TNO innovation for life

HUMAN ENHANCEMENT

TRUCK PLATOONING

Two or three trucks connected by a ‘virtual tow bar’. The leading truck is controlled by a driver while the following trucks accelerate, brake and steer all by themselves without the intervention of a driver. Platooning saves on fuel, cuts emissions and optimises costs. And the driver sitting in the second or third truck can occupy his time with something else or take a rest for a while.

HUMAN ENHANCEMENT

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FOREWORD

The demands made by our work are changing in many sectors. Technological developments are happening faster than ever. Just think about digitalisation, robotisation, the Internet of Things, big data. As a result, jobs are disappearing and new ones appearing, and most of all, the actual work itself is changing.

The new demands being made by technology have to be aligned with the human being to optimise how humans perform with the technology. TNO develops new methods, models and tools to realise the best human-work-technology alignment, geared specifically to adaptive support in highly demanding, complex and dynamic operating environments.

Situational awareness, or having an overview of the situation and being able to respond effectively, is key here. In traffic, whether on the road or on the water, the transfer of tasks plays an important role. Self-driving cars are on the rise as is autonomous, unmanned, sailing. But it will still take some time before this is fully operational. Until then the driver or operator will have to directly intervene to take over the tasks of the technical system. This brings together expertise on technology and behaviour, a unique combination offered by TNO. We develop state-of-the-art methods and tools to assess the mental and physical state of the human driver in real-time to ensure the seamless transfer of control between the human and the automation so that driving and sailing becomes safer, more productive and more comfortable.

Resilience of employees is a second key element. In the safety and security domain it is vital to strengthen resilience so that soldiers, the police or fire-fighters can handle stressful situations effectively. The risk of excessive stress and a potential burn-out are always just around the corner. We develop methods and tools that make use of wearable technology to monitor people both physiologically and psychologically over an extended period. We also develop predictive models specific to individuals to provide recommendations on stress management at both an individual and organisational level.

Security is the third key aspect. In the cyber domain we are seeing a huge increase in the number of attacks on computer systems. Computer Security Incident Response Teams have to be able to respond effectively, and the human factor is an essential component for these teams: situational awareness, information management, training and support are crucial to the efficient and effective operation of these teams. TNO develops tools for this. ■

— Dr. Mark Neerincx (professor)
— Dr. Jan Maarten Schraagen (professor)

OPTIMAL **HUMAN-MACHINE** INTERACTION

Not only have the established car manufacturers thrown themselves into the development of the self-driving car but so have tech companies. After ABS and cruise control, vehicles increasingly have more automated onboard systems as part of the standard package. Today the aim is safer and more sustainable traffic along with comfort. Many of the developments target better engineering but this can leave many complex issues of human (inter)action and safety on the back burner. This is where TNO comes into view.

'A hundred per cent automated driving is not yet feasible. We still have decades of human-machine interaction ahead of us first. This is where the two areas of TNO expertise converge, namely technology and behavioural science, a combination of knowledge areas in which we have a leading international position," says professor Marieke Martens of TNO, an expert in intelligent transport systems and professor of Human Factors at the University of Twente.

'At TNO our focus in this research programme is to optimise the alignment of the automatic systems to the human being, in this case the driver. One of the crucial questions being asked by parties all over the world is how many seconds does a person need to retake control of a self-driving vehicle at the moment this becomes necessary. Since we know that there is no single specific reaction time for everyone and in all circumstances, we decided to tackle this in quite a different way.
We are developing methods and models that can predict how long it will take for a specific driver to retake control in specific circumstances. We're a world leader in this respect." ■

KNOWLEDGE QUESTION

HOW CAN YOU OPTIMISE THE COLLABORATION BETWEEN THE **DRIVER AND SELF-DRIVING VEHICLE**?

DRIVER READINESS MODEL

The first major steps towards the partial automation of driving are currently being taken for trucks, also known as truck platooning, in which two or three trucks are connected by a 'virtual tow bar'. The leading truck is controlled by a driver while the following trucks accelerate, brake and steer all by themselves without the intervention of a driver. In 2016 the Netherlands, as EU chair, organised a demonstration whereby six truck platooning convoys from different places in Europe drove to the Tweede Maasvlakte in the Netherlands in normal traffic. Apart from Sweden, Denmark, Germany and Belgium, TNO was an active participant along with NXP and DAF. Platooning saves on fuel, cuts emissions and optimises costs. And the driver sitting in the second or third truck can occupy his time with something else or take a rest for a while.

In the coming years a lot of research still has to be done on the role of the driver in the second or third truck. For instance, how the driver can be given back control of the truck in a responsible way if this is deemed necessary. This may be for route selection or if the convoy is caught up in a situation where traffic safety is at risk due to worsening weather conditions or road works, for example. So we have used our advanced TNO truck driving simulator to run a variety of tests with truck drivers to study the behaviour of non-active drivers and arrive at an assessment of individual reaction times. We used sensors to constantly monitor their body posture and the position of the head, eyes, seat, backrest, hands and feet as well as used cameras to analyse behaviour, activities and attention span.

We did this in different scenarios: alert drivers with hands on the steering wheel, drivers who worked with a tablet during platooning and drivers who took a short nap.

The data generated allowed us to determine the reaction speed of the driver in all kinds of driving situations, in greater and less critical situations, at a longer and shorter headway distance. On the basis of this we created a model using machine-learning techniques that let us predict at any given moment during the journey how much time a driver needs to retake control of the vehicle.

This is key to safe interaction between the human being and the system. If we know the time for a driver is a bit longer, then we can make sure that systems take action somewhat earlier to ensure safety or warn the driver that bit earlier.

We are continuing to refine our Driver Readiness Model (DRM). In the near future it will become possible to build this into trucks and constantly assess the reaction time online. Later on, the technology can be made available for passenger cars. ■

On the basis of individual personal factors the Driver Readiness Model constantly predicts how much time a specific driver needs during automated driving in a truck platoon to safely retake control of the vehicle.

KNOWLEDGE QUESTION

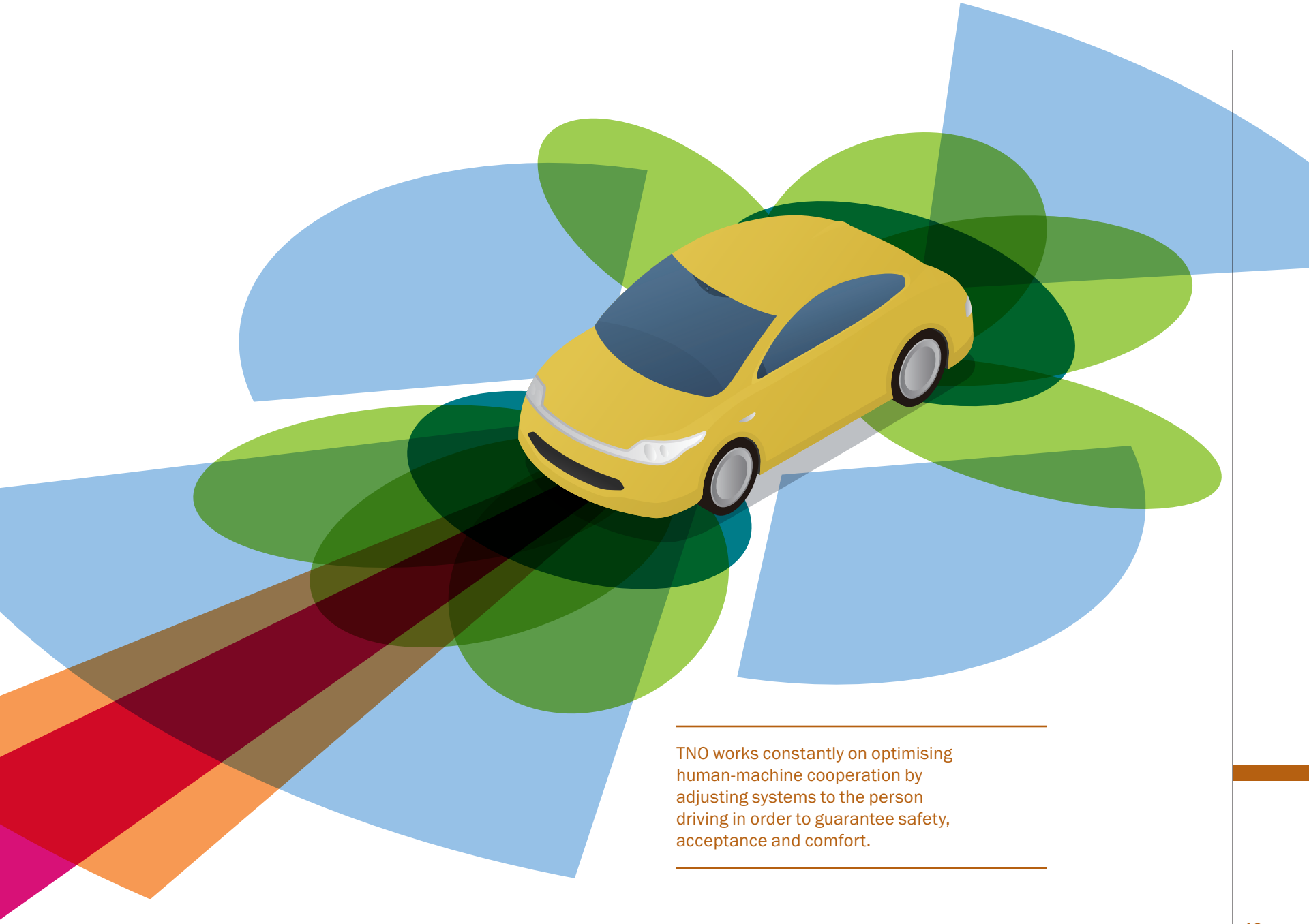
CAN SYSTEMS FOR **ADAPTIVE CRUISE CONTROL** BE ALIGNED TO MY **PERSONAL DRIVING STYLE**?

PERSONALISED ADAPTIVE CRUISE CONTROL

At the human-machine interface we develop systems that give more personalised support to the driver of a car and make driving for all drivers safer and more comfortable. Cruise control was originally conceived as an aid to enabling the car to drive at a constant speed. Nowadays Adaptive Cruise Control (ACC), which adjusts the headway to the vehicle in front by braking or accelerating, is fairly common. The current ACC parameters such as preferred speed and headway can be adjusted by the driver but only to a very limited extent. In practice, car drivers tend to adjust the system settings once and after that hardly touch them again. In many cases, drivers choose to do the braking themselves, which straightaway switches off the system.

It is the TNO philosophy that traffic can be made safer and more comfortable by adjusting systems much more to the person driving. This is why we work on personalised adaptive cruise control (PACC), not a generic system that works in the same way for everyone but one that is customised to an individual's driving style. From the moment a person starts the car, we use sensors to register how he or she accelerates, keeps a distance and brakes in different situations, taking account of the traffic intensity, corners and how the other traffic acts.

The PACC system records all the driving style data in the personal preferences but research teaches us that you must not simply copy these one for one to the behaviour of the automatic system. It is interesting to note that many people would still like the system to behave a little differently. TNO has developed algorithms that automatically activate these preferences for the PACC settings per person in each given situation. In this way PACC offers a lot of added value for the future self-driving car. In fact, this algorithm is also used to personalise all kinds of systems that support the driver. A system that takes account of the individual driving style boosts the comfort, thereby promoting acceptance, and prevents hazardous situations in which a driver is taken by surprise if the system acts in an unexpected way. ■



TNO works constantly on optimising human-machine cooperation by adjusting systems to the person driving in order to guarantee safety, acceptance and comfort.

SUPPORT SYSTEM FOR

EXTREME CONDITIONS OFFSHORE

Whereas cars have cruise control on board, various sailing vessels use Dynamic Positioning (DP) systems. These can be found on large, floating drilling platforms, for instance. The DP system keeps the vessel on course or in place. But current systems cannot always cope with extreme conditions, and then a human operator has to take over control of the ship. The human-machine interaction is really critical here.

“Many of these systems take too little account of the end user, thereby threatening timely and efficient intervention by the operator, with all the consequences of taking wrong decisions or taking action too late. We work with leading Dutch companies and knowledge institutions on adaptive automation solutions that enable the operator to be aware of the situation and to intervene correctly at the right moments,” says senior researcher Dr. Hans van den Broek of TNO and lecturer at the Rotterdam University of Applied Sciences. “Sometimes people have to act to support automation and in other cases the technology has to keep people focused on their task and support them. This principle was the starting point for designing an Intelligent Operator Support System (IOSS), a novelty for the offshore industry. It is generally very seldom that anything goes wrong with dynamic positioning, but the industry is, in fact, over-dimensioned and four operators at least are needed 24/7. That can be done in a smarter, more efficient way.” ■

KNOWLEDGE QUESTION

HOW CAN YOU HELP OFFSHORE OPERATORS TO BE ALERT AT THE RIGHT MOMENTS

INTELLIGENT OPERATOR SUPPORT SYSTEM (IOSS)

In many offshore operations dynamic positioning systems keep ships in a specific position for an extended period, for instance, to pump up oil. This requires four operators on board working in shifts to keep watch on the system so as to prevent the platform from drifting. It is an important but monotonous activity that comprises hours of concentrated monitoring of data on a computer screen. Research reveals that operators are often quickly distracted and their situational awareness is not always optimal especially at night time. A better system design has to make the work more interesting and allow fewer operators to do more.

The IOSS has been built to support the operator's tasks and uses techniques like machine learning, Internet of Things (IoT) and intelligent interfaces. We apply semantic technology with smart notifications to communicate meaningfully with operators. The interface has an identifiable avatar that acts as a team member for the operator.

The idea behind this is that it is not only people that have to understand the system but that the system also has to know what the human being is doing and register whether the operator is conscious of the circumstances and takes the right decisions. The IOSS uses sensors that perceive where the operator is, follows his eye movements behind the screen and other physical functions to ascertain whether he is sufficiently alert to intervene efficiently. The system also detects what is happening in the vicinity of the ship, such as changing weather conditions, waves, or ships nearby.

If the circumstances are favourable, the operator can leave the bridge and get on with other work or take a break. Should a storm be in the offing, then he will receive a signal via his smartwatch advising him to return to his workplace within a certain time. The system helps the operator create just-in-time situational awareness, so that he can become aware of the actual circumstances in good time. Artificial Intelligence (AI) ensures that the system not only warns but also explains what is, or threatens to go, wrong and the measures the operator can best implement. In this way he gets exactly the information he needs in that context to take the right action. The system uses sensors to determine how alert the operator is at that moment and knows how much support is needed in that situation.

COOPERATION

The IOSS arose in close cooperation with the RH Marine and Bluewater companies along with a contribution from STC Group, the training and knowledge institution for shipping, transport and port industries. The system has since been extensively tested in simulated environments. In creating the design TNO was able to use a DP system of RH Marine. The expertise from both sides proved highly complementary. ▸

"An intuitive system for human-machine interaction that leads to correct decisions by the operator is crucial in the DP industry. This project with TNO, Bluewater and STG is an initial important step in that direction. The IOSS boosts safety and prevents the drifting of platforms."

— Ehab el Amam. consultant RH Marine

HUMAN-MACHINE INTERACTION

Accidents involving DP systems where platforms lose their position, for example, may cause pipelines to break and result in environmental damage and expensive loss of production. Virtually all incidents are caused by diminished situational awareness. Human factors studies suggest that this can often be attributed to incorrectly designed human-machine cooperation. We believe the solution is not more but different automation. The lack of situational awareness occurs when people are compelled to watch over processes rather than actively perform them. In doing so they move 'out of the loop' and cannot intervene properly when there is a sudden disruption.

Designers see automation as enabling more efficient and improved performance. In highly automated environments the role of the human is shifting from 'executor' (helmsman) via 'operator' to 'supervisor'. The supervisor is left with only 'residual tasks' to do. These are often time-critical whereby automation is not good at anticipating a situation in which the human has to unexpectedly intervene.

FULLY AUTOMATED SAILING AND DRIVING

Machines and algorithms are taking over more and more of the human workload, even tasks which, until recently, we thought impossible to fully automate, like driving a car or sailing a ship. But before this becomes a reality, humans and automation will have to do the job together. So we will have to begin by sailing with a reduced crew, followed by a phase without a crew, but in both cases with assistance and remote control provided by an operator. ■

We believe the solution is not more but different automation

HANDLING STRESS WITH MORE RESILIENCE

STRESS & RESILIENCE

Stress at work is a problem high on the agenda of government, employers and employees. The figures don't lie: 2.7 million people work under high pressure, with a third of all absence from work being the result of work stress, and nearly a million people suffer from burn-out symptoms. TNO develops methods and tools to enable employees to be more resilient to stress and workload.

"We have been studying this phenomenon for a long time. The novelty now is that we can use 'wearables' like smartwatches and fitness trackers to register physiological aspects like people's heart rate and physical exercise. So we can combine objective, physical data with subjective information about stress, performance and motivation for instance. By incorporating these data in models, we can develop applications that detect whether employees handle workload resiliently or run the risk of dropping out in the longer term due to stress-related symptoms," senior researcher Dr. Wim Kamphuis of TNO explains.

"For our study we developed a wearable resilience application in which employees can gather data in a straightforward way on all kinds of factors relating to stress, both physiological and psychosocial. This information is fed back to them visually so that they gain insight into the physical and psychological circumstances that influence their stress level. Based on an underlying predictive model, the system can also detect whether there is a risk of developing stress-related symptoms. Stress is a major cause of absence from work due to illness. By identifying this early on, we can give the employee specific and personal advice on how best to deal with this. For the employer this will create better employability for his personnel in the longer term." ■

"The National Police Force is shifting its focus from absence due to illness to management by employability. So it's a must for personnel to find out for themselves what factors affect their resilience."
— Jan de Jong, National Team for Safe & Healthy Working, National Police Force

HOW CAN WEARABLE TECHNOLOGY ENABLE EMPLOYEES TO BE **MORE RESILIENT** TO **STRESS**?

KNOWLEDGE QUESTION

Stress at work has significant impact on employees and organisations. Psychological and physical stress on the work floor forms a threat to the motivation, performance and health of personnel while resilient employees, on the other hand, are better able to deal with that stress and its impact. Investment in the resilience of people, or the capacity to handle stress and workload, contributes to the wellbeing of employees and performance of the organisation.

Police work makes great demands on the resilience of personnel. On the beat at any given moment they can be confronted with physical violence or exposed to human suffering while the organisation is subject to bureaucracy and reorganisations. Stress-related symptoms are therefore a major risk for police personnel. This is why we collaborate with the police force on developing new technologies to prevent and tackle stress. The knowledge we gain here can also be used for other professions where there is a major risk of stress.

In the Oost-Brabant unit, the Maas en Leijgraaf team, we monitored dozens of operational personnel for a number of weeks. They used the prototype of the wearable resilience application we had developed, wearing a smartwatch during work shifts and also when sleeping that registered heart rate, sleeping pattern and physical activity. After each shift they filled in a short questionnaire via the smartphone. They got the combined results back straightaway on their smartphone via a dashboard where they could consult information about stress phenomena and fill in their own experiences. This gave them insight into the things that cause them stress and what impact this has on their sleep, performance and wellbeing. They were also warned in the event that there was a risk to them developing stress-related symptoms and burn-out. They were also given personal advice via the dashboard on how they could better deal with stress and workload. ▸

For the police force it is essential to work on the resilience of personnel

At organisation level managers and HR professionals can gain insight from the data to determine what causes stress among personnel and where there is less stress in specific aspects or types of work. This enables the organisation to take measures to optimally support the resilience of its employees. The dashboard we have been developing for this shows not only the stress-related factors but also resources that employees can use along with indicators for wellbeing, performance and motivation.

TOP SPORTSPEOPLE

The system we have developed with wearables and a dashboard is ideally suited for top sportspeople for whom a little stress in the form of pre-match tension stimulates performance but where this is excessive, may be detrimental to performance. And that can mean the difference between winning and losing, gold and silver. This was the reason for the Dutch Korfbal Association (KNKV) to equip the players of the national team and Jong Oranje with the smart wristband and smartphone resilience application for a few months. National coach Wim Scholtmeijer also took part.

RESILIENCE APPLICATION

1. Wearable constantly registers heart rate, physical activities and sleep
2. App asks a few questions each day on performance, motivation, wellbeing
3. Dashboard provides personal advice on dealing better with stress and workload

The aim of the exercise was to ascertain per player what kinds of stress he or she was subject to and how this could be handled. That then resulted in personal recommendations on getting more out of themselves, do more training or train less, to rest more often or to talk to others. And while the recommendations were not always so surprising, the internationals found them valuable and effective. Ultimately, the readings should help individuals perform better and thereby the team as a whole.

REFINING MODELS

All the different measurements of physiological and psychosocial factors among different groups of employees have given TNO a lot of valuable data. These data serve as a basis to further refine the models and also predict in the longer term whether an employee is at risk of a burn-out as a result of exposure to stress. With a few adjustments, the models TNO has developed for the police and korfbal players can be used in every kind of domain. ■

One of the agents who took part in the pilot:
"I noticed the big impact sleep has on me. When I am stressed, I eat a lot and sleep poorly. I stopped taking nibbles and notice an improvement in my sleep. That became evident."

Partners/customers:
National Police Force, NOC/NSF, Dutch Korfbal Association (KNKV)

Cyber incidents are time-sensitive, complex, affect multiple parties, have significant financial impact and require specialist knowledge to solve them

"How does an individual employee determine the relevance of an incident in the right way? Can he or she get support in doing this?"
— *Thales*

DIGITAL FIRE-FIGHTING AGAINST CYBER INCIDENTS

Companies and organisations affected by cyber attacks are compelled to call in help from specialist Computer Security Incident Response Teams (CSIRT). Some companies have their own teams while others hire in the services of a commercial CSIRT. How effectively do these teams actually perform? And how can they improve? Literature provides few clues. TNO does research into this and develops tools.

“We were even amazed ourselves to see how little research had been done on this. We talked with members of different teams and security companies. This revealed that there was quite a need for insight into their performance and they wanted to find out how they could improve. This was a question that fits in well with our other research activities on cyber security on the one hand and human-machine interaction on the other. In this case: how do teams perform when technical incidents occur?” is the question asked by Dr. Rick van der Kleij and Dr. Heather Young, senior researchers at TNO.

“It is because these teams only spring into action when there are serious incidents that it is important to know whether their response continues to be efficient and effective or not. They get working when panic breaks out so they have to work fast but with control. How do the individuals in the team work together? Do they all see the situation in the same way? Can they support each other more effectively? What can be done better in an organisational, procedural, technical and human way? These are the questions we tackled.” ■

“It would be fantastic to get tools that help us gain insight into who does what. We don’t yet have such tools at the moment.”
— Fox-IT (FIR)

KNOWLEDGE QUESTION

HOW CAN YOU ENSURE BETTER **INFORMATION MANAGEMENT AND ENVIRONMENTAL AWARENESS** DURING A **CYBER INCIDENT** SO THAT CSIRTS CAN PERFORM BETTER?

IMPROVE MUTUAL COMMUNICATION

From discussions held and our own initial investigation, it appears that the exchange of information amongst team members is not as efficient as it should be. People tend not to know who is doing what and what the status of the incident is at that moment. TNO is now examining how the situational awareness of the team members can be improved and how the communication between them promoted. For this purpose, various aids are available, like smart visualisations.

An added complication is that the suspected seriousness of the incident lies at the heart of forming the composition of teams. In some cases it begins with one specialist but it quickly becomes evident that this has to be scaled up, and reinforcing the team with more people also increases the complexity of the organisation and provision of information. Apart from the size of the team, the location may differ: on site at the company affected or tackling the systems remotely, or a combination of both. Internal IT specialists are suddenly confronted by having to work with unfamiliar external experts.

In some situations it is quickly clear what the scope of the attack is and which parts of the system have been hacked or contaminated; in other situations it can take hours or days to identify this.

INSIGHT INTO TECHNICAL AND HUMAN PROCESSES

There is no lack of technical resources, both hardware and software, to tackle cyber attacks these days. But what is lacking is insight into how the team and the individual members can be better supported in an organisational and communicative sense. In other words, apart from good technical insight into the nature and scope of the cyber incident, insight is needed into the human processes. Everyone has a task to do behind the screen but team colleagues are hardly aware of what the other is doing. In this project TNO therefore develops innovative procedures and tools that focus on the human aspect of the response by way of supplementing the existing technical process depictions. These are intended to give the members of the team a handle on their new way of working.

The presence of good procedures and tools alone is not sufficient to guarantee the effectiveness of a CSIRT. Team members need to be willing to cooperate to ensure real success. This means that the way the members of the team think has to change to allow them to be open to new ways of working.

MAJOR EFFICIENCY GAIN POSSIBLE

TNO is convinced that a major efficiency gain is possible, which will enable incidents to be solved better and faster. This not only saves time but also results in financial gains in terms of less productivity loss and damage. The fast resolution of an incident also means less risk of data loss or leakage. Knowledge and insight are also needed into the culture of the teams, the organisation, the procedures, the tasks and the behaviour. We research innovative ways of working and the tools the teams need to perform better. ▶

The key notions here are:

- OBSERVABILITY: team members each have a view of events
- DIRECTABILITY: the team has to be managed efficiently
- PREDICTABILITY: ability to constantly predict events.

One of the resources TNO considers using is a smart tool, such as Amazon (Echo) and Google (Home) are putting on the market. They act as a search engine where you can put questions or give spoken commands. In this case TNO takes the role of 'reporter' that talks with team members to find out what kind of incident the team is dealing with, what the workload of everyone is and how tasks can be performed more efficiently. Each team member is given an example. TNO experts are currently fleshing out this reporter. The device detects, for example, who is occupied with what and can suggest distributing tasks differently. ■

Tools that support the team include organising large quantities of data to quickly identify patterns or simultaneous communication with other team members on a multi-dimensional situation

COLOPHON

TNO, Soesterberg location
- *Adaptive Automotive Automation: Dr. D.M. Hoedemaeker*
- *Adaptive Maritime Automation: Dr. J. van den Broek*
- *Stress & Resilience: Dr. W. Kamphuis*
- *Cyber: Dr. H.J. Young*

Text
Ruud van der Ros

Editorial Board
Dr. J.M.C. Schraagen (professor)
M. Roelofs, MSc.

Layout and design
Grafisch Ontwerp Pi&Q, Zeist

Printed by
MediaCenter, Rotterdam


+11,00.00

TNO is an independent research organisation that connects people and knowledge to create innovations that boost the competitive strength of industry and the well-being of society in a sustainable way.
TNO focuses its efforts on seven themes: Healthy Living, Industrial Innovation, Energy, Mobility, Urbanisation, Information Society and Defence, Safety & Security.

TNO innovation for life

TNO.NL

17-9341 september 2017