#### ROBOTICS

# **MADE IN HOLLAND**

Today vs tomorrow // People-friendly robots // Ultimate system integrators // Rehabilitators // Dutch football // Milking, refuelling: how far can we go?

How much more **versatile** can **robots** become?



**Pioneers in international business** 

# From factory equipment



A robot has replaced the baker's assistant in this bakery. Sure, the robot is less fun to be around, but it is never in a bad mood and works almost for free. It used to be the case that robots were long steel arms that could only perform tasks such as drilling holes in car bodies, and you only ever saw them in factories. Nowadays, however, they're in bakeries, rose nurseries and hospitals and soon they will even be working at filling stations. The robot has left the factory floor and entered our world to do all the jobs that we don't want to do. Soon, a robot could be your companion, your physiotherapist, or your jack-of-all-trades in and around the house.

# to household pet

Norman the ball. like the the This is Bas. He thinks Aibo is amazing - a robot that can play with a ball, cry softly and obey its master like any other good dog. What is Bas thinking? Will they become friends? Even if they don't, this future rocket scientist can already go to Science Center NEMO in Amsterdam to get to know a world that might not be as far off as his parents think.









# www.hollandtrade.com



# Powerhouses

K LINE

126L

**Robotics in the spotlight** 

KLIN

Y YANG MING

Y YANG MING

Y YANG MING

NG MING

Since the release of Asimov's *I*, *Robot*, people have been fascinated by smart computers with human characteristics. Sixty years ago, the American sci-fi writer's stories were still pure fiction, but for the last few decades, however, robots have been a reality. And they are quickly becoming more and more versatile: Honda's ASIMO robots and ASML's high-speed precision instruments demonstrate the wide range of tasks they can perform. Both in industry and in other sectors, the Netherlands is playing a key role on the world stage in the development and use of robots. >> *By Xavier Teunissen* 



#### // Advanced industry

The miniaturisation of information technology, the rise of artificial intelligence and the swift development of mechatronics have all contributed to the creation of industrial robots capable of performing more and more complex tasks. Machines with visual and sensory capabilities are becoming the standard. The strength of Dutch businesses lies in their expertise in taking existing robots and 'linking them together' enabling flexible and reliable operation of the resulting complex systems by means of smart software. Above all, this is possible thanks to close cooperation in the industry as well as the solid partnerships with universities of technology and knowledge institutes.

## A **warehouse** like an old-fashioned **jukebox**

#### // Logistics champion

For centuries, the Netherlands has been the world leader in logistics. Once, it was the trading nation that dominated the world's oceans, and now - thanks to its unique position in Europe - the Netherlands is the most important transit port to the European hinterland. All that time, the Dutch have been second to none in the storage and transhipment of goods. Many players in this sector have dreamed of having a totally automated storage system, so that you can operate a warehouse like an old-fashioned jukebox where you just press a button to automatically bring out the item you want. With this as its starting point, the Dutch high-tech company Vanderlande joined forces with knowledge institutes to develop a robot system incorporating automatic guided vehicles that can >>



perform every conceivable warehouse task with tremendous flexibility.

#### // From cows to roses

Dutch robots have also conquered the agro-food industry. This should come as no surprise when you consider the scale of operations in the industry. As the second largest exporter in the world, the Netherlands is a leader in the production of flowers, cheese, fish and meat. The cattle breeding and horticulture industries, in particular, benefit from sophisticated robot technology. For instance, as cows walk independently and voluntarily through a self-cleaning cowshed, they are milked by a fully automated milking robot. And horticulture businesses are increasingly using state-of-the-art cutting insertion systems, which take fragile cuttings - from roses, for example - and plant them in the ground.

## An entire **minifactory**

#### // State-of-the-art

When it comes to technology and mechatronics, the Netherlands is a major international player with not only giants of the industry such as Philips, ASML and Océ, but also highly specialised SMEs such as Sioux. Their robots play a vital role in manufacturing computer parts, such as processors, lasers, RAM memories or transistors, as these products are hardly touched by human hands anymore. For example, only the most advanced robot systems can position wafers in ASML chip machines in fractions of a second to within a few nanometres (one one-millionth of a metre) as regards location accuracy. The same can be said of the systems' complexity. For instance, Océ's industrial copy machines are like entire factories >>

# Always **clean and dry** feet in the cowshed

LIN

packed into a small housing. This is where the specialised system knowledge of the Dutch truly shines.

#### // Welding

Metalworking is yet another field where robots have been used for years. In the shipbuilding and automotive industries, fully automated systems perform nearly all aspects of the welding, cutting and spraying of metal. For this market, the Dutch are developing state-of-the-art welding robots which will be able to work as integrated systems that minimise the need for operation while maximising flexibility. Directly importing 3D CAD data is the key. This also forms the basis for the new welding robot system from Kranendonk Production Systems with Rinas Weld - the world's first total welding system with autonomous welding analyses and robot programming. Just think how much time and money that saves!

# Increasing surgical precision

#### // Robots improve health

Robots also come in handy in the manufacture of high-end medical equipment. For example, Philips Healthcare is a leader in the development of scan equipment such as MRI and CT scanners and is also helping to improve the performance of surgical robots using new methods such as 'image guided interventions'. In addition, the universities of technology are developing surgical robots to help surgeons perfect their work, and the University of Twente has launched a rehabilitator, which is a robot that gives the patient an 'extra pair of legs': the robot 'walks' while the patient follows on the treadmill. <<

Photo: Marijke Volkers



# The advantage of a similar outlook

### "Top-notch research"

Name: Stefano Stramigioli Age: 41 Place of birth: Italy Profession: Professor of Advanced Robotics, University of Twente, Senior Member of the IEEE

"What's it like working in the Netherlands? I've been here for 14 years now and I don't ever want to leave. I especially like the working culture. People work in an extremely professional and structured manner. I also think it's great that people appreciate the value of giving and receiving criticism, because that's good for innovation. They don't let hierarchical relationships stand in their way.

As small as the country is, when it comes to mechatronics - the building blocks of robots - the Netherlands is of course world-renowned, thanks to companies such as ASML and Philips. Therefore, fertile ground has been laid for robotics and the university research is also top-notch. In this country, where everything is close together and the three universities of technology (3TU) are not far from each other either, you also benefit from the fact that the Dutch have a similar outlook. Their attitude of 'we'll put it together as a team' has no equal anywhere in the world!"

## What do robots mean to you?

People can have any number of associations with robots. While one person fears for his job, another may see a fun household pet in a robot, while others think of the tremendous increase in efficiency offered by owning a robot. As it turns out, this last view turns out to have the most truth to it. The market for robots appears to have finally come of age. According to a study by BCC Research, the worldwide robotics market achieved a turnover of about 17.3 billion dollars in 2008 and will grow by an average of 14% in the coming years to reach a turnover of 21.4 billion by 2014. These figures include industry, domotics, professional services, military applications, security and space travel. Currently, the industrial robot segment has the largest market share with a turnover of 11.5 billion dollars in 2008. The professional services segment has the second largest market share at 3.3 billion dollars of turnover in 2008, while the military applications segment ranks third.

#### www.robotics-benelux.info

# High-tech in the country

Wageningen University and Research Centre (Wageningen UR) is putting science to work to achieve agricultural advancements by using smart robots that can remove or spray weeds down to the last square centimetre. Environmental concerns and labour costs place considerable demands on today's agriculture industry, so extremely precise field robots are required that can handle substantial differences as regards the shape of the terrain, the temperature, dust levels and rainfall. In 2003, Wageningen UR launched a Europe-wide contest, the Field Robot Event, where student teams could demonstrate the latest in robot-aided precision agriculture. bouke.devos@wur.nl



www.wur.nl



# **Rocking robots**

Yngwie Malmsteen's intricate guitar riffs are no problem for TeamDARE robots. In fact, TeamDARE's guitar and drum robots won first prize at the 2009 international ARTEMIS Orchestra Contest in Nice. In particular, the judges were impressed by the robots' ability to play together, their diverse repertoire and their natural sound. It is especially remarkable that a camera can record a conductor using his arms to set the tempo for the robots. TeamDARE plans to expand its range of musical robots and to perform at music festivals in 2011. So if Malmsteen ever gets tired of playing, we always have robots that can stand in for him. frank.van.heesch@gmail.com

#### www.teamdare.nl

# A mound of knowledge

It is only natural to collaborate in a country like the Netherlands with such a high knowledge level and a small surface area. During the first Dutch Robotics Symposium in May 2009, for example, RoboNed was launched. According to Professor Maarten Steinbuch of Eindhoven University of Technology (TU/e), who is one of the main driving forces behind the project, RoboNed is a network association devoted to "the development of a leading international robotics cluster in the Netherlands". The network was founded by the three universities of technology – working together as 'the 3TU Centre of Excellence for Intelligent Mechatronic Systems (3TU COE IMS) – and Philips Applied Technologies. The 3TU network is already working on the humanoid robot TUlip, which will demonstrate its football skills at the international Robocup World Championship. Furthermore, in addition to the universities of technology, the universities in Amsterdam and Groningen are also contributing to the ongoing development of robots.





#### www.3tu.nl | site.dutchrobocup.com

## **Spilt coffee**

Under the leadership of Dutchman Dr Patrick van der Smagt, a European research team is currently developing the most human robotic arm ever created. The arm will be capable of emulating nearly all human arm movements and will be operated partly by a 'brain' modelled on the human cerebellum. Robo Habilis – as the robot is called – will be able to snap its fingers, hold an egg without breaking it and pick up a cup of coffee without spilling it. The hand on the end of the robotic arm will be coated with a layer of carbon with an electrical resistance that changes as the pressure changes, thus imitating the sensory capacity in our fingertips. Each of the 29 joints in the hand will be fitted with two small motors that generate power and control a whole range of movements. smagt@dlr.de

#### www.robotic.dlr.de

## About this publication

The **Made in Holland** sector specials provide information on specific Dutch sectors, such as Delta Technology, Design and Horticulture. Centres of excellence and commercial companies are given the chance to comment on the latest developments in the sector and on their products and services. **Made in Holland** does not have regular subscribers, but instead reaches a new foreign readership with each issue. The publication is translated into multiple languages and is circulated worldwide. Additional information on this publication can be obtained from the Netherlands' diplomatic representations abroad.

www.hollandtrade.com

#### **MADE IN HOLLAND**



# **Quality guarantee**

What do a hand blender, a webshop and a packet of biscuits have in common? The answer is that they all have quality marks. With a quality mark, you can rest assured you will get a good quality product. So why not have a quality mark for industrial robots? This year, the Robotics Association Benelux (RAB) began issuing such a mark, the so-called 'safety mark',



to Dutch robot suppliers and system integrators that comply with the EU Machinery Directive. The directive focuses in particular on safety issues. Businesses receive the safety mark based on audits, which are performed by an independent bureau. The advantage of the safety mark is that it guarantees compliance with safety standards and therefore improves the image of the robotics industry. Additionally, robot suppliers can use it as an extra 'hook' for making a sale. On 15 October 2009, the first safety mark will be officially issued, which will also signal the start of a campaign to spread the word about the safety mark. bne@fme.nl

#### www.robotics-benelux.info



### Safe remote working

Being exposed to X-rays on a daily basis can be harmful for health care workers. Developing a remote-controlled robot that could take the X-rays is one way to reduce human exposure. Eindhoven University of Technology (TU/e) and Philips are part of an organisation called Remote Robotics which is doing just that. The robot will be designed for use in hospitals (curative medicine) and in homecare (care-based services). With a few alterations, the robot will be able to perform multiple tasks. Marketing the robots as cheaply as possible will be key. In about seven years, the first affordable robot is expected to roll off the assembly line. m.steinbuch@tue.nl

> w3.wtb.tue.nl/nl www.apptech.philips.com/robotics



### A centre full of robotics

The initiators of the Robotics Centre Twente envisage one large robot lab, where scientists can tinker with, demonstrate and test their creations. At the centre, which is affiliated with Twente University of Technology, the university and companies will be able to collaborate in the fields of robotics and mechatronics. The centre will provide personalised support and smart services, as well as designing medical robots and developing socially relevant applications for them. A number of projects are already underway, including one to develop a system capable of checking gas pipes for holes from the inside out.

www.romech.nl | www.tvalley.nl | www.utwente.nl

## **Good to great**

According to Roel Kramer of the Point-One association, the fields of nanoelectronics, embedded systems and mechatronics together form the "cornerstone of a worldwide value chain". The health care, energy, IT, leisure, transport and security sectors would not be able to function without these disciplines. Under the motto 'from good to great in Dutch technologies', Point-One wants to increase the turnover of the Dutch high-tech industry by bringing high-tech companies and knowledge institutes together in an open network. The association consists of businesses and knowledge institutes that are participating in the Point-One Phase 2 Innovation Programme of the Ministry of Economic Affairs.

www.point-one.nl

# Uncompromising

What makes the Netherlands' contribution to the worldwide robotics industry so important is above all the original approach and the ability to collaborate, according to Jan van Eijk, Professor of Mechatronics at Delft University of Technology (TU Delft) and chairman of the eponymous working group in the government's High Tech Systems innovation programme. >> By Joost van Kasteren

Photo: Dierk Hendriks

An excellent example of this uncompromising approach is 'Denise', a two-legged walking robot (see box) which is the first of its kind. Van Eijk says, "Compared to people, humanoid robots always look very wooden when they move. Martijn Wisse from TU Delft developed a robot that walks like a human, enabling it to move about without remote operation using a minimum amount of energy." The results of the Robocup, a sort of Champions League for robots, attest to the Netherlands' special contribution. "The ultimate goal of this worldwide programme is to win a football match against the world's best players by 2050," relates Van Eijk. "For the time being, the robots play in teams of four against each other. In the annual championship, the Netherlands almost always finishes in the top three."

#### // Beyond industry

The robot footballers constitute the prototype for a new generation of robots: autonomous, smart systems that are able to adapt in a changing environment. Van Eijk says, "Industrial robots perform best in a well-structured environment in which they can carry out a number of well-defined tasks in a flexible fashion. We are currently witnessing a transition from relatively simple industrial robots to robots that can function in more dynamic environments, such as milking robots, which have to work with varying udders that need to be milked, or a tomato-picking robot, which has to see what it's picking. The universities of technology are also working with Philips to develop a health care robot, which can take over some of the tasks from health care workers."

#### // In every household

In the longer term, say in ten to 15 years from now, we will even welcome robots into our homes, where, according to Van Eijk, they will be able to perform various tasks. "The Tamagochi has shown that people can bond with mechanical devices. I can imagine robots acting as mechanical pets for senior citizens in nursing homes, for example, or people switching on a special robot to play a game of virtual tennis. Many people would welcome a robot that helps them to operate complex technical devices, too." Although the idea of a robot as a personal assistant may raise a few eyebrows, according to Van Eijk, it's inevitable. "Just look at e-mail or mobile phones, or even personal computers. When they were first introduced, most people dismissed them as gadgets for a small group of nerds. But now, we wouldn't be able to function without them. The same thing is going to happen with robots, once they are affordable. That, too, will happen: Philips is working hard to make the affordable robot a reality."

#### // Good at collaboration

As already stated, Dutch researchers and businesses have a special role in the robot's 'transition' from factories to cowsheds and fields and ultimately into households. According to Van Eijk, this has to do with the Dutch culture. "First of all, we are not afraid of new technologies. Mobile telephony and the Internet are examples of technologies that caught on faster in the Netherlands than almost anywhere in the world. We are also good at collaborating. That's a skill that not only helped us in our battles with floods, but is also useful in robotics, or rather mechatronics, because mechatronics is a field that combines many different disciplines, ranging from electrical and mechanical engineering to artificial intelligence, ergonomics and psychology. Lastly, we are not afraid to think 'out of the box', even if the boss is looking over our shoulder. We have the guts to be original."<<

#### Contact

s Professor jan van Eijk studied at TU Delft and has worked in Pakistan and Sri Lanka. After receiving his Ph.D. in 1985, he worked on precision systems for the assembly of optical discs, electron microscopes and wafer steppers at Philips Applied Technologies. He has been parttime Professor of Mechatronics at TU Delft since 2000. He has also worked as an independent mechatronics consultant since 2007. www.tudelft.nl

# Things catch on faster in the Netherlands than almost anywhere else

#### DENISE

Robots look wooden when they walk because they have to balance on one leg. However, in 2004, Denise, which was developed by the Biorobotics Laboratory in Delft, was the first robot to be designed with the human gait in mind. The design was revolutionary – not even Sony or Honda had gotten this far. When we walk we actually fall forward and then catch ourselves again with each step. The human gait requires little energy because we allow gravity to pull our feet down as we walk. In the meantime, Denise now has a few brothers and sisters that can walk even better than she can.

#### At work

Photo: Wiebe Schievink

#### HIGHLIGHTS

> Valk Welding has been making welding robots for 30 years. For the last 15 years, nearly all of these have been complete systems, incorporating everything from engineering to maintenance and training, including the welding wire. www.valkwelding.com > Rolan Robotics specialises in robot systems for industrial applications in the metalworking, food and non-food industries. Often, it supplies welding robots together with handling robots. www.rolan-robotics.nl > WWA focuses on both automated production and product development. Welding robots are sold as part of a total solution that centres on the client's requirements. www.wwa.nl > NedClad specialises in laser cladding: a high-powered laser welding robot is used to fuse a pore and crack-free coating, which improves the quality and service life of products. www.nedclad.nl

# Welding robots

#### // JUST AS EXCITING AS DUTCH FOOTBALL

The reason why Dutch football teams are so interesting to watch is that the players switch from one task to another so quickly. The same applies to welding robots. Footballers switch from defence to attack (counterattack), while welding robots switch from one product to another. "The Netherlands is the only country in western Europe where extremely small batches of a product and one-off items are made," says Remco Valk of Valk Welding. Towing hooks, for instance, are produced in batches of between five and 25, each of which can require up to five minutes of welding. In other words, in extreme cases, the system must be re-programmed every half hour. This requires welding robot systems that are flexible enough to keep the time required to re-adjust the robot's settings to an absolute minimum. Valk Welding supplies systems that use a 3-D drawing for totally automated programming of the welding robot within just a few minutes. However, that flexibility does mean that few autonomous welding robots are produced. The added value of Dutch companies is that they deliver complete systems, including equipment for loading, unloading and handling the parts to be welded, as well as software that is tailored to the client's needs. The solutions are turn-key, so the client need only switch on the machine to begin production.

Niche markets drive the Dutch robotics industry: robots are imported from abroad for tailor-made applications. Therefore they are always adapted to the buyer's requirements, which is a complex task made possible by world-class knowledge institutes, a solid industrial basis in mechatronics and an excellent understanding of machines, production processes and new products and services.

# **55%**

In the Netherlands, 55% of the robots are used for handling, whilst 24% are used for welding.

# 35

The number of patent applications for mechatronics products submitted in the Netherlands is the second highest in the world (35 per million inhabitants). Japan ranks first (41 per million inhabitants) and the U.S.A. and the EU15 are third and fourth, respectively.

# 300

How do you control 300 robots in one room? The 3TU network and the Dutch business sector are researching the frontiers of automation in a warehouse in the Falcon project.

Photo: David Joosten

Sources: Netherlands Patent Office, IFR Statistical Department, BCC Research EU15: Pre-2004 composition of the EU.



At the football world championship for robots, the Robocup, a team of Dutch researchers from Eindhoven University of Technology called Tech United were runners-up two years in a row. They also won the European championship in 2008.

> In 1980, the University of Twente demonstrated the power of multidisciplinary mechatronic designs for the first time with the pioneering MART (Mobile Autonomous Robot Twente).

In terms of the number of patent applications, ASML ranks fourth in the world and Philips ranks eleventh as regards state-of-the-art motion systems for the semiconductor industry.

# 17.3 billion

The global robotics market achieved a turnover of 17.3 billion dollars in 2008. Growth in the coming years is expected to reach an average of 14% (17.4 billion dollars in 2009 and 21.4 billion dollars by 2014).

#### // 60

Dutch company Lely's milking robot is used to milk cows in over 60 countries around the world.

# 4,347

In 2007, 4,347 robots were in use in the Netherlands, which was 14% more than in 2006.

www.hollandtrade.com 21

# Rehabilitation

#### // A HELPING HAND

Jaap Buurke, who is responsible for 'the restoration of human function' at Roessingh Research & Development, says that Dutch robot systems for rehabilitation purposes revolve around the patient. "Many other systems are technology-driven, whereas the patient's learning and training process is central to our designs. For example, we place great emphasis on learning theory and the use of serious games." This approach, which is typically Dutch, is the result of close collaboration between clinics, researchers and businesses. For instance, rehabilitation clinic Het Roessingh has been successfully collaborating with the University of Twente, Northwestern University in Chicago and the Dutch business sector for many years. Thanks to their combined efforts, a number of unique robot systems have been created for patients who were partly paralysed (after a stroke, for example). What makes the systems unique is that they actually work with the patient. The 'Freebal', for instance, compensates for gravity when the patient moves his or her arms. Researcher Gerdienke Prange comments, "We've shown that this helps patients learn to use their arms again." In the meantime, this robot is being manufactured in Switzerland, while two others, the 'Dampace' and the 'Limpact', are being used for targeted training in certain movements where they increase/lower resistance. Finally, the 'Lopes', which is an exoskeleton, teaches patients how to walk again following paralysis.

Photo: Lopes, developed at the University of Twente by Ruben Keestra

#### **REHABILITATION AND TECHNOLOGY**

> BAAT Medical Engineering uses research results to create new projects. BAAT stands out from the competition because of its unique combination of technical and medical knowledge. www.baatmedical.com. > **Demcon** develops mechatronic systems for a variety of sectors, ranging from the semiconductor industry to rehabilitation. Collaboration between disciplines produces effective solutions. www.demcon.nl > XSens Technologies develops motion sensors that precisely determine their own movement, condition and location. They are used in rehabilitation, navigation of unmanned vehicles and in the games and film industries. www.xsens.com > Re-Lion develops and implements systems for virtual training and simulation with a natural human-machine interface for applications including robot-aided rehabilitation training and embedded fitness. www.re-lion.com

# obots

w.hollandtrade.com 23

#### THE NETHERLANDS IS A MAJOR CHEESE PRODUCER. WHAT DOES THAT HAVE TO DO WITH ROBOTS?

"During the aging process, the cheese has to be rotated, brushed and coated in plastic. This has to be done by human beings – at least that used to be the case. Now, a robot lifts the cheese off the shelf, rotates it, and puts it down on the conveyor belt so that it can be brushed and coated in plastic. Then it puts the cheese back on the shelf, where it will continue to age. Our robot system positions the product. In this case it's cheese, but it could just as well be a roof tile or a casting."

#### IS THE ROBOT PART OF A LARGER

SYSTEM? "Yes, it is. We call ourselves a 'system integrator' because we build complete systems with robots plus other machines, based on the client's requirements. For example, the system has to be able to rotate and brush 800 blocks of cheese, as well as coat them in plastic, without damaging them, in one hour. Then we set about devising a customised system that is guaranteed to work."

#### **Р** но "о

#### HOW CAN YOU GUARANTEE THAT?

"Once the design has been approved, we build the entire system and let it run for a while at our own premises. During that time, we can correct any problems and train the client's operators and maintenance mechanics. Then we take the system apart again, transport it to the client's premises and reassemble it."

#### THE NETHERLANDS DOES NOT MAKE INDUSTRIAL ROBOTS. SO HOW DO YOU EXPLAIN THE IMPORTANT ROLE WE PLAY IN ROBOTICS? "When it

comes to designing and building production systems, the Dutch are extremely innovative. All kinds of considerations are involved. How do you pick up a block of cheese and set it down again without damaging it? How can a robot best be used to load roller containers? In addition to technical know-how, Dutch designers understand the client's problems and wishes."

WHY ARE ROBOTS IMPORTANT FOR THE FOOD INDUSTRY? "Robots are well capable of handling fragile products, such as biscuits, without damaging them, although they aren't used for this purpose on a large scale yet. We've developed special grippers for this work, which greatly reduces the amount of rejects, sometimes by as much as 25 percent. Additionally, using robots is also more hygienic, which is of course essential when dealing with food items."

IN WHAT OTHER SECTORS IS ROBOT USE ON THE RISE? "In all

sectors, basically: they are used in everything from baggage handling to car manufacturing. But robots could be used even more, particularly in the metalwork industry where small batches are often produced involving a great deal of manual work that could be done by robots. That's good for productivity, which in turn increases competitiveness. Robots work longer hours than people and don't need to take a coffee break." HOW CAN YOU KEEP ROBOTS AND HUMANS FROM GETTING IN EACH OTHER'S WAY? "One quarter of a system integrator's work is thinking about how to prevent robots from injuring people. That's why safety is such an important subject at the Robotics Association Benelux. We've introduced a quality mark that our members and affiliate companies can use to demonstrate that they comply with the European directives. Their eligibility for the quality mark is re-audited on a regular basis."

IS THERE ENOUGH INTEREST IN THE ROBOTICS BUSINESS AMONG YOUNG PEOPLE? "Probably, but the education system isn't sufficiently geared to the sector yet. There aren't enough robots in the schools. The government and business community are working hard to change matters. The new generation is very interested in robotics. The Lego League, a competition in which kids are

challenged to build robots from Lego, is very popular. For these youngsters, robots are already part of their lives."

#### INFORMATION

> The Robotics Association
Benelux (RAB) is the trade
organisation for the robotics
sector. In addition to safety, the
RAB promotes education and
other fields that are essential for
developing, sharing and passing
on knowledge regarding the added
value of robots.

www.robotics-benelux.info > Ferdar Automation Technology is a system integrator active in product handling using robots that designs and constructs turn-key equipment, mainly for the food industry. www.ferdar.nl

Photo: Jaap Spieker

# Tailoring experts

FERDAR

# Since 1996, Fred Bokhorst has been the owner and director of Almere-based Ferdar Automation Technology, which specialises in

robotics system integration for various sectors, including the food industry. He is also chairman of the trade organisation Robotics Association Benelux. In 2006 he was voted most innovative entrepreneur of the 'polder province' of Flevoland. <<

#### 1 // Jaguar, United Kingdom

VDL Steelweld is completely integrating the body of the new XJ into an existing production line. Car experts welcome the new XJ, which promises to impress with its design and use of materials.

#### 2 // LandRover, United Kingdom

2

The company is developing and designing the entire production process for the new LandRover and is also bidding for the contract to install the future production line.

#### 3 // Ford, Spain

In 2009, VDL Steelweld completed work on the production lines for the assembly and installation of the doors, bonnet and boot lid on the Ford C-Max.

3

# Delicate cars

This company designed the production line for the brand-new Jaguar XJ. Volvo and Ford also work closely with these Dutch experts, which are part of a robust family-owned company. So who are they? They are none other than VDL Steelweld, the production automation systems supplier. >> *By Arnoud Veilbrief* 



#### 4 // Ford, Germany

The company has completed work on the production lines for the assembly and installation of the doors, bonnet and boot lid on the Ford Focus.



#### 5 // Volvo, Belgium

Due to the overwhelming success of the XC60, VDL Steelweld was asked to increase production capacity by 30 percent. In principle, this can be achieved fairly easily, but it was even done without interrupting production.

#### 6 // Volvo, China

VDL Steelweld completed the production line for the long-wheelbase version of the Volvo S80, as well as supplying the tools, software programs, robots, welding lines and laser lines. The robot monitors its own copper welding points. "They're like pencil points," says Maurice Donders, Head of Purchasing and Sales at VDL Steelweld. If the robot senses that they are getting dull, it sharpens them. And if they have really reached the end of their useful lifetime, the robot replaces them itself within just a few seconds, without the need for a maintenance man or for production to be interrupted for even a second. However, that is not all the robot can do: it can also assess the quality of the tools, cool a pair of pliers in water, and all independently and at exactly the right time. Although, you cannot really say these actions are 'independent' – the robot was of course programmed by the engineers at VDL Steelweld to perform these tasks.

#### // 'Time is money'

According to Donders, "a robot definitely has to be running 99.98 percent of the time here. Nowhere else is the old saying 'time is money' as true as in a car factory. Ten seconds more on the production time costs millions of euros annually. That's why everything here is aimed at the production line being as efficient as possible."

VDL Steelweld designs and arranges production lines for car makers such as Ford, Volvo, Jaguar and LandRover. The robots are accurate in their tasks to within a tenth of a millimetre. A new Fiesta therefore rolls off the Ford production line every 58 seconds, thanks in part to VDL Steelweld ensuring that the entire production process runs at maximum efficiency. That is a remarkable achievement for a Dutch company, because the Netherlands does not really have its own car industry. "We have to attract the customers with our expertise. We therefore guarantee that the production process will be complete with a specified time – without fail. That's our strength and it sets us apart from the rest."

Clients can choose from a wide range of services. VDL Steelweld designs production lines based on the client's needs, regardless of who will subsequently arrange the production line on site. Donders says, "It's entirely possible that a client will select one of our competitors to actually organise the line at the client's premises."

#### // Integrating and optimising

Arranging production lines – particularly where the assembly of the various car body parts is concerned – is VDL Steelweld's most important activity. "They've got the body parts and the robots. Our speciality is to see to it that a car is built and with the greatest precision possible. No two cars are exactly alike when they roll off the production line. If you measure precisely enough – and I'm talking about tenths of a millimetre – you will always find variations. However, they have to be minimal – miniscule."

Deviations in the doors are the most conspicuous. This is where VDL Steelweld's speciality comes in: installing the doors in the body of the car. "Our vision system is one-of-a-kind. Cameras examine with extreme precision whether the door is installed correctly in the car, both as regards the right point along the side of the vehicle and at the right height. The cameras then send the information to the robots." In this case, too, VDL Steelweld integrates products made by other manufacturers, because the cameras, software and robots are already there. "We integrate and optimise."

#### // Delicate jobs

In these times of outsourcing and specialising, VDL Steelweld has chosen to keep its own design department. "You can outsource an activity to a company in India, but will you still understand how a certain tool or a car works? What if there's a problem in a production line, will you be able to solve it yourself? That's another area that sets us apart." This commitment to quality sometimes results in very delicate jobs. "Volvo asked us to assess the work of a competitor. If they do good work, we say so, of



// SOUND FAMILY BUSINESS VDL STEELWELD HAS BEEN PART OF THE VDL GROUP SINCE 1995. WHAT STARTED IN 1953 AS A CONSTRUCTION AND METALWORK FACTORY HAS EVOLVED INTO A CONGLOMERATE WITH A TURNOVER OF 1.7 BILLION EUROS AND OVER SIX THOUSAND EMPLOYEES. "THE FACT THAT WE ARE PART OF A LARGE, PROFITABLE FAMILY-OWNED BUSINESS MAKES US EVEN MORE POPULAR AS A PARTNER," SAYS MAURICE DONDERS. "DESIGNING PRODUCTION LINES REQUIRES A LONG PERIOD OF PREPARATION AND HAVING A SOUND PARTNER IS ESSENTIAL. WE OFFER OUR CUSTOMERS THAT CERTAINTY." WWW.STEELWELD.NL

course. You have to be very honest in that respect. I think it says something about our reputation that we get those kinds of jobs, where the risk of a conflict of interests is extremely high."

However irrelevant cultural peculiarities may seem in a global sector such as the car industry, there is nevertheless something typically Dutch about VDL Steelweld. Sometimes an employee does not want to implement an order from the supervisor, relates Donders. "If a worker is told to screw in a bolt with a certain torque, but he thinks that the structure will not withstand that level of torque, he will simply refuse to do so. If I insist, he'll give me the wrench and say: 'Here, do it yourself'. That sounds like insubordination, but he's the expert when it comes to his job. In my opinion, being involved in the thought process at every level and daring to contradict your boss, if necessary, is a typical Dutch strength." <<

#### Column

# No more sceptics

Name: Henk Hofman

Company: Rotec Date of birth: 14 October 1953 Education: higher education in engineering and technology (HTS) – electrical engineering Own businesses: Insentec (barn automation)

1979 - 2005 Rotec Engineering (robot maker) 2005 - present



feel lucky to be a robot designer, because people love robots. That is, until a robot takes over their work. Then they are quick to say, "Is that really necessary?" At some point, I hope to be able to design a talking robot that specialises in persuading sceptics of the value of robots. That would make my job much easier.

Actually though, people's reactions to robots are probably the most amusing part of my work. Take our milking robot, for instance. Thanks to the continuing advancements in 3-D vision technology and the increasingly sophisticated mechanics, the robots can find the udders and milk the cow effortlessly.

The funniest part is the farmer's reaction, who doesn't believe it will work at first and keeps a close eye on whether the job is done correctly. Then, when the robot has done a perfect job milking the cow, he says, "Wow, that's handy."

The same applies to our refuelling robot. At first, people are sceptical. After all, people can refuel their cars themselves, right? And if the weather is nice, I really can't argue with them. But what if the weather is nasty, wet and cold, or boiling hot, as it is in the Gulf region? Then people think it's wonderful that they can stay in their cars while the robot takes care of everything. There is even an automatic process to pay for the petrol. You will never again have to worry about the floor mats in your car stinking of diesel.

Gradually, people are becoming accustomed to all this technology. Ten years ago, they would be amazed when they saw what a robot was capable of, whereas now, they are often surprised when there is something the robot cannot do. Apparently, robots are becoming part of our everyday lives. That means we will have to try harder and harder to come up with something that surprises people.

### Automatic loader

For the most part, loading baggage is a thing of the past for staff at Amsterdam Airport Schiphol. Now, a loading robot loads the baggage into the loading units, containers or carts. Vanderlande Industries developed the software and scanner which enable the robot to sense how much cargo space there is, how large the bags are and how the cargo space can be used as economically as possible. Two robots are currently in use at Schiphol Airport. A further six will be added in 2010.

www.vanderlande.com





# Reject, don't damage please

How fast can products be selected and removed from a conveyor belt if they weigh too little or too much or are incorrectly labelled? With its compact paddle system, ITEC's High Speed Ejector can eject 170 packages per minute. The paddles are adjusted so that the ejector can quickly sweep products off the conveyor belt at just the right time without damaging them in any way.

www.itec.nl

## Happier cows

Milking cows more than twice a day increases milk production and the cows also feel better, but it is very labour-intensive. However, farmers can now turn to the milking robot developed by the Dutch company Lely to lighten their workload. The cows know when it is time to be milked, whereupon they calmly step into a stall. There, the milking system finds the cow's udder and begins milking. This robot system is not only efficient, but also extremely animal-friendly.

#### www.lely.com





# No more tissue damage

"What's needed is an endoscopic instrument enabling surgeons to feel how hard they are squeezing the tissue. That will help to prevent tissue damage", says Michiel Oderwal of the Netherlands Organisation for Applied Scientific Research (TNO). He has therefore joined forces with the surgeon Dr Vleugels of EFI BV to develop the Force Reflecting Operation Instrument (FROI). With the instrument's smart haptic sensors, even tele-robots can feel the force applied. michiel.oderwal@to.nl

www.tno.nl

#### Showcase



## Mobile disease tracker

Finding virus-infested and abnormal flowers in bulb fields is a big job. Until recently, only the professionals – the so-called 'disease trackers' – could do it. However, Wageningen University and Research Centre has now made this task easier with the 'disease tracker', which is a robot that moves through bulb fields checking for diseases using sensitive camera technology. In 2008, laboratory tests showed that the robot performs every bit as well as its human counterparts. joop.vandoorn@wur.nl

www.wur.nl

# New processing robot

Never before was it so easy to finish castings or mill complex pieces of wood, now that Trento Robotics has developed a robot that can work in three dimensions. The CADCAM software means that the robot no longer needs to be manually programmed, which means that materials can be processed directly based on 3D CAD drawings. Now anyone can produce single items. jvanraaij@trento.nl



www.trento.nl



## **Underwater rescue robot**

The world watched in amazement when they salvaged the 'Kursk' nuclear submarine, but the unmanned mini-submarines (ROVs) operated by Mammoet Salvage are in fact capable of even more remarkable feats. In 2009, for example, they were deployed from a barge on the water in the middle of a fragile nature conservation area and succeeded in lifting a fuel truck filled with diesel, without human divers having to go down to help with the lift. johan.pastoor@mammoet.com

www.mammoetsalvage.com

# Palletising is a piece of cake

CSi's i-Pal is a robot that performs various tasks, including lifting boxes onto a pallet. The i-Pal is extremely versatile and can also palletise objects other than boxes, such as trays and other forms of packaging. The Easy-Clean, a variation on the i-Pal, is easy to clean, making it ideal for the food industry. Installing the i-Pal is easy and quick, so it is also perfect for temporary use. SyboltvandenBosch@csiweb.nl

www.csiweb.nl



## Waste clearer

The company Demcon and students from various faculties at the University of Twente are working together to develop the 'autonomous litter clearing robot', which will be capable of recognising, grasping and clearing away cans, bottles and other street litter quietly, and completely automatically. According to Maarten Bonnema of the University of Twente, "our prototype shows that it's possible: we can eliminate litter."

#### www.utwente.nl | www.demcon.nl

## Within four seconds

The ProBot is a smart modular assembly platform capable of assembling various end products. A large number of products with various dimensions are placed on the conveyor belt and a camera registers the position and orientation of each product. The robot then uses this information to grasp the products and assemble them. Within four to six seconds, the robot has assembled five different small or medium-sized products, making it the ideal solution for assembling product families, for example. ilse.buter@ims-nl.com

#### www.ims-nl.com





### Hot stamps

Despite their formidable size of 2.5 metres, picking out the right roll of steel when the hall is full of them can be difficult. That is why it is essential that products can be correctly identified on the basis of their markings. Tebulo has developed robots to apply the markings immediately after the product has passed through the hot roller. The robot sprays the markings on the steel using a special paint at a temperature of 1000 degrees Celsius. By using this method, no human beings are exposed to the heat and the correct mark is applied and is always legible. jos.liefting@tebulo.com

#### www.tebulo.com

## Robot with anti-cow protection

The life of a farmer may seem idyllic and traditional, but in the Dutch cattle breeding industry, robots are now widely used. For instance, the JOZ-tech stall-cleaning robot can automatically clean various types of cubicle stalls. Working at four kilometres an hour, the robot removes the manure from most corners and crevices. In case a cow or other obstacle blocks its path, the robot is also equipped with a protection system, enabling it to seek an alternative route. bob.anthoniesse@joz.nl

www.joz.nl



# Coming up roses

Get a glimpse of the Loadmax robot at work and you will be reeling within seconds. The gripper grasps the sausages that are scattered to the left and right and places them neatly in a small box with mind-blowing speed and precision. It would work just as well with biscuits or peppers, because the Loadmax can be adjusted to pick up any product you want. The Loadmax can fill box after box with greater speed and precision than any human being. >> By Arnoud Veilbrief



The Loadmax is a brand-new robot invented by Dutch machine building company Jentjens. Jentjens is based in Veghel, in the southern province of Noord-Brabant, where the largest chocolate manufacturer in the world also has a huge factory. Jentjens is a family-owned company with a turnover of around 10 million euros.

# // Compliments from the competition

Director George Jentjens has high hopes for the Loadmax. "It's extremely fast, intelligent and remarkably versatile. I don't want to boast, but competitors of ours have complimented us on the Loadmax. They told us that the design is brilliant, the Loadmax has something truly new to offer and that it can certainly be used in various different markets. Naturally, that gives us a very satisfied feeling."

The Loadmax can be used in numerous segments of the food industry. The software enables the Loadmax to select products based on any number of visual features, such as shape, colour and size. "It does what you want it to do," says sales manager and engineer Erik Wekking. "If you want it to work with peppers, you set it for peppers. If you only want the red ones, then it will only pick those out. If you want one green, one yellow and one red pepper in each bag, it can do that too. If you set it for biscuits, then it will separate out the broken biscuits. The Loadmax is an intelligent and flexible robot system that can perform all conceivable tasks in the selection process."

#### // Model strategy

In order to discover how this company was able to develop such a smart system, we must first look at a key question that all companies in Europe are currently facing: how do we respond to the exodus of industries like textiles and electronics to low-wage countries? In this respect, Jentjens' history >>



// "THE LOADMAX SELECTS BASED NOT ONLY ON COLOUR, SHAPE AND TYPE, BUT ALSO ON WEIGHT. YOU CAN SET THE LOADMAX TO FILL EACH CONTAINER TO PRECISELY THE CORRECT WEIGHT, WHICH MEANS THAT MANUFACTURERS OR GROWERS WILL NEVER AGAIN LOSE MONEY ON GIVE-AWAY WEIGHT. IF YOU PROCESS A MILLION PEPPERS EVERY YEAR, THAT WILL SAVE YOU A LOT OF MONEY," SAYS SALES MANAGER ERIK WEKKING.

> makes it a model case. Jentjens was founded in 1952 as ship-repair company. In time, however, the harsh winters and the changing requirements of its clients forced it to become a machine builder specialising in oriented handling. Jentjens is without doubt a success story, though not a typical one.

> Until 1990, Jentjens operated on a contract basis. Clients came to Jentjens with technical drawings asking the company to build a prototype, which it then did. The downside of this working method was that Jentjens was not developing its own products that it could market and use to attract more customers – until Jentjens junior decided that Jentjens should be designing its own solutions for its clients. "This led to an increase in our knowledge, and in turn in the added value of our services. We became a purely knowledgebased organisation." What started as a machine building company working on a contract basis for third parties became a machine building company with its own intellectual property.

#### // Horticulture: a new market

This decision to develop its own solutions came right on time because the company was losing a number of major clients who were outsourcing production to other countries. Jentjens had to look for new clients in sectors that were not going to disappear from the Netherlands in the near future. That is how it set its sights on horticulture, a sector in which the Netherlands plays a predominant role on the world stage. Jentjens also needed a unique selling point that was genuinely state-of-the-art and truly distinctive. It chose 'oriented handling', which is the automated recognition, packaging and transport of products of all shapes and sizes. The oriented handling technology led to the creation of two new robots: the cutting insertion system and the rose harvesting robot. The cutting insertion system consists of a conveyor belt, a camera software unit and a robotic arm. The arm takes the cuttings from the conveyor belt as they pass by and places them very gently and precisely in small pots. "The robot doesn't only save a great



**// ORIENTED HANDLING** IS A SYNTHESIS OF NEW TECHNOLOGIES THAT ENABLE THE ROBOT TO PERFORM COMPLEX TASKS. UNTIL RECENTLY, ROBOTS WERE ONLY ABLE TO CARRY OUT STANDARDISED PROCESSES, SUCH AS SCREWING A CAP ONTO A WHEEL. WITH ORIENTED HANDLING, ROBOTS HAVE NOW LEARNED TO 'SEE' AND 'THINK' USING 3-D VISION TECHNOLOGY AND ROBOT MECHANICS. THEY CAN CATEGORISE PRODUCTS BY CERTAIN FEATURES OF THE PRODUCTS' SHAPE, WITHOUT EACH OBJECT HAVING TO BE EXACTLY THE SAME SHAPE.

deal in terms of labour costs," says Wekking. "It also ensures consistent quality. Turnover in unskilled labour in the horticulture sector is considerable, which results in fluctuating quality. And that's assuming you can find anyone at all to do this monotonous work."

#### // Cutting costs

The rose harvesting robot is Jentjens' latest horticulture invention. A combined camera and robotic arm scans the roses from above. If the robot decides based on the colour that the rose is ready to be picked, the arm descends and cuts the stem with no more than a centimetre of tolerance in cutting position accuracy. The rose is grabbed and the rest of the processing and packaging is completely automatic.

The demand for the machine's development came from the Dutch rose growers themselves. The Horticulture Marketing Board, Wageningen University and Research Centre (WUR) and Jentjens decided that a robot of this kind had to be made and took the initiative in starting development work. The European Union also helped pay the development costs. The reason for developing the harvesting robot was, again, the increased competition from rose growers outside of Europe. Automated systems are needed in order to cut costs. According to Jentjens, "in recent years, many flower growers have ceased trading or moved to Africa, which does have the advantage, however, that the remaining companies have been able to expand. You need to be fairly large to make a robot of this kind cost-effective. So this has been a favourable situation for us."

The harvesting robot has already been tested on a Dutch grower's premises. Although investments are lagging behind somewhat due to the economic crisis, Jentjens believes that this is only temporary. "We are entirely confident that sales will pick up once the recession ends. The demand came from the sector itself, which says enough." <<

#### Contact

Jentjens started off as a ship repair company, then went into steel construction and is now a highly innovative machine building business with clients in various sectors, such as the medical, automotive and consumer goods industries, although the food and greenhouse farming industries are Jentjens' specialty.



#### // 9-12 MARCH 2010, TECHNI-SHOW, JAARBEURS UTRECHT, THE NETHERLANDS

These days, the question on everyone's lips in the manufacturing industry is 'should I do it myself or have someone else do it?' If you want a glimpse into what western Europe has to offer in terms of industrial production technologies, processing and finishing of metals, fittings and accessories, as well as top-of-the-line delivery services, outsourcing and engineering, visit the Techni-Show (for in-house solutions) or the ESEF (for contracting out). These two events are the largest and most important trade fairs for the manufacturing industry and will take place simultaneously. www.technishow.nl | www.esef.nl

#### **Meet the Dutch**

2-3 DECEMBER 2009, PRECISION FAIR 2009, VELDHOVEN, THE NETHERLANDS Over 200 companies and knowledge institutes will bring you their latest solutions at this trade fair for precision technology. Admission is free. www.mikrocentrum.nl

#### 24-26 JANUARY 2010, LAB AUTOMATION, PALM SPRINGS, U.S.A.

Lab Automation is the world's leading conference and exhibition for emerging laboratory technologies. In 2010, scientists, engineers and professionals from around the world will come together once again for the premier laboratory automation event. www.labautomation.org

16-17 APRIL 2010, EMVA BUSINESS CONFERENCE, ISTANBUL, TURKEY The European Machine Vision Association will hold its annual conference in 2010 in Turkey. www.emva.org

#### 26-27 MAY 2010, VISION & ROBOTICS 2010, VELDHOVEN, THE NETHERLANDS

This seminar and exhibition offers a complete range of vision systems and robotics. All of the latest developments from Dutch knowledge institutes and universities will be well represented, including the latest in machine vision, robotics, machine safety, cameras, optical sensors, lighting, software, and frame grabbers. www.mikrocentrum.nl

#### 31 MAY - 3 JUNE 2010, EUSPEN, DELFT, THE NETHERLANDS

In 2010 euspen is returning to the Netherlands for its annual international meeting. This will provide a leading-edge forum to research and communicate the latest advances and market developments in precision processes and manufacturing, as well as fabrication, metrology, sensing applications and cutting-edge materials. www.euspen.eu



#### 7-9 JUNE 2010, ISR/ROBOTIK 2010, MUNICH, GERMANY

SR/ROBOTIK 2010 brings together the 41st nternational Symposium on Robotics (ISR 2010) and the 6th German Conference on Robotics (ROBOTIK 2010). The robotics exhibition 'Automatica' is also a partner in SR/ROBOTIK 2010.

#### 8-11 JUNE 2010, AUTOMATICA, MUNICH, GERMANY

Automatica is an international trade fair for automation and mechatronics, which will take place at the New Munich Trade Fair Centre. The fair will feature a whole range of topics relating to robotics: visitors can learn about both industrial and service robots and related topics. automatica-munich.com

#### 28 SEPTEMBER - 1 OCTOBER 2010, HET INSTRUMENT, AMSTERDAM, THE NETHERLANDS

HET Instrument, which is organised once every two years in Amsterdam RAI, is the largest technology trade fair in the Benelux with some 450 exhibitors from the fields of industrial electronics, industrial automation and laboratory technology. www.hetinstrument.nl

#### 27-30 MARCH 2012, ANUGA FOODTEC, COLOGNE, GERMANY

From comprehensive solutions to special components, Anuga FoodTec transcends the boundaries between technologies and sectors and brings all relevant business areas for food technology together under one roof. www.anugafoodtec.com



Robotics Association Benelux (RAB) is dedicated to sharing and disseminating knowledge to increase awareness of the added value of industrial robot systems. Members include system integrators, importers, engineering companies and producers from across the Benelux. www.robotics-benelux.info

**Mikrocentrum** is an independent knowledge centre that has supported businesses and institutions in their efforts to increase their understanding of a wide range of technical and organisational disciplines since 1968. www.mikrocentrum.nl

FHI is a collective comprising technology companies active on the Dutch market as providers of industrial electronics, industrial automation, laboratory technology and medical technology. federatie.fhi.nl

SenterNovem is part of the Dutch Ministry of Economic Affairs and offers a large number of schemes and programmes in relation to sustainability and innovations on the government's behalf. These schemes are intended to support companies, government bodies, knowledge institutes and, in certain cases, consumers in sustainable and innovative projects. www.senternovem.nl

The Netherlands Organisation for Applied Scientific Research (TNO) is a publicly funded research institute. It is also the only organisation whose activities span the entire spectrum of consultancy and research services for clients and research partners, covering everything from safety and health promotion to registration and technology. www.tno.nl

The High Tech Systems Platform is a platform of businesses founded by ASML, Philips Healthcare, FEI Company, Thales, Vanderlande Industries and Stork. The platform's mission is to strengthen and promote industry and the competences of each company. www.htsp.nl

Point One is an innovation programme which originated as a joint initiative of the Dutch high-tech industry, knowledge institutes and the Ministry of Economic Affairs. The programme aims to create a Dutch 'Silicon Valley' by forging close partnerships between industry, knowledge institutes and the government in the development of new applications for nanoelectronics, embedded systems and mechatronics. www.point-one.nl The Holst Centre is an independent open-innovation R&D centre that develops generic technologies for Wireless Autonomous Transducer Solutions and Systems-in-Foil. It has employees from around 25 countries and is named after Gilles Holst, a Dutch pioneer in Research and Development and the first director of Philips Research. www.holstcentre.com

The Embedded Systems Institute, which is affiliated with Eindhoven University of Technology, is committed to increasing knowledge about embedded systems. It has the explicit aim of making this knowledge publicly available. The ambition of the institute is to become a leading expertise centre for embedded systems. www.embeddedsystems.nl

**The TWA Network** is part of the Dutch Ministry of Economic Affairs and serves as a liaison for international R&D contacts and cooperation. From its many offices throughout the world, the TWA Network seeks partners for research and technological development or innovative applications of technologies. www.twanetwerk.nl

