Eindhoven University of Technology
PO box 513, 5600 MB Eindhoven
The Netherlands
T +31 (0)40 247 35 36
smartmobility@tue.nl

Coordination and production
TU/e Communication Expertise Center

Layout
Volle-Kracht, Eindhoven

Photography
Bart van Overbeeke

Print
Drukkerij Snep

www.tue.nl/smartmobility

Where innovation starts

Smart Mobility

Driven by Technology

Brainport Eindhoven

THE WORLD'S SMARTEST REGION

TU/e Technische Universiteit **Eindhoven** University of Technology

Where innovation starts

Where innovation starts

Eindhoven University of Technology (TU/e) is an internationally renowned research university specialized in engineering science and technology. The challenges of our present day society inspire our scientists and students to pursue exciting educational programs and breakthrough innovations that are beneficial for all. Our activities are embedded in strong partnerships with industry, governments and knowledge institutions worldwide. TU/e is situated in the Brainport region, the technological heart of the Netherlands.

Our society faces tremendous challenges in the fields of energy, climate, safety, sustainability, healthcare, mobility and communication. We believe technology is crucial for finding solutions, and it is our aim to contribute significantly to doing just that with our research and innovation activities. We've therefore combined our research into three strategic areas to help us maximize strengths. These areas are: Energy, Health and Smart Mobility, themes that also play an important role in the areas of education and knowledge valorization.

TU/e is helping to build a sustainable world. Efforts to that end include people-oriented technology, science for society, less pollution and fewer unexpected traffic jams, chemotherapy with fewer side effects, and solar power that charges your phone and lights your offices.

Content

Our world faces numerous social challenges presented by the everlasting demand for mobility and the impact this has on space and environment. Transportation networks in most urban centers are often packed, and any small disruption can easily lead to long traffic jams. Moreover, our transportation system, with its polluting emissions, has a negative impact on our habitat and on global warming.

Smart Mobility
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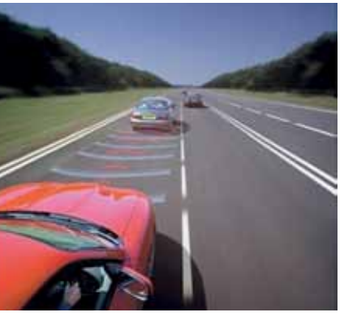
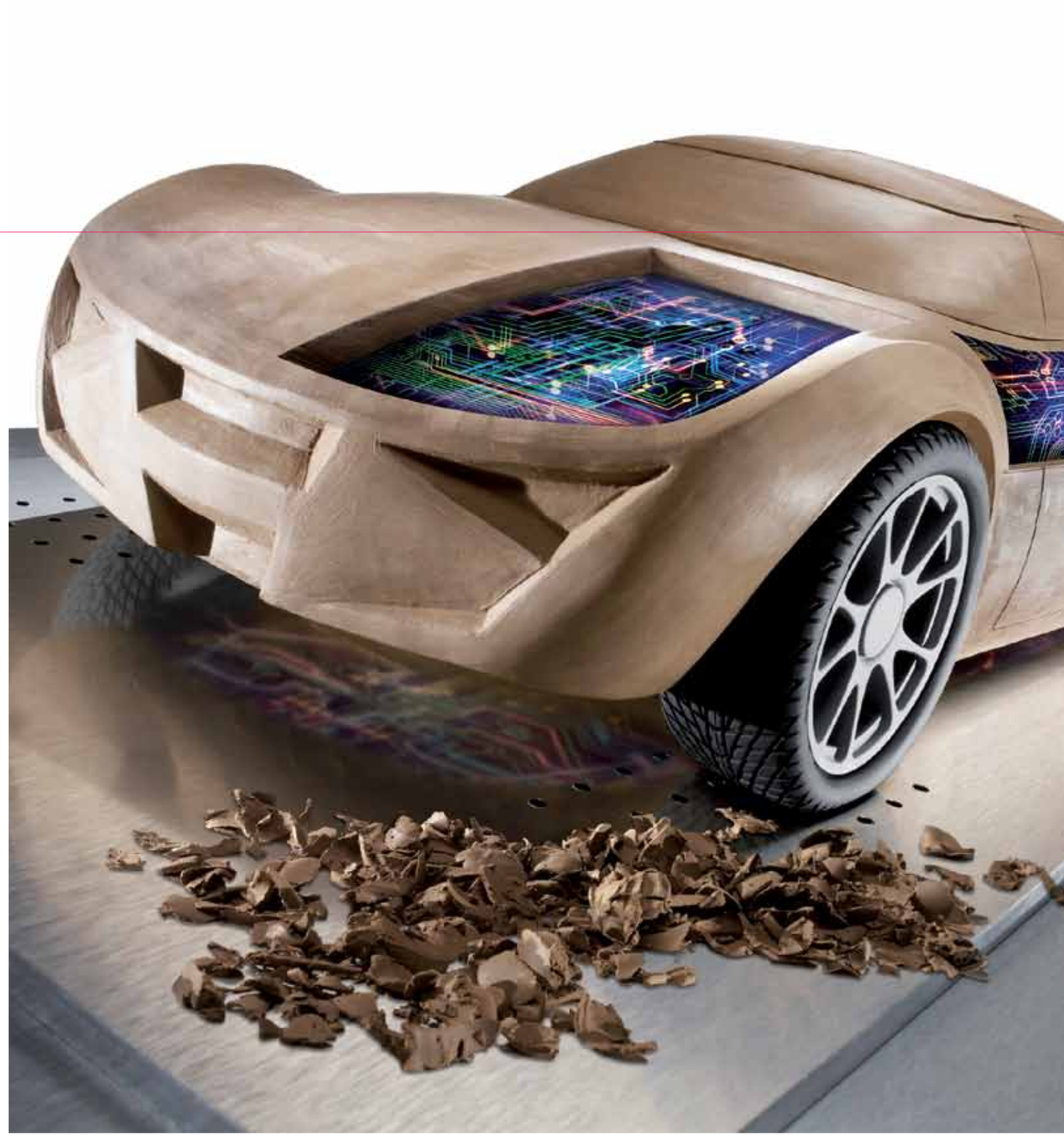
Beyond that, 1.2 million people worldwide are killed in traffic accidents every year. These phenomena detract from the pleasure and freedom we experience from driving. They also endanger our health and cost society a lot of money.



TU/e believes that technology is the answer to these problems. Traditionally, it has held a great deal of expertise in the fields of Intelligent Transport Systems, Automotive Technology, Logistics and Planning Systems, and ICT/ Embedded Systems. These are the kinds of expertise needed to play an important role in helping the world transition toward smarter, more sustainable mobility. That is the reason Smart Mobility has been designated as one of the university's three strategic areas.

TU/e is committed to develop knowledge and innovative technologies to help achieve sustainable mobility for society. More than 200 researchers contribute every day to make mobility and transport more intelligent and productive, and to make vehicles safer, cleaner, and more efficient. TU/e is heading towards a world in which mobility issues are a thing of the past.



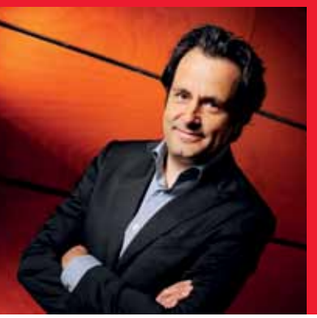
“We want to maintain the pleasure and prosperity mobility has brought us. We can resolve the negative aspects using technology.”

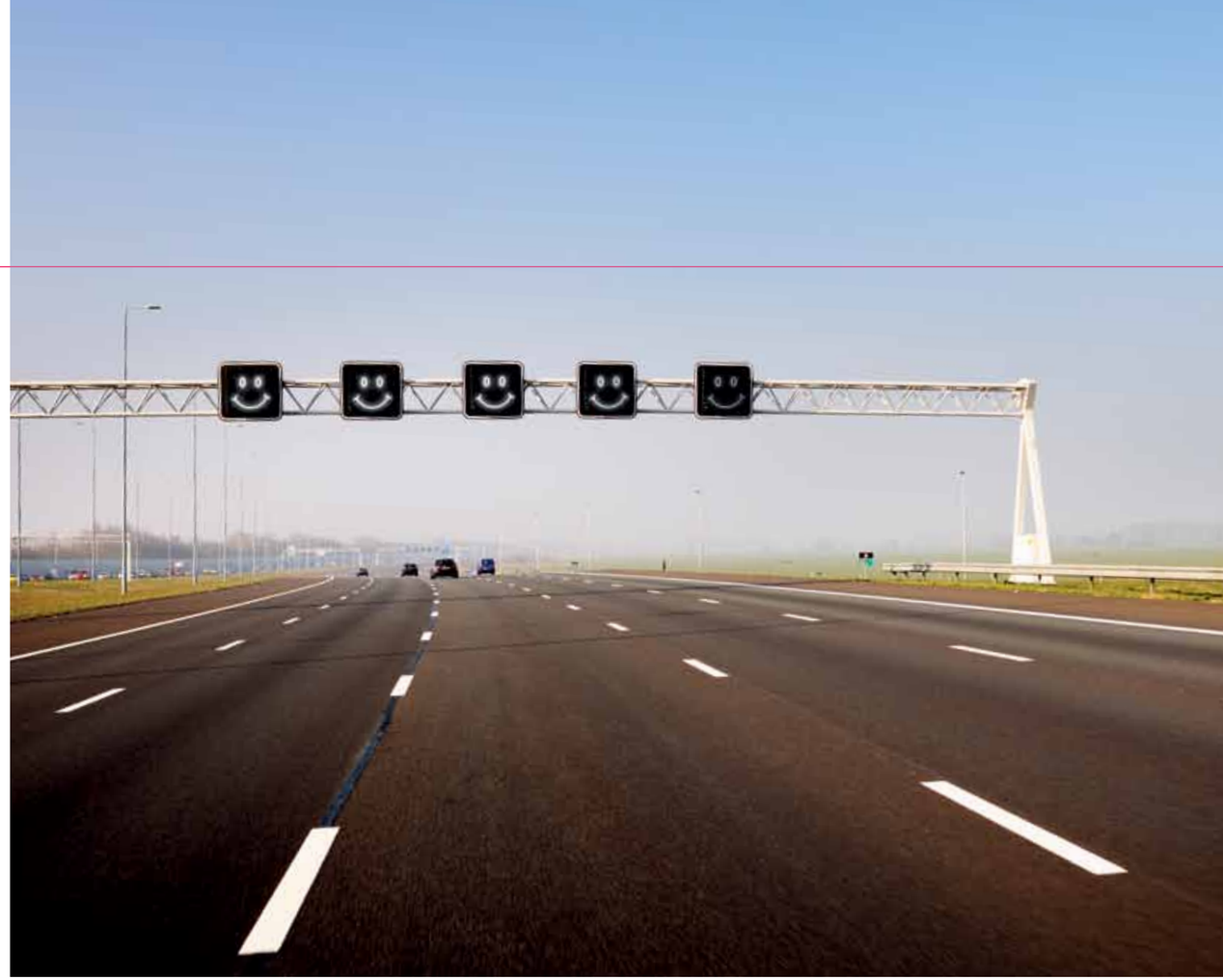
“Less stress on the road, no more unexpected delays caused by traffic jams, less impact on the environment, and accident prevention. It seems like an impossible task, because our growing population and prosperity may lead to even more traffic. However, at TU/e we see many opportunities for tackling mobility problems with technological solutions. We aim to achieve sustainable mobility without losing sight of the freedom and joy that cars have brought us.

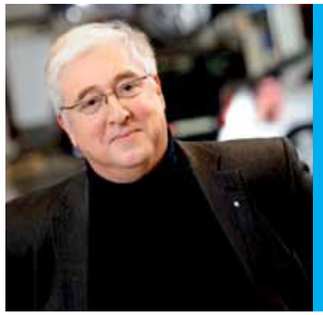
Making cars smarter, cleaner, and safer. Cars that know exactly which route to take to avoid traffic jams. Cars that can brake, accelerate, and steer on their own, thanks to intelligent sensors that perform even better than humans do. That increases safety. We see a bright future for electric power trains and focus a lot of our research in that area. We are also working on developing engines that run on sustainable fuels, with exhaust fumes that are cleaner than the surrounding environment. Going beyond zero emissions is an attractive goal.

A productive and efficient traffic network calls for smart planning and communication. For well-organized logistics and traffic flows to ensure, for example, that there are no empty trucks on the road. For models that will provide insight into the future mobility needs of people, so we can act accordingly. And for Intelligent Transport Systems: vehicles that communicate with one another, their drivers, and the environment and can travel safely, without delays, through traffic. We develop the road towards in-car centric traffic management that will soon make those dynamic routing panels and other roadside equipment redundant.”

Dr.ir. Carlo van de Weijer
Director, TU/e strategic area Smart Mobility
Current position: Vice President Traffic Solutions at TomTom
Previous positions: Managing Director at TomTom Eindhoven;
General Manager of the Development Center Netherlands at Siemens VDO;
Division Manager Powertrains at TNO Automotive







“We are continuing to work on cooperative mobility and intelligent transport systems, but we also need to think much further ahead. Think outside the box and take everything into consideration.”

Prof.dr. Henk Nijmeijer,
Automotive Technology

“Coordination, consolidation, and collaboration are the new credos in the field of logistics. This will consolidate volumes and increase the load factor. The ideal picture? To have as many full vehicles as possible travelling from Point A to Point B at exactly the right time.”

Prof.dr. Tom van Woensel,
Transport & Logistics

Research themes

In the Smart Mobility strategic area, TU/e is able to combine its strengths in Automotive Technology, Transport & Logistics, Intelligent Transport Systems, Mobility & Traffic and ICT/Embedded Systems under two research themes.

Sensible: intelligent and productive mobility and transport

This research theme focuses on enhancing traffic flows through intelligent logistical planning and Intelligent Transport Systems (ITS). After all, a lot of transport is unnecessary or inefficient or could be better organized using a different modality. An intelligent and efficient planning of goods transportation, including combining trips, results in fewer trucks driving 'empty' kilometers, lower costs, and, of course, less traffic and fewer emissions. Using intelligent vehicles, we are developing connected cars that can exchange information with their drivers, their environment, and other vehicles. This connected mobility forms the basis for the many applications that result in fewer traffic jams, less exhaust, and increased safety and personal comfort.

The research subjects within the Sensible theme include:

- Efficient logistics planning
- Optimizing synchromodal logistics chains
- Data mining & management
- Behavior analysis decision models
- In-car centric traffic management
- Condition-based maintenance methodologies
- Models for insight into mobility patterns

Durable: clean, safe and efficient vehicles

Sustainable vehicles are more efficient, cleaner, and safer. And that is exactly what researchers in the Durable theme hope to accomplish: from electric and energy-efficient cars, cleaner engines, and new, cleaner fuel to smart cruise control and a connected car that communicates with other cars. The car of the future is a computer full of high-tech electronics; an intelligent car that guides itself through traffic without delays and without emitting polluting gases; a clean iPad on wheels.

The research subjects within the Durable theme include:

- Future fuels
- Clean engines
- Active safety systems
- Electric drive systems
- Stable and safe embedded system design for highly complex systems
- Connected mobility for efficient, safe, and clean transport

"How do people travel? When and where to? That is the kind of information we need to design cities and traffic networks well. By using models to chart mobility issues, we contribute to smart mobility."

Prof.dr. Harry Timmermans, Mobility & Traffic

"To radically reduce our dependence on nonrenewable energy and material sources, we need to improve existing energy conversion technologies for combustion engines or hybrid and electric vehicles. We've plucked all the low-hanging fruit; now, we need to strain even harder to get to the fruit at the top of the tree."

Prof.dr. Elena Lomonova, Automotive Technology

"Cars are rapidly developing into computers on wheels. Compare them with televisions: 20 years ago they were full of electronics, and now, they are just computers. Will the car of the future just be fitted with an Intel processor? I don't think so, but we're headed in that direction. And with a view to privacy, data security is critical."

Prof.dr. Mark van den Brand, ICT/Embedded Systems

"In 2040 we will be driving electric cars that come right up to the front door and adapt their interior to match your mood. They will be fully automated, going from Point A to Point B by the most efficient route, with safety and comfort guaranteed."

Prof.dr.ir. Maarten Steinbuch, Automotive Technology

Sensible

Smart logistics: 4C4More

In the field of distribution, clients are becoming more demanding, while the complexity of product requests, production, and distribution networks continue to grow. These trends, combined with the need for more efficient and sustainable goods transport, are placing great demands on the compact between service providers, manufacturers, and retailers. The key idea behind 4C4More is to create economies of scale through partnerships within and between distribution chains. This includes developing the necessary legal framework and information support for such partnerships, as well as computational models and decision supporting software for predicting demand and transport planning. Several universities, RSM, and six manufacturers and logistical service providers are participating in this project with TU/e. The concrete results will be cheaper production, transportation, and storage, using fewer materials and with fewer emissions.

Sensible and durable

Cooperative driving

TU/e is working to make cooperative driving a reality. Wireless communication is used to regulate speed and distance between vehicles with Cooperative Adaptive Cruise Control (C-ACC). In C-ACC, automated information on variables such as speed and acceleration is obtained from other vehicles on the road. The corresponding controller ensures that any changes in speed by the driver in front of you are immediately registered in the cooperative vehicle.
TU/e has successfully installed a C-ACC controller in a DAF truck, and in 2011, it participated in the Grand Cooperative Driving Challenge on the highway between Helmond and Eindhoven. Cooperative driving combines a lot of technologies and disciplines, such as regulation engineering, software engineering, electrical engineering, embedded systems, vehicle dynamics, and human—machine interactions.

Durable

Electric car: Lupo EL

Battery electric vehicles are a suitable path to reduce the dependency on oil, to allow driving with zero local emissions in city centers and to reduce CO_2 emissions when powered with electricity from renewable sources. The Lupo EL is a fully electric research vehicle developed by TU/e using a VW Lupo 3L as donor vehicle. Researchers completely replaced the diesel powertrain with an electric one. The energy is stored in batteries with a combined weight of 273 kg. The resulting vehicle has an interesting combination of a relatively low mass (1060 kg), large battery capacity (27 kWh), and good range (170 km @ 100 km/h) and performance (0-100 km/h in 12 seconds). Thanks to these optimal specifications, the car won first prize in the Michelin Challenge Bibendum, 2011, in Berlin. The Lupo EL can be a striking duo together with the DAF truck when it comes to coopperative driving.

Durable

Fast-charging batteries

One of the barriers to the successful introduction of electric cars is the time it takes to charge their batteries. It can take 6 to 8 hours to fully charge a battery through a conventional socket. A special quick-charging station can reduce this time to no more than 15 minutes, but the high volume of direct current needed for this process raises new challenges. TU/e is developing a new technique that uses separate batteries in the loading station as an extra source of energy to help provide the necessary peak capacity. These batteries can also provide temporary storage capacity to help improve the performance of future electricity networks.

Successful projects

Durable

Electromagnetic suspension systems for cars

TU/e, in collaboration with the Swedish company SKF, has developed an active electromagnetic suspension system that makes driving a car 60% more comfortable. In addition, cars with this suspension system are safer because they do not tilt when cornering. The new suspension system was successfully demonstrated on a luxury BMW 530i. This technology is also perfectly suited to ambulances, since it reduces shaking and makes transporting patients quicker and safer. The system replaces standard shock absorbers in cars and consists of a passive spring, an extremely powerful electromagnetic actuator, a propulsion unit, and batteries.

Sensible

Environmentally friendly transport in cities

With the 4C4D project, TU/e and Tilburg University aim to improve transport options within cities, while reducing emissions, traffic jams, and noise pollution. The greatest gains can be achieved by combining goods traffic, which can be accomplished through sharing freight space and combining planning and routes. These solutions need to be created through better cooperation between logistical service providers and larger and smaller retailers. The 4C4D project brings the various players in cities together to develop a combined approach that will result in more efficient and more environmentally friendly transport in cities.

Durable

Saving fuel with smart hybrid trucks

TU/e is working with DAF Trucks to improve hybrid propulsion as part of the Hybrid Innovation for Trucks (HIT) project. One promising area of research involves intelligent power regulation. TU/e has developed an energy management system that intelligently combines data on speed, load weight, incline, and curve radius. The system then uses that information to create the optimum power requirement and distribution between the diesel engine and the electric powertrain, as well as optimum vehicle speed and transmission ratio of the power train. The driver gains immediate fuel savings of between 7% and 16%, and the new technology informs the driver of the optimum vehicle speed, enabling further fuel savings.

Sensible

Predicting family movements in cities

The simulation model Albatross shows the long-term trends in the effects of an aging population on people's mobility. The model shows how people organize their activities individually and at the family level according to time and space, along with the traffic flows that result from this. These mobility patterns are generated from the characteristics of individuals and families and the urban area and traffic systems, supplemented with information and communications technology, such as navigation systems. Albatross is already being used by the Dutch Ministry of Infrastructure and Environment as a prediction model for large-scale investments in public housing and infrastructure works.

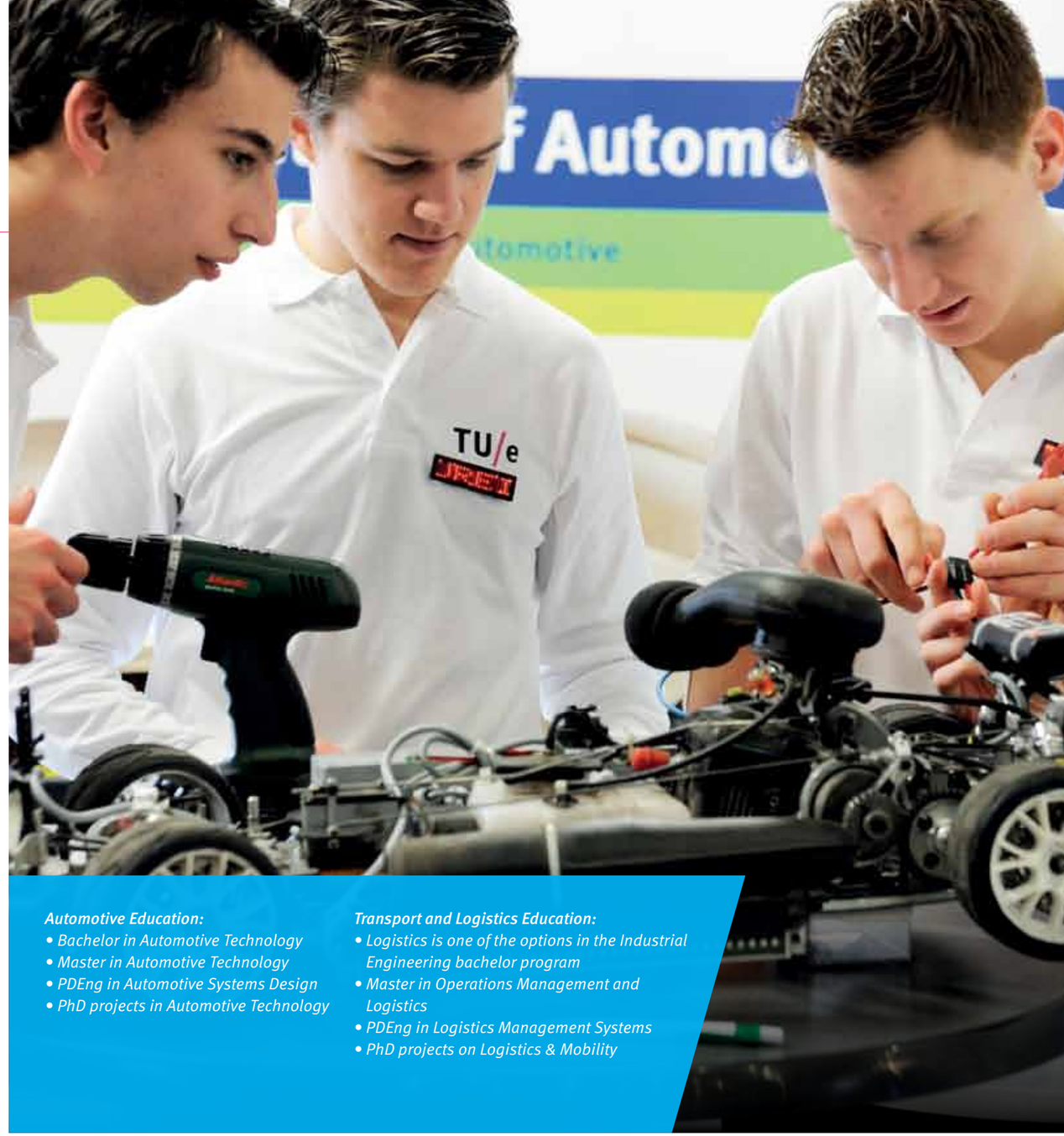
Society's need for highly educated, multidisciplinary engineers in the field of logistics and automotive science is increasing rapidly. That is why TU/e invests in educational programs to prepare students and young researchers for a career in Smart Mobility. Our students learn how to work in teams to solve, with great passion, the technological challenges in a number of extremely important social issues.

Education options in Smart Mobility at TU/e

Smart cars will help make clean driving and fewer traffic jams a reality. But to get the most out of the technologies in terms of efficiency, we must design vehicles based on a full system analysis and work towards optimizing the parts of a vehicle that work together. At least 50% of the added value in new cars is achieved through microprocessors: electric, electromagnetic, and network components. The challenge in the automotive industry is to ensure that the integration of these embedded subsystems does not affect reliability, safety, or profitability. Creating a car like a computer on wheels will also require well-educated, multidisciplinary engineers.

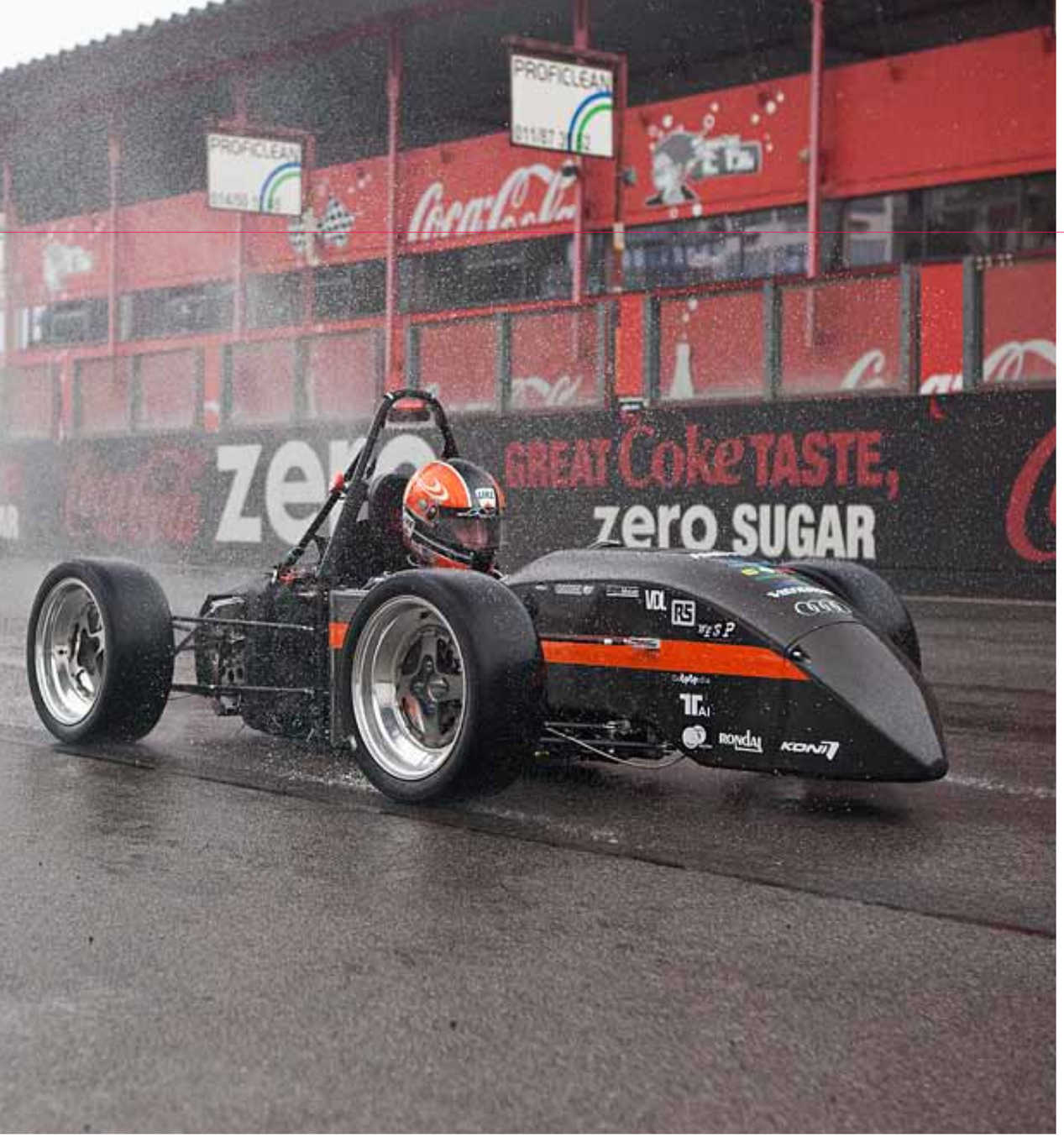
Logistics ensures that products are delivered to clients on time, at a low cost, and with little environmental impact. With good planning, products can arrive at their destination without delays, on cost-effective trucks that are optimally loaded. This is how engineers with logistical knowledge can make an important contribution to intelligent and productive mobility.

TU/e offers a range of education options in the field of Smart Mobility. In 2011, we launched the first university Bachelor program in Automotive Technology. We also have three Master programs and two Designer programs available in the domain of Smart Mobility. Approximately 1,700 TU/e students are exposed to automotive or logisticsrelated subjects during their education.



Automotive Education:
- *Bachelor in Automotive Technology*
- *Master in Automotive Technology*
- *PDEng in Automotive Systems Design*
- *PhD projects in Automotive Technology*

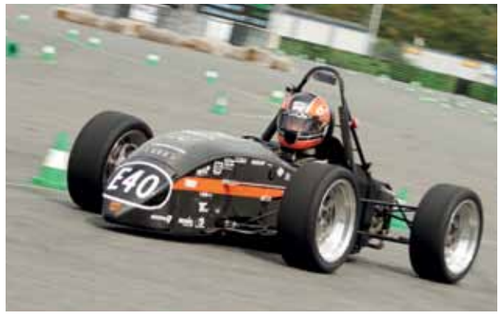
Transport and Logistics Education:
- *Logistics is one of the options in the Industrial Engineering bachelor program*
- *Master in Operations Management and Logistics*
- *PDEng in Logistics Management Systems*
- *PhD projects on Logistics & Mobility*



Durable

University Racing Eindhoven

Every year, the TU/e team University Racing Eindhoven (URE) takes part in the Formula Student Competition. This is an international race car competition, with approximately 450 teams competing. The competition incorporates all aspects of automotive engineering. The TU/e team competes each year on legendary racing tracks, such as Hockenheim and Silverstone. It consists of approximately 60 students, who build a new and improved race car every year, under the supervision of TU/e professors. The car's design and performance are then tested at the competitions. Recently, the electrical class was launched: Formula Student Electric. The URE participated with Benelux's first electric Formula Student race car. In Austria URE won the first prize in 2010 and the second prize in 2011.



Sensible

More efficient transport to flower auctions

With support from the Dutch Institute for Advanced Logistics (Dinalog), the DaVinc3i project aims to bolster the Dutch horticulture sector by developing concepts for coordination, consolidation, and collaboration in the distribution chain. DaVinc3i researches ways for the sector to strengthen its leading European market position in worldwide sourcing and flower and plant sales in a virtual trade network. Two TU/e graduate students contributed to DaVinc3i's final results with their thesis. They discovered ways to reduce the cost of transporting flowers and plants between six auction houses in the Netherlands by optimizing the organization, planning, and transport routes. The key to this was the close cooperation between the auction houses and the fact that they shared services. In addition to reducing transport costs, the students also managed to reduce the amount of harmful emissions to the environment during transport.

As an internationally recognized research university, TU/e plays a key role in the Brainport region, where knowledge institutes and industry cooperate intensively. TU/e is located in the hub of the Dutch automotive industry, which is concentrated in the southern Netherlands.

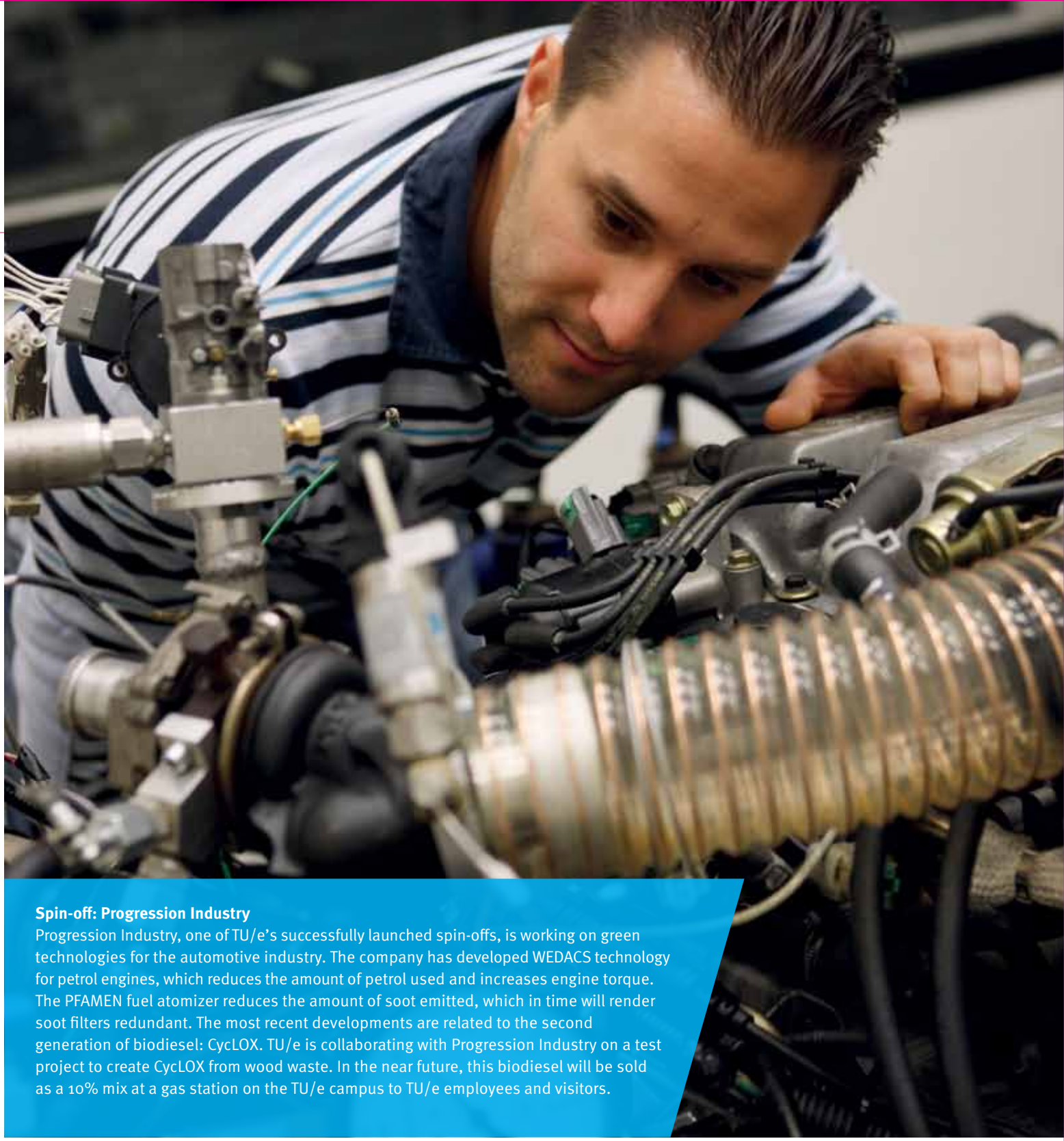
Smart Mobility innovations and valorization

In developing innovations, TU/e enjoys a long-standing and close cooperation with strategic partners. TU/e is a strong partner of the nearby High Tech Automotive Campus in Helmond and the Dutch Institute for Advanced Logistics (Dinalog) in Breda. It is also closely linked to public-private innovation programs such as AutomotiveNL and Logistics and Supply Chain Management.

TU/e is one of the partners in Dutch Integrated Test Site Cooperative Mobility, an open development environment located in southeast Brabant. Other parties involved in that collaborative effort include TomTom, DAF/Paccar, NXP, Vanderlande Industries, SKF, VDT/Bosch, Peek Traffic, TNO Automotive and the Holst Centre.

TU/e is also collaborating with TNO and the Dutch Ministry of Infrastructure and Environment to create a knowledge and innovation network to address automotive, logistics, and accessibility issues within the 'Beter Benutten' program.

Internationally, TU/e has acquired a strong position in a large network of partners. For instance, it is linked to a number of international research programs, such as the European Supply Chain Forum and the Green Car Initiative. The university also has intensive contact with partner universities abroad and works closely with MIT's Center for Transportation and Logistics.



Spin-off: Progression Industry

Progression Industry, one of TU/e's successfully launched spin-offs, is working on green technologies for the automotive industry. The company has developed WEDACS technology for petrol engines, which reduces the amount of petrol used and increases engine torque. The PFAMEN fuel atomizer reduces the amount of soot emitted, which in time will render soot filters redundant. The most recent developments are related to the second generation of biodiesel: CycLOX. TU/e is collaborating with Progression Industry on a test project to create CycLOX from wood waste. In the near future, this biodiesel will be sold as a 10% mix at a gas station on the TU/e campus to TU/e employees and visitors.