MAXWELL

Magazine of the Electrotechnische Vereeniging

Edition 15.1
November 2011

Graduation report
Improving air traffic efficiency

Circuit Bodging
A simple lie detector

Freshman Weekend
A report to recall this terriffic weekend

ISIS
Gathering data from low earth orbit

Het laagste punt van Nederland is ook het veiligste

Gezocht: Ingenieurs

Als een auto te langzaam door de Westerscheldetunnel rijdt, wordt dat direct waargenomen door detectielussen in het wegdek. De tunneloperator krijgt een melding en kan de snelheden in de tunnel aanpassen of een rijbaan afsluiten met een rood kruis op de matrixborden. Hij kan de bestuurder toespreken via een van de 300 luidsprekers in de tunnel. Bij calamiteiten kan hij zelfs Giel Beelen of Edwin Evers onderbreken. Al deze elektrotechnische installaties zijn van Croon. Wil je graag aan de slag bij een interessante werkgever? Lees meer over werken op 60 meter diepte en andere projecten waar je zelf aan zou kunnen werken op onze website. Of bel 0800 - 276 66 34.

croon
TBI techniek

We leven elektrotechniek **werkenbijcroon.nl**

Dear Reader,

A few of the most hectic and exciting weeks of our lives have passed by since the start of the new year. From the end of the freshmen's weekend my fellow board members and I have slowly taken over the tasks from our predecessors. Because we are one of many in Delft, we went to visit almost all inauguration drinks of other study associations. These drinks can become pretty wild at times, but are the ideal events to meet students from other boards.

As fulltime board members we will not be following any courses in the upcoming year. We keep the ETV-room up and running. You might already have bought books at our desk. From our point of view the bookselling is working out great, apart from some misprints which took longer to replace than expected. But of course our policy consists of more than just providing our members with shiny books and fresh coffee.

Even in these busy times our members have already organised some of the most entertaining events. The 'Welcome back Barbecue' held in the second week was an immense succes. The freshman activities committee showed they were still enthusiastic even after entering their second year.

Monday the 3rd of October the traditional "Kwintjesavond" was held in the / Pub. Each year all members are invited to relive the atmosphere of our introductory week, and to feast on cheap beers and pizza. Even though attendance among freshmen was low, we still have a lot of special /Pub evenings in the pipeline for them.

But there is much more being planned and organized at the moment. In fact, the summit of all excursions is reaching it's completion. Of course I am talking about our Sunrise Study Tour. What makes this trip so special is the fact that 22 ETV members will venture into the lands of the Chinese, Korean and Japanese. A great journey like this one is taking place every four years and will consist of four weeks travelling. We have a fantastic committee consisting of five people, namely four old board members and another master student, who have already invested a lot of time over the past year.

You might think the destinations are quite trivial in the sense that the ETV has visited China a few times before. Nevertheless cities like Beijing, Shenzhen, Seoul, and Tokyo are a true heaven for oncoming electrical engineers. For example, the HV-DC test center in Beijing will show the participants how to transport electrons across the gigantic distances in China. And a visit to Mitsubishi Electric gives them insight in the latest Electrical Vehicle prototypes.

Even though the younger students have to wait half a year for the Electrip if they would like to visit another country with ETV members, we have some really interesting excursions coming quarter. So come by the ETV desk, and pick up our activities flyer! You are always welcome to subscribe to activities, to discuss the classes or just to chill out with some coffee. See you in the Boardroom!
On behalf of the Original board,

Adriaan Taal

A.J. Taal	President
P.J. Marcelis	Secretaris
R.L. van der Plaats	Thesaurier
L.W. Boeke	Vice-President & Commissaris Extern
S.G. van Wee	Commissaris Onderwijs

Main content

Graduation report Erwin Stout:
Improving air traffic efficiency by using real-time scheduling algorithms

Language:

Circuit Bodging:
A simple lie detector

Language:

Freshman weekend:
A vivid picture to recall this terrific weekend

Language:

ISIS:
Gathering data from low earth orbit

Language:

ETV MAGAZINE "MAXWELL" Year 15 – edition 1 – November 2011 **PRINTING** DeltaHage B.V., Den Haag **NUMBER OF COPIES** 800 **EDITORS** Ben Allen, Benjamin Gardiner, Jeroen Ouweneel, Richard Spijkers, Ester Stienstra, Adriaan Taal **CONTACT** Maxwell, p/a Electrotechnische Vereeniging, Mekelweg 4, 2628 CD Delft, phone: 015-2786189 or 015-2781989, e-mail: maxwell@etv.tudelft.nl, website: www.etv.tudelft.nl **CHANGE OF ADDRESS** Please send your changes to the address above, or use the website **ADVERTISEMENTS** Croon (p.2), TenneT (p.20), Technolution (p. 26), National Instruments (p. 31), ASML (back) **SUBSCRIPTIONS** Non-members can receive the Maxwell four times a year, against a contribution of €10,- per year. For more information, please contact the Maxwell Committee.

... and more

- From the board 3
  A short word of the new board of the ETV
- Newsflash 6
  The latest inventions in Electrical Engineering
- Smart dikes 9
  An introduction to intelligent dikes, who can monitor their own stability
- Photo page 11
  The largest photovoltaic power plant of the world.
- Activities of the ETV 12
  The ETV has organized a lot of activities last quarter. Take a look here to see what you have missed!
- Mysteries of the Universe 17
  The ball baring engine
- The Falcon electron detection camera 18
  A new way to investigate biological matter
- TenneT 27
  Investing in innovations with societal issues in mind

Editorial

Fifteen years ago, the magazine Maxwell was born. A lot of people have put effort in realizing it during the last fifteen years. Since then, it has gone through quite some changes regarding lay-out and content. As committee, we found that it was again time to change the lay-out of the Maxwell. It is one way of celebrating its fifteenth anniversary!

You have probably already noticed the changes concerning lay-out. However, we have also changed some content this time. You will gradually notice this during reading this edition. I can promise you that for the upcoming year, more changes are on the road.

As during the last fifteen years, we are also still putting a lot effort in realizing this magazine, with positive outcome. We keep the Maxwell fresh and keep up with the times, in order to deliver an interesting magazine for our readers. This is done by either making sure the content is interesting and also update the lay-out once in a while, like this time.

If you have any suggestions, tips or would you like to join the team in realizing all this? Let us know by sending an e-mail to maxwell@etv.tudelft.nl.

For now, happy reading!

Richard Spijkers
Editor

Newsflash

Author: Jeroen Ouweneel

Nuon Solar team gets second place

On the 20th of October, the Nuna 6 passed the finish line of the World Solar Challenge 2011, earning the team from Delft second place. After an exciting race, which even had to be stopped for almost four hours due to a bushfire, only the team from the Japanese Tokai University was able to stay in front of the Delft team – as was the case in the previous World Solar Challenge.

Different from last year, however, was the time between finishing. Whereas last year the Nuna got beat by several hours, this year the difference was only one hour – which would have been conciderably less if it weren't for the very cloudy last day. The first finisher after the Nuna was the Qantum, made by students from the University of Michigan, with a time difference of almost two hours. The other Dutch entrant, Solar Team Twente, managed to finish in fifth place, about 11 hours after the Nuna.

Out of the 37 contestants, only 7 teams managed to reach the 2998 kilometer goal, with average speeds ranging from 92 to 62 kilometers per hour.

Source: www.nuonsolarteam.nl, www.worldsolarchallenge.org

Figure 1: The Nuna 6 in Australia

Chip on brain converts thoughts to motion

Ever since a motor accident seven years ago, a 30 year old man from Pennysilvania had not been able to move his arms or legs. And although it wasn't his own arm, scientists from the University of Pittsburgh were able to let the man steer a robot arm with just his thoughts.

To achieve this, first they placed a chip on the man's brain surface. This is quite extraordinary, as usually sensors like these have to be implanted deep in the brain tissue. The sensors were able to pick up the man's thoughts – by reading the activity of groups of brain cells in the motorcortex - and convert them into a usable input for a robot arm. While this is not the first time a human moves a robot arm with his thoughts, this time around the patient didn't have to be hooked up to a computer.

The robot arm that was used for the experiment was initially developed for DARPA, the Pentagon's research agency, by the Johns Hopkins University Applied Physics Laboratory – a 100 million dollar project at the time.

Although it will be years before systems like this are commercially available, the result of the test was very encouraging, ensuring that this exciting research will be continued.

Source: http://medicalxpress.com

Figure 2: A robot arm

Massively parallel computer built from single layer of molecules

Modern computer chips handle data at the mind-blowing rate of some 10^{13} bits per second. Neurons, by comparison, fire

at a rate of around 100 times per second or so. And yet the brain outperforms the best computers in numerous tasks.

One reason for this is way computations take place. In computers, calculations occur in strict pipelines, one at a time.

In the brain, however, many calculations take place at once. Each neuron communicates with up to 1000 other neurons at any one time. And since the brain consists of billions neurons, the potential for parallel calculating is clearly huge.

Computer scientists are well aware of this difference and have tried in many ways to mimic the brain's massively parallel capabilities. But success has been hard to come by.

Today, Anirban Bandyopadhyay at National Institute for Materials Science in Tsukuba, Japan, unveil a promising new approach. At the heart of their experiment is a ring-like molecule called 2,3-dichloro-5,6-dicyano-p-benzoquinone, or DDQ.

This has an unusual property: it can exist in four different conducting states, depending on the location of trapped electrons around the ring. What's more, it's possible to switch the molecule from one to state to another by zapping it with voltages of various different strengths using the tip of a scanning tunnelling microscope. It's even possible to bias the possible states that can form by placing the molecule in an electric field

Place two DDQ molecules next to each other and it's possible to make them connect. In fact, a single DDQ molecule can connect with between 2 and 6 neighbours, depending on its conducting state and theirs. When one molecule changes its state, the change in configuration ripples from one molecule to the next, forming and reforming circuits as it travels.

Given all this, it's not hard to imagine how a layer of DDQ molecules can act like a cellular automaton, with each molecule as a cell in the automaton. Roughly speaking, the rules for flipping cells from one state to another are set by the bias on the molecules and the starting state is programmed by the scanning tunnelling microscope.

And that's exactly what these guys have done. They've laid down 300 DDQ molecules on a gold substrate, setting them up as a cellular automaton. More impressive still, they've then initialised the system so that it "calculates" the way heat diffuses in a conducting medium and the way cancer spreads through tissue.

And since the entire layer is involved in the calculation, this a massively parallel computation using a single layer of organic molecules.

Bandyopadhyay and co say the key feature of this type of calculation is the fact that one DDQ molecule can link to many others, rather like neurons in the brain. "Generalization of this principle would...open up a new vista of emergent computing using an assembly of molecules," they say.

Source: http://www.technologyreview.com

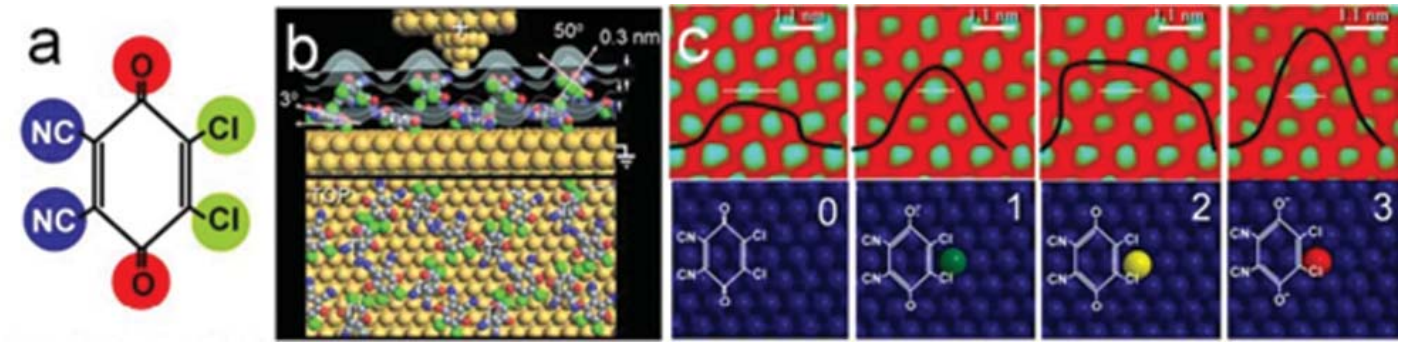


Figure 3: Principle of how the DDQ acts as an automaton

Battery anode capacity increased eight times

Researchers from the Berkely Lab (University of California) have come up with a new technology that improves the energy capacity of lithium-ion batteries. They did this by replacing the usual graphite anode with a new silicon polymer.

Research in this field is not new – it was already known that silicon is a good candidate for replacing the current battery anodes in terms of capacity: it can store up to ten times more lithium ions than graphite. There was, however, one big bottleneck in this technology: when the lithium ions are stored, the silicon swells to over three times its original volume – and when discharging, it returns to it's original size. Eventually, this expanding and contracting breaks the electrical contacts within the anode, making this technology useless.

To solve this problem, the Berkely Lab researchers developed an electricity conducting polymer, which binds closely to the lithium-storing silicon particles. Even when the silicon particles expand three times their size, the polymer keeps the electrical contact between the particles. With this technique, the researchers were able to develop an anode that can store eight times the amount of lithium compared to normal modern day batteries.

Source: http://newscenter.lbl.gov

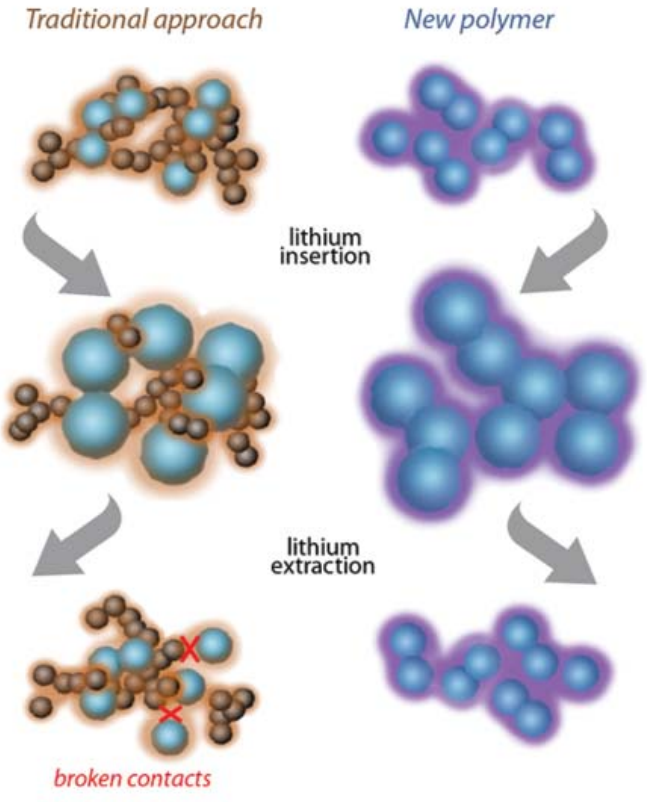


Figure 4: The principle of the old and new silicon anode

Stretchable transistors developed

In the near future, flexible displays will probably be widely used - which is why scientist are looking for ways to make them. One of the big problems is making transistors bendable, since generally, bending semiconductors makes them lose their electrical properties.

Researchers at the South Korean universities of Seoul and Suwon, however, were able to make stretchable transistors. They did this by starting with a flexible basis material, on which graphene and copper were added in layers, etching the components along the way. Using this process, they were able to develop stretchable integraded circuits.

Testing revealed that even after stretching the resulting chips for five percent, one thousand times in a row, they stayed operational. Stretching beyond five percent, however, quickly reduces the chips' operation.

Source: http://www.physorg.com

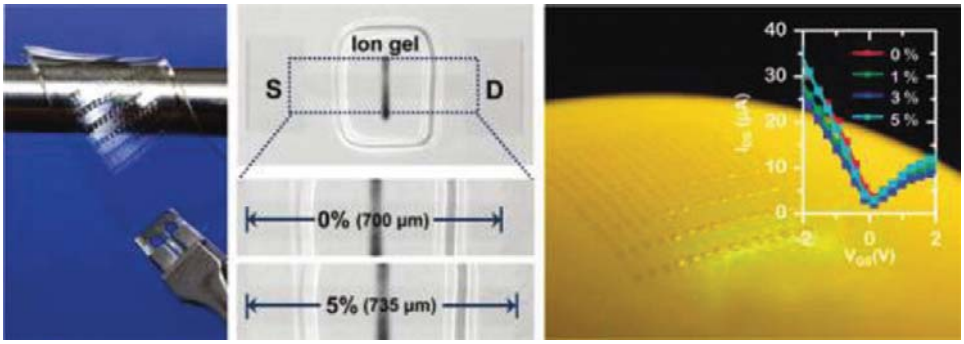


Figure 5: The flexible transistors (left, right) and their stretch performance (middle, right)

Smart dikes

In Holland, we sometimes think of dikes as a typically Dutch phenomenon. But nothing could be further from the truth. Around the world, 136 coastal cities with populations of more than one million rely on the protection offered by dikes. The danger in these cities is steadily increasing as a result of climate change. The answer? Creating intelligent dikes, that can monitor their own stability.

Author: Siemens Nederland

The classic way to meet increased risk of flooding is to increase the height of dikes and reinforce them. "But simply reinforcing dikes is not an effective solution," warns Prof. Robert Meijer, a dike protection expert and information technology specialist at the University of Amsterdam and TNO. "First of all, this involves an upgrade of the entire dike. That costs a lot of money - €2,000 euro and more per meter. The second problem is that this method only buys time, and even after that, you still won't have any idea when a specific section is in danger of breaking apart."

In the European UrbanFlood project, an alternative strategy is being developed. Instead of reinforcing or upgrading hundreds of kilometres of dikes, the idea is to make them more 'intelligent'. By equipping dikes with smart technology, they can monitor their own stability and predict fractures. The technology used was developed by Siemens, and is based on existing software for monitoring industrial production facilities. In factories, this system is fed with all available production data. By comparing this information with data obtained from sensors mounted on machines, the system can recognize errors in the making, and issue an alarm before they occur.

Sensors for modern dike monitoring

According to Bernhard Lang (Siemens Corporate Technology), monitoring a dike is not as different from monitoring a production process as you might think. "It's only the definition of the problem to be solved that's different. The challenge with the UrbanFlood project was to generate the data we needed to programme our sensor system. In this case, we needed information on when specific factors will result in dike damage."

Destroying dikes

To find out, Lang and his team constructed several test dikes near Eemshaven, in Groningen. These dikes were fitted with sensors and were then intentionally destroyed, using different methods. "We eroded the back of one dike by deluging it with water, which is exactly what happened during the great North Sea flood of 1953," Meijer explains. "In another test, we simulated piping – a process in which water persistently penetrates a dike, creating a small tunnel. Eventually, within just a few minutes, the barrier falls apart like a house of cards." Piping is one of the main causes of dike damage, and was one of the reasons why New Orleans suffered such severe flooding during hurricane Katrina.

During the Eemshaven tests, team members calibrated their software in line with the parameters measured, such as water and air pressure, dike widening, and humidity and temperature differences between the dike interior and exterior. "Destroying the dikes provided us with data that's indispensable for reliable monitoring," says Lang. "By programming our software with these parameters, it can recognize and forecast dangerous situations before anything serious happens."

Interpreting measured data under realistic conditions

Saving human lives

In a two-year trial, the software is 'taught' to correctly interpret dike-sensor data under real-life wind and weather conditions. Several existing dikes in the Netherlands, as well as in the UK and Australia, have been equipped with the monitoring system. Also, researchers are working on alarm notification options. Sensor positioning technology, for example, would make it possible to inform authorities of the precise location of a damaged section, which would allow them to repair it as quickly as possible. If a breach is unavoidable, all mobile phones operating in the affected area could be notified, speeding up evacuation. It would even be possible to instruct vehicle navigation systems to guide vehicles around and away from areas deemed to be at risk. After all, the real goal of smart dikes is not just to save money, but to save human lives.

If a dike isn't strong it had better be smart...

Sarnia Photovoltaic Power Plant

This power plant is the biggest photovoltaic power plant in the world. This plant, near Sarnia, Ontario in Canada, covers nearly 4 square kilometres and the thin film panels cover nearly 1 square kilometre. It has a capacity peak of 80 MW, which is enough power to meet the needs of about 12,800 homes.

Source: http://www.enbridge.com

Activiteiten van de Electrotechnische Vereeniging

Excursion Epyon

Author: Ralph van Schelven

On Thursday the 13th of October some fellow freshmen and I have been on an excursion to Epyon in Rijswijk. This company, founded by three ex-TU Delft students, is designing fast-chargers for electric cars. With these fast-chargers it would only take 20 minutes instead of 10 hours to fully load the battery of an electric vehicle. Not that long ago Epyon was bought by the international company ABB. This is why they have become a serious player on the world market of fast-chargers.
After a biking trip and a brief investigation to the exact location of the small company we arrived at Epyon. We were welcomed by one of the founders, who has actually studied Electrical Engineering for a while, with a presentation about what Epyon is and what they do. After this he gave us a brief tour through the workplace, he showed us the different types of chargers and a Nissan LEAF. Then he gave a small demonstration about how the charging would take place (all the cars were fully loaded) and he showed us the special plugs. The day ended with a question round about the cars, Epyon and of course the chargers.

Excursie LUMC

Auteur: Lennart Boeke

Op 27 september had ik als Commissaris Extern de eer om een groep eerstejaars mee te nemen naar het LUMC. Ik was eerst ook benieuwd naar wat je als Elektrotechnisch ingenieur nou bij een ziekenhuis kan doen, maar na een presentatie werd het al een beetje duidelijker. In die presentatie werd ook uitgelegd wat de verschillen zijn tussen bijvoorbeeld röntgen, MRI en CT.

Het leukste deel van de excursie was echter de rondleiding en dan voornamelijk de MRI-scanners. We bekeken allereerst een CT-scanner en er werd ons verteld voor wat voor soort ingrepen die gebruikt wordt. Daarna bekeken we verschillende MRI-scanners met magnetische fluxdichtheden tussen de 1,5T en eentje van 7T als klapstuk. Die laatste was de eerste 7T MRI-scanner in Nederland. We mochten die scanner ook van dichtbij bekijken, maar niet voordat we een uitgebreide test ondergingen en onze zakken 4 keer op voorwerpen van metaal hadden gecontroleerd. Na een test met een ijzeren kettinkje en een schaar aan een touw kregen we pas echt door hoe groot de krachten zijn in de buurt van zo'n apparaat. Zoek op youtube maar naar 'Dangers of MRI' en krijg zelf ook een indruk.

De Philips MRI Scanner in het LUMC

Lunchlezing Siemens over Traffic Control Systems.

Op de kwintjesavond genoten de EOW-gangers van ernstig goedkoop bier, fris en pizza!

Welkom terug barbecue in de tweede collegeweek was een succes!

Lunchlezing Siemens

Auteur: Paul Marcelis

13 oktober was de eerste lunchlezing van het jaar. Een spreker van Siemens was naar EWI gekomen om de geïnteresseerde voor te lichten over dynamisch verkeersmanagement en welk aandeel Siemens hierin heeft. Terwijl de studenten in de zaal van hun broodje Leo genoten vertelde dhr. Verhoeven over verkeerssystemen zoals de groene golf, kentekencamera's en detectielussen in het wegdek. Daarnaast kwamen duurzame ontwikkelingen zoals laadpunten voor elektrische auto's ook goed aan bod. Na afloop ontving dhr. Verhoeven nog een presentje.

Excursie Mapper Lithography

Auteur: Marc Zwaluwa

Op maandag 26 september mochten wij als eerstejaars een kijkje nemen achter de schermen bij Mapper Lithography. Dit bedrijf maakt machines die vervolgens wafers kunnen bewerken. Een ander bedrijf wat dit doet is ASML, maar in tegenstelling tot ASML kunnen machines van Mapper de wafers bewerken met behulp van elektronen in plaats van fotonen.

Dat dit verschil allerlei voordelen biedt, werd ons op heldere wijze duidelijk gemaakt. Goedkoper, kleiner en flexibeler waren de drie kernwoorden van de presentatie. Maar van alleen dia's kijken word je nog niet veel wijzer. Daarom volgde er een uitgebreide rondleiding door het pand van Mapper. Verscheidene prototypes in de cleanroom konden van achter een raam bewonderd worden.

Na enkele wafers te hebben gezien kon de rondleiding worden voltooid in de pub van Mapper. Na een paar biertjes gedronken te hebben zat de excursie er weer op. Kortom, een best leuke invulling van je maandagmiddag.

De lunchlezing van TenneT beschreef het Randstad 380KV project.

Improving air traffic efficiency by using real-time scheduling algorithms

One of the biggest challenges in air traffic is its growth. It is expected that the total number of flight movements worldwide continues to increase with approximately three percent per year (figure 1). This growth is larger than the increase of handling capacity of airports and air traffic controllers. Therefore a lack of capacity is expected in the future. To deal with this problem, changes are needed in the way the air traffic is handled.

Author: Erwin Stout, M.Sc.

The most promising option to improve the handling capacity is by improving the scheduling accuracy. Of course scheduling is already used for air traffic. Each aircraft has an estimated departure and landing time. However, this schedule cannot be very precise because of the high uncertainties. Air traffic operates in a highly dynamic environment. For example passengers which do not show up, weather conditions and the required safety checks before takeoff can cause delays which can't be foreseen in advance. This makes the time at which the aircraft is ready for pushback very unpredictable. Therefore the schedule which is calculated days in advance needs very big uncertainty margins for all aircraft.

Real-time scheduling

When it would be possible to adapt the schedule to the current situation in real-time, the uncertainty margins in the flight schedule could be reduced and thus the capacity of the airports might be used more efficiently. Due to the differences in separation requirements between the aircraft classes (table 1), reordering can improve the efficiency of the departure schedule. This reordering can be used to increase runway capacity and improve the efficiency of the departure schedule. The process of continuously scheduling to adapt the schedule to the situation in real time is called real-time scheduling. This scheduling is not done in advance, but directly after the moment each aircraft is ready for pushback. At this moment the optimal schedule for this and the other aircraft is calculated.

It is impossible to simply calculate and evaluate all possible sequences. For example, a situation where twenty aircraft are involved already results in 2.4×10^{18} possible sequences. The available time is too short to evaluate all these sequences. Scheduling algorithms are a method to find or to estimate the optimal solution in a smarter way, without having to investigate all options. The work done by these scheduling algorithms to calculate the final departure schedule can be divided into two phases.

The first phase is sequencing. During this phase an optimal departure sequence is calculated. This sequence defines the order

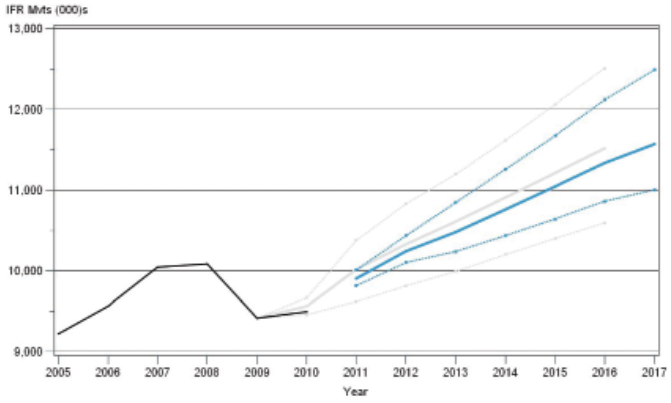


Figure 1: Expected growth of flight movements in the near future as expected by Eurocontrol

		Trailing aircraft			
		Small	Large	B757	Heavy
Leading aircraft	Small	2.5	2.5	2.5	2.5
	Large	4	2.5	2.5	2.5
	B757	5	4	4	4
	Heavy	6	5	5	4

Table 1: Wake vortex separation requirements (NM)

in which the aircraft will take off. As mentioned before, this order defines the total required separation time and thus the efficiency of how the runway is used. This sequence is determined by solving the departure scheduling problem. The departure scheduling problem is modeled as a cost function for each aircraft. An example of such a cost function is shown in figure 2. This figure shows that the costs are minimal when the aircraft departs at its target time. The target time used during this research is the ideal takeoff time of the aircraft. The algorithms try to minimize the costs and thus this delay. All individual cost functions can be added together to form a complete cost function (function 1). This is not a very complicated function. However, the difficulty does not lie in solving this function, but in determining the parameters for this function. There is no uniform definition for this cost function. The cost function used during this research aims at minimizing the total delay of all aircraft. The second part performed by the scheduling algorithms is the actual scheduling part. During this phase a departure time is assigned to each aircraft. The departure sequence

$$Z(\overline{x}) = \sum_{i=1}^{P} (g_i \max[0, T_i - x_i] + h_i \max[0, x_i - T_i])$$

Function 1: the complete cost function

determined in the first phase is used as a leading factor when calculating the departure times.

Algorithms

There exist many algorithms designed for scheduling air traffic. Besides this, there are even more algorithms designed for scheduling other processes which might also be used for scheduling air traffic. However, for the algorithms to be usable for the real-time scheduling, they must meet the following requirements. First, the algorithms must perform the complete scheduling process. Some algorithms only provide a departure sequence, or do only generate a schedule based on an existing sequence. To be able to use the algorithms in this situation, the algorithms most perform both the sequencing and the scheduling process. The next requirement is that the algorithms should be able to do the scheduling operation with the provided input parameters and they must provide the required output parameters. Finally, the scheduling process should be fast enough. Because of the real-time scheduling, there is only very limited time available for the scheduling process. The algorithm should be able to do the scheduling within this time span.

When taking a deeper look at all algorithms that do meet these requirements, these algorithms can be divided into four categories. These four categories were not known before, but they are found as a result of this research. The four categories are:

- First come first served algorithms
- Branch and bound algorithms
- Greedy search algorithms
- Genetic algorithms

Evaluation of the algorithms

To be able to investigate the efficiency improvement when these algorithms they are used for scheduling departure traffic, a simulation environment is needed. This simulation environment gives the user the possibility to test and evaluate the scheduling algorithms. The evaluation is done by simulating a traffic scenario, letting the algorithms determine the

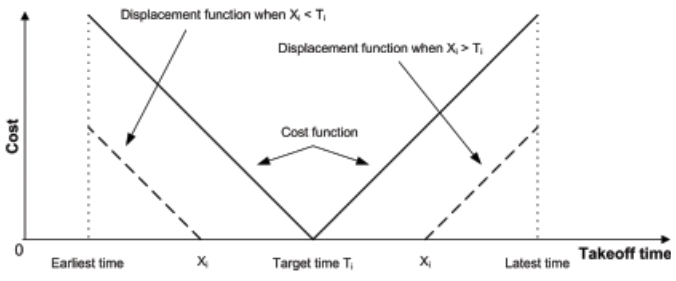


Figure 2: Cost function for an individual aircraft

Figure 3: Aircraft queuing up waiting for takeoff should be avoided as much as possible

departure schedule, and evaluation of the effect and efficiency of this departure schedule. As mentioned before, there is no uniform definition of 'efficiency'. Therefore this efficiency is not presented to the user as a single parameter, but via multiple output parameters. These parameters include the number of rescheduling operations, the total delay, runway throughput and the time and speed windows of the aircraft. The number of rescheduling operations is a measure for the robustness of the schedule. The more robust a schedule, the better it can handle disturbances and the less rescheduling operations are needed. The delay can be split up in three types of delay. Delay at the gate, at the runway and during taxiing. Sometimes it is inevitable. In that situation gate delay is preferred, because when the aircraft is still at the gate, it can wait with its engines still off. This will decrease the costs for the delay. Waiting with the engines running (figure 3, previous page) should be avoided as much as possible. From all these output parameters the user can determine the efficiency of the algorithms.

To make the simulation as realistic as possible, the traffic scenario that is simulated includes multiple aircraft classes, speed ranges and traffic densities. Disturbances are also taken into account to make the simulation as realistic as possible. It is expected that the added value of the algorithms is the highest in case when some aircraft are disturbed.

Evaluation of the simulation environment

After having designed the simulation environment, it is used to evaluate the four algorithm categories. This goal of this evaluation is bilateral. It is used to check whether the system functions in an appropriate way and also gives a small insight in the efficiency of the algorithms. The simulations are based on the situation at Schiphol using runway 24 (figure 4). During the simulations all input parameters are varied one by one. Using this method, the effect of each individual input parameter on the outputs and the efficiency of the calculated schedule can be investigated. Figure 5 shows an example of the result of a simulation where the amount of aircraft that is fed into the system is gradually increased to more than the runway capacity and after half an hour decreased again. The two blue vertical bars show the time for which the amount of aircraft ready for pushback is higher than the runway capacity. A moving window of 30 minutes is used to calculate the average waiting time. This figure shows that the genetic algorithm is able to handle the aircraft much better than the greedy and first come first served algorithms. The performance of the branch and bound algorithm is much worse, so this algorithm is not usable in these situations.

Besides using the simulation environment for evaluation of algorithms within a well chosen environment of aircraft and airport layout, there are more situations where this simulation environment is valuable. For example to help air traffic controllers to make an optimal scheduling decision in or to investigate the impact of their decisions before they are put into practice. So even when there is no need for capacity increase of the air traffic system yet, the system can help to improve the efficiency and thus reduce delays and operational costs.

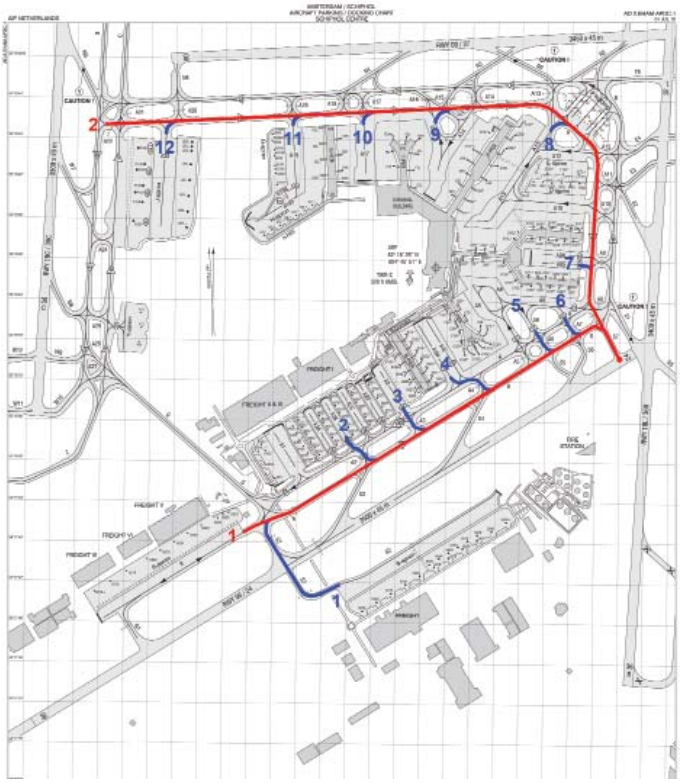


Figure 4: Location of the taxiways as used during the simulations

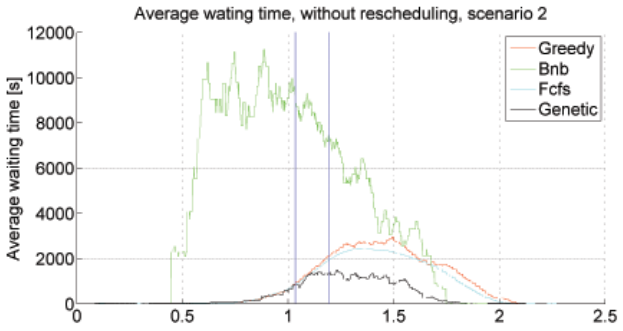


Figure 5: Average waiting time using all four algorithms

Mysteries of the Universe:
The ball bearing engine

Author: Benjamin Gardiner

The idea for mysteries of the universe

During the summer vacation period our newest honorary member came to the board room and told us about the most amazing piece of machinery made. Not because of its complexity but in fact because of its simplicity. He thought it might make for a good article in the Maxwell because even now no one has been able to figure out how it exactly works. So we decided to make a new topic in the Maxwell called "Mysteries of the Universe". In this addition of "Mysteries of the Universe" we are going to show you the "ball bearing engine".

What is the ball bearing engine?

It is an electronic engine that consists out of two ball bearing rings and a rod that connects the ball bearing rings (figure 1). The two ball bearing rings are held by clamps to which wires are attached. When a current is passed through the ball bearing rings and the metal rod (figure 2) nothing happens. The system needs an initial push to get started, but when it starts moving it speeds up very quickly and it gets incredibly hot. This happens due to friction but also because there is a huge current traveling through the parts.

It does not matter in which direction the rod is pushed, it works in both ways. It also does not matter if you use an AC or DC voltage supply. As you can see in figure 2 it does require a large current.

Any ideas on how it works?

There are some theories on how the engine works, but not a conclusive one. So if you have an idea how this works send us an e-mail with your explanation or if you have another mystery object and you would like to know how it works let us know. You can contact us by sending an e-mail to maxwell@etv.tudelft.nl regarding mysteries of the universe.

With special thanks to:
Prof.ir. L. van der Sluis
Dhr. R. Schoevaars

Figure 1: The ball baring engine

Figure 2: The voltage supply

The search for the ultimate picture

The Falcon electron detection camera

Author: Technolution B.V.

Biological matter is difficult to investigate with electron microscopes. It has very little contrast and deteriorates under the influence of electrons. However, a new type of sensor enables smaller amounts of electrons to be used, enabling more information to be obtained before the sample deteriorates. Based on this sensor, Technolution has developed a new camera for microscope manufacturer FEI.

FEI is a world leader in the manufacture of high-end electron microscopes. Using transmission electron microscopes (TEM), it is possible to distinguish details that are less than one Ångström (10-10m) in size. These microscopes are used in the electronics industry, the biomedical sector and research institutions. In a TEM, the electrons pass through the slide just like the light in an ordinary (light) microscope or slide projector. Electromagnetic lenses enlarge the beam and focus the slide onto a camera which sends the images to a PC. Biological matter displays very little contrast in a TEM and deteriorates rapidly when subjected to electron radiation. In biological research, low doses of electrons are preferred, although with conventional cameras, this results in a poor signal-to-interference ratio and low resolution. For this reason, FEI has ordered the design of a more sensitive CMOS sensor in order to directly detect electrons.

From sensor to direct detection

In conventional TEM cameras, a scintillator converts the electrons into light which is then registered by the sensor. This conversion process is necessary to protect the sensor from the electrons, although it results in inefficiency and lower resolution. The new sensor has been specially designed to reduce the influence of direct lighting with electrons, making it much more sensitive. As a result, with the same quantity of electrons, you can create three times as many images that are equal in quality to those of regular sensors. Equally, you can use onethird of the usual quantity of electrons to create the same amount of images as with a regular sensor.

From sensor to camera

A sensor is not the same as a camera. The key to turning a sensor into a camera is signal processing. However, the right casing is also important. The sensor is a large 16 megapixel silicon chip, provided on a printed circuit board which must fit completely into the TEM's existing sensor chamber. The physical space available for electronics is therefore extremely limited. By wire bonding the sensor directly onto the print, the space is used far more efficiently. Furthermore, the high vacuum in the sensor chamber demands careful design of the printed circuit board in order to prevent contamination of the vacuum. Furthermore, it must be possible to extract the sensor from the sensor chamber in order to make room for a second camera: this requires flexible PCB technology. And of course, strict requirements also exist regarding transmission of the sensor output. In order to comply with these requirements, simulations and field-solving techniques are employed which analyse and optimise the function of the analogue signal pad.

Vacuum and cooling

As mentioned earlier, electron microscopes work in high vacuums, which results in additional technical challenges. The electron microscope works in a high vacuum to prevent scattering of the electron beam. The sensor is also located in the

Figure 1: an example of a high detailed photograph.

vacuum, which makes cooling a challenge. Cooling is necessary to improve the signal-to-interference ratio. The sensor is cooled using a Peltier element, and the heat is conducted away by water. Due to the limited cooling and space, the necessary electronics must be kept out of the vacuum as much as possible. The camera is read out on a vacuum-compatible printed circuit board. The raw image data is transmitted directly through the vacuum chamber, whereupon it is digitised and transmitted from the camera via a 10Gbps fibre-optic cable. The cable carries the data to an external processing unit, which processes the image.

Image processing

Each pixel is calibrated separately with regard to offset and gain. With such a large chip (4K x 4K = 16 megapixels), the chances of defective pixels are high. However, the software can compensate for this. The algorithms are run by the TEM software installed on the operator's PC. Ultimately, the operator decides which settings are used. Due to the large volume of pixel data, it is not possible to run these algorithms on a standard PC. These algorithms are therefore run in a separate processing unit. The processing unit reduces the 10Gbps data flow in order to make it compatible for PC use. The processing unit is connected to FEI's PC via a standard 1Gbps Ethernet connection, and this PC operates a software module that communicates with both the processing unit and the PC's own software.

New experiences

It was a new experience for Technolution to fundamentally examine the physics and technology at such an early stage in the product's development. We not only investigated how the sensor worked, but also the entire TEM technology that surrounded it. The project was particularly interesting as we investigated complex questions on the cutting-edge of modern innovation, such as how the components and factors such as electron radiation, X-rays, vacuums and vibrations affect one another, and how the design can be optimised within the constraints of this environment. In order to develop and manufacture the mechanics (the camera casing), Technolution worked together with Demcon. Technolution played the lead role in the project, developing the electronics, the software and the programmable logic. We also created a life-cycle-management plan to ensure that the new camera remains properly maintained for years to come.

The complete picture is important to FEI, and as such, they have maintained intensive contact with their clients in order to monitor their needs and desires. And with the new electron detection camera, the company has a powerful tool to further optimise the service they provide to their customers.

Figure 2: the Titan Krios

Link yourself to the power of TenneT

Netwerken: daar gaat het om bij TenneT. Letterlijk en figuurlijk. We zijn de eerste grensoverschrijdende elektriciteitstransporteur van Europa met 20.000 kilometer aan hoogspanningsnetwerken in Nederland en Duitsland. Onze focus is gericht op de ontwikkeling van een Noordwest-Europese energiemarkt en de integratie van duurzame energie. Tegelijkertijd staat de continuïteit van de elektriciteitsvoorziening voorop. 24 uur per dag, 7 dagen per week. We zoeken de samenwerking met professionals die interesse hebben in een unieke uitdaging. Wil jij op hoog niveau aan de slag in je vak? Bij een bedrijf dat in meerdere opzichten netwerken verbindt? Link yourself en ga vandaag nog naar

www.werkenbijTenneT.nl

TenneT zoekt:

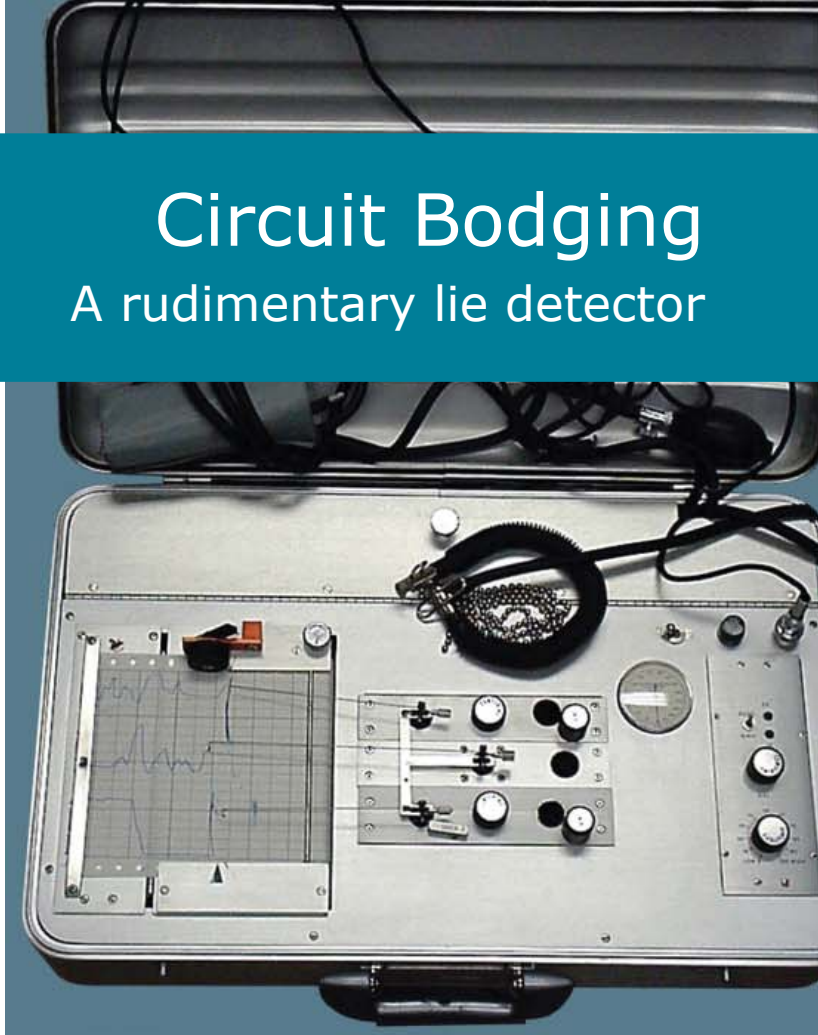
Ambitieuze technici en andere professionals

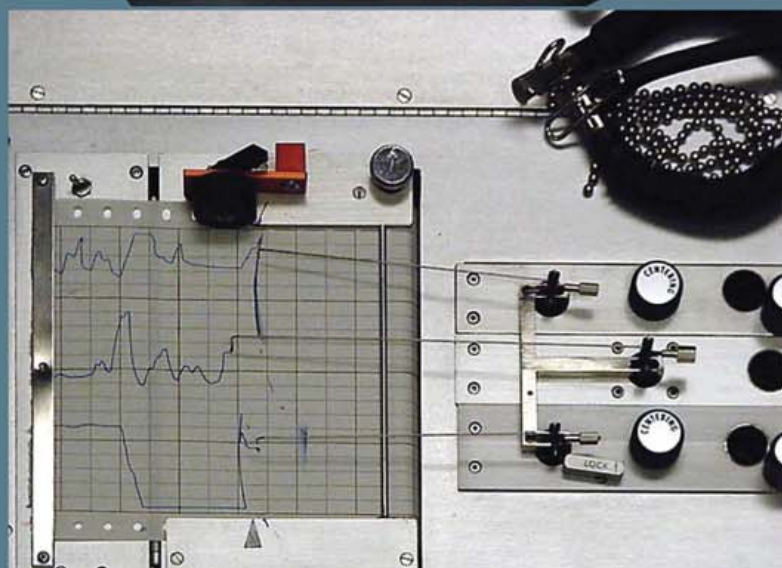
TenneT
Taking power further

Circuit Bodging

A rudimentary lie detector

The machine you see to the right is the staple of many a spy movie: the polygraph lie detector. It works by measuring parameters of a subject's physical condition that indicate stress or discomfort, such as heart rate, blood pressure, respiration rate, and perspiration. Whilst we can't faithfully reproduce a full polygraph machine, we're going to showcase a rudimentary perspiration monitor that could give you an indication of whether you're being lied to. Turn the page, and let's take a look.





The polygraph was invented in 1921 by a man named John Augustus Larson, a medical student and police officer. While many scientists consider polygraphy a pseudoscience, nevertheless the polygraph is used in some countries as an interrogation tool. US Federal agencies such as the FBI and CIA are known to use polygraph examinations to interrogate suspects and also require new employees to pass a polygraph screening.

Author: Ben Allen

Introducing the polygraph

These days most courts recognise that a polygraph test is to unreliable to be admissible as evidence in court. Nevertheless the device finds widespread use in law enforcement and intelligence, if only to scare a suspect into answering.

Let's do some measuring!

First of all, let's focus on what we're measuring: the skin resistance of our subject. When a person holds the two probes in their hands, the resistance of their skin is in parallel with R2 and acts like a variable resistor. R1 and the R2-human system together form a voltage divider. When the subject sweats - which happens when a person lies - the resistance of the R2-human system drops, causing the voltage at the base of Q1 to drop.

Because of the fact that us humans don't float around in empty space, we need to consider noise induced by power lines and other external factors. For this reason we include C1 to make sure our signal is relatively clean. Q1 is set up as an emitter follower to buffer the input and seperate the measurement circuit from the comparator.

Information processing

Now we have a circuit that is capable of measuring the skin resistance of a subject, and outputs an analogue voltage based on said skin resistance. Now we must implement a second circuit stage to turn this information, which is hard to

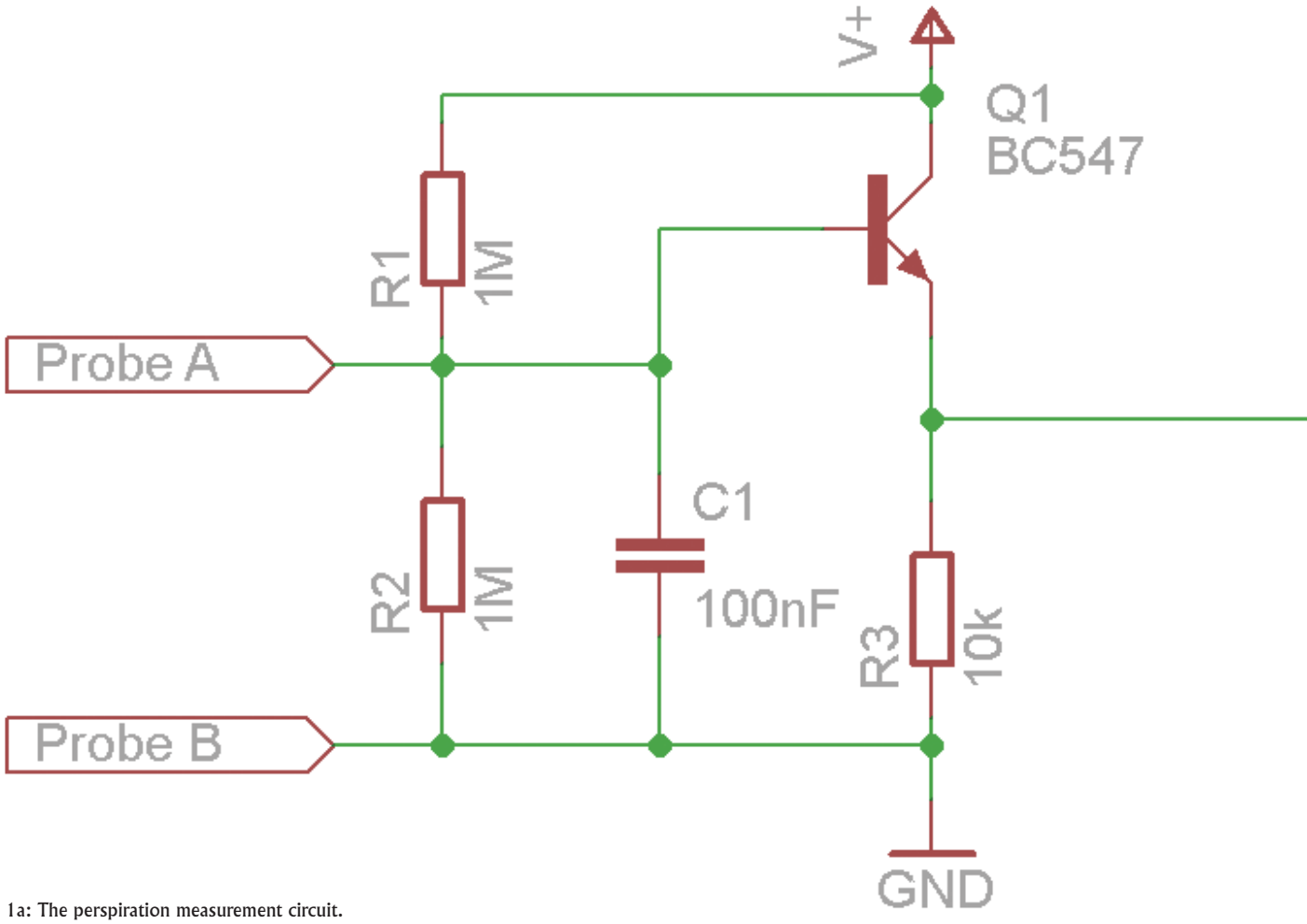


Figure 1a: The perspiration measurement circuit.

read, into a simple readout that tells us if our subject is perspiring.

So what do we know? We know that the output of our detector drops slightly when the resistance between the probes drops. As a result the output voltage of the sensor stage drops. The obvious choice for a detection mechanism is the use of a comparator. This will tell us when the input voltage is higher or lower than a set reference voltage, which is set by R4.

At this point the lie detector circuit is essentially complete, save for one glaring flaw; when our subject's skin resistance drops, the output of the comparator switches from logical 1 to logical 0. We need to use this active-low signal to switch our indicator - whatever it may be - on. In the circuit below, Q2 switches LED1 on when the comparator's output is low.

The astute reader might suggest that using a MOSFET for a switching application as simple as this is massive overkill - but this choice was made with flexibility in mind. R6 and LED1 can be replaced with pretty much anything the user desires, for example, a relay could be used instead of the LED in order to switch some other device on.

Catcher in the lie

Have your subject hold the probes, which can just be a piece of wire, and adjust R4 until the LED is turned on, then roll back R4 until it extinguishes. When they start to perspire, LED1 should turn on.

In conclusion

This "lie detector" is a far cry from the real-world polygraph. Nevertheless, it should prove fun to play with.

Part list:

R1,R2	1MΩ
R3	10kΩ
R4	10kΩ potentiometer
R5	3kΩ
R6	4.7kΩ
C1	100nF
Q1	BC547
Q2	Any p-channel MOSFET
IC1	Any comparator IC
LED1	Any LED

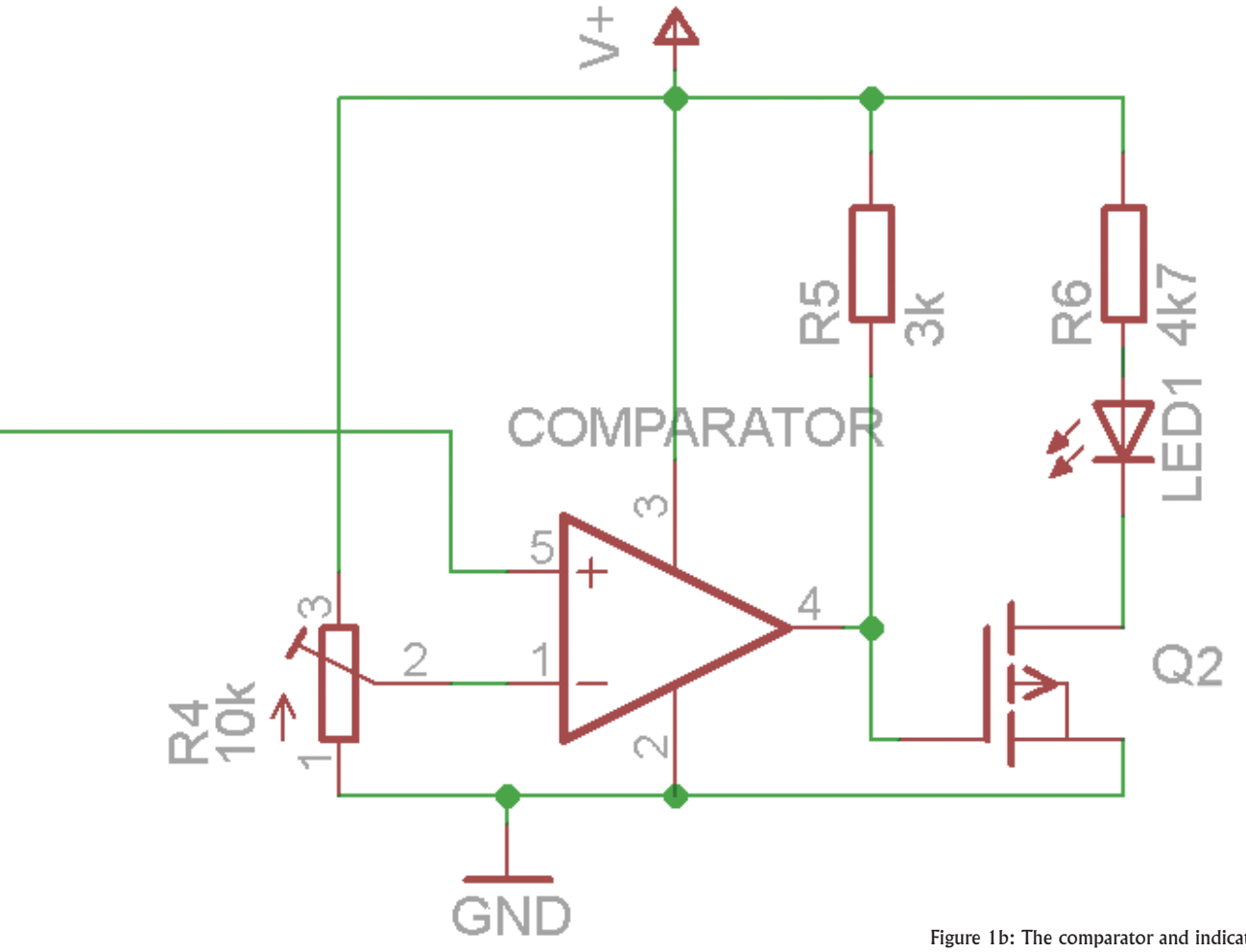


Figure 1b: The comparator and indicator circuit.

Verslag Elektro Ontvangstweekend

Eindelijk was het zo ver. Met een, hoogst waarschijnlijk, veel te vol bepakte weekendtas liep je een gebouw in, waar je op dat moment alleen nog maar van wist dat 'het best hoog' was. Dat dit gebouw voor de komende jaren de plek zou zijn waar je het grootste gedeelte van je tijd zou slijten en dat je daar, gek genoeg, nog enorm trots op zou worden ook, besefte je je nog niet. Een allerlei aan willekeurige mensen was om je heen druk aan het praten en twee mensen in 'apenpakkies' stonden klaar om je naar de balie te verwijzen. Vrijdag ochtend: met een nieuwe pul en een schone overal begon het weekend.

Auteur: Derk-jan Hulsinga

Wat je niet wist, was dat achter de schermen de commissie, het 139ste en het 140 bestuur hun adem inhielden. Waar voor een lange tijd aan was gewerkt, en wat januari (!) dit jaar al in gang was gezet kwam nu tot een eindproduct. Nullen die binnendruppelden, zichzelf aanmelden en snel gingen integreren: het was al direct een prachtig beeld.

Direct lieten we ze integreren. Zoals veel dingen wel, en sommige dingen niet, verliep de vrijdag ochtend goed onder het mom van een ronde speeddaten, een stevige sessie zingen en uiteraard de gebruikelijke foto's. Chronologisch verdeeld over de rest van de dag hebben de nullen EWI leren kennen door middel van een rondleiding, de bestuursbak door enkele memorabele ronden bakduwen, hun eerste studentensportvereniging door middel van een diner bezoek aan Proteus-Eretus, en elkaar door middel van het beursspel. De laatste reeks aan perikelen in het beursspel was uiteraard het belangrijkst.

Aller eerst een bijzonder informatie ronde 'Delftsche traditie's' onder leiding van twee heren uit 137, waar we veel complimenten over gehad hebben. Hierna een minder informatieve, minder begrijpelijke maar vele male representatiever commissie bedankje – Wat vele mooie cadeau's opleverde, hulde! – en voordat onze nieuwe leden gedropt werden een prima zure sessie. Zouden er nullen geweest zijn die verwachtte dat er bestuursleden in hun ondergoed aan deze tafel zaten? Vermoedelijk niet, maar er zijn wel degelijk vermoeden vanuit de commissie. Waar anders, om het even ergens anders over te hebben, kon deze avond overigens beter afgesloten worden dan in onze eigen /pub.

Op de eerste ochtend werden de nullen opvallend snel wakker. Persoonlijk ben ik een ochtend mens, dus het keren van de mentoren was weer een heerlijkheid maar dit viel tegen bij de eerstejaars. Gemengde gevoelens waren er toen ze voor opstaan

Elke mogelijkheid tot relaxen werd aangepakt.

tijd al bezig waren met inpakken. Na ontbijt en de ietwat aparte ochtendgymnastiek stapte iedereen dapper op de fiets om met wind in de haren en de zon in de ogen richting het kampterrein te fietsen. Of het altijd goed weer was tijdens deze rit is me niet bijgebleven. Na een goed voedende lunch werd iedereen er op uit gestuurd om te doen wat electro'ers graag horen te doen: het verzamelen van electrokeck. Met niet veel meer dan 2 weerstanden en enkele spelregels onder de arm gingen ze op pad, om even later met een enorm berg units en jetsers aan te komen op het strand. Waar de bikkels goed

hebben gezwommen en anderen hebben genoten van de Nederlandsgrijze lucht boven hen, was het strand zeker geslaagd. Een hardhandig spelletje 'Aarde' werkte dit gelukkig alleen maar in de hand.

's Avonds, terug op het terrein, werd er weer met veel genot gebarbecued. Met alle nullen achter de komma, ouwe lullen op de bank en onze gasten verspreid over het terrein werden we geserveerd met een goed stukje vlees van de barbecue koningen. Omdat het goudgele gerstenat al rijkelijk gevloeid had, en omdat de instrumenten ondertussen gestemd waren was het tijd om het hoogte punt van de avond te bereiken. Met de, bij zowel de oudere als de nieuwe leden, allom bekende 'Als Je Maar Kaal Band'. Iemand vroeg mij of dat nou ook echt leuk was. De naam zegt het natuurlijk al, maar zoals de quote ons altijd zal bijstaan, vonden de nullen het 'een opvalled leuk bandje'. Ik zeg, volgend jaar weer! Net als de hierop aangesloten pinten estafette en het ontspannen rond het kampvuur.

Tot mijn grote vreugd was het opstaan zondag een heel stuk lastiger. Niet voor mijzelf uiteraard, maar voor veel andere wel. Nu de dag opgang werd gebracht met wat prachtige electro-moves en het gerob richting het ontbijt (Bootsman kan dit opvallend goed) werden er overal en nergens steeds meer mensen wakkerder. Deze dag zou in het thema staan van de mentor groepjes en in hoog tempo ontstonden ze: slechte grappen. Gelukkig hebben deze twee causaal niet zo veel met elkaar te maken maar het waren wel de steek woorden van de tijd tussen opstaan en tussen de middag.

Als groteske afsluiting en ultieme test van groepsvorming werden de nullen getest op de stormbaan. Dit 21 meter lange beest werd lauter goed getemd door nullen die zowel het adtje als de 10 rondjes pindakaas mooi konden voltooien. Nog even onderbroken door het versieren van

Fanatieke nullen op weg naar de overwinning in de kratjesrace!

De Als je maar kaal band met eigen ETV'ers!

De pindakaaspottenrace met (vanaf nu) Altijd Zo Geweest springgadget op de achtergrond.

Groots feest tijdens het bandoptreden!

het PB (Waren ze niet om op te eten?) uiteraard. Met een groepsfoto als aller, allerlaatste activiteit moest iedereen toch maar weer met de fiets terug naar EWI.

Met hun tas terug onder hun arm en een berg met te verwerken herinneringen en indrukken, moesten ze weer door. Door naar het Owee. Als commissie keken we trots terug op een weekend wat een berg afgepeigerde nullen had opgeleverd en waarin we vanuit de vereniging als eerste onze stempel mochten drukken op een select groepje dat ooit de toekomst moet gaan vormen. Ons werk was voltooit, wij waren content.

Namens de commissie, wij vonden het weekend prachtig – Uiteraard bedanken we hiervoor: Onszelf, ETV'ers en andere die hierbij hielpen, maar ook zeker elke nul die er bij aanwezig was. We koesteren de positieve verwachting dat jullie succesvolle EE'ers en actieve ETV'ers worden!

Nuldejaars en nu al een doel voor ogen!

Elektrohelden!

TenneT

Investing in an innovative future

Most of you will know TenneT TSO. It's the company that manages and maintains the Dutch and an important part of the German high-voltage electricity grid. This is, of course, easier said than done. While innovation is the key to a modern and efficient grid, political and social pressures also play a part. In an interview with Dr. ir. Sander Meijer we explored these issues and see how they fit in the engineering challenge that the grid presents.

Readers who had the pleasure of attending Dr. Meijer's lunch lecture on October 20th will already be familiar with the Randstad380 project. This project aims to expand the national transport grid on the Maasvlakte, catering to an increasing demand for electricity.

To do this, TenneT must construct new lines and cables to expand the energy transportation capacity. But who decides when and what to build?

Dealing with change

In essence, the government decides where power plants can be built in certain locations, and TenneT is charged with making sure the grid can transport the additional energy. One of the largest problems is the fact that a power plant can be built in a matter of years, while the construction of a new power line is a lengthy and costly process. Because of this, a power plant might be put into operation before any modifications to the grid can be implemented. At this point a network strategist reviews the capacity of existing connections and where bottlenecks might occur. The strategist must come up with a plan to deal with these bottlenecks while the possibility of a new line is explored. In the end, the company has multiple options on how to deal with the situation, each with their own price tags. When a solution is chosen, it is implemented, with the costs of the development being integrated in TenneT's rates.

Supervision

TenneT enjoys a unique position in that it has full control of the only transmission grid available. It's not hard to imagine why, as multiple grids in parallel would be confusing, expensive, and impossible to manage. As such, TenneT is the only TSO in Holland. To prevent them from exploiting this monopoly, TenneT is monitored by the NMA - de Nederlandse Mededingingsautoriteit - which roughly translates to the Dutch Competition Authority. This government agency monitors the economy and is charged with dealing with cartels and price fixing and other monopolistic situations.

Because TenneT has been appointed by the government to be the sole operator of the grid, the NMA has been appointed as regulator of the company. They monitor costs and efficiency, and sets conditions and boundaries within which TenneT is expected to operate. When innovation - which is always more expensive than implementing existing technology - is called for, the NMA are the people to authorise the use of more expensive equipment.

The cost of innovation

The world of maintaining our society's electricity supply is not without politics. On the contrary, political and social pressures are omnipresent in the daily operation of the grid. So what does the company prefer doing? Is innovation more important than business?

The answer is, of course, subtle.

TenneT's mission is to take security of supply to the highest level. Simply put, more expensive solutions are not preferable, but sometimes external influences force the company into innovating. Case in point: the new Wintrack pylon. Designed to reduce magnetic fields around the power line, the new pylon is significantly more expensive than the traditional tower. Nevertheless, the pylon is now being tested in the field.

Maintenance

Thinking about maintenance before a piece of equipment is installed is an important step, but often reality is different from theory. Staying with the Wintrack pylon, not all necessary/required accessories were identified. As a result, it is difficult to climb the tower and to bring necessary equipment along. For this reason maintenance is also being performed with hydraulic platform lifts. This poses challenges of its own, as steps must be taken to prevent the lift from falling. Thinking of solutions to this kind of problem is the kind of challenge faced by engineers in all fields, as difficulties can not always be foreseen, and things that seem easy don't always turn out to be that way.

International interest

Holland is not the only country experimenting with innovations such as the new Wintrack pylon. Other TSO's have expressed an interest, but for different reasons. For example, the Wintrack pylon was designed to look unobtrusive and aesthetically pleasing - for this reason Austria has expressed an interest in implementing this new pylon.

Careers at TenneT

TenneT employs engineers from all kinds of fields. Almost anyone with an Electrical Engineering degree can apply, as TenneT doesn't deal in power electronics, it also has its own telecommunications system, not to mention the control systems involved in daily grid operation. But they also employ mathematicians, civil engineers, and financial and management experts.

If you're interested in applying for a job at TenneT, please visit:

http://www.werkenbijtennet.nl/

You may also send an unsolicited application.

Improvements in nanosatellite radio communication systems

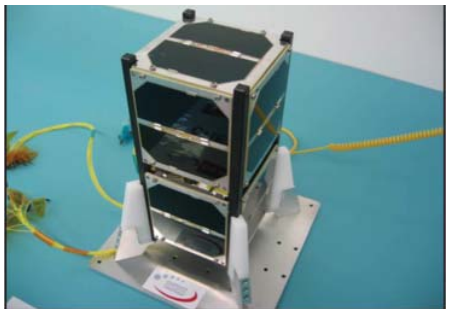
TU Delft launched its first satellite in 2008, the Delfi-C3. At present, its successor Delfi-n3Xt is being built. Because of their small size compared to more traditional satellites they are called nanosatellites. Since several years, nanosatellites are being built all around the world for scientific research and technology demonstration.

Authors: Johan Erasmus, Eddie van Breukelen (ISIS)

Nowadays they are also being designed for commercial applications such as Earth observation and keeping track of shipping traffic on the oceans. The sector is growing very fast. Most of the nanosatellites conform to the CubeSat standard, an international standard that makes it easier to arrange satellite launches.

ISIS – Innovative Solutions In Space BV designs, builds and launches nanosatellites and CubeSats commercially. The founders of the company originate from the Delfi-C3 nanosatellite project of TU Delft. In the past five years the company has grown to around 35 people, many of whom have studied at TU Delft as well. The company has its offices and labs in the YES!Delft business incubator on the university campus. One of the key capabilities of the company is its expertise in satellite radio communication systems. This article describes ISIS' vision on the development of higher performance communication systems for nanosatellites.

The first CubeSats carried simple beacon transmitters or could downlink only a limited amount of data. As they were the first of such extremely small satellites, this was a big achievement at the time. Since that time, the radio communication systems in nanosatellites have been experiencing an extremely fast evolution.



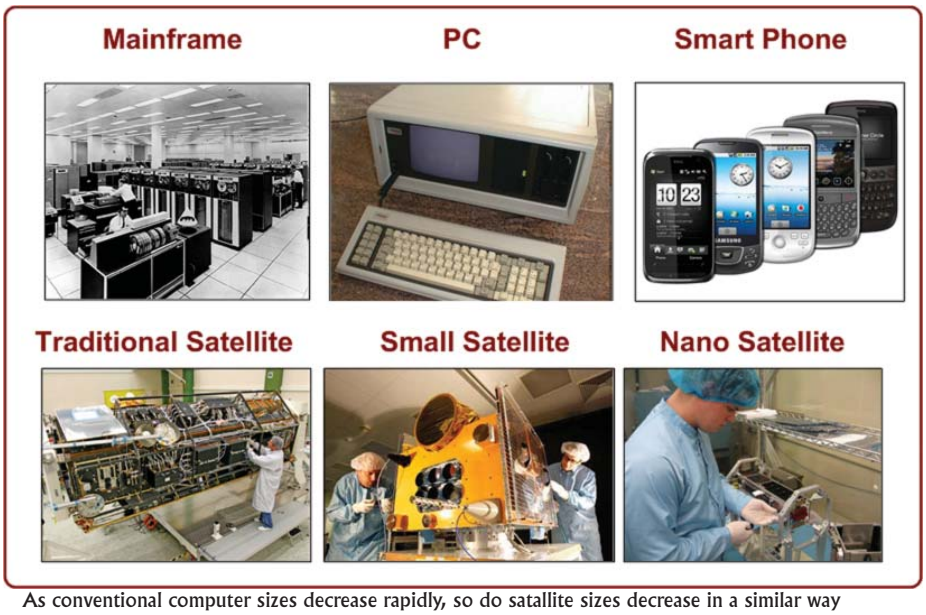
A 2-unit Cubesat in the clean room at ISIS

Connecting the deployable antenna system

From the technology side this growth has been driven by the miniaturisation and increase in capabilities of the available electronic components. From the satellite application side there are many developments with several advanced scientific CubeSat missions in orbit and even more proposed. Several commercial Earth observation systems based on nanosatellites are being designed as well. The developments result in a strong demand for higher data rate communication for such missions.

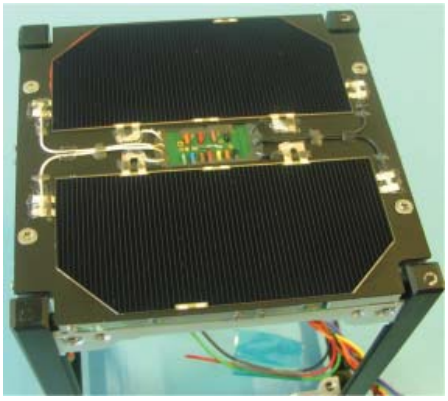
Frequency Selection aspects

The use of radio frequencies is coordinated internationally and the available portions of the frequency spectrum for nanosatellite missions have always been



As conventional computer sizes decrease rapidly, so do satallite sizes decrease in a similar way

very limited. Proper selection of frequency bands can have a major influence on a mission. For non-commercial missions the use of bands traditionally allocated to amateur radio use has proven to be a way to streamline the coordination process, but limitations exist on the spacecraft applications for this method and a counterservice to the amateur radio community is generally required. For purely commercial missions different frequency bands are required leading to a more complicated frequency coordination process that can easily take more than a year. To cope with the long coordination process, there is a general design trend for frequency generation using synthesized frequency sources. This allows for flexibility in frequency allocation and potential late changes in assigned frequencies.



ISIS deployable antenna system

Modulation and Coding improvements

Exactly as was the case in the past for commercial micro- and mini-satellites, the need for mission capabilities in nanosatellites requires improvements in data downlink throughput and an efficient use of the available spectrum. ISIS considers advanced modulation and coding techniques to be the key to better performance and improved spectral efficiency. Software Defined Radio based radio ground stations allow ease of implementation and flexibility.

Network protocols

Communication links between satellite and ground are often implemented using simple network protocols. The most common is AX.25, used over amateur bands. It is quite a robust and simple protocol, but its performance is limited and several more efficient alternatives are being considered.

Satellite Antenna developments

For VHF and UHF antennas the main development trend has not been primarily in the improvement in the overall performance of these systems, but rather in the reduction of the volume required to house these systems. ISIS for instance has developed a miniature package that fits just below the top or bottom Solar panels of a CubeSat and on command deploys UHF and VHF antennas of up to 50 cm long.

For the relatively newer and higher frequency bands the trend is to design patch type antennas first with simpler linear polarisation, then also with circular antenna polarization as an option. Future trends are to develop higher gain antenna systems with beam steering enabled while limiting the requirements on power and surface area for these systems.

Hardware to Software migration

Thanks to the improvement of electronic circuits performance, many building blocks used in radio receivers and transmitters are being implemented using digital circuits and even software applications. This allows to dramatically increase the flexibility of radio equipment and also to accommodate complex modulation and coding schemes, which would not be feasible using past generation receivers and transmitters. In general we see a transition from radio-amateur legacy hardware to modern software-based transmitting and receiving systems.

Looking to the future

ISIS expects continued increase in communication systems performance to fulfil the needs of commercial and scientific missions. Anyone who aims to launch a nanosatellite in the coming 1-2 years should definitely take these developments into account. For command uplinks, data rates up to 9600 bps are expected. For VHF/UHF telemetry downlinks up to 115000 bps are feasible and for higher frequency systems such as S-band systems, with a need for download rates of 10-20 Mbps in the near future in order to be able to support high rate imaging payload onboard advanced nanosatellites.

Polar Space Launch vehicle with four Cubesats

As with many increases in performance of electronic systems the developments are going very fast and it is expected that this will speed up even more. It is a very interesting field where engineers from many disciplines are working together. RF engineers, electronic designers and embedded software developers work together to build hybrid analog/digital systems to establish ever faster data links to feed the world's appetite for information gathered using satellites.

Build Your Engineering Career @ NI

Join the National Instruments Engineering Leadership Program (ELP) and engineer the tools of scientific discovery!

Wij zijn op zoek naar talentvolle engineers die klaar zijn voor een uitdaging; jong talent dat klant- en oplossingsgericht werkt en gaat voor resultaat. Het Engineering Leadership Program (ELP) van National Instruments biedt een 18 maanden durende opleidingsprogramma. Naast deze hoogwaardige opleiding bieden wij een aantrekkelijk salaris en een uitdagende baan bij één van de beste werkgevers wereldwijd.

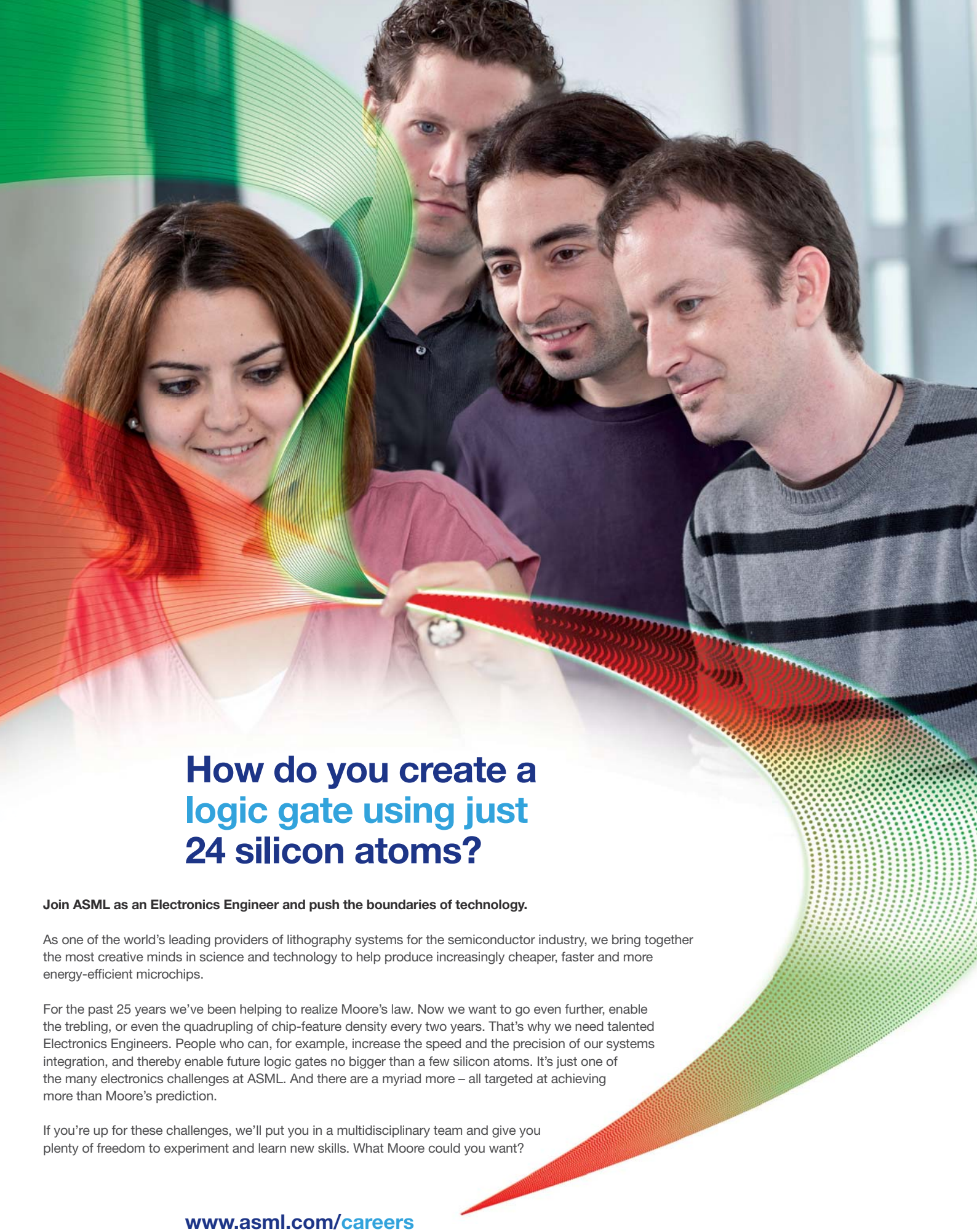
Ben jij die talentvolle engineer die de uitdaging aan wil gaan? Neem dan contact met ons op via **jobs.netherlands@ni.com** of bel **0348-433466**

- Worldclass Training Program
- Attractive Compensation
- Great Company Culture
- Career Opportunities

>> Voor informatie over het ELP programma, bezoek **netherlands.ni.com/elp** **0348 - 433 466**

National Instruments Netherlands BV ▪ Pompmolenlaan 10 ▪ Postbus 124 ▪ 3440 AC Woerden
Tel +31 348 433 466 ▪ Fax +31 348 430 673 ▪ Chamber of Commerce ▪ # 301 168 13 ▪ Utrecht

NATIONAL INSTRUMENTS™



How do you create a logic gate using just 24 silicon atoms?

Join ASML as an Electronics Engineer and push the boundaries of technology.

As one of the world's leading providers of lithography systems for the semiconductor industry, we bring together the most creative minds in science and technology to help produce increasingly cheaper, faster and more energy-efficient microchips.

For the past 25 years we've been helping to realize Moore's law. Now we want to go even further, enable the trebling, or even the quadrupling of chip-feature density every two years. That's why we need talented Electronics Engineers. People who can, for example, increase the speed and the precision of our systems integration, and thereby enable future logic gates no bigger than a few silicon atoms. It's just one of the many electronics challenges at ASML. And there are a myriad more – all targeted at achieving more than Moore's prediction.

If you're up for these challenges, we'll put you in a multidisciplinary team and give you plenty of freedom to experiment and learn new skills. What Moore could you want?

www.asml.com/careers

ASML

For students who think ahead