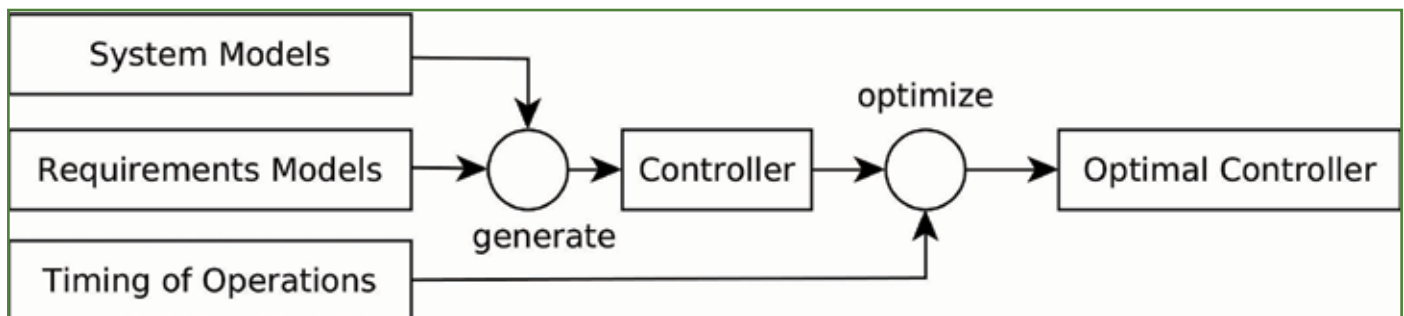


Figure 1: Work flow to automatically generate an optimal controller.

An advantage of the proposed work flow is that we can do early design-space exploration, where we compare different designs of the same system. This is enabled by the model-based approach. If we adapt the model to formalize a different system configuration, we can generate a new controller for the system with a push of a button. This new controller can then be compared with other controllers for different system configurations. In the next sections we describe each step of the work flow in more detail.

System Models: What can the system do?

The first step in the design flow is modeling the capabilities of the system to describe what the system can do. This means that we define the components in the system, and the actions that each component can perform. We also model system activities, that may contain multiple actions and dependencies between those actions. These activities can be scheduled by the controller. An example of such an activity is performing an operation on a product, or picking up a product at one processing station, and bringing it to another processing station.

As an example, consider the xCPS platform (www.xcps.info) shown in Figure 2. This platform mimics a production line capable of assembling and disassembling objects. One of the components in this platform is the turner, shown in Figure 3, which can turn objects. To model this turner, we need to model both the actuators and sensors. The actuators are the motor of the vertical arm,

the gripper, and the rotator. Two sensors are modeled to detect when the vertical arm is up or down. The Turn activity specifies the order of actions to correctly turn a piece. First, we ensure that the vertical arm is down. Then, we pick up the product by closing the gripper and moving up the arm. When the arm is up, we can rotate the piece. After rotating, the arm is moved down, and the gripper is opened to release the now correctly oriented product.

Given the operations in the system, we describe the behavior of the system in terms of system states and transitions between these states. We use state machines to formally capture these states and transitions. The information of these states is for instance related to which processing stations are currently processing some product, or the location of products. The transitions represent the operations that can be executed from a given system state. For instance, when a product is on a processing station, this station can start processing the product. Since we use a modular approach to describe the system, we define different state machines for different system components and their behaviors. This allows us to consider each aspect in isolation. If one looks at the full system behavior, all these different state machines interact and influence each other.

To get a full system specification, we also model the environment of the system. The environment can change the system state, and the controller has no control over these changes. For example in the xCPS platform, the environment influences the orientation



Figure 3: Turner in the xCPS platform and the corresponding models.

of pieces that enter the system. Dependent on the orientation of a piece, a Turn activity needs to be executed. To distinguish the controller and the environment, there are two types of transitions in the state machines. Transitions with operations are called controllable transitions, and transitions with actions of the environment are called uncontrollable transitions.

Requirement Models: What should the system do?

To generate a controller for the system, we need to specify the requirements that the controller needs to enforce. These requirements specify in which order certain operations or actions are allowed to occur, and thereby restrict the behavior of the system to prevent undesirable behavior. For instance for safety, we want to ensure that two robot arms do not start moving towards each other and collide, or that products are damaged when placed on top of each other. Requirements also prescribe the life cycle of operations, such that the machine only outputs a product once it has gone through all production steps in the right order.

Generating a controller

We have a method to automatically derive from the state machine models of the system and the requirements, a state machine model of a controller that respects all requirements, if such a controller exists. Therefore, no model of the controller has to be made by hand. The generated controller model enforces the requirements on the system, and is correct-by-construction. Figure 5 shows the controller for our example. ►

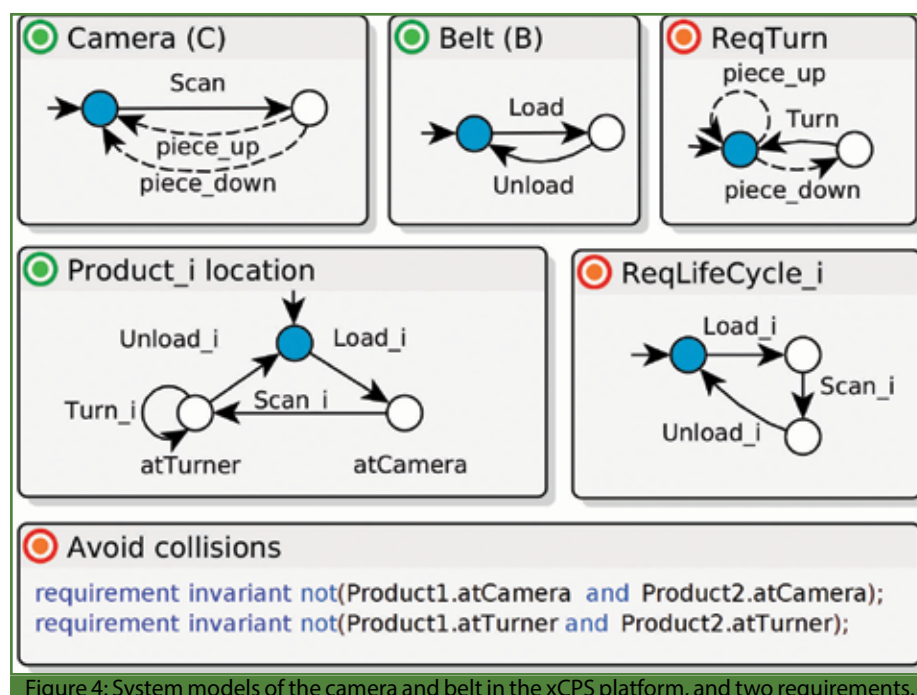


Figure 4: System models of the camera and belt in the xCPS platform, and two requirements.

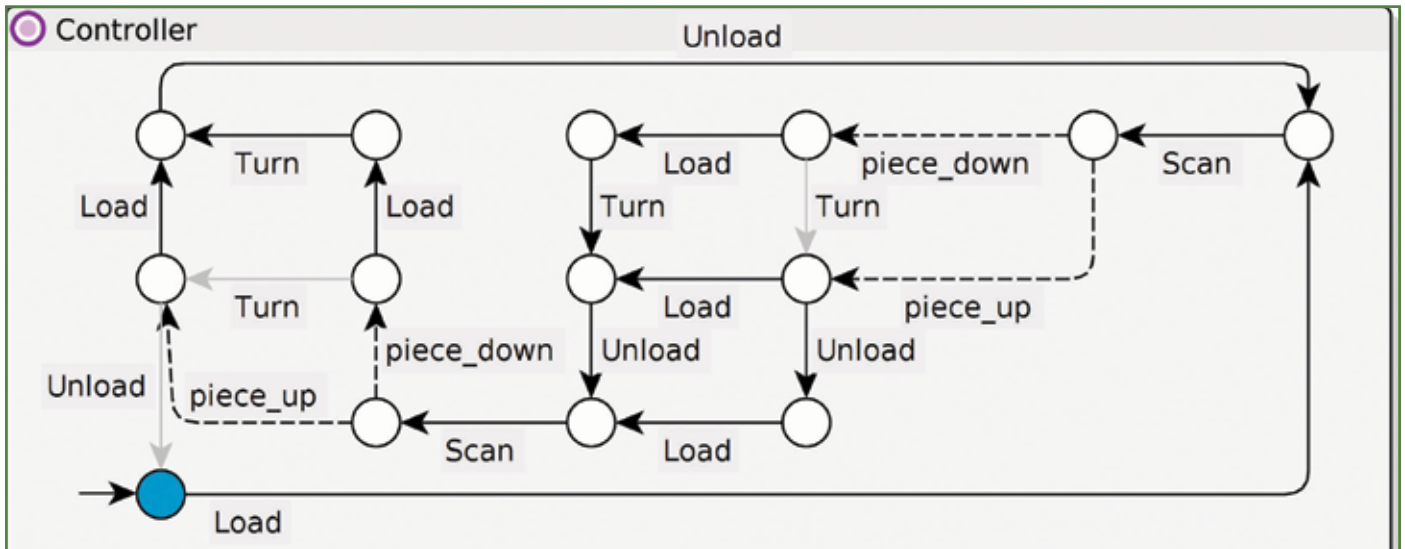


Figure 5: Resulting supervisory controller for the example.

We obtain a controller that allows all control decisions that do not violate any of the requirements. This means that in some system states, there can be multiple control decisions enabled. A controller implementation may select an arbitrary operation among the enabled ones.

Optimizing Productivity

After generation of a controller, there can be system states where multiple transitions are possible. In such states, we look for the optimal decisions that maximize productivity. To find these decisions in each system state, we include the timing information of the operations. Since transitions from the environment are not controllable, we can only choose the controllable transitions. The uncontrollable transitions all remain, because the controller cannot disable those. Therefore, we look for the best control decisions for productivity under consideration of all uncontrollable transitions.

In Figure 5, the optimal control decisions are marked in black. The gray transitions correspond to suboptimal control decisions. The optimal controller already starts with the load as soon as the scan of the previous product finished, instead of waiting for the whole system to be empty first.

Just like in describing the system, we also use state machines to capture the requirements. Each requirement is modeled as an individual state machine. This makes it easier to remove, add or adapt requirements.

To complete our example on xCPS, we introduce three additional system models and three requirements. These models are shown in Figure 4. The first two system models describe the behavior of the camera and belt

respectively. The third system model keeps track of the location of a product with identifier I, and system activities involved with this product. Each product that enters the system is given an identifier. Activities with no identifier suffix in the model refer to any product. In the system we can have at most two products; one at the camera, and one at the turner. Therefore, the transition with activity Scan for example refines to Scan_1 and Scan_2.

The first requirement (ReqTurn) describes that a piece must be turned if it is down (piece_down), and not if it is up (piece_up). The second requirement (ReqLifeCycle_i) describes the work flow that a piece shall first be loaded, then scanned, and finally unloaded. The third requirement (Avoid collisions) makes sure that we do not have two products at the same location in the system. These requirements ensure that pieces will always be unloaded in the correct orientation, and no product collisions will occur.

Designing a controller for wafer scanners

We apply the proposed design flow at ASML, which is the world-leading provider of lithography machines. These machines (see Figure 6) are used in the production process of electronic chips. You can find those chips in your mobile phone, tablet, laptop, or smart television. Designing controllers for these systems is a challenging task, due to the large scale of the actions and operations, and all the use cases that the controller needs to be able to handle. In our research project, we focus on the product (wafer) logistics in these machines. The logistics controller ensures that each product is handled correctly, and optimizes production over time.

So far, we have created system models and requirement models of the logistics under assumption of nominal behavior. We take into account the life cycle of products, how many products can be at a processing station, robot collisions, product order requirements, and situations where the user of the system explicitly tells how the product should be handled. This model is linked to a formal model of the real system, that describes in more detail and with timing information what the system can do.

Due to the complexity of the problem, we have not yet been able to derive a controller that enforces all the requirements mentioned before upon the system. Currently, a controller can be generated if we leave out the opportunity for the user to specify how the product should be handled, and assume the same recipe for each product. In next steps, we want to extend the model to cover other use cases, tackle the challenge of controller generation, and realize the automatic generation of controller implementations from the controller models.

The work flow of automatically generating a controller has various advantages. It allows system designers to take a step back from unnecessary details, and focus on actually designing system requirements. Each system aspect is modeled formally, which forces the designer to be precise. The models can be validated already in an early stage, because they can be simulated and verified. Designers can investigate the impact of requirements, by choosing a selection from all requirements and looking at the system behavior that results after generation. Another use case is design-space exploration, where we can change the duration of certain actions and

see the impact on the overall system performance, by repeating the step of finding an optimal controller.

Research

In the first two years of the research project, we have developed a formal modeling approach to specify the system. We have shown that this approach can capture the requirements in wafer logistics in a very natural way. The resulting model maps intuitively onto the requirements of the system designers. We have also developed new algorithms to optimize a controller model for throughput.

There are many research questions on the road ahead for the next two years. We want to investigate the scalability aspect of the automatic generation. In case of logistics in lithography machines, there are many requirements and use cases that have to be covered. This results in a large model, for which automatic generation is infeasible with the current techniques. There are ways that try to tackle this problem by restructuring the model, or generating a set of controllers that

work together to control the system. Another interesting aspect is determining optimal control decisions. In the current flow we first look at all valid control decisions and then find the decisions that are optimal from a performance point of view. Combining these two steps might be more efficient. The model describing these optimal control decisions finally needs to be translated in a controller that can be implemented in software. In the end we would like to have a controller that is able to cover all use cases and optimizes productivity of the system.

Conclusion

In the design of the next generation manufacturing systems, we will no longer design our controllers by hand, but rather describe what it should do with a model. From this specification, we can automatically generate an optimal controller. The initial work flow already gives nice results, and we are working hard to solve the next interesting research questions to make it ready to be used by industry.

Further Reading

If you are eager to know more about the research, then you can have a look at the website www.bramvandersanden.com. In our research we use CIF3 (<http://cif.se.wtb.tue.nl>) for synthesis of controllers, and SDF3 (<http://www.es.ele.tue.nl/sdf3/>) for performance analysis. Some relevant papers are listed below.

van der Sanden, Bram, et al. "Modular Model-Based Supervisory Controller Design for Wafer Logistics in Lithography Machines." Model Driven Engineering Languages and Systems (MODELS), 2015 ACM/IEEE 18th International Conference on. IEEE, 2015.

van der Sanden, Bram, et al. "Compositional Specification of Functionality and Timing of Manufacturing Systems." Forum on specification and Design Languages 2016 (FDL).

Adyanthaya, Shreya, et al. "xCPS: a tool to eXplore Cyber Physical Systems." ACM SIGBED Review, Vol. 14, Issue 1, Oct. 2016. ■



Figure 6: Lithography Machine of ASML.

Fifty-nine years Thor, time for a party!

By: Elwin Hameleers

Voortgetrokken, door zijn bokken, daalde Thor op aarde neer. Achtentwintigste november, hogeschool en lichtstad eer!" (Translation: Pulled by his billy-goats, Thor descended on earth. On the twenty-eighth of November, in honor of the University and light-city). This is the very first verse of the Thor song. As you might know, the study association Thor was founded on November 28 in 1957. This means that in the week of November 28 we celebrate our birthday, often referred to as 'Dies' (as abbreviation of 'Dies Natalis'). This year the birthday week of Thor was from Monday, November 28 to Friday, December 2, and as usual the week was organized by the previous Board of Thor. Of course, a birthday party is not complete without a theme, and this year the theme was: "Wir gehen Skifahren!" (translation: we're going skiing!), which also was the recurring theme throughout the previous year.

The birthday week of Thor started, naturally, with the official opening of the week. The President of Thor said some words and, as is normal for someone who's celebrating their birthday, it was time to eat some pie. A lot of different pies and 'Limburgse vlaaien' were present, displayed on several different tables on the first floor, and were gone within minutes. The following evening, another activity was planned. This was a cantus. A cantus is an activity revolving around singing songs, drinking beer and having fun with friends. This spectacle is led by the Praesidium, this time consisting out of Messrs. Van den Biggelaar, Oomen and Van Nunen.



They made sure everyone drank enough, but not too much, determined the songs everyone should sing and, if their instructions were not followed to perfection, determined the punishment. These punishments included some creative and funny ways of drinking your beer, although not every beer ended up in the stomach of one of the participants, called the 'Corona'.

On Tuesday, an excursion was planned to IHC Merwede. IHC Merwede is a company specialized in designing, developing and building ships and equipment for the dredging and offshore industries. On Wednesday, the

committee was up early to prepare things for the next activity. This activity was the Glühwein drink, because glühwein belongs to a real ski-themed birthday week! The committee was preparing 40 liters of glühwein, enriched with limes, oranges and cinnamon. This glühwein was sold that afternoon in Het Walhalla. After the Glühwein drink, the committee had chosen a movie which was both surprising and fitting to the theme to watch. The movie was 'Cool Runnings', a movie about the very first bobsled team of Jamaica. After we enjoyed the glühwein and watched the film, everyone went home to be well-rested for the next day.



The Thursday started off with a bow tie tying course. During the break on Thursday, Tom van Nunen taught the interested members of Thor how to make a bowtie from a regular Thor tie. With this special Thor bow tie, several Thor members showed off during the gala for the 60th anniversary of the TU/e. Later that afternoon, the real Dies party was held in Het Walhalla. To create a real ski-theme in Eindhoven, Het Walhalla was made extra cold by holding the doors to the roof terrace open. Next to this, a playlist was made with only German and Austrian après-ski music. For the finishing touch, the committee rented a snow blower to make it snow in Het Walhalla. To lure as many people as possible, there was budget for enough kegs of beer to make everyone warm again. This worked, Het Walhalla was completely packed and everyone had a good



time. For the hungry partygoers there was a snack bar present in front of Flux. The party ended at 10 o'clock in the evening after which most party people continued the festivities in the city of Eindhoven.

The fifth and final day of the birthday week of Thor started off with a hangover breakfast, organized by the activity committee of Thor. This breakfast consisted of eggs and bacon, pancakes, coffee and everything else you would want to cure a morning after headache. Even though the people who subscribed themselves for the hangover breakfast were still at home in bed with a – you guessed it – hangover, the organization and other hungry Thor members were present in Flux to cure their hunger and to trade their hangover for some energy to keep them going during the day. The afternoon was reserved for the 'Oude Bokkenborrel'; a special drink organized for all the old Board members of Thor. The current Board welcomed everyone and, again, Het Walhalla was completely full,

but this time with people in suits (because the Oude Bokken like to suit up). Not only previous Board members were present, also their dates for the dinner afterwards and current Thor members, with their dates, were in Het Walhalla to bring the birthday week of Thor to a festive ending. The people who only knew Thor from Potential (or even E-hoog) reminisced about how things were in the past (some even persisted in their views that everything was better 'in the good old days') and sometimes made this tenaciously clear to the younger guests. The younger guests, in return, praised the way Thor is at the moment and even got some nuances out of the Thor members from a long time ago. At one time, everything has to come to an end, just like the 'Oude Bokkenborrel'. Luckily, this was not yet the end of the birthday week of Thor. After the drink for the old Board members, there was a bus ready to bring us to a special place. This was the castle of Heeswijk. We entered the castle of Heeswijk over a bridge over a moat and went into the cellars. There we



were received in a hall where we got a sparkling wine and the President, the chairman of the committee, old Presidents and honorary members all gave speeches on the past, present and future of Thor. Once the speeches were done, the Board gave the previous Board funny and relevant presents before we continued with a lovely luxurious dinner. The three courses were accompanied by delicious wine and everyone ate (and drank) their belly full. The dinner was the official end of the birthday week of Thor but this did not stop Thor members to add an unofficial after party in the city of Eindhoven.

The Dies committee enjoyed organizing the various activities for the 59th birthday of Thor. We wish Thor many more years of helping students of Electrical Engineering and Automotive in both studying and relaxing.

Geen Gedonder! ■



Fluxcursions

By: Sander Wasser, Alexandros Rikos and Marcella Gunther

Last year Thor organized a new event: the Fluxcursions. The Fluxcursions were meant to help the student choose a research group for their master Electrical Engineering. During your time at the university you have to make quite some choices, but to choose the specialization of your graduation project is one of the harder ones. This is because you have to make this choice, more than a year before you start your graduation project, based on a 15-minute presentation. To support the student in this difficult position Thor asked the research groups to organize a tour at their facilities. After the events a few students were asked to talk about their experience of the Fluxcursions.

At the start of the previous academic year I was close to finishing my bachelor of Electrical Engineering, so I had to look into the possibility of following a master at this university. At that time there was the Explore Your Master event, which are two days of presentations of all the Electrical Engineering masters. After the presentations there was an information market where I first heard of the Fluxcursions. Because of the presentations of the event I knew I was mainly interested in the Control Systems and Electronic Systems groups, so I decided to go to these two Fluxcursions. At Control Systems there was a presentation of Siep Weiland who

showed a couple of example projects which are relevant for the Control Systems research group. Also we were allowed to come to a final presentation of a graduation project

the labs in Flux where the research group works and a lot of projects are stationed, like a couple of 3D printers and a Cyber-Physical System which consists of a lot of sensors and

The Fluxcursions helped me a lot to determine my choice for Electronic Systems which I started this year.

to get a feeling for what we would learn in the master. At Electronic Systems there was a presentation of Twan Basten together with a couple of researcher who talked about their progress and solutions. We also visited

actuators. The Fluxcursions helped me a lot to determine my choice for Electronic Systems which I started this year.

Sander Wasser

In the previous academic year, the excursion program was slightly different per group, but you can surely expect the following: first of all, you will attend a presen-

their laboratories. For example, during the Fluxcursion to the Electromagnetics group, you will have the opportunity to enter the anechoic chamber and understand how

But even if you have already decided, it is useful to attend Fluxcursions to verify if the group and their projects meet your expectations.

tation where general information is given about the research group, such as their fields of research and on-going projects. Secondly, many groups will give you a tour around

antennae are tested. At the end of each Fluxcursion, you will have ample time to ask all your questions while enjoying some drinks.

The Fluxcursions are aimed primarily towards 2nd and 3rd year students who have trouble deciding what field of Electrical Engineering or Automotive they want to pursue in their master's study. But even if you have already decided, it is useful to attend Fluxcursions to verify if the group and their projects meet your expectations. So, keep an eye on the Thor website if you want to sign up and good luck choosing your master!

Alexandros Rikos

One of the reasons for participating in the Fluxcursions is that it helps with choosing the direction at which you want to graduate. During Explore Your Master (EYM) you already get a general overview of

you also get plenty examples of current master and PhD projects.

The second reason for participating in the Fluxcursions was because I simply wanted to

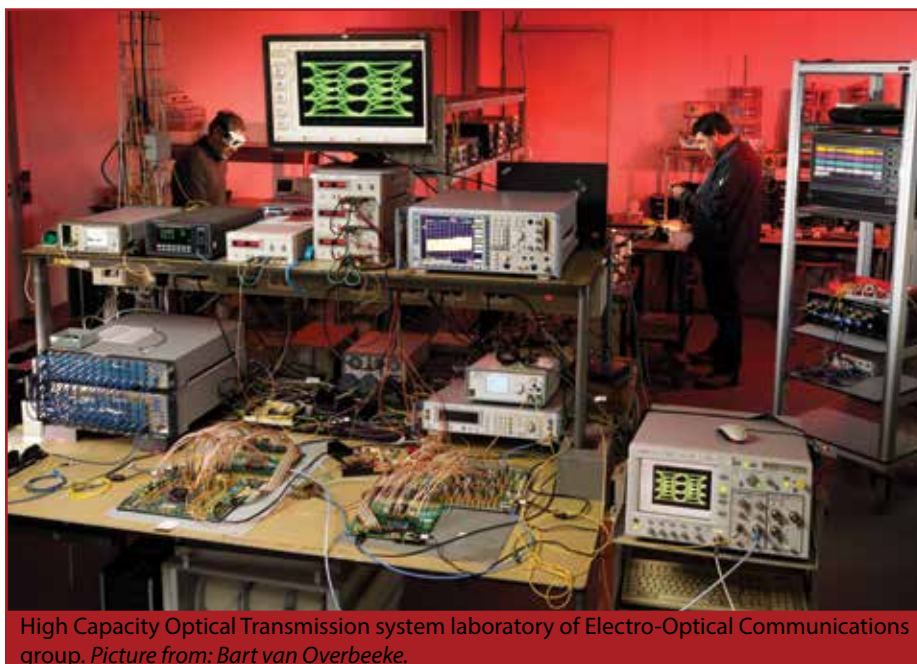
courses of the same capacity group, hence you have a few moments when you actually hear about it. With the Fluxcursions you have an extra moment.

"What's the difference between Control Systems at electrical engineering and the master Systems and Control" and I know who I can contact for more specific topics within a capacity group.

the different groups during the short presentations of the different capacity groups. However to get more detailed insight you should go to the Fluxcursions. Besides a clear overview of the group itself,

know more about the research that is been conducted at our faculty. During courses you often get plenty of examples of the current projects at different capacity groups. However during your bachelor you only have a few

For me, the Fluxcursions definitely played a role in my choice for a capacity group in the master. I could ask more specific questions regarding courses, or for example "What's the difference between Control Systems



High Capacity Optical Transmission system laboratory of Electro-Optical Communications group. Picture from: Bart van Overbeeke.

at electrical engineering and the master Systems and Control”, and now I know who I can contact for more specific topics within a capacity group. Especially the latter is also useful, since some staff members are quite busy and it is sometimes difficult to go to them. I was in doubt between three groups, but even if you already know at which group you want to graduate, participating in Fluxcursions is interesting. Just like any other excursion.

Marcella Gunther

This year the Fluxcursions will be organized again starting in the fourth quartile. So if you are interested and/or have to make the choice yourself, be sure to attend the events! ■

Dies excursion IHC Merwede

By: Gijs Neerhof

Tuesday morning the 29th of September, early after the dies cantus, ten of us went to Kinderdijk to see the shipyard at IHC Merwede. First, there was a presentation about all different kinds of vessels they produce and the specific ship that was in production at that time. Some interesting things were the electrical features like two 3-phase generators on a single diesel engine axle to generate half of the ship's power and numerous power inverters for all frequency dependent components.

After the presentation, we put on helmets, ear protection, shoes with steel toecaps and high-visibility jackets, and entered the huge shipyard. This is where workers were putting the final details on Minerva, a 32MW sludge dredger for ocean use. With its launch the next Saturday, sparks from welding and cutting were flying around the hall and hundreds of cables were going to and from the ship. This specific ship uses a cutter head on the end of an arm that can reach the ocean's bottom. Held on the ground by sheer gravity, the cutting head rotates to remove sludge from the ocean floor and pump it up towards the ship. Once in the ship, it could either be sprayed out of the back ('rain-bowed') or pumped over to a storage vessel, since the ship didn't have a sludge storage compartment. The ship was exceptional in its size class, since it didn't need a tugboat to

move it. Standing only meters away from this dredger gave a really good impression of its enormous size. At the shipyard they produced not only sludge dredgers of all sizes, also pile drivers and cranes for all sorts of offshore applications, like windmill farms, were built. Huge pile heads were being tested for their flatness and spare parts of all sizes could be found in storage.

After seeing all these awesome ships, we returned to the train station with the bus.

During the ride, the driver gave in to our request to make an extra turn on the roundabout which was the highlight of the day. Overall the excursion was very interesting and IHC definitely offers a challenging environment for electrical engineers. Seeing the huge ships being built there and the electronics needed to drive it all certainly showed us that electrical engineering doesn't only concern microelectronics, and that these ships are colossal. ■



Studentbody EE/AU

By: Niels Vertegaal

Did you ever hear about the StudentBody or see it on the poster screens in Flux and wondered what it was? The last time that a Connecthor article was written about the StudentBody dates a few years back. Meanwhile, we moved to Flux and new generations of students started studying Electrical Engineering and Automotive. This article will explain our most important tasks and how a student can participate in education. Our department consists of many committees and councils where students can give their opinions. At the head of the University is the Executive Board, responsible for policy and day to day activities of the TU/e. A lot of cases however are decided at department level without the involvement of the Executive Board. A prime example of this is the education program. For this reason, each department has its own board.



StudentBody EE/AU

The StudentBody consists of three students: Bram Witteman, Tom van Teeffelen and Niels Vertegaal. Any student who has suggestions, complaints or questions about the education of both Electrical Engineering and Automotive can contact one of us. You can find us via mail at StudentBody@tue.nl or you can find one of us in Flux most of the time, don't hesitate to contact us.

Year Council

Next to always being available for students of the department, our most important task and source of information are the year councils. These year councils, consisting of 8 – 15 students (including the Commissioner of Education of Thor), guard the quality of the education of every year and try to solve the problems that arise. These year councils meet once a week (depending on the year council) during the lunch break and everything is discussed ranging from the quality level of the slides to the difficulty level of the exam. Smaller problems can be solved by visiting or mailing the responsible lecturer.

However, when problems are more difficult to solve for the Commissioner of Education and the StudentBody, students are invited to the Panel of Education.

Information from the year councils is gathered inside a quartile report, which is written by the StudentBody. This report, including

passing percentages and course evaluations, is used by the Education Committee to evaluate and improve courses where needed.

Panel of Education

In the Panel of Education (PoE) there are representatives from all the councils and committees of the department, and often the Directors of Education from both the Bachelor College and Graduate School join in as well. The StudentBody, Commissioner of Education and students from the year councils will also be present. Here it is quickly determined how

to solve the problem. The PoE is organized once per two weeks during a lunch break. This meeting is also used by members of the panel to update each other about things happening in each separate committee.

Explore your master

Yearly, the StudentBody organises the Explore Your Master event. During the Explore Your Master event, all master options and Graduate School information will be presented. During both days, presentations will be given by the capacity groups. This year, Explore Your master will take place on May 1st and 3rd. A market will be organized on May 1st in the afternoon. Here you have the opportunity to ask questions in a more informal way.

Our other tasks include, but are not limited to, the organisation of the Introduction Week in collaboration with Thor, organization of the Education BBQ for everyone who participated in improving the education, and distribute the yearly education award for the best teacher.

If you still have any questions, don't hesitate to mail us at StudentBody@tue.nl. ■



Symposium future of Electrical Engineering

By: Jan Vleeshouwers



Electrical Engineering in the Netherlands is growing. We attract an increasing amount of students and the areas in which Electrical Engineering is applied to solve problems, seem to expand limitlessly. What are we heading for in our profession? If we are to focus, what are the most crucial topics in which society can profit from our expertise? Which are the big technical hurdles we are about to encounter? And how are we going to address them?

On January 19th, 2017, our faculty will host a symposium, in which the Dutch faculties of Electrical Engineering of Twente, Delft and Eindhoven and IEEE Benelux try to find some answers to these questions. At the time of this writing, the date is still in the future, but we'll report on the outcomes in the next Connector. A worldwide view on the future of Electrical Engineering will be presented by dr. Roberto Saracco, Chairman IEEE Future Directions. He has been involved in many topics regarding future developments, in particular in ICT research for over 40 years, most of them in Telecom Italia. You will get an idea by reading his blogs on <http://www.eitdigital.eu/blog/>.

Previous developments in Electrical Engineering have shown to be very diverse, and often in unexpected areas. But Electrical Engineers have never refrained from taking up challenges just because a topic seems unrelated to Electrical Engineering. To show where this attitude is leading to, three distinguished researchers will present their most inspiring research. Professor Miro Zeman will focus on the future of solar-powered energy systems, professor Peter de With will

sketch the future of medical applications, and professor Bram Nauta will explore the magic possibilities of engineering.

The overview by Roberto Saracco and the examples from Miro Zeman, Peter de With and Bram Nauta will be the basis of a panel discussion which will focus on long term questions, such as:

- Are we still missing areas in which Electrical Engineering can be fruitfully applied?
- Do we need to focus or do we need to explore all possible leads?
- What does our society need to direct more technical talents towards a life in engineering?
- Are the systems which EE engineers help to develop, running into complexity limits?
- If we keep on expanding, will the diversity of applications lead to a subdivision in the field, or will the potential of one engineer covering the full breadth of field still keep it unified?
- Will the competition for funding help our new ideas develop or will it be an obstacle?
- What drives the development in Electrical Engineering most: the creativity of engineers or the demands of society?

In the panel two engineers from industry, Jan van Vlerken (ASML) and Korneel Wijnands (ProDrive) will try to keep the academics' feet on the ground.



IEEE Benelux General Assembly – Meet the Fellows

On January 19th, 2017, in the evening, the IEEE Benelux General Assembly will be held. The Section Chairperson, Bart Smolders, will give an introduction on the Benelux Section and on the proposed committee after which the official election will take place. The General Assembly is followed by a 'Meet the Fellows' event. Three of the new Fellows elected in 2015 and 2016 will give a keynote talk and present their research fields and their evolutions to a wider audience: Professor Claude Oestges from Université Catholique de Louvain will discuss MIMO wireless communications, professor Eugenio Cantatore from Eindhoven University of Technology will describe his research on flexible large-area electronics, and professor Stefano Stramigioli from University of Twente will present his research on complex robotic systems. ■

Grettis Saga

By: Fer Radstake

Besides being named after the Norse god of thunder, e.t.s.v. Thor has much more to do with the Vikings. The names of committees like Ivaldi and Kvasir, our fileserver Mjolnir and our pub Het Walhalla all come from Norse mythology. Our members like to behave like a bunch of Vikings too, loudly chanting the Thor song on every occasion and cheerfully raiding the “constitutieborrels” of the other associations, never returning without some kind of loot. In short, we’re a real Viking association. So like the Vikings of old, let yourself be entertained by this comical tale about Thorsteinn Ásmundarson and his lover Spes.

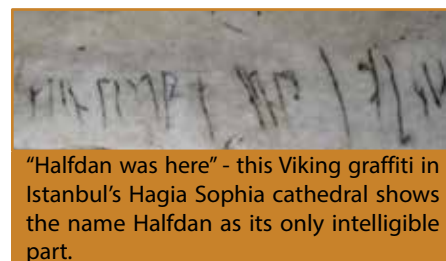
Grettis Saga (c. 1320) is one of the Sagas of Icelanders, a loose collection of sagas about various figures in Icelandic history. Grettis Saga tells of Grettir Ásmundarson, a famous outlaw who amongst other things defeats the draugr¹ Glámr. The final part however deals with Gretti’s brother Thorsteinn, a Varangian Guard in service of the Byzantine emperor. Although the saga deals with matters likely taking place in the early 11th century, it clearly shows a strong medieval influence in its comedical nature.

Beginning in the early 10th century, Vikings from their stronghold in modern Kiev fought as mercenaries in the Byzantine army. In 971 this was formalised in the Varangian Guard², which soon became one of the most reliable and powerful forces of the Emperor. News of the good pay in service of the Byzantines soon reached the Varangians’ brethren in Scandinavia, and Swedes, Norwegians and even Englishmen continued to travel to Constantinople until at least the 13th century.

Long ago in Constantinople lived a rich and high-born lady called Spes. She was married to a man called Sigurd, but she had married him for his wealth and it was not a marriage of love. Then one day, she met the Varangian Thorsteinn. The two fell in love, and started an affair. Spes often gave Thorsteinn gold, and one day Sigurd came to her: “You squander your money in many ways and pay little attention to our affairs. You seem to be in a dream, and never want to be where I am. I’m certain there’s something going on! Is there some man you prefer to me?” “I told you when we married that I’d be my own boss about matters concerning myself, that’s why I don’t spare your money. I won’t speak to you if you accuse me of such things!” Spes answered, and Sigurd dropped the subject for the time.

One evening Spes and Thorsteinn were sitting in a room where Spes kept her treasures. Thinking her husband had gone drinking, she asked Thorsteinn to sing something. After a short while, her husband and his servants came banging at the door, demanding she’d unlock it. Spes had just opened a large chest to show Thorsteinn her jewellery, and said to him: “Quick, get into the chest and keep quiet!” She locked the chest and sat upon it, just as her husband broke through the door.

“Now you have revealed yourself! Where is the man I just heard singing? You undoubtedly think his voice is better than mine.” “You always think you’re so cunning, and try to pin your lies on me, as in this case. Well, go ahead and find that man. He can’t have escaped through the walls or roof!”



“Halfdan was here” - this Viking graffiti in Istanbul’s Hagia Sophia cathedral shows the name Halfdan as its only intelligible part.

After Sigurd had searched through the room and found nothing, he asked his men whether they had heard what he had. When they saw how angry Spes was however, they answered that one was often mistaken about sounds. Sigurd then went away, quite certain he knew the truth, although he couldn’t find the man.

Some time later, Thorsteinn and Spes were making out in her dressing room, when suddenly her husband came up with some troops and started breaking into the room. Quick-witted, Spes covered Thorsteinn with a bundle of clothes, and she leaned against the heap as the men entered.

“Do you again deny there was a man with you?” Sigurd said. “Oh, you’ll find him surely now. Just don’t act so violent and don’t push me about.”

The men searched the room, but found nothing and eventually gave up.

“Of course you won’t find what’s not there. Now, will you admit you were wrong and free me of your slanderous accusations?” “By no means,” Sigurd answered, “as I know that what I accused you of is true. This time



This miniature from the Skylitzes Chronicle shows the Varangian Guard. Note their battleaxes.

1. An undead zombielike creature. Many possess intelligence and great magical abilities. Popularised in the famous video game Skyrim.
2. From Old Norse Væringjar, “sworn companion”, “one who has sworn fealty to a lord”.



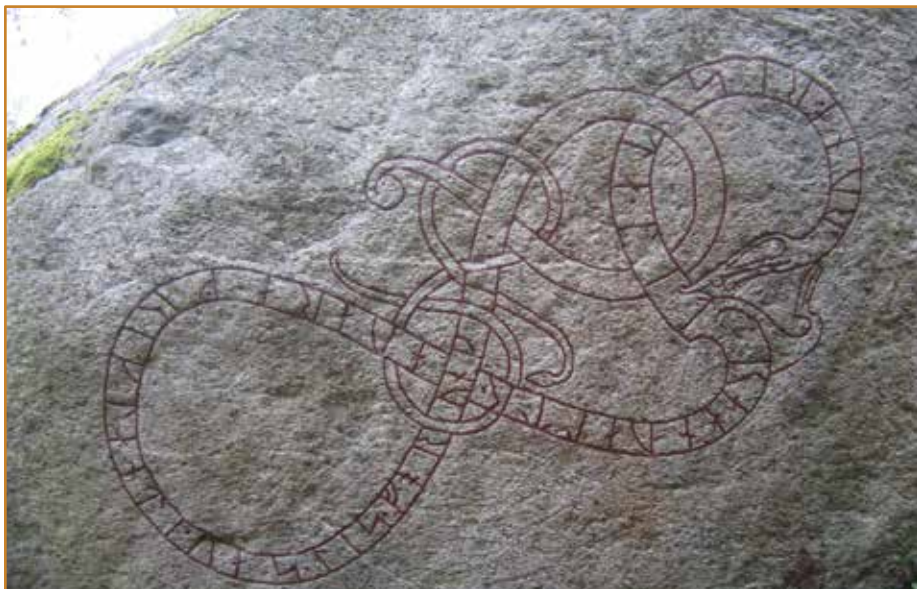
This miniature depicts a Byzantine woman killing a Varangian who tried to rape her, whereupon his comrades praised her and gave her his possessions.

you will have to clear yourself, as I'll never let your shameful deeds go unpunished. Take an oath before God, and deny your unfaithfulness, and that you expended my money and property!" "I'm quite ready to do that. I'll go at once, tomorrow morning, before the bishop so that he may fully acquit me of this charge."

So it was, that on a rainy morning Spes left for the cathedral with her entourage. Rain had been falling all night, and the streets of Constantinople were wet and muddy. After a while the party came to a particularly large pool, and although Spes looked hard for a way to cross it without spoiling her expensive clothes, she couldn't find any. Then a large and bearded man stepped forward from the crowd of beggars and vagabonds that were always asking for alms.

"Let me, good lady, carry you across," he offered. "I'll do my utmost best, and it can be only advantageous for you to show compassion for the poor like me."

"Very well, but know that if you don't carry me well, I'll have you beaten!"



"Ragnvald had these runes carved; he was in Greece, where he was commander in the army."

"I'll gladly risk that," the beggar said and took Spes on his broad shoulders. He carried the princess with ease at first, but the pool was broader than he expected and he staggered as he continued. "Don't dare to put me down here in the mud!" Spes shouted, and the poor man staggered on. By the time he neared the far side of the pool, he trembled from exhaustion, and just before he reached dry land he collapsed and fell forward. Spes could just make it onto dry land, but the beggar fell face-first into the mud. As his hands searched for something to pull himself up, he touched the lady's upper legs, and Spes screamed:

"Keep your hands off me, you dirty beggar! I'll have you beaten for this!" "I thought I just did you a service! I'd hoped to receive an alms,

but instead I get but threats and curses for my service!" the beggar replied angrily, and the whole crowd of beggars around the pair voiced their support.

"All right, all right. It wouldn't be fair if you weren't paid for your work. Now disappear from my sight," Spes answered, and she cast a gold piece at the vagabond.

Spes had now reached the church and she entered as a great crowd had assembled to watch her take the oath. Sigurd eagerly put forward his case before the bishop, and asked if she could free herself from his charges.

Now Spes said: "What man have I supposedly been with? Of course I meet many worthy men, which is not a cause of shame. But I hereby swear, that I have given gold to no-one, and have had no-one defile my body, except for my husband and that wretched beggar who laid his hand on my inner thigh on my way over here!"

Having sworn her oath, Spes' kin complained about how shameful it was for a woman of her standing, to be falsely charged with such things as adultery, a crime punishable by death. So Spes asked the bishop for a divorce, and with the support of all her kin it was readily granted. Sigurd was driven from the land, and he would never be seen again. And Thorsteinn and Spes? They married soon after, and although it was rumoured that the beggar had been Thorsteinn in disguise, they lived happily together until they died of old age. ■



This manuscript in Old Russian details of the Viking king Oleg (Helgi) of Novgorod's raid on Constantinople in 907 CE.

From stair lift to submarine

By: Joske van der Horst & Marc Troost (AME)

“To the customer, it might seem like an uncomplicated mechanism that just climbs up and down the stairs with a simple joystick. But in reality, this stair lift contains the state of the art technology”.

Marc Troost (28), System Engineer at Applied Micro Electronics “AME” B.V. (AME) in Eindhoven, becomes enthusiastic when he talks about his latest project. For the last three years, he worked in close cooperation with colleagues on a complete redesign of an already existing stair lift. The particular contribution of Marc consisted of the development and testing of the hardware and the development of a part of the motor control software.

The customer of this project was a producer of stair lifts, who involved AME in the development and production of the electronical parts of the new stair lift system. The intensity of the cooperation between AME and a customer, which is always a business-to-business relationship, differs per project and per customer. Within this particular project, the contact with the customer was relatively intensive. “Sometimes a customer has a general idea of a new product and wants us to come up with a concrete proposal”, tells Marc. “That gives us a lot of freedom in our work. However, in

the case of the stair lift, it was another situation because the customer brought in their own engineers to intensively participate in the development process. This created close cooperation and a mutually beneficial relationship, which raised the project to a higher level than both parties could have reached individually.”

A part of the target group consists of older consumers who did not grow up with the technical developments like we did. They benefit from an operation system that does not differ too much from the previous version they were accustomed to, even if the underlying technology of the new version is totally different. Therefore, a great challenge within this project was implementing the newest and complex technology with the uncomplicated user friendliness in mind. However, an even greater challenge consisted of the ability of the chair lift to keep itself upright. “We wanted the chair of the stair lift to stay perfectly horizontal, even if it is weighted unevenly or if the passenger moves. Some



stair lifts are placed with an extra rails on the wall to keep the chair balanced. By desiring a more attractive design by leaving out this extra rails, we made the project even more complex than it already was. Many calculations and many simulations in MATLAB resulted in the current chair that works like an inverted pendulum: it compensates itself when it is moved out of balance.”

If this characteristic would malfunction, the consequences could be severe. Therefore, a major part of the development phase consisted of accurate testing. At the premises of AME, the stair lift ran for three months automatically on a test rails with every possible twist and turn uninterrupted during day and night. This was repeated for every software and hardware release candidate. In addition, external authorized bodies audited the hardware and software. In the end, all relevant test had been done in order to be assured the product complies with that latest safety standards and is of the highest quality. This brought the process to the current status: the production phase. Every month, between 1200 and 1500 pieces are produced and distributed around the world. For Marc, his involvement in this project ends at this stage. Completing this project gives him room to attend to a new project: developing the control software of a DC/DC converter for the control systems of a submarine. “All projects are quite diverse and challenge you to improve yourself every time, due to the freedom and responsibility you are given. But all projects have one thing for me in common: the satisfaction when it works. Experiencing that your initial ideas and calculations are actually up and running, that really gives me a boost.” ■



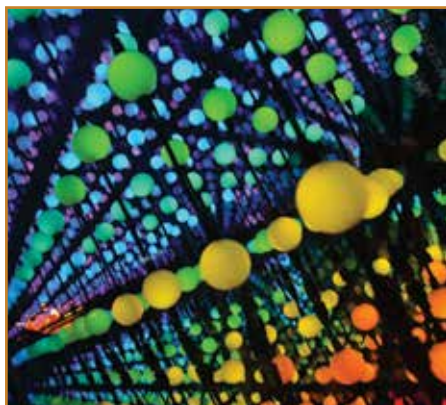
GLOW, a well visited Light Festival

By: Pauline Hoen, Pictures by: Johan van Uden

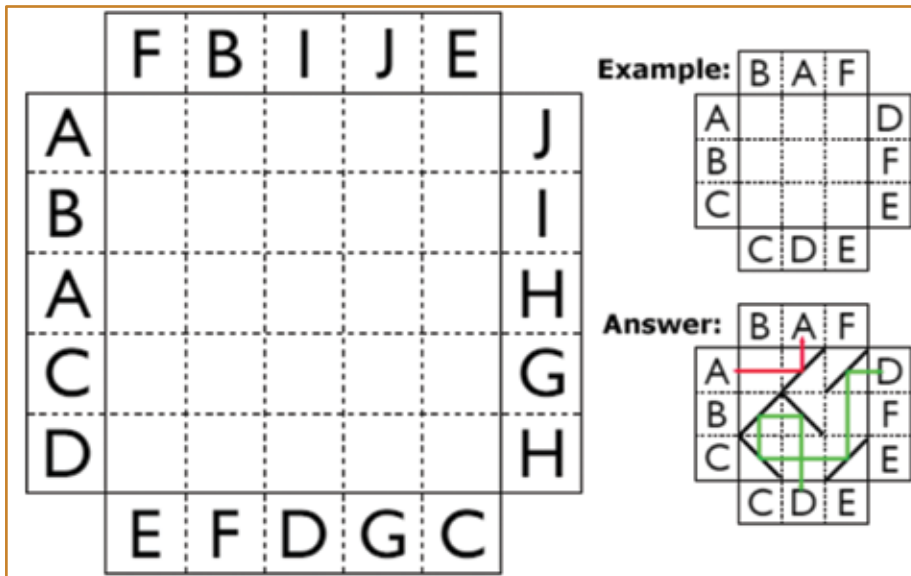
From November 12 to November 19, GLOW Eindhoven has attracted 740,000 visitors, not only from The Netherlands, but also from Germany, Belgium and other European countries. Because the light-installations of GLOW were spread out well, the 7 kilometers of GLOW were pleasantly busy.

Glow was divided into two parts; GLOW City and GLOW Science. The latter ran over the TU/e campus. The Tesla Coil's "The Origin of Life" was the first project people saw when entering our campus. An official world record for the longest created by man thunder bolt was won by a special and technically very clever project "Exploding Wire", with a length of 80 meters.

The 2017 edition of GLOW Eindhoven will take place on November 11 to 18. ■



Puzzle



Objective / Rules

Your objective is to place some diagonal 'mirrors' into the grid.

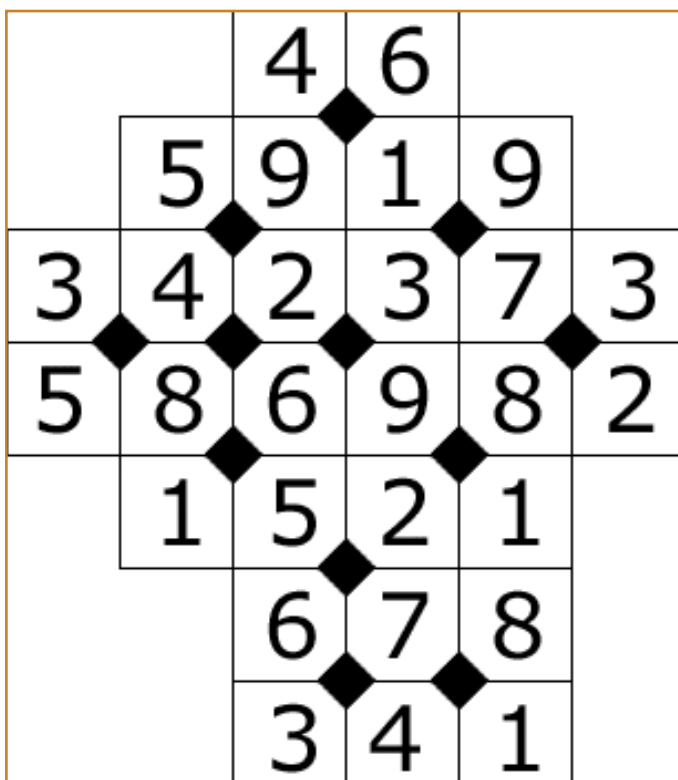
If a ray of light is shone into the grid from each of the letters, and allowed to bounce off the internal diagonal mirrors, each will exit the grid at the twin of the letter that it entered the grid. For example, a ray entering at either letter D will bounce off some mirrors and exit the grid at the other letter D.

Each row and each column will contain exactly two of the diagonal mirrors.

Please send your answer to connecthor@thor.edu before 7 April.

Winner previous puzzle

The winner of the previous puzzle is Ward de Groot.



Puzzle solution December edition (Connecthor 36)



Ward with his prize

I'm a believer

By: Tom van Nunen

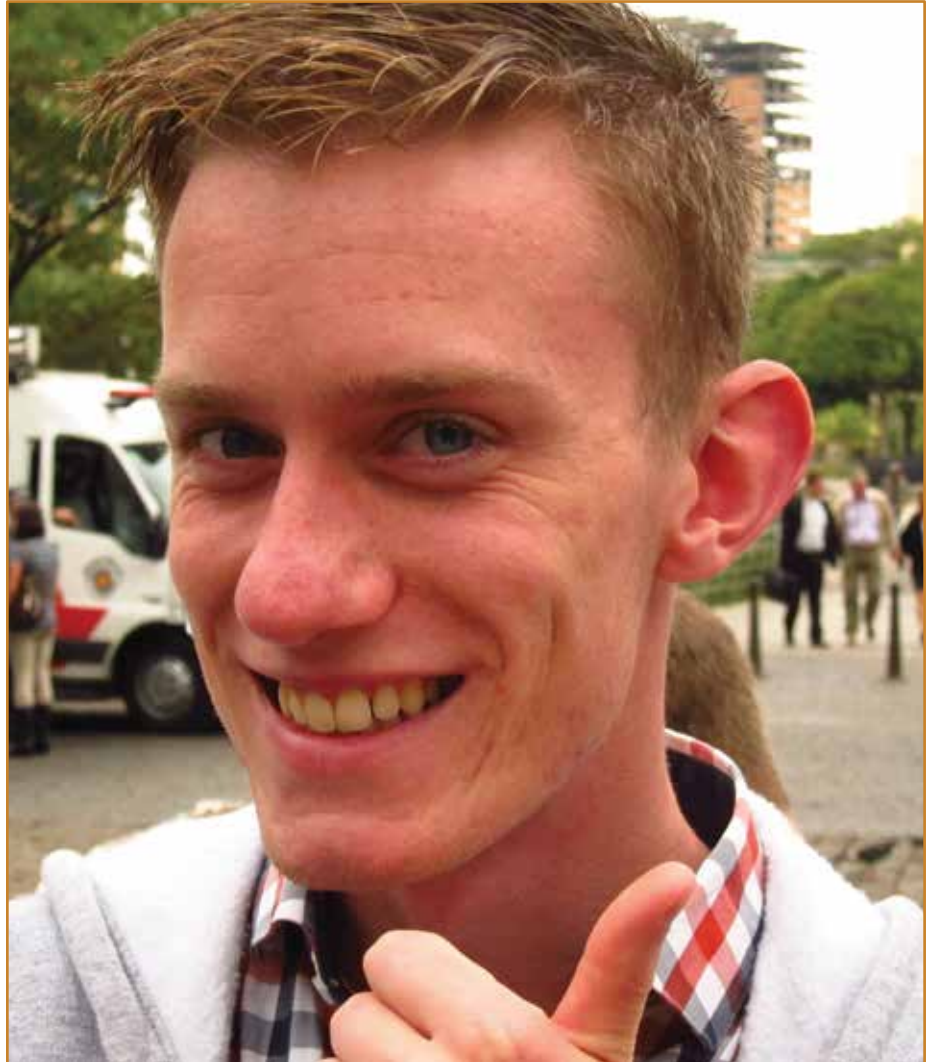
A little while ago, the university elections took place. Students could vote for their representatives in the Faculty and University Councils. The Cursor reported on some of the promotional activities and interviewed students about whether or not they were planning on voting and how they decided who to vote for. One answer they got baffled me.

The reporter was talking to two students of the Mechanical Engineering department and asked the questions. The students answered they were not going to vote because they don't *believe* in voting. Ehm, what?! You don't believe in voting? How can one not believe in voting? At a university I didn't expect to encounter people that don't understand voting.

I honestly don't understand it. Do they think there are no good candidates to choose from? I can assure you, there are some very capable people on those lists, and even if that weren't the case, you can always vote blank. Don't they trust the way the votes are counted or the seats are divided? Well I don't think that makes any sense. Or maybe they don't believe in democratic principles in the first place, maybe they think we might be better off with the Executive Board running this university as if it were a dictatorship. Let's hope not.

We need staff and student representatives in the Faculty and University Councils, how else can we ensure the decisions and policies are made in a way that's fair for everyone? Let's make one thing clear: it's not that I don't trust the Faculty Boards and the Executive Board. I have no reason to assume that they don't want the best for the university and the people that work and study there. I do, however, think that we have to continuously pay attention and have discussions with them to ensure that what they're doing is indeed the best. So far, it's working out just fine, if you ask me.

Outside of the university I encounter more people that don't understand voting. Take for example the PVV, a somewhat controversial Dutch right wing political party, currently running number 1 on the polls. A survey tells us that a significant amount of supporters think that the party leader should automatically become prime minister in case their party gets most of the votes coming elections.



No people, that's not how it works. Becoming the biggest party doesn't mean the party leader automatically becomes prime minister, period. Get used to it.

Another striking example can be found in Great Britain, the days after the Brexit referendum. After the result was announced some people who voted in favor of leaving the EU, said that they did so because they wanted to make a statement against the elite and didn't think it would really count. Ehm, what?! Which part of the referendum was about the elite again? That's right: it wasn't. Those people are influencing the future of their country, apparently based on an opinion about something completely unrelated. And what about people who verbally or physically attacked people with a colored skin, because 'we voted you out'. Absurd.

Just to be clear: if you have good arguments to vote for something, please do so. If, on the other hand, you're using completely unrelated arguments to validate your vote, you're abusing your right to vote.

In my opinion, everybody should do research on the full scope of the subject before voting anything. Don't just look at the side you're already planning on voting for, but also take a look at the other sides. If you have any expectations, ask yourself if they are honestly realistic. Make sure you understand the subject and, more importantly, the consequences of your vote. Please people, the future depends on it. ■



Wist je dat er een technologie- bedrijf bestaat met een speciaal pizza budget voor medewerkers?

Bij technologiebedrijf Sioux vinden we het belangrijk dat onze medewerkers alle kansen krijgen om zichzelf te ontwikkelen. Meer dan 60% van onze engineers is lid van een of meerdere expertise groepen, waar gezamenlijk aan innovatieve studieprojecten wordt gewerkt zoals Model Driven Software Engineering, Mobile App Development, Project Management, Oculus Rift en nog veel meer. Sioux sponsort de hardware en de food for thought. We noemen dit het Sioux Pizza Budget, omdat pizza de meest populaire voedselkeuze bij deze bijeenkomsten is.

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