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5G BLUEPRINT

Next generation connectivity for enhanced, safe & efficient transport & logistics

D8.5: Minor-course
Automated Vehicles in Logistics

Work package	WP 8
Task	Task 8.1 Dissemination and communication
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Abstract

The objective of deliverable 8.5 is to present an educational program for bachelor students in which students can explore, understand and apply the technical aspects and characteristics of autonomous systems and explore potential applications and their impact on mobility and society in general. We focus primarily on professional bachelor level because the integration of autonomous systems is about solving practical issues within companies and social organizations. The chosen format consists of a minor for bachelor students that consists of a full-time educational program for a period of 20 weeks. The study load is 30 ECTS. Deliverable 8.5 presents the objectives, principles, structure and content of the minor. The level of elaboration concerns the identification of the learning objectives per session, the teaching methods and links to the literatures that will be discussed.

Keywords:

Teleoperated driving, business model, value network, driver activities

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V0.2	25/05/2021	Internal review	M.C. Campodonico (MAR), Karel Kurak (HAN)
V1.0	30/05/2021	Final editing	Thierry Verduijn (HZ)

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CI	Classified, information as referred to in Commission Decision 2001/844/EC	
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* R: Document, report (excluding the periodic and final reports)

DEM: Demonstrator, pilot, prototype, plan designs

DEC: Websites, patents filing, press & media actions, videos, etc.

OTHER: Software, technical diagram, etc

EXECUTIVE SUMMARY

The objective of deliverable 8.5 is to present an educational program for bachelor students in which students can explore, understand and apply the technical aspects and characteristics of autonomous systems and explore potential applications and their impact on mobility and society in general. We focus primarily on professional bachelor level because the integration of autonomous systems is about solving practical issues within companies and social organizations.

The objective of the minor is to teach students:

- What are the characteristics of teleoperated and autonomous transport systems
- What the most important technical, organizational, economic and social issues are in the introduction and application of autonomous systems
- Which stakeholders play a role in the development and application of autonomous vehicles
- What the impact of autonomous systems can be on transport systems and society

The minor focuses on two target groups:

- Students from technical studies who are interested in developing and applying technology in autonomous vehicles. These students want to build up the technical knowledge and skills to be able to work on autonomous systems in the future. This may concern students from the following courses: mechatronics, mechanical engineering, electrical engineering, ICT, data science, applied mathematics. These are the disciplines that are essential for the design and development of autonomous systems.
- Students interested in applying autonomous systems to improve business processes or solve societal issues. These students have a background in a specific domain (logistics, tourism, mobility, care) or a discipline that can contribute to the development and application of applications (business management, commercial economics, communication, law).

The chosen format consists of a minor for bachelor students that consists of a full-time educational program for a period of 20 weeks. The study load is 30 ECTS. Deliverable 8.5 presents the objectives, principles, structure and content of the minor.

Students work in small working groups on a research project for a client related to teleoperated and autonomous transport and are supported with lessons on the topic, lessons on research skills and coaching. At the end of the semester, students are assessed on their personal development of professional and research skills and the project result achieved. In order to offer a broad orientation on the technology, development and applications of autonomous vehicles in logistics and passenger transport, knowledge is provided in the form of lessons, workshops and guest speakers. The lecture program is divided into four themes:

- **Technology** (situational awareness, collision avoidance, route planning, connectivity, HMI)
- **Innovation eco-system** (business cases, business models, regulations)
- **Applications** (logistics - road transport, passenger transport and smart shipping)
- **Societal Impacts** (safety, health, infrastructure).

Depending on the preferences of the students, they register for a technical or a transport solution project. For a technical project, students can opt for the HZ Autonomous Transport Challenge, in which students build an autonomous vehicle themselves or a technical client of a company over a three-year period. In a transport solution project, the students work on an issue of a company or government in which autonomous or teleoperated vehicles are used.

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The progress of students in the development of their professional skills, research capacity and knowledge on autonomous transport will be assessed at the end of the semester. During the project the students have worked on their project and have completed milestones linked to the learning goals of the minor. During the minor students have collected evidence of their progress in a portfolio. All this evidence is evaluated in the assessment.

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ABBREVIATIONS

AV	Autonomous Vehicles
BSc	Bachelor of Science
CAD	Connected and Automated Driving
CAM	Connected and Automated Mobility
CAPEX	Capital Expenditure
ECTS	European Credit Transfer and Accumulation System
MaaS	Mobility as a Service
MOOC	Massive Open Online Course
ODD	Operational Design Domain
OEMs	Original Equipment Manufacturer
OPEX	Operational Expenditure
SME	Small Medium Enterprise
SPOC	Specific Private Online Course

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1. INTRODUCTION

1.1 Connected and automated driving

Connected and Automated Driving (CAD) is expected to revolutionize transportation and logistics by providing benefits such as safety, traffic efficiency, comfort, and reducing emissions as well as enabling novel concepts such as robo-taxis, car-sharing and truck platooning (Milakis et al., 2017). Recent advancements in vehicle and communication technologies have enabled connected and automated driving in certain controlled environments (e.g., driving in motorways under normal weather conditions). However, some technological challenges for enabling connected and automated driving in all driving domains and under all conditions remain unresolved.

According to (SAE International, 2018), there are five levels of vehicle automation. Driving automation systems at level-1 and level-2 provide the driver with longitudinal and lateral control (i.e., adaptive cruise control and lane keeping). Such technologies are available on some vehicles currently sold on the market. At level-3, automated driving systems monitor the environment and execute driving tasks on certain operating design domains (e.g., driving in motorways), allowing the drivers to avert their attention from driving tasks while being ready to take back control in case of a failure in the automated driving system. Level-4 automated driving systems are expected to handle the fail-safe situation autonomously; however, within a limited operating design domain. Therefore, level-3 and level-4 vehicles cannot activate their automated driving systems in all driving domains. Finally, level 5 refers to fully autonomous vehicles with unlimited operating design domains. This last level of automation signals a major evolution in the prospect of mobility, but it is not expected in the near future (Shladover, 2016).

1.2 Impact of Connected & Automated Driving

For passenger cars, it is likely that the level of autonomy will increase step by step when the technology makes it possible to drive the car autonomously in more driving domains. In logistics and other commercial applications, there is only a positive business case for autonomous driving if a driver is no longer needed in the vehicle. The development of autonomous transport in commercial operation may become financially feasible when vehicles are teleoperated, whereby a driver controls the vehicle remotely. It will then be possible to gradually increase the level of autonomy and to have the operators monitor and support multiple vehicles instead of a single vehicle, like a driver.

Teleoperated driving is expected to have major implications for logistics or fleet operations. It is suggested by (D'Orey et al., 2016) that teleoperated taxi fleets could revolutionize urban mobility by offering a cost-effective and safe door-to-door transportation service. The authors use an empirical evaluation to conclude that the implementation of the service can reduce the number of drivers by up to 27%. The operational performance of fleets of teleoperated vehicles is explored in Goodall (2020). The authors assumed that a team of teleoperators would be responsible for monitoring a large fleet of automated vehicles and would take control of the vehicle upon request by the vehicles' automated driving system. Such concepts are relevant when the teleoperated vehicles are level-4 automated vehicles. Teleoperation can also enable passenger car and truck platooning (Bhoopalam et al., 2018; Boban et al., 2018), which can significantly reduce logistics or fleet operations costs and environmental impacts.

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1.3 Goal of 5G-Blueprint

The overall objective of the 5G-Blueprint project is to design and validate a technical architecture, business and governance models for uninterrupted cross-border teleoperated transport based on 5G connectivity. The project's outcome should be usable as the blueprint for subsequent operational pan-European deployment of teleoperated transport solutions in the logistics sector and beyond.

To achieve this, the 5G-Blueprint will explore and define:

- The economics of 5G tools in cross border transport & logistics as well as passenger transport: bringing CAPEX (capital expenditure) and OPEX (operational expenditure) into view, both on the supply (telecom) side and the demand (transport & logistics) side for the transformation of current business practices as well as new value propositions
- The Governance issues and solutions pertaining to responsibilities and accountability within the value chain dependent on cross border connectivity and seamless services relating to the Dutch & Belgian regulatory framework (telecommunications, traffic and CAM (Connected and Automated Mobility) experimentation laws, contracts, value chain management)
- Tactical and operational (pre-) conditions that need to be in place to get the full value of 5G tooled transport & logistics. This includes implementing use cases that increase cooperative awareness to guarantee safe and responsible teleoperated transport

1.4 Objective of Deliverable 8.5

The task of Work Package 8 of the 5G Blueprint-project is to define and implement a comprehensive and effective set of dissemination and communication activities, creating awareness about project results and stimulating involvement of private and public stakeholders.

One of the dissemination channels is the transfer of knowledge about teleoperated and autonomous transport to bachelor students who will start working as professionals in the logistics sector or mobility-related sectors in the coming years. By transferring knowledge about the development of autonomous and teleoperated systems, the application possibilities and the impact of the applications on society to students, this knowledge can reach a large number of companies and organizations. Young professionals who have become acquainted with the technology during their training can accelerate and facilitate the adoption process of this new technology during their professional career.

The objective of deliverable 8.5 is to present an educational program for bachelor students in which students can explore, understand and apply the technical aspects and characteristics of autonomous systems and explore potential applications and their impact on mobility and society in general. The chosen format consists of a minor for bachelor students that consists of a full-time educational program for a period of 20 weeks. The study load is 30 ECTS. Deliverable 8.5 presents the objectives, principles, structure and content of the minor. The level of elaboration concerns the identification of the learning objectives per session, the teaching methods and links to the literatures that will be discussed. The specific elaboration of slide of lectures, detailed instructions for the assignments are not part of the design phase reported in deliverable 8.5

During the 5G-Blueprint project, the minor course is offered to students of HZ University of Applied Sciences and via "Kies op Maat" to all students in the Netherlands. "Kies op Maat" is the website that publishes all the minors that are offered by the Dutch Universities of Applied

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Sciences that are open to students of other universities. The program will also be offered to foreign exchange students who want to follow the minor in Vlissingen for a semester. The course is offered in English only. The minor is the prelude to the development of a MOOC (Massive Open Online Course). The objective of the MOOC is to provide a form of education for other target groups (professionals or academic students) who can follow the program independently via the Internet. However, no ECTS points or certificate are awarded for this. The MOOC will be delivered as Deliverable 8.6 of the 5G-Blueprint project.

1.5 Outline of the deliverable

Deliverable 8.5 consists of 6 chapters. In chapter 2 we describe the objectives and learning objectives of the minor. Chapter 3 contains the structure and structure of the minor. Chapter 4 deals with the content (learning objectives, structure and content of the lessons and assignments and the partners involved) of each session and of the projects. The assessment is discussed in chapter 5. In chapter 6 we go deeper into the development process of the MOOC / SPOC based on the experiences with the MOOC.

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2. LEARNING OBJECTIVES

2.1 Human capital challenges

The development of CAD not only impacts the functioning (flow, safety and costs) of the traffic and transport system, it offers opportunities for new applications, services and business models:

- **New mobility services:** CAD can offer access to mobility and tailor-made solutions to groups that are currently unable to move independently in the mobility system. Examples are students and elderly people who do not have a car or driving license and who are not always able to use public transport. Autonomous or teleoperated taxis can lower the barrier to flexible and on-demand solutions through the technology and lower costs and provide mobility services in times and places where services are currently not financially feasible or affordable, such as overnight or rural transportation services.
- **New business models in mobility:** CAD offers new forms of mobility services and opportunities for new business models. A combination of taxi services and car rental can arise, whereby a service provider can deliver a vehicle to a customer via teleoperation, who can then drive it himself. This flexible form of vehicle use can also lead to more car sharing
- **Urban development:** CAD can reduce the need for parking facilities and provide opportunities for urban redevelopment. After the user has stepped out, self-driving or teleoperated vehicles can drive themselves to a parking location that is more favorable in price than a downtown parking garage. But it is not the intention that the vehicles will park for free just outside the paid parking zone, because that causes many problems locally. Urban planners and policymakers will have to take this into account in the design of the city.
- **Reconfiguring logistics systems and operations:** CAD will lead to adaptation of logistics processes and structures. CAD makes it possible to handle more logistics flows at night by setting up hubs that can load, unload or connect and disconnect trailers at night, so that the logistics traffic will burden the road network in a different way. 24-hour operations also mean that lead time in logistics networks can be shortened and that the distance between warehouse and customer can be increased. Logistics service provider and shippers can therefore manage with fewer, but larger warehouses. As a result, locations and requirements for warehouses (in volume) may change in the future. The development and implementation of these new applications, services and business models generates new application-related issues for companies and governments. The challenge is not only to develop knowledge about the technology for this development, but also knowledge and skills about the application of CAD to ensure the successful introduction and adoption of these systems.

In this phase of the development of autonomous transport, there is a particular demand for technically trained professionals in the field of Sensoring, Data Science and Artificial Intelligence. The main challenge is to further expand the operational design domain of autonomous vehicles so that vehicles can operate safely in mixed traffic and can therefore be used in more situations. With the expectation that the step to full autonomous (level 5) can take another 10 years, the need for these professionals will be great and will continue to exist for the time being.

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As technology continues to develop and autonomous vehicles can be used in more situations, it will become interesting for companies, governments and social organizations to develop and implement concrete applications of autonomous vehicles. This requires professionals who can properly design, organize and manage solutions in which autonomous systems play a role. These professionals have a good understanding of the technical possibilities and impossibilities and have in-depth knowledge of the application domain to seamlessly integrate solutions with autonomous vehicles. There will also be a need for employees who can maintain and repair the vehicles. Professionals with a bachelor's degree are particularly valuable in the development and implementation of practical applications of autonomous systems.

2.2 Objective of the minor

The objective of the Development of Autonomous Transport Solution minor is to train human capital for both the need for technical professionals and professionals who are focused on the development and implementation of applications within a specific domain. We focus primarily on professional bachelor level because the integration of autonomous systems is about solving practical issues within companies and social organizations.

2.3 Learning objectives of minor

The objective of the minor is to teach students:

- What are the characteristics of teleoperated and autonomous transport systems
- What the most important technical, organizational, economic and social issues are in the introduction and application of autonomous systems
- Which stakeholders play a role in the development and application of autonomous vehicles
- What the impact of autonomous systems can be on transport systems and society

2.4 Target groups

The minor focuses on two target groups:

- Students from technical studies who are interested in developing and applying technology in autonomous vehicles. These students want to build up the technical knowledge and skills to be able to work on autonomous systems in the future. This may concern students from the courses on mechatronics, mechanical engineering, electrical engineering, ICT, data science, applied mathematics. These are the disciplines that are essential for the design and development of autonomous systems.

- Students interested in applying autonomous systems to improve business processes or solve societal issues. These students have a background in a specific domain (logistics, tourism, mobility, care,) or a discipline that can contribute to the development and application of applications (business management, commercial economics, communication, law).

2.5 Multidisciplinary approach

Current social developments and changes raise new questions and challenges. These challenges are often very complex. By collaborating with stakeholders, you will develop widely accepted improvements. This means that you have to be able to address these challenges with an integral (systems thinking) approach and in an interdisciplinary team. By definition, in interdisciplinary collaboration the disciplines need each other to find solutions. You will have

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to cross the boundaries of your own discipline and act in disciplines where others are specialized in. Mutual influence determines the content and details of meaningful and desired solutions.

Solutions to societal relevant challenges can be developed by interdisciplinary teams. The different stakeholders involved form a Coalition of the Willing. They aim to jointly understand and validate the challenge, determine the scope and boundaries of the project and search for widely accepted improvements. They collaborate and feel responsible for achieving a shared goal, yet everyone has his or her own responsibilities, interest and role to play (Figure 1). In this situation client - contractor relationships, where usually students are asked to develop solutions for the work field, are no longer effective. After all, students are our future colleagues. This calls for an ongoing process of lifelong learning and knowing how to implement jointly developed improvements. The relationship master - apprentice seems more appropriate here. Experts collaborate within educational programs to identify best practices which can be transferred to other societal relevant challenges as well. It is very helpful when good practices and lessons learned are shared at a Body of Knowledge and Skills. At an individual portfolio a professional can demonstrate he acquired relevant skills and experience - and possibly earn a certificate - by contributing to interdisciplinary challenges.

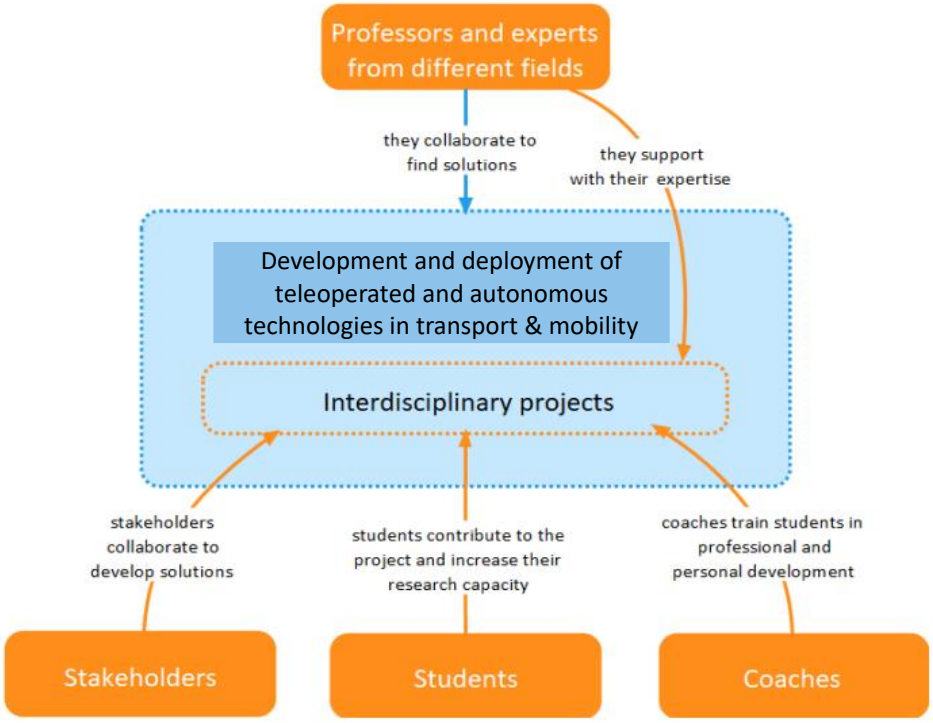

Figure 1: Jointly developing solutions to societal relevant challenges

In multidisciplinary collaboration everyone keeps thinking and working from his own field and expertise. There is a shared problem that is looked at and translated from the various disciplines. In transdisciplinary collaboration the participants try to work from thinking and working methods of different disciplines than their own. They use each other's medium, technology and expertise. By optimally mixing these, new 'interdisciplines' or working fields can arise.

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3. PROGRAM DESIGN

3.1 Becoming Fit to the Future

The minor is set up within the format of Becoming Fit to the Future that is used within HZ University of Applied Sciences to allow students to participate in state-of-the art research projects. The Becoming Fit to the Future format uses an educational set-up in which students develop their research skills and professional skills. Students work in small working groups on a research project for a client and are supported in this with lessons on the topic of the assignment, lessons on research skills and coaching. At the end of the semester, students are assessed on their personal development of professional and research skills and the project result achieved.

The learning objectives for research skills and professional skills in Becoming Fit to the Future are:

1. Improve the challenge based on a professional and proactive attitude.
2. View and understand the challenge from different perspectives.
3. Design, execute, monitor, interpret and/or validate the professional product systematically.
4. Propose a desirable follow-up and critically evaluate the professional product (result) and the associated development process.
5. Share and record the results in a structured manner and, based on your results, you potentially contribute to enriching existing knowledge.
6. Project related goal (specified by or with help of work field).

The project-related goal consists of carrying out a research project for a client. This can consist of answering a research question or designing a product or system. For goal 6 it is tested whether the result meets the wishes of the client, whether the student has built up sufficient knowledge to arrive at the correct result and is also able to justify choices made in the project with substantive arguments.

The learning objectives of minor Developing Autonomous Transport Solutions are linked in two ways to the learning objectives of Becoming Fit to the Future:

- **Personal learning goals**
  In addition to the general learning objectives for professional and research skills, students also formulate two personal learning objectives at the start of the minor. A student formulates a learning objective for developing or strengthening professional skills, for example project management skills, leadership, or language skills in English. But also building substantive knowledge can be chosen as a learning objective. For the minor Developing Autonomous Transport Solutions it is prescribed that the student formulates the development of substantive knowledge about autonomous systems as a learning objective. During the semester, the student actively works on building up knowledge and makes a report of the accumulated knowledge in a portfolio. The portfolio is tested in the assessment. The substantive learning objectives consist of the learning objectives for autonomous transport that are presented in chapter 2.
- **Project related goals**
  The students carry out a project in the field of autonomous transport for a client. Several clients are approached from the minor to submit a research question that will be worked out jointly with the students over a period of 20 weeks. By working on the projects, students

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also build knowledge and skills in autonomous systems. In the assessment the end result is assessed, the end result of the project and the justification of the result

3.2 Lectures and workshop on autonomous transport

In order to offer a broad orientation on the technology, development and applications of autonomous vehicles in logistics and passenger transport, knowledge is provided in the form of lessons, workshops and guest speakers. The college program is divided into four themes:

- **Technology**
  The technology theme deals with the technical components that make up an autonomous vehicle: a vehicle equipped with various sensors and actuators, intelligent systems for situational awareness, collision avoidance and route planning and navigation, connectivity for communication with the immediate vicinity of the vehicle and a remote operator to be able to monitor the system and, if necessary, intervene. The students learn what the characteristics and functions are of each of these components and what the critical parts of an autonomous system are in terms of safety (detection of objects, making the right choices, fast and reliable communication). It also goes into more detail about what exactly makes the vehicle autonomous.

- **Innovation eco-system**
  The theme innovation eco-system gives the student insight into which stakeholders play a role in the development and implementation of autonomous systems and which goals and interests the various stakeholders have. Within the theme we go deeper into stakeholders: vehicle OEMS, autonomous system developers, connectivity providers, mobility & logistics service providers, other supply chain partners, suppliers / service providers to users of autonomous systems (insurance, parking, fuel), the government, users and the public. We discuss the complexity of coordinating operational, financial, organizational, legal and safety issues.

- **Applications**
  Autonomous vehicles can be used in different domains: modalities, types of operations and types of roads. In most cases, autonomous vehicles offer advantages because they make a transport system less dependent on labour (lower costs, higher availability and less human error) and thus increase the productivity, safety and reliability of the transport system. For each application in transport and mobility, specific characteristics and preconditions will have to be met. This requires insight into these circumstances. In the minor we focus on logistics in the city and on corridors, on public transport, tourism, parking and smart shipping (inland shipping and sea shipping).

- **Societal Impacts**
  The development and introduction of autonomous systems can have a profound impact on society in various ways. Topics are the effect on employment and the structure of the logistics sector. The possibility to deploy autonomous systems 24/7 makes different use of the infrastructure possible with an increase in logistics movements in the evening and night. Autonomous systems can increase the mobility of people who cannot drive themselves. An important change in society is the way in which the risks of autonomous systems are assessed and accepted. A substantive elaboration of the program of lessons and workshops is presented in the next chapter..

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3.3 Project

Besides the lecture program, the students work on a project in which they research a real issue in the field of autonomous vehicles for a client. The project consists of three phases:

1. Discovery & Preparation phase
2. Action & Validation phase
3. Conclusion & Reaching out phase

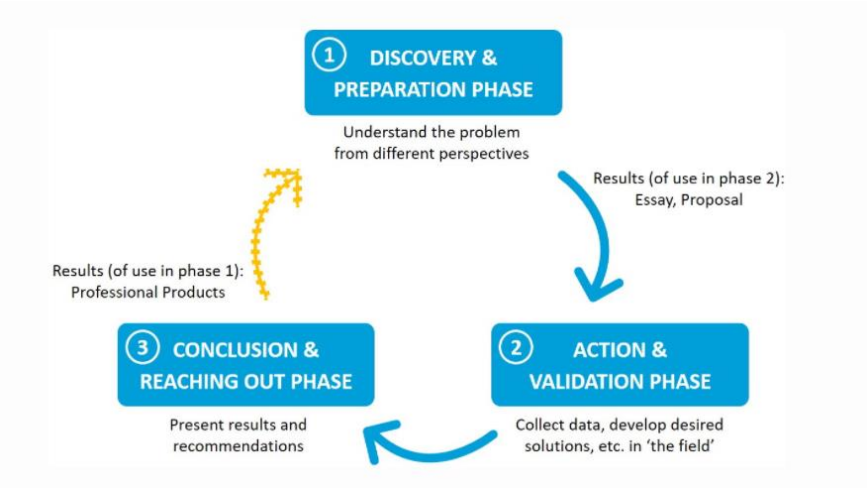

Figure 2: Phases in the execution of the project

At each stage, the students deliver between products to show their progress. Throughout the semester, the students are guided by a project coach and their client. The project coach has a weekly appointment with the group to discuss progress. However, the students themselves are responsible for their process-related and substantive progress and use the coach to receive feedback and feed forward. The students are also responsible for organizing coordination with the client and for scheduling interviews with other experts and stakeholders. The students also receive feedback through peer reviews from other students on the essay, project plan, final report and poster presentation.

Examples of projects are also explained in chapter 5.

3.4 Schedule of the minor

The schedule of the minor is presented in Figure 2: Schedule of the minor activities. The lectures on Technology and Applications are offered in block 1 (week 1 to 10 of the semester). For each subject there is a weekly part of the day with lectures or a workshop. So, in the first block, the students have lectures for 2 half-days. In the second block the lectures and workshops for the topics innovation eco-system and societal impacts follow. Lectures are offered during 6 weeks, because the last four weeks of the semester are devoted to the completion of the project, presentations and assessment.

Parallel to the lecture program, the students work on their project. In the first four weeks, the students are engaged in the phases discovery & preparation, action & validation, conclusion & reaching out.

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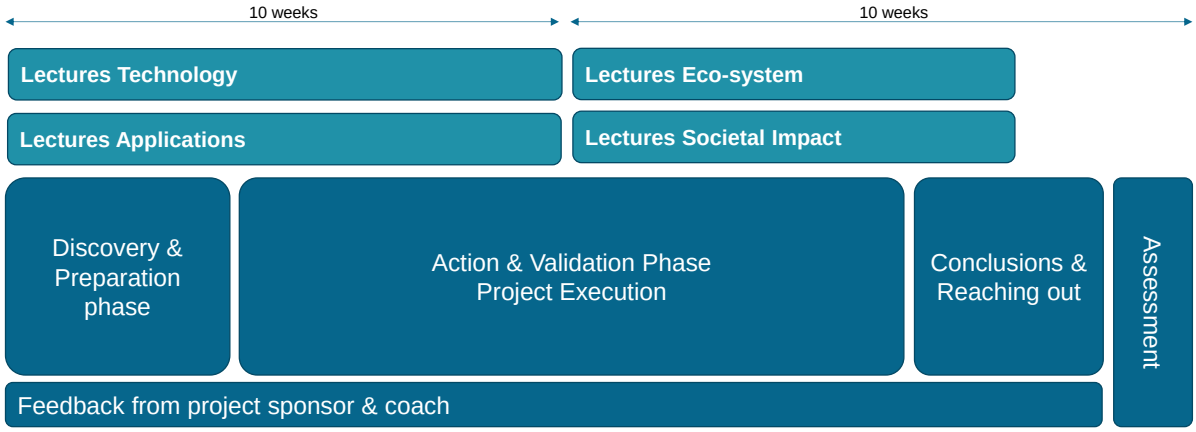

Figure 3: Schedule of the minor activities

3.5 Evolution of the minor

The choice for the format of Becoming Fit to the Future is a pragmatic one. The reason for choosing the format of Becoming Fit to the Future when developing the minor Developing Autonomous Transport Solutions is that important educational and educational logistics matters (administrative and financial matters) have already been elaborated and the focus can be on the substantive development of the minor and defining relevant and interesting issues for students.

In Becoming Fit to the Future the emphasis is on the development of the student's professional and research skills and the substantive knowledge is not tested in the traditional way with a knowledge test. When it appears in practice that there is a need for a different balance building up and testing the substantive knowledge and the development of professional skills, if there is sufficient interest among students and participation in the minor in further development, the choice will be made to adjust the educational background. format. In the assessment, more attention can be paid to testing the substantive knowledge, as is the case in the format of the minor Offshore Renewable Energy, in which a substantive program and project is also offered.

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4. COURSE CONTENT

4.1 Schedule

The classes and workshops of the four topics are spread over 17 weeks. The last three weeks of the semester are reserved for the assessment and resit. The subjects Technology and Applications are programmed in the first 10 weeks because they provide basic knowledge that is directly applicable in the projects that students carry out. In the remaining 7 weeks of the semester until the assessment, we delve deeper into innovation eco-system and societal impacts. These themes provide students with knowledge that can be used to properly advise clients on how to apply the results of the project that students are carrying out.

<table>
<tr><td>Week</td><td colspan="10">1 2 3 4 5 6 7 8 9 10</td><td colspan="7">11 12 13 14 15 16 17</td><td colspan="2">18 19 20</td></tr>
<tr><td rowspan="2">Themes</td><td colspan="10">Technology</td><td colspan="7">Innovation Eco-system</td><td colspan="2" rowspan="2">Assessment</td></tr>
<tr><td colspan="10">Applications</td><td colspan="7">Societal Impacts</td></tr>
</table>

Figure 4: Planning of lectors on the four topics within the 20 weeks of the minors

In Figure 5 and Figure 6 we present a more detailed overview of the weekly schedule including for the four themes including the topics, guest lectures and workshops for each of the lectures. More detailed information on each lecture is provided in the sections 4.2 to 4.5.

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	Week day	Week	36 S1.1 **B1**	37 S1.2 **B2**	38 S1.3 **B3**	39 S1.4 **B4**	40 S1.5 **B5**	41 S1.6 **B6**	42 S1.7 **B7**	43 S1.8 **B8**	44 S1.9 **B9**	45 S1.10 **B10**
Technology	Thursday 13.00-16.00	Topic	**Introduction autonomous systems and the Agile Way of Working**	**Introduction to driving client systems and cloud platforms**	**Localization**	**Perception**	**Deep Learning in Autonomous Perception**	**Prediction and Routing**	**Decision making**	**Engineering Planning and Control**	**Preparation on Battle Autonomous Vehicle**	**Battle Autonomous Vehicle**
		Guest lecture	-	KPN	AI in Motion	VDL		-	Captain AI	Terberg	-	-
		Workshop	Battle with build MODAUTO using remote control	ROS installed on MODAUTO	Install/connect several sensors on MODAUTO	Several Runs with MODAUTO to gather data	Use predefined datasets to identify objects	Use a road layout to follow a track with the MODAUTO	Apply several MODAUTO and Obstacles to run the track	Apply speed variation to safely reach the end of the track		Battle between autonomous MODAUTO
Applications	Tuesday 9.00-12.00	Topic	**Introduction Autonomous Vehicles**	**Logistics - transport/ terminals 1**	**Logistics – transport long haul**	**Logistics - Last Mile Delivery 1**	**Logistics - Last Mile Delivery 2**	**Passenger Transport - Mobility**	**Passenger transport - Tourism**	**Passenger Transport - Parking**	**Smart Shipping 1**	**Smart Shipping 2**
		Guest Lecture		Kloosterboer		Amsterdam UAS Airlift Systems		Connextion Rebel Group Navia		Goudappel Coffeng	Captain AI Damen Naval Shipping Factory	TU Delft Seafar
		Workshop			Design an international logistics network with autonomous vehicles		Success factors of delivery robots		Business opportunities in Tourism			Business case tele-operated or autonomous shipping

Figure 5: Schedule of the topics Technology and Application

	Week day	Week	46	47	48	49	50	51	52	1	2	3	4	5
			S1.1	S1.2	S1.3	S1.4	S1.5	S1.6			S1.7	S1.8	S1.9	S1.10
			B1	**B2**	**B3**	**B4**	**B5**	**B6**	**Holiday**	**Holiday**	**B7**	**B8**	**B9**	**B10**
Innovation Ecosystem	Thursday 13.00-16.00	Topic	**Value Network/ Human Innovation System**	**Business models**	**Government**	**Technology providers of autonomous systems**	**Connectivity providers**	**Business cases**			**Completion of project**	**Completion of project**	**Assessment**	**Assessment**
		Guest lecture		IMEC	Ministry of Transport	Terberg VDL	KPN/TELENET	Logistics Service Provider			**Completion of project**	**Completion of project**	**Assessment**	**Assessment**
		Workshop									**Completion of project**	**Completion of project**	**Assessment**	**Assessment**
Societal Impacts	Tuesday 9.00-12.00	Topic	**Safety & Risk management**	**Regulation and liability**	**Social acceptance**	**Societal impact/health**	**Access to mobility & travel preferences**	**Impact on Infrastructure**			**Completion of project**	**Completion of project**	**Assessment**	**Assessment**
		Guest Lecture	VDL	Legal firm	KiM Netherlands Institute for Transport Policy Analysis		ANWB	TU Delft Road Authority			**Completion of project**	**Completion of project**	**Assessment**	**Assessment**
		Workshop									**Completion of project**	**Completion of project**	**Assessment**	**Assessment**

Figure 6: Schedule of the topics Innovation Eco-system and Societal Impacts

4.2 Technology

In this track students will develop a very basic autonomous module. Each week, the theory is explained in a lecture of approximately 30 to 40 minutes. Then students work on their autonomous module in groups in a workshop applying the theory. The basis parts are prepared by teachers to enable students to assembly an autonomous module in 8 weeks. In the last week, the students will enter in a classroom competition with the modules they have prepared during the course.

Week 1	**Introduction into autonomous systems and the Agile Way of Working**
Learning objective	Learn the WHY and the essential characteristics of autonomous systems. Learn the principles of Agile.
Issues	What makes a system autonomous from a technical perspective? How do the levels of autonomy differ in terms of technology?
Learning module	- Preparation: Read Chapter 1 - 00:45 Lecture (45 min) - 00:55 Break (10 min) - 01:10 Construct your TEAM (15min) (2 *technical/ICT, 1*economic and 1*social) - 01:40 Desk Research about autonomous and create mood board (30 minutes) - 02:00 Showcase your teams mood board (nr. Of teams * 5min) - 02:10 Break (10 min) - 02:30 Create Agile contract defining way forward (20 minutes) - 04:00 Meet and build the BOTS (90 min)
HZ lecturers	HZ Research group Supply Chain Innovation HZ Dept Information & Communication Technologies
Guest lecturers	-
Information (Literature, video)	Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot (2020) Creating Autonomous Vehicle Systems (Synthesis Lectures on Computer Science) 2nd ed. Edition PiRacer AI Racing Robot voor Raspberry Pi 4 (sossolutions.nl)

Week 2	**Introduction to driving client systems and cloud platforms**
Learning objective	Learn the components of an autonomous system
Issues	What is Robotics Operating System (ROS) and how does it connect? How to simulate autonomous ?
Learning module	- Preparation: Read Chapter 8 & 9 - Preparation specific for technical team members: ROS for beginners, the construct (unit 1,2) - 00:45 Lecture (45 min) - 00:55 Break (10 min) - 01:40 Desk Research Autonomous components and create mood board (30 min) - 02:00 Showcase your teams mood board (nr. of teams * 5 min) - 02:10 Break (10 min) - 02:30 What is ROS, work with a prepared simulation (30 minutes) - 04:00 Meet and build the BOTS (90 min)

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HZ lecturers	HZ Research group Supply Chain Innovation HZ Dept Information & Communication Technologies
Guest lecturers	TUDelft
Information (Literature, video)	Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot (2020) Creating Autonomous Vehicle Systems (Synthesis Lectures on Computer Science) 2nd ed. Edition Intro to Robot Programming - ROS | Learning Path - The Construct (theconstructsim.com) Autonomous 2WD Robot - Gazebo Package - fjp.github.io

Week 3	**Localization**
Learning objective	Learn to define your position based on multiple sensors. Learn how to fusion these sensor inputs.
Issues	What type a sensors can be used and what are there characteristics ?
Learning module	- Preparation: Read Chapter 2 - Preparation specific for technical team members: ROS for beginners, the construct (unit 3,4) - 00:45 Lecture (45 min) - 00:55 Break (10 min) - 01:40 Desk Research about sensors and create mood board (30 minutes) - 02:00 Showcase your teams mood board (nr. Of teams * 5min) - 02:10 Break (10 min) - 02:40 What is data fusion (guest lecture) (30 min) - 04:00 Learning by doing data fusion (80 min)
HZ lecturers	HZ Department of Engineering HZ Research group Data Sciences
Guest lecturers	Captain AI SWYCS AI in Motion
Information (Literature, video)	Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot (2020) Creating Autonomous Vehicle Systems (Synthesis Lectures on Computer Science) 2nd ed. Edition Intro to Robot Programming - ROS | Learning Path - The Construct (theconstructsim.com) Autonomous 2WD Robot - Gazebo Package - fjp.github.io

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Week 4	Perception
Learning objective	Learn how interpret datasets of sensor data
Issues	How to plot your environment based on datasets?
Learning module	- Preparation: Read Chapter 3 - Preparation specific for technical team members: ROS for beginners, the construct (unit 5,6) - 00:45 Lecture (45 min) - 00:55 Break (10 min) - 01:40 explore the data (30 minutes) - 02:00 Showcase your initial findings (nr. Of teams * 5min) - 02:10 Break (10 min) - 02:40 What is a world map (guest lecture) (30 min) - 04:00 Learning by doing creating a world map (80 min)
HZ lecturers	HZ Research Group Data Science
Guest lecturers	Captain AI
Information (Literature, video)	Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot (2020) Creating Autonomous Vehicle Systems (Synthesis Lectures on Computer Science) 2nd ed. Edition Intro to Robot Programming - ROS | Learning Path - The Construct (theconstructsim.com) Autonomous 2WD Robot - Gazebo Package - fjp.github.io

Week 5	Deep Learning in Autonomous Perception
Learning objective	How to apply Artificial Intelligence
Issues	How to identify obstacles and impact
Learning module	- Preparation: Read Chapter 4 - Preparation specific for technical team members: ROS for beginners, the construct (unit 7) - 00:45 Lecture (45 min) - 00:55 Break (10 min) - 01:40 explore the algorithms (30 minutes) - 02:00 Showcase your initial findings (nr. Of teams * 5min) - 02:10 Break (10 min) - 02:40 What is a obstacle and how to define their impact (guest lecture) (30 min) - 04:00 Learning by doing creating a recognized obstacle (80 min)
HZ lecturers	HZ Department of Data Science
Guest lecturers	TUDelft Captain AI

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Information (Literature, video)	Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot (2020) Creating Autonomous Vehicle Systems (Synthesis Lectures on Computer Science) 2nd ed. Edition Intro to Robot Programming - ROS | Learning Path - The Construct (theconstructsim.com) Autonomous 2WD Robot - Gazebo Package - fjp.github.io

Week 6	**Prediction and Routing**
Learning objective	Learn how to build scenario's to define the ideal route (safe and efficient)
Issues	What are the scenario to avoid collisions with obstacles ?
- **Learning module**	- Preparation: Read Chapter 5 - Preparation specific for technical team members: ROS for beginners, the construct (unit 8) - 00:45 Lecture (45 min) - 00:55 Break (10 min) - 01:40 explore the scenario's (30 minutes) - 02:00 Showcase your initial findings (nr. Of teams * 5min) - 02:10 Break (10 min) - 02:40 What is the ideal route (guest lecture) (30 min) - 04:00 Learning by doing creating a scenario (80 min)
HZ lecturers	HZ Department of Data Science
Guest lecturers	Captain AI
Information (Literature, video)	Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot (2020) Creating Autonomous Vehicle Systems (Synthesis Lectures on Computer Science) 2nd ed. Edition Intro to Robot Programming - ROS | Learning Path - The Construct (theconstructsim.com) Autonomous 2WD Robot - Gazebo Package - fjp.github.io

Week 7	**Decision making**
Learning objective	Learn what autonomous decision making is and how systems can be trained or programmed to take decisions autonomously
Issues	What are the decisions to be made to avoid collisions with obstacles
Learning module	- Preparation: Read Chapter 6 - Preparation specific for technical team members: ROS for beginners, the construct (unit 9) - 00:45 Lecture (45 min) - 00:55 Break (10 min) - 01:40 explore the trained model (30 minutes) - 02:00 Showcase your initial findings (nr. Of teams * 5min) - 02:10 Break (10 min) - 02:40 What to include in decisions making (guest lecture) (30 min) - 04:00 Learning by doing creating a collisions avoidance decision (80 min)

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HZ lecturers	HZ Research Group Supply Chain Innovation
Guest lecturers	none
Information (Literature, video)	Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot (2020) Creating Autonomous Vehicle Systems (Synthesis Lectures on Computer Science) 2nd ed. Edition. Intro to Robot Programming - ROS | Learning Path - The Construct (theconstructsim.com) Autonomous 2WD Robot - Gazebo Package - fjp.github.io

Week 8	**Planning and Control**
Learning objective	Learn how to apply motion and feedback control
Issues	- What is the role of actuators ? - What is the role of drive-by-wire?
Learning module	- Preparation: Read Chapter 7 - Preparation specific for technical team members: ROS for beginners, the construct (unit 9) - 00:45 Lecture (45 min) - 00:55 Break (10 min) - 01:40 explore the data (30 minutes) - 02:00 Showcase your initial findings (nr. Of teams * 5min) - 02:10 Break (10 min) - 02:40 What is a world map (guest lecture) (30 min) - 04:00 Learning by doing creating a world map (80 mi
HZ lecturers	HZ Department of Engineering
Guest lecturers	Terberg Benschop VDL
Information (Literature, video)	Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot (2020) Creating Autonomous Vehicle Systems (Synthesis Lectures on Computer Science) 2nd ed. Edition. Intro to Robot Programming - ROS | Learning Path - The Construct (theconstructsim.com) Autonomous 2WD Robot - Gazebo Package - fjp.github.io

Week 9	**Autonomous driving competition**
Learning objective	Apply all the knowledge and skills developed in this theme
Issues	Problem solving and increasing complexity
Learning module	Prepare for battle between autonomous MODAUTO 4 hours practical work on the demo vehicle
HZ lecturers	HZ Department of Engineering

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Guest lecturers	-
Information (Literature, video)	Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot (2020) Creating Autonomous Vehicle Systems (Synthesis Lectures on Computer Science) 2nd ed. Edition. Intro to Robot Programming - ROS | Learning Path - The Construct (theconstructsim.com) Autonomous 2WD Robot - Gazebo Package - fjp.github.io

Week 10	**Autonomous driving competition**
Learning objective	Apply all the knowledge and skills developed in this theme
Issues	Problem solving and increasing complexity
Learning module	Battle between autonomous MODAUTO
HZ lecturers	HZ Department of Engineering
Guest lecturers	-
Information (Literature, video)	Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot (2020) Creating Autonomous Vehicle Systems (Synthesis Lectures on Computer Science) 2nd ed. Edition. Intro to Robot Programming - ROS | Learning Path - The Construct (theconstructsim.com) Autonomous 2WD Robot - Gazebo Package - fjp.github.io

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4.3 Applications

The 'Applications' track is split into three subthemes: logistics, passenger transport and smart shipping.

4.3.1 Theme 1: Autonomous vehicles

An autonomous car is a vehicle capable of sensing its environment and operating without human involvement. A human passenger is not required to take control of the vehicle at any time, nor is a human passenger required to be present in the vehicle at all. However, autonomous vehicles are part of a transport system consisting of infrastructure, other road users and users of the vehicle (freight, passengers, operators). The introduction of autonomous vehicles in the transport system will bring new applications, new actors and change the tasks, responsibilities and businesses existing actors.

Week 1	Autonomous Vehicles
Learning objective	Learn what autonomous vehicles are and way they can have a big impact on the mobility system and the whole society
Issues	- What is autonomy? - Why is autonomy interesting or beneficial - Levels of autonomy of autonomous vehicles - Overview of the innovation eco-system (block 2) - Overview of topics presented in the minor (block 1 & 2)
Learning module	Lecture introduction of autonomous vehicles (45 min) Workshop: Relevant issues in autonomous vehicles - Assignment: brainstorm and scan relevant issues in autonomous vehicles (30 min) - Break (15 min) - Discussion of issues and topics identified (20 min) - Overview of the innovation eco-system (20 min) - Break (15 min) - Overview of topics presented in the minor (25 min)
HZ lecturers	HZ Research Group Supply Chain Innovation)
Guest lecturers	none
Information (Literature, video)	Students have to look for sources themselves

4.3.2 Theme 2: Logistics

Autonomous Transport can be used for freight and logistics. The options for replacing a driver with an autonomous system strongly depend on the complexity of the traffic situations in which the vehicles operate and the characteristics of the logistics operation itself. The situation for which an autonomous vehicle has been developed is referred to as ODD (Operational Design Domain). Those ODDs in the term of logistics operations are, for example, city logistics, long-distance transport and industrial zones / terminals (Smart Yards). In addition, the introduction of autonomous systems can have a major influence on the structure of the transport market (in which many SMEs / self-employed drivers are now active) and on the design of logistics networks and supply chains because robots are active 24/7 and the costs of road transport will decline.

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Week 2	Logistics - transport/terminals 1
Learning objective	Learn different operational design domains in logistics operations, the impact of autonomous transport on design of supply chains and the impact on the structure of the transport market.
Issues	- Development of autonomous vehicles in freight and supply chains - introduction to logistics operations & types of transport - application to smart yards and long haul transportation - operational issues: no driver in the truck - tactical issues: planning of autonomous trucks - strategic issues: competition to other modes, design of logistics networks (warehouses & inventories) - - business cases
Learning module	- Lecture introducing the characteristics the freight transport and the application of autonomous transport in supply chains. (45 min) - Break (15 min) - Guest lecture on smart yards from business and operational perspective (45 min) - Break (15 min) - Assignment linked to guest lecture (30 min) - Plenary discussion (30 min)
HZ lecturers	HZ Research Group Supply Chain Innovation
Guest lecturers	Kloosterboer Verbrugge
Information (Literature, video)	- Minimizing the trade-off between sustainability and cost effective performance by using autonomous vehicles https://doi.org/10.1016/j.jclepro.2018.02.302 - Autonomous Vehicles and Autonomous Driving in Freight Transport https://link.springer.com/content/pdf/10.1007%2F978-3-662-48847-8.pdf - Assessing Long-Term Impacts of Automation on Freight Transport and Logistics Networks by a Large-Scale LRP Integrated in Microscopic Transport Simulation for Strategic Transport and Logistics Network Planning https://trid.trb.org/view/1759711

Week 3	Logistics – transport long haul
Learning objective	Learn different operational design domains in logistics operations, the impact of autonomous transport on design of supply chains and the impact on the structure of the transport market.
Issues	Integral design of international transportation network of autonomous vehicles - how to design the network (infrastructure) - how to plan the vehicles (balance the capacity) - how to service the trucks (fuel - maintenance - security) - how to handle the trailers/cargo
Learning module	Workshop: Design an international logistics network for a fleet of autonomous vehicles - introduction of the challenge (15 min) - brainstorm (30 min) - discussion and identification of different issues/aspects (30 min) - design phase for each issue/aspect (60 min) - presentations of issues/aspects (45 min)
HZ lecturers	HZ Research Group Supply Chain Innovation

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Guest lecturers	option to invite an expert to present the case and take part in the assessment
Information (Literature, video)	Trucking 4.0: An autonomous vehicle ecosystem - YouTube https://www.strategyand.pwc.com/gx/en/insights/2016/the-era-of-digitized-trucking/the-era-of-digitized-trucking-transforming.pdf

Week 4	**Logistics - Last Mile Delivery 1**
Learning objective	Learn the application, business cases and operational & functional requirements of autonomous logistics solutions in last mile delivery. A delivery robot is an automated robot that brings your delivery directly to your door. These robots aren't walking and talking humanoids; rather, these robots are small delivery containers on wheels. As with other delivery services, you make your purchases through an app with vendors based on your location. The robot trundles to the vendor---whether for shopping, food, drinks, or otherwise---and then it makes its way to your home. The route between a vendor and a delivery point might look A-to-B if you plug the locations into a navigation app... but there are extra considerations for a delivery robot, including sidewalks, crossings, driveways, humans, animals, vehicles, and so on.
Issues	- Development of autonomous vehicles in the last mile - What is a delivery robot? - What is the state-of-the art and roadmap of the operational design domain? - What is the potential benefit of delivery robots in city distribution or rural areas? - What are conditions for successful deployment? (economic, social, safety)
Learning module	- Lecture introducing the specific characteristics and challenges of delivery robots in the last mile. (45 min) - Break (15 min) - Guest lecture in which an expert, technology provider or authority provides in-depth knowledge and insights on specific issues (45 min) - Break (15 min) - Assignment linked to guest lecture (30 min) - Plenary discussion (30 min)
HZ lecturers	HZ Research Group Supply Chain Innovation
Guest lecturers	Amsterdam University of Applied Sciences Airlift Systems
Information (Literature, video)	- Study of Sidewalk Autonomous Delivery Robots and Their Potential Impacts on Freight Efficiency and Travel https://doi.org/10.1177/0361198119849398 - The adoption of self-driving delivery robots in last mile https://doi.org/10.1016/j.tre.2020.102214

Week 5	**Logistics - Last Mile Delivery 2**
Learning objective	Learn the application, business cases and operational & functional requirements of autonomous logistics solutions in last mile delivery
Issues	Exploration of solutions to existing challenges for deployment of delivery robots in cities or rural areas?
Learning module	- Workshop Success factors of delivery robots - Round 1: Each group specifies a specific problem/challenge that needs to solved to deploy delivery robots successfully (30 mins) - Round 2: Another group aims to solve a challenge defined by another group (60 mins)

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	- Break: 15 minutes - Round 3: Pitches and assessment by other groups (60 min)
HZ lecturers	HZ Research Group Supply Chain Innovation
Guest lecturers	option to invite an expert to present challenges and take part in the assessment
Information (Literature, video)	Not yet determined

4.3.3 Theme 3: Passenger Transport

New technology, including autonomous vehicles, will drastically change the classic landscape of passenger mobility over the next 10 years. Sharing concepts, Mobility as a Service platforms (MaaS) and autonomous vehicles make a system for on demand mobility possible. In addition, car ownership will be declining and the role of different types of service providers is increasing. The use of autonomous vehicles also influences parking policy because autonomous vehicles do not necessarily need a parking space in the city, but can drive themselves to another parking space. This generates opportunities for redevelopment of space that is currently used for parking, but moves the problem to other locations.

Week 6	**Passenger Transport - Mobility**
Learning objective	Learn how autonomous vehicles are used in personal mobility (own car, taxi and public transport) and what impact and benefits this has for specific groups of travelers and the challenges when introducing autonomous systems for passenger transport (shuttles)
Issues	- Overview of developments in mobility and role of autonomous vehicles - changes in mobility concepts (shared, pooled, MaaS, autonomous vehicles) - customer preferences - uses cases in passenger transport with shuttles or buses
Learning module	- Lecture providing an overview development in public transport and impact of autonomous vehicles (45 min) - Break (15 min) - Guest lecture on developments from a private operator or technology provider (45 min) - Break (15 min) - Assignment linked to guest lecture (30 min) - Plenary discussion (30 min)
HZ lecturers	HZ Research Group Supply Chain Innovation
Guest lecturers	Rebel Group Navya
Information (Literature, video)	Estimating potential increases in travel with autonomous vehicles for the non-driving, elderly and people with travel-restrictive medical conditions https://doi.org/10.1016/j.trc.2016.09.003

Week7	**Passenger transport - Tourism**
Learning objective	Explore which specific applications are possible for tourism and what impact this can have on existing value propositions. To date, the applications mentioned in the

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	literature are still very conceptual and the question is what added value these applications offer for tourism and their impact is very unclear.
Issues	Link between autonomous vehicles and tourism. - Overview of concepts presented in literature - Critical thinking: real added value of autonomous vehicles
Learning module	Lecture introducing the topic of tourism and automated mobility (45 min) Workshop: Business opportunities in Tourism - Introduction of assignment (15 min) - Break (15 min) - 1st round (25 min) - Pitches & Feedback (20 min) - 2nd round (35 min) - Pitches & Feedback (20 min)
HZ lecturers	HZ Center for Coastal Tourism
Guest lecturers	None
Information (Literature, video)	- All work and no pay? Autonomous vehicles and non-commuting journeys https://doi.org/10.1080/01441647.2020.1857460 - Autonomous vehicles and the future of urban tourism https://doi.org/10.1016/j.annals.2018.10.009 - Future tourism in a robot-based economy: a perspective article https://doi.org/10.1108/TR-05-2019-0172

Week 8	**Passenger Transport – Parking**
Learning objective	Learn how autonomous vehicles change the need for parking and what consequences and possibilities this has for parking behavior, enforcement, spatial planning and real estate development in inner cities.
Issues	Impact of autonomous vehicles on parking 1) on urban/spatial planning & investments: what happens with the need for parking places and do we need to invest in parking garages in town centres? 2) on parking of vehicles in low fare areas or cars that keep driving: what are possible scenario's and what could be solutions to unwanted impacts?
Learning module	Problem introduction (30 min) Group assignments: 2 different assignments on impact of autonomous vehicles on parking - Part 1: reading & brainstorming (30 min) - Part 2: plenary advice (3x10 min) - Part 3: creating solution (30 min) - Discussion (3x 20 min) - Total: 180 min (09.00-12.00)
HZ lecturers	HZ Research Group Supply Chain Innovation
Guest lecturers	Goudappel Coffeng
Information (Literature, video)	- Parking Spaces in the Age of Shared Autonomous Vehicles: How Much Parking Will We Need and Where? https://doi.org/10.3141/2651-09 - The autonomous vehicle parking problem https://doi.org/10.1016/j.tranpol.2019.01.003

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	- Designing parking facilities for autonomous vehicles https://doi.org/10.1016/j.trb.2017.12.017 - Autonomous Vehicles and Commercial Real Estate - Exploring the Economic, Environmental, and Travel Implications of Changes in Parking Choices due to Driverless Vehicles: An Agent-Based Simulation Approach https://doi.org/10.1061/(ASCE)UP.1943-5444.0000488 - Het effect van automatische voertuigen op de parkeerlocatie keuze: een stated preference onderzoek (report in Dutch)

4.3.4 Smart Shipping

Autonomous systems can also be applied in shipping. Although there is more crew on board a ship that a captain, the transition towards unmanned ships will probably take longer or never take place. However, autonomous systems can improve safety by deployment of collision avoidance systems or reduce the number of qualified shippers on board for a 24/7 operation. With the shortage in qualitied shippers in barge transport, the introduction of teleoperated barges could provide an attractive opportunity for young people to step in the transport sector.

Week 9	**Smart Shipping 1**
Learning objective	Learn how autonomous systems can be applied in shipping and learn the similarities and differences between application of autonomous systems in road transport, maritime and inland shipping
Issues	Introduction of smart shipping - Roles of captain, crew and waterway and port authorities in safe shipping - Levels of autonomy in smart shipping - Impact on autonomous ships on crew levels Business case of smart shipping - Impact on the supply chain - Differences between cars and vessels (Sintef presentation)
Learning module	- Lecture (30 min) - Break (5 min) - Student presentation of paper 1 (20 min) - Student presentation of paper 2 (20 min) - Break (5 min) - Guest lecture (40 min) - Total: 120 min (09.00-11.00)
HZ lecturers	HZ Department of Maritime Officer
Guest lecturers	Captain AI Damen Naval Shipping Factory
Information (Literature, video)	- Design of an autonomous transport system for coastal areas http://yadda.icm.edu.pl/yadda/element/bwmeta1.element.baztech-cb10f0d1-fa32-4512-afe3-13fa07c7b9e2 - Autonomous vessels: state of the art and potential opportunities in logistics - https://doi.org/10.1111/itor.12785

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Week 10	Smart Shipping 2
Learning objective	Learn how autonomous systems can be applied in smart shipping and learn the similarities and differences between application of autonomous systems in road transport, maritime and inland shipping
Issues	Teleoperation in barge transport - concept autonomous & teleoperated shipping on inland shipping voyage - business case of teleoperated or autonomous vessel
Learning module	- Guest Lecture (40 min) - Group exercise: developing business case for teleoperated or autonomous shipping levels (40 min) - Student have to provide arguments what elements are relevant in the business case for a specific level of autonomy. Expected output is a conceptual model in which the factors and how they influence the business case. Groups explore different levels of autonomy and the business cases of the various levels are compared during the discussion. - Discussion (40 min) Total: 120 min (09.00-11.00)
HZ lecturers	HZ Research Group Supply Chain Innovation
Guest lecturers	TU Delft Seafar
Information (Literature, video)	SmartPort - Smart ships and the changing maritime ecosystem TKI Dinalog - Vision Paper on automated barging SINTEF - Assessing Business Cases for Autonomous and Unmanned Ships

4.4 Eco-system

Week 11	Value Network/Human Innovation System
Learning objective	Learn which stakeholders are required to develop and implement tele-operated and autonomous driving successfully, what their role, objectives and contribution is in the process of development and implementation.
Issues	A number are issues are presented to identify the various stakeholders: - Rules and regulations for AV's in logistics - Accountability issues - Design of distribution network and set up first-last model - What will be effect on productivity - Impact on congestion - What savings in parking space - Stress reduction on current health care system How to plot these issues in the Human Innovation System
Learning module	- Lecture Introduction Human Innovation System (45 min) - Group assignments: 3 different assignments on how to apply the HIS for Autonomous Transport Solutions - Assignment 1: applying the general innovations (technology) of Autonomous Transport to the HIS model (45 min) - Assignment 2: applying the autonomous Shuttle (service)to the HIS model (30 min)

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	- Assignment 3: describing the inputs from other domains to the Autonomous Transport domain (30 min) - Discussion (30 min) Total: 180 min (09.00-12.00)
HZ lecturers	HZ Department of Industrial Engineering HZ Research Group of Supply Chain Innovation
Guest lecturers	none
Information (Literature, video)	Handbook of Organizational Creativity Chapter 4 - Fields, Domains, and Individuals https://doi.org/10.1016/B978-0-12-374714-3.00004-5

Week 12	**Business Models**
Learning objective	Learn how tele-operated and autonomous transport technology may lead to new business models and transform existing mobility markets
Issues	- Why does the technology have disruptive features? - How do new entrants enter the market and why are they successful or not? - What activities and actors are most vulnerable for disruptive autonomous services
Learning module	- Guest Lecture (40 min) - Group exercise: developing business model autonomous bus transport (40 min) Students have to provide arguments what elements are relevant in the business model for an autonomous bus for elderly in Zeeland. Expected output is a business model canvas for an autonomous bus service - Discussion (40 min) Totaal: 120 min (09.00-11.00)
HZ lecturers	HZ Department of Industrial Engineering HZ Research Group of Supply Chain Innovation
Guest lecturers	IMEC
Information (Literature, video)	- The impact of autonomous trucks on business models in the automotive and logistics industry–a Delphi-based scenario study https://doi.org/10.1016/j.techfore.2019.119736 - Logistics and the networked society: A conceptual framework for smart network business models using electric autonomous vehicles (EAVs) https://doi.org/10.1016/j.techfore.2019.119824

Week 13	**Government**
Learning objective	Learn what the role of government is in terms of need for regulation, economic perspectives, infrastructure management and social impacts
Issues	Government needs to protect the privacy of its civilians, which requires among others regulation concerning Data Security and Protection. Governments also need to protect the public health which involves areas such as liability and insurance. Government needs to stimulate innovation to help create new economy
Learning module	- Guest lecture (60 min). - Break (10 min) - Case on how government influences the role out / adoption of a specific autonomous transport solution. (30) - Discussion 30 min.

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	Total 130 min.
HZ lecturers	HZ Research Group Supply Chain Innovation
Guest lecturers	Ministry of Infrastructure & Waterworks/Ministry of Transport
Information (Literature, video)	Freight Autonomous Vehicle Deployment Scenarios and Preliminary Implications for Public Agency Autonomous Vehicle Planning https://trid.trb.org/view/1759290

Week 14	**Technology providers of autonomous systems**
Learning objective	Learn which type of technology providers play a role in autonomous systems and what their goals, drivers and success factors are.
Issues	- OEMS/Integrators - Developers of autonomy kits, senor units, etc.. - Product Proposition: what is the actual product ? hardware or autonomous kit?
Learning module	- Lecture (30 min) + - Guest lecture (60 min). - Discussion 30 min. - Total 120 min.
HZ lecturers	HZ Research Group Supply Chain Innovation
Guest lecturers	Terberg Benschop VDL
Information (Literature, video)	- 5G Blueprint Deliverable 3.2 and 3.3 Value networks

Week 15	**Connectivity providers**
Learning objective	Learn what the critical issues are for telecom service providers providing connectivity for tele-operation and monitoring of fleets
Issues	- Characteristics and role of 5G - Technological Issues – latency, reliability - Business models in 5G - Cross border issues
Learning module	- Guest lecture on connectivity requirements of connected & automated driving (60 min) - Break (10 min) - Guest lecture on business issues for 5G connectivity providers (60 min)
HZ lecturers	HZ research group Supply Chain Innovation
Guest lecturers	KPN / TELENET IMEC
Information (Literature, video)	- 5G Blueprint deliverable 3.2 to 3.6

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Week 16	Business cases
Learning objective	Learn to create a business case for autonomous transport systems and identify and recognize the typical trade-offs in business cases of autonomous transport solution
Issues	- Typical differences in operational characteristics and cost structures o autonomous transport systems (operating speed, labor costs, capital costs) - Impact of autonomous systems on productivity and utilization rates of equipment, - Role of tele-operator/vehicle ratio for business case calculation - Calculation of OPEX, CAPEX and ROI
Learning module	Lecture on the business case in autonomous transport (40 min) Break (10 min) Workshop: productivity and the business case of transport operations - Explanation of assignment + Working groups: impact of teleoperation on productivity of transport operations (40 min) - Explanation of the simulation model Working groups: analyzing the impact on productivity using the model (40 min) - Break (10 min) - Explanation of business case dashboard + Working groups: defining an advise to a transport company (40 min) Total: 180 min (09.00-12.00)
HZ lecturers	HZ Research Group Supply Chain Innovation
Guest lecturers	Regional transport company to introduce a case from practice
Information (Literature, video)	- 5G Blueprint D3.1 Bussiness Cases & Organisational Requirements - Business cases of projects Living Lab Autonomous Transport Zeeland

4.5 Societal impacts

Week 11	Safety of autonomous systems
Learning objective	Learn why safety is the biggest societal issues of autonomous systems and how safety of autonomous systems is defined and safeguarded by industry standards and regulations.
Issues	- What are the main challenges in safety of autonomous systems? - How is safety of autonomous systems approached different than safety of regular vehicles? - What risk analysis and management approaches are used for safety of autonomous systems? - What regulations and standards apply for safety of autonomous systems?
Learning module	- Lecture on safety challenges and issues for autonomous systems (60 min) - Break (10 min) - Guest lecture on risk management approach or regulations (60 min) - Break (10 min) - Discussion (40 min) Total: 180 min
HZ lecturers	HZ Department of Industrial Engineering

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Guest lecturers	VDL RDW
Information (Literature, video)	Experiences of main risks and mitigation in autonomous transport systems; https://iopscience.iop.org/article/10.1088/1742-6596/1357/1/012012/meta

Week 12	**Liability**
Learning objective	Learn how liability is legally defined in term of drivers and autonomous vehicles and how industry and government ?
Issues	- How is liability defined in traditional traffic laws? - How do autonomous vehicles fit (or not fit) in existing laws & regulations - What kind of arrangements are made by government to allow use of autonomous vehicles and how do countries in the EU differ in their approach.
Learning module	- Guest lecture on traffic regulation and liability issues now and then (before autonomous mobility) (60 min) - Break (10 min) - Discussion (30 min)
HZ lecturers	HZ Research Group Supply Chain Innovation
Guest lecturers	VDL Legal firm
Information (Literature, video)	Who is to blame for crashes involving autonomous vehicles? Exploring blame attribution across the road transport system https://doi.org/10.1080/00140139.2020.1744064

Week 13	**Social Acceptance**
Learning objective	Learn why and how social acceptance will influence successful introduction of autonomous vehicles
Issues	- Accepting autonomous starts with the trust in technology. How can you build this trust and what are the key drivers? - What is the current digital awareness and how do we look at all the data autonomous collected ? - Who are the early adaptors and what is the approach to get more accepting this technology?
Learning module	00:45 Lecture (45 min) by TUDelft 00:55 Break (10 min) 01:40 Desk Research about Social acceptance (30 minutes) 02:00 Showcase your teams mood board (nr. Of teams * 5min) 02:10 Break (10 min) 02:40 What is the social acceptance of our project for HZ and region 04:00 Discuss with your team and showcase your mood board (80 min) Total: 240 min
HZ lecturers	HZ Research Group Supply Chain Innovation
Guest lecturers	KiM Netherlands Institute for Transport Policy Analysis

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Information (Literature, video)	- Public perception of autonomous vehicles: A qualitative study based on interviews after riding an autonomous shuttle https://doi.org/10.1016/j.trf.2020.05.012 - Public perception of autonomous vehicles: GATEWAY Project (UK) https://trl.co.uk/projects/gateway-project/ (Project website) https://www.youtube.com/watch?v=tWFXhaJeYPA (VIDEO) - https://www.tudelft.nl/en/stories/articles/robot-and-humans-have-to-understand-each-other

Week 14	**Societal impact/health**
Learning objective	Learn how the introduction of autonomous vehicles can influence public health and what factors are most influential
Issues	- To what extend does autonomous change the demographical impact of mobility? - What are the effects of autonomous to human health and healthcare? - What are now jobs at the horizon and which become disrupted? - What is the SDG contribution of Autonomous ?
Learning module	Preparation: reading on the recommended papers 00:45 Lecture (45 min) 00:55 Break (10 min) 01:40 Desk Research about Social impact (30 minutes) 02:00 Showcase your teams mood board (nr. Of teams * 5min) 02:10 Break (10 min) 02:40 What is the societal impact/health of autonomous mobility (30 min) 04:00 Discuss with your team and showcase your mood board (80 min)
HZ lecturers	HZ Department of Healthy Region
Guest lecturers	
Information (Literature, video)	- Impacts of Autonomous Vehicles on Public Health: Conceptual Model and Policy Recommendations https://doi.org/10.1016/j.scs.2020.102457 - Autonomous Vehicles and Public Health https://doi.org/10.1146/annurev-publhealth-040119-094035

Week 15	**Access to mobility & Travel preferences**
Learning objective	Explore the expected impact on urban movements and public transport?
Issues	- Are there sustainable benefits regarding autonomous? - To what extend does autonomous change the demographical impact of mobility?
Learning module	Preparation: Paper 00:45 Lecture (45 min) 00:55 Break (10 min) 01:40 Desk Research about Mobility & Travel impact (30 minutes) 02:00 Showcase your teams mood board (nr. Of teams * 5min) 02:10 Break (10 min) 02:40 How does urban movements look like in 2030 (30 min) 04:00 Discuss with your team and showcase your mood board (80 min)
HZ lecturers	HZ Research Group Supply Chain Innovation

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Guest lecturers	ANWB
Information (Literature, video)	- Can autonomous vehicles enable sustainable mobility in future cities? Insights and policy challenges from user preferences over different urban transport options https://doi.org/10.1016/j.cities.2021.103134 - Aged mobility in the era of transportation disruption: Will autonomous vehicles address impediments to the mobility of ageing populations? https://doi.org/10.1016/j.tbs.2020.03.004 - Estimating potential increases in travel with autonomous vehicles for the non-driving, elderly and people with travel-restrictive medical conditions https://doi.org/10.1016/j.trc.2016.09.003 - Parents' perspectives on using autonomous vehicles to enhance children's mobility https://doi.org/10.1016/j.trc.2018.10.001

Week 16	**Impact on infrastructure**
Learning objective	Learn why and what adjustments are required to prepare road infrastructure to accommodate and enhance safety of autonomous vehicles.
Issues	- Role of the road authority in safety management and infrastructure management? - Contribution and costs of infrastructure adjustments? - How to invest in an autonomous ready infrastructure network?
Learning module	- Lecture on risks, risk mitigation and the role of infrastructure and road authorities (60 minutes) - Break (10 minutes) - Guest lecture on the trade-offs and decision making process of road authorities (60 minutes) - Break (10 minutes) - Discussion (40 minutes)
HZ lecturers	HZ Research Group Supply Chain Innovation
Guest lecturers	TU Delft Road Authority
Information (Literature, video)	- Preparing Road Infrastructure to Accommodate Connected and Automated Vehicles: System-Level Perspective https://ascelibrary.org/doi/pdf/10.1061/%28ASCE%29IS.1943-555X.0000593 - Road infrastructure readiness for autonomous vehicles, https://hammer.purdue.edu/articles/thesis/Road_Infrastructure_Readiness_for_Autonomous_Vehicles/8949011/1

4.6 Project

Depending on the preferences of the students, they register for a technical or a transport solution project. For a technical project, students can opt for the HZ Autonomous Transport Challenge, in which students build an autonomous vehicle themselves or a technical client of a company over a three-year period. In a transport solution project, the students work on an issue of a company or government in which autonomous or teleoperated vehicles are used.

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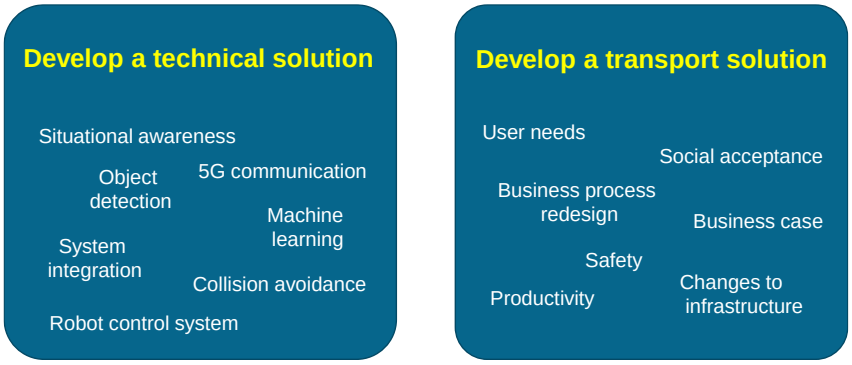

Figure 7: Overview of project topics

Example 1: Safe departure with teleoperated vehicles

- **Setting:** A technology provider is offering teleoperation kits and control rooms to transport companies. This technology enables transport companies to operate vehicles form the control center and reduce the number of drivers that is needed to operate the fleet. One of the safety measures that needs to be taken when a teleoperator is picking up a vehicle at a warehouse is safe drive away. This means that a teleoperator must make sure that there
- **Problem:** The technology provider is wondering how it can include sensors or other measures in its offering to support safe drive away and to what extent safe drive away would become a barrier to deployment for transport companies if the technology provider does not provide a solution.
- **Assignments:**
  1. Design a technical solution that the technology provider can offer to guarantee safe drive away.
  2. Define the alternatives to a transport company and make a cost benefit analysis comparing the designed solution and the alternatives identified.

Example 2: Reading Road signs in winter and bad weather

- **Setting:** Autonomous vehicles are trained to recognize traffic signs. When traffic signs are well maintained and visibility is good, the sensors and algorithms have no problem with recognizing the traffic signs. However, with snow and other adverse whether there is a risk that the traffic sign will not be interpreted correctly and increasing the risk of dangerous situations or accidents.
- **Problem:** A company providing technology for situational awareness wants to determine under what whether conditions the algorithms are no longer capable of recognizing the right traffic sign and how it can prevent risks from happening.
- **Assignments:**
  1. Analyse what (lack of) quality of sensor data create problems and risks in detecting the right traffic sign.
  2. What options does the company have to guarantee safety if this type of adverse weather is present?

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Example 3: Strategic perspective on the competitiveness of logistics companies

- **Setting:** A transport company is offering transport services to a terminal operator in the Port of Flushing transporting containers from a nearby production facility to the terminal. The terminal operator is exploring the investment of autonomous terminal tractors for mixed traffic on the terminal. In the future, autonomous vehicles could also be deployed for short haul operations on public roads within the port.
- **Problem:** The transport company is wondering whether it should invest in autonomous vehicles in its short haul transport operations or it faces the risk of losing this business because the terminal operator will deploy its fleet of autonomous vehicles itself or whether new entrants will enter the scene with new technology.
- **Assignments:**
    1. Define multiple scenarios for the deployment of autonomous vehicles in the Port of Flushing and indicate the strategic impact on the competitive position of the company?
    2. What investment strategies should the transport companies adopt for each of these scenario's and what is the most robust strategy given the uncertainties?

Example 4: Impact of autonomous mobility on congestion and parking space at the beach

- **Setting:** Zeeland is well known for its nice beaches and recreation areas. Each year thousands of people visit these beaches travelling from nearby campsites and holiday parks by private car. To accommodate this growing seasonal mobility more valuable space needs to be allocated for parking areas. If autonomous vehicles would be able to return to the campsites or holiday homes will their owners are at the beach, no additional land would be to be allocated to parking or land could even be returned to nature or agriculture. On the other hand, the return flow of vehicles creates additional congestion on the roads to and from the beach, which may further increase congestion in the morning and afternoons.
- **Problem:** The municipalities in Zeeland and Province of Zeeland want to know what the impact of autonomous vehicles will be on mobility of tourists travelling to the beach and the need for parking space and what options the authorities have to stimulate the use of parking facilities elsewhere.
- **Assignments:**
    1. Define a method that the municipalities can apply to assess the impact of autonomous mobility used by tourists on traffic flows, congestion and parking space needed;
    2. Estimate the required parking spaces at the beaches using different scenario's of the adoption of autonomous vehicles;
    3. Develop an incentive program that the authorities can use to stimulate the use of parking spaces elsewhere in Zeeland.

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5. ASSESSMENT

5.1 What will be assessed?

The progress of students in the development of their professional skills, research capacity and knowledge on autonomous transport will be assessed at the end of the semester. During the project the students have worked on their project and have completed milestones linked to the learning goals of the minor. During the minor students have collected evidence of their progress in a portfolio. All this evidence is evaluated in the assessment.

Table 1: Overview of milestones & link to the learning goals

Milestone	Learning goals
1a: (Y)our ambitions	1, 2
1b: Essay	1, 2
1c: Project proposal	1, 2, 3, (6)
2: Execution and validation	1, 3, (6)
3: Reaching out with professional products	1, 4, 5, (6)
Progress, reflections and evaluations	1, 2, 3, 4, 5, 6

The knowledge that students have accumulated on the topic of autonomous transport solutions is not assessed separately in a written exam. It is not tested for initial knowledge, but for the ability to process and apply the knowledge provided for a specified problem. Therefore, the knowledge on the development of autonomous system is assessed on the level of understanding of the problem and on the way in which the student argues that the product meets the customer's needs and the conditions in which it can be applied.

5.1.1 Discovery & Preparation Phase Milestone 1a

Assignment

Personal ambitions:

- Perform self-assessment of student's professional skills, qualities and team roles
- Define personal ambitions for skills development and knowledge and competencies related to autonomous and teleoperated vehicles
- Discuss how the teams' members can support each other in achieving their ambitions

Project exploration:

- Get to know the projects' goal and challenges and talk about this with experts, clients and stakeholders from the field.
- Specify learning goal 6 (= project related goal): what kind of professional product needs to be developed?
- Prepare an initial planning for the project, including appointments with the work field, to share, discuss and validate progress and interim project results.

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Deliverable Milestone 1a

Progress and Reflection report (individual report). The Progress and Reflections report is a 'developing report'. Per Milestone you will add your reflections etc. as indicated.

5.1.2 Discovery & Preparation Phase Milestone 1b

Assignment

- Write an essay about the subject of the project
  - Explore literature on the topic
  - Review existing views and knowledge about the subject
  - Write the essay from your own point of view and expertise, and support and reinforce your views with help of knowledge and ideas from experts in the field.
- Perform a peer review of an essay of two other students
- Use the peer reviews performance to improve your essay

Every team member of project group will individually write such an essay. Later on, during the minor, the essays are combined to build a theoretical framework for the project.

Deliverables Milestone 1b

- Improved Essay (individual product)
- Information Search Log with sources found and reviewed (individual product)
- Updated Progress and Reflection Report initiated in Milestone 1a. (individual report)

5.1.3 Discovery & Preparation Phase Milestone 1c

Assignment

- Develop a Project proposal to carrying out your project
  - Speak with stakeholders from the field and understand their views on and desires for the challenge
  - Describe the challenge and the reason why you want to execute the project.
  - Develop a theoretical framework based on the individual essays.
  - Elaborate on the methods and materials needed to execute the project,
  - Present feasible planning both in time and financially.

Deliverables Milestone 1c

- Improved Project proposal (team product)
- Information Search Log with sources found and reviewed (individual or team product)
- Progress and Reflection report

5.1.4 Action & Validation Phase Milestone 2

Assignment

- Execute the plan as described in the Project proposal.
  - Collect and analyse data
  - Design and implement the solution or results
  - Co-create with the experts and stakeholders to get to desired and widely accepted solutions and improvements and discover new views, desired next steps or adjustments for your project, consider these as well.
- Organize and execute a session to validate results - ideally with the stakeholders involved.

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Deliverable Milestone 2

- Updated Progress and Reflection report (individual report)

5.1.5 Conclusion & Reaching Out Phase Milestone 3

Assignment

- Develop and review professional products.
- Present your results during a poster or PowerPoint session.
- Meet regularly (almost daily) with your project team to work on the project and your professional ambitions.
- Meet at least once per week with your project team and coach to discuss the project, identify progress, lessons learned and next steps for the project and development of your professional skills. Add short notes of these meetings to "Appendix I - Weekly progress" of your Progress and Reflections report.
- Reflect at working on your project and developing professional skills.

Deliverables Milestone 3

- Improved Final report (group product)
- Power point / Poster presentation (group product)
- A short summary of project results, including evaluation of the entire project process and lessons learned (group product)
- Potentially: other Professional Products (individual or group product)
- Progress and Reflection report (use the one you have uploaded for Milestone 2) (individual report)

5.2 Assessment criteria and grading

Table 2: Assessment criteria

	Criteria	Evidence	Weight
1	**You work together on the project and jointly find solutions based on a professional and proactive attitude.** Details: you collaborate, take responsibility and think critically, your actions are based on critical reflections, you want to understand, validate and achieve, you are constructive, respectful, reliable, curious, creative, and objective, you present yourself professionally and with proper etiquette, and you want to share your results and lessons learned. ***This learning goal applies to goals 2-6 as well.***	**Progress and Reflections report** including **(Y)our ambitions** (Milestone 1a) and reflections from all project phases ***This is evidence for goals 2-6 as well.***	0,50
2	**You view and understand the challenge from different perspectives.** Details: you find relevant, reliable and up-to-date information, analyse and apply it in a systematic way and conduct a literature review. You collaborate with stakeholders to identify the	**Essay** (Milestone 1b) **Proposal** (Milestone 1c) **Professional products** (Milestone 3)	0,25

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	challenge. You present the challenge clearly and well-founded.		
3	**You design, execute, monitor, interpret and/or validate the professional end product (result) systematically.** Details: in a structured manner you collaborate to develop, and possibly adjust the development of, a validated Professional product.	**Proposal** (Milestone 3) **Execution & validation** (Milestone 4) **Professional products** (Milestone 5)	0,25
4	**You propose a desirable follow-up, and critically evaluate the professional product and the associated development process.**Details: you identify good practices and lessons learned. You reflect at your own role (me), the one of your team and stakeholders (we) and the results of your project (it).	**Professional products** (Milestone 3)	0,25
5	**You share and record the results in a structured manner and, based on your results, you potentially contribute to enriching existing knowledge.** Details: you describe the project process to achieving the results clearly and well-structured. You share the results in relevant ways, e.g. via a Body of Knowledge and Skills.	**Professional products** (Milestone 3)	0,25
6	**Project related goal.** Details: specify.	**Specified by or with help of the client / workfield**	0,50

Table 3: Scores

Score and description
10 - Developed and visible beyond expectations
8 - Good developed and visible
6 - Sufficiently developed and visible
5 - In development, but requires further elaboration and effort
2 - A start has been made, the first steps have been taken
0 - Not present

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Table 4: Calculation of final grade

Elements to be assessed	Credits	Calculation
Final score Portfolio (assessment criteria 2-5)	22,5 ECTS Minimum score 5.5/10	Sum of score x weight
Final score Professional skills and project related goal (assessment criteria 1 and 6)	7,5 ECTS Minimum score 5.5/10	Sum of score x weight

5.3 Level (towards BSc)

The level of the minor is determined on the basis of the Dublin descriptors for bachelor education: knowledge and understanding, applying knowledge and understanding, making judgements, communication and lifelong learning skills. All these competencies are included and assessed in the minor. The minor also complies to the Dutch standards for bachelor education and the regulations for Bachelor of Engineering.

Table 5: Contribution to bachelor level

Level*	Nature of the TASK	Nature of the CONTEXT	Degree of INDEPENDENCE
I	- Simple - Structured - Applies known methods	- Known Simple - Monodisciplinary	- Steered guidance
II	- **Complex**** - **Structured**** - Uses known methods in varying situations	- **Known**** - **Complex**** - Monodisciplinary - In practice**	- **Guidance through coaching****
III (BSc)	- **Unknown**** - **Complex**** - **Multidisciplinary**** - In practice	- Independent - Guidance if necessary	- Independent - Guidance if necessary

* If two out of three aspects are present, the level is achieved. Level III is at BSc (bachelor) level.

** Covered in this minor

5.4 Assessment process

Duration of the assessment is 45 minutes in total, of which 30 minutes for the interview by assessors (your own coach and a coach from another project team) with you, and 15 minutes for the assessors to discussing their feedback to the development of your research capacity. After this discussion you will receive the assessment result orally. The filled-out assessment form will be signed and added to your portfolio shortly after the assessment.

5.5 Re-sit

In case you do not pass the assessment, you do a re-sit with a deadline of two weeks after the first assessment. Scheduling a re-sit is done by the assessors and students themselves.

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6. DEVELOPMENT OF THE MOOC/SPOC

6.1 Introduction and purpose

To expand the exposure of the educational material developed, the minor will be converted into a Massive Open Online Course (MOOC) or a Specific Private Online Courses (SPOC). A massive open online course (MOOC) is an online course aimed at unlimited participation and open access via the internet. In addition to traditional course materials, such as filmed lectures, readings, and problem sets, many MOOCs provide interactive courses with user forums or social media discussions to support community interactions among students, professors, and teaching assistants, as well as immediate feedback to quick quizzes and assignments. Early MOOCs (cMOOCs) often emphasized open-access features, such as open licensing of content, structure and learning goals, to promote the reuse and remixing of resources. Some later MOOCs (xMOOCs) use closed licenses for their course materials while maintaining free access for students.

Specific Private Online Courses support blended learning and flipped classroom learning, which variously combine online resources and technology with personal engagement between faculty and students. Early research results point to improved learning and student outcomes using such approaches. When a SPOC is implemented at an institution, in concert with students, faculty determines which features and course content to utilize. This can include video lectures, assessments (with immediate feedback), interactive labs (with immediate feedback) and discussion forums used in MOOCs. Using MOOC technology allows the faculty to organize their time with students in different ways, such as allowing more time in class for project-based work instead of grading assignments or preparing lectures. SPOCs have been analogized to “next generation textbooks,” by allowing faculty to decide how to use some or all parts of the SPOC. In a SPOC as in a MOOC, students typically access interactive content at their own pace. Unlike MOOCs, SPOCs have limited enrolment and are often used as part of a course for credit.

We will explore the benefits and advantages for developing a MOOC or a SPOC. Although a MOOC provides the opportunity of reaching a lot of students and professionals, the effort of promoting and communicating a MOOC could be intensive and might step into a direct competition with courses offered by other universities. In a MOOC, it is difficult to offer real life projects for students to work on. Offering a SPOC that can be used and integrated by other universities into their own program could also be valuable approach. In that case, the SPOC provides building blocks (lectures, video’s and assignments) that teachers can offer to students for self-study, but they can offer discussions and feedback sessions to have direct contact with their students to guide and support them. It also allows schools to add their own industry projects and to guide them in executing these projects.

6.2 MOOC/SPOC design

Although the focus has been on designing minor, some initial ideas for the structure of the MOOC / SPOC have been developed. The MOOC / SPOC will be set up on the basis of the four themes that are also used as a structure in the minor. Each theme focuses on one or more assignments / issues that must be worked out by a student. In order to be able to complete the assignment, knowledge is offered in the form of articles, lectures and videos. The student can test himself with formative knowledge tests (multiple choice), which gives the student insight into the knowledge level that is already up to standard. The student completes the assignment with the knowledge base. The student can then test the result of the

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assignment with a formative test that is aimed at understanding and being able to apply the knowledge.

If all four themes have been successfully completed, a student will receive an integration assignment in which aspects of all four themes are reflected. This assignment consists of an essay or paper that will be assessed by the lecturers of HZ in the event of a MOOC or by the home university if the education is offered in the form of a SPOC.

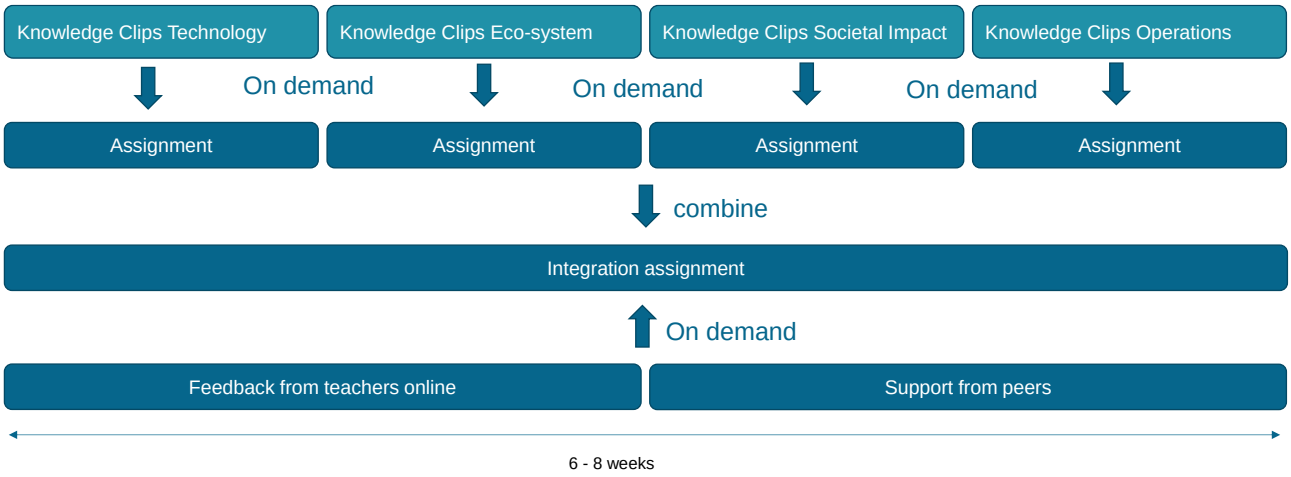

Figure 8: Design of the MOOC/SPOC

6.3 Development process

During the course of the 5G Blueprint project, the MOOC / SPOC will be developed and tested step by step. The teaching materials and assignments are first worked out and tested within the classroom of the minor and then converted to the online version. An outline of the development process is shown in Figure 9: Development processFigure 9.

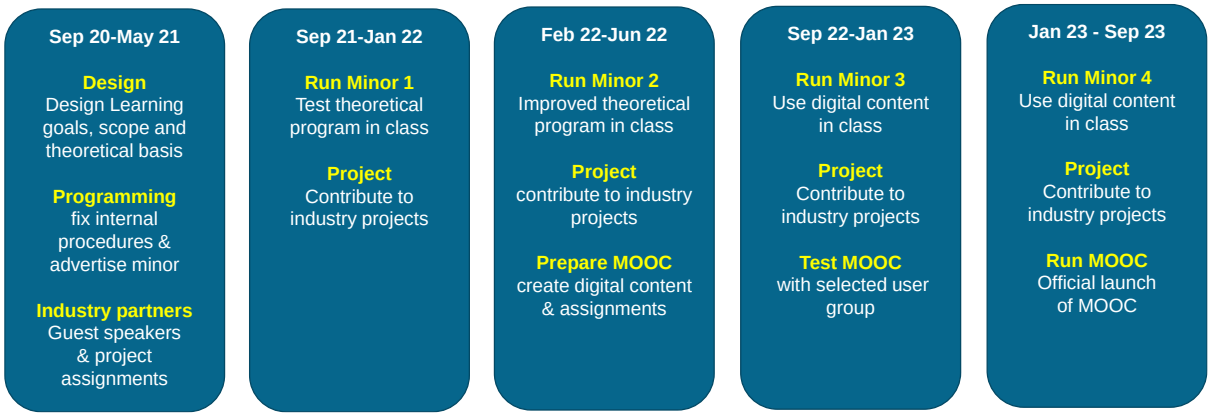

Figure 9: Development process of the minor and MOOC/SPOC

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LITERATURE

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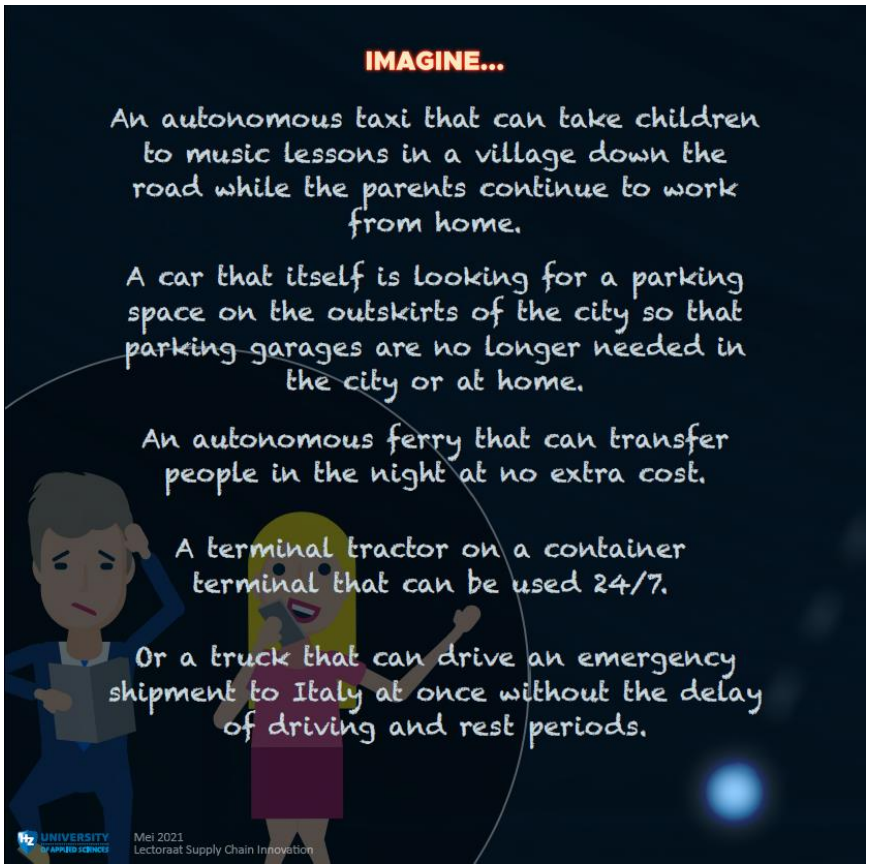
ANNEX: MINOR BROCHURE



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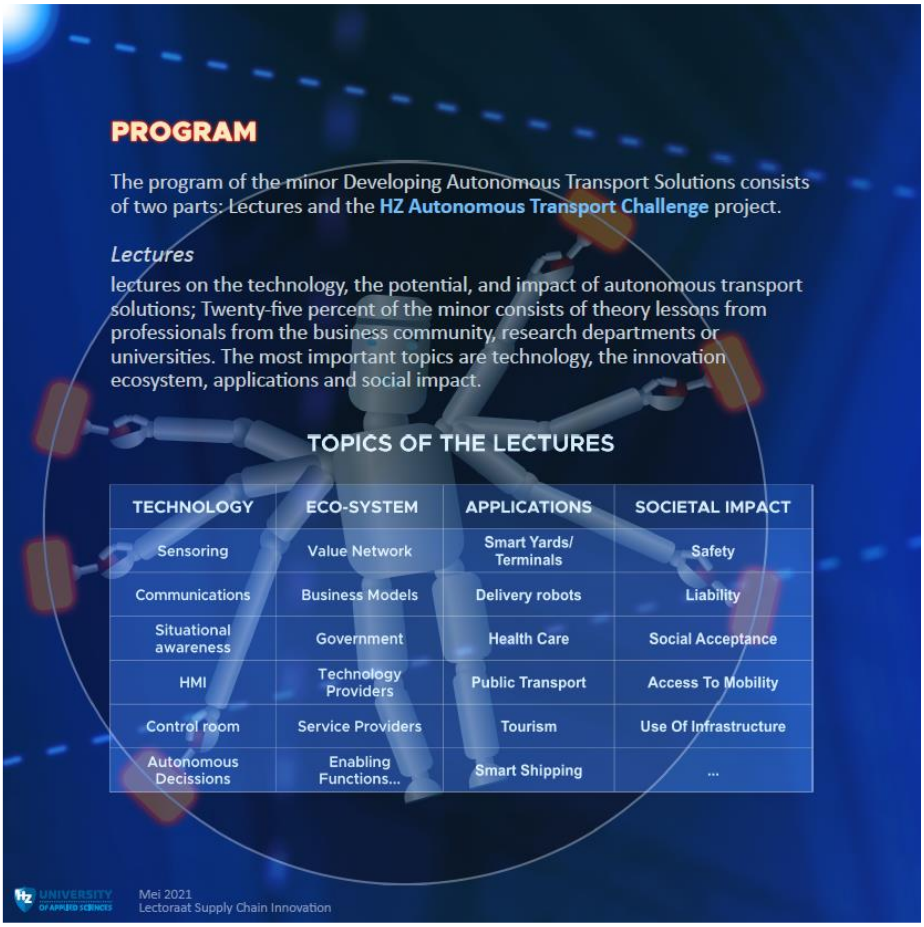
PROGRAM
The program of the minor Developing Autonomous Transport Solutions consists of two parts: Lectures and the HZ Autonomous Transport Challenge project.
Lectures
lectures on the technology, the potential, and impact of autonomous transport solutions; Twenty-five percent of the minor consists of theory lessons from professionals from the business community, research departments or universities. The most important topics are technology, the innovation ecosystem, applications and social impact.
TOPICS OF THE LECTURES
TECHNOLOGY
ECO-SYSTEM
APPLICATIONS
SOCIETAL IMPACT
Sensoring
Value Network
Smart Yards/ Terminals
Safety
Communications
Business Models
Delivery robots
Liability
Situational awareness
Government
Health Care
Social Acceptance
HMI
Technology Providers
Public Transport
Access To Mobility
Control room
Service Providers
Tourism
Use Of Infrastructure
Autonomous Decissions
Enabling Functions...
Smart Shipping
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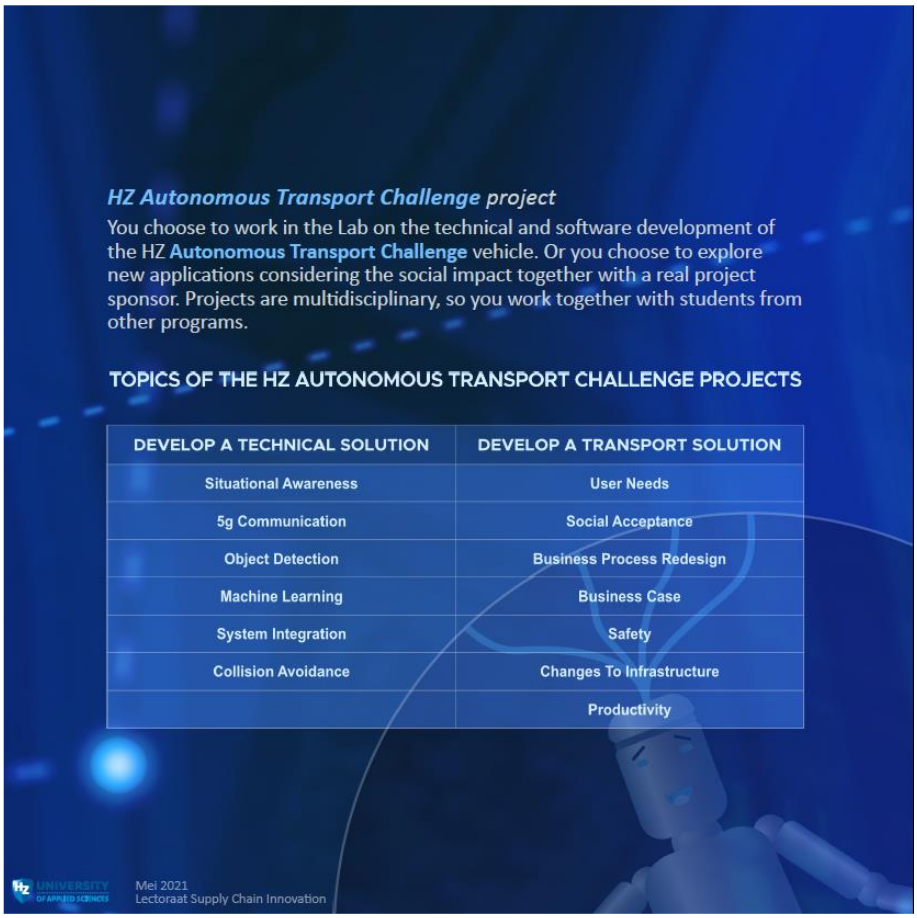
HZ Autonomous Transport Challenge project
You choose to work in the Lab on the technical and software development of the HZ Autonomous Transport Challenge vehicle. Or you choose to explore new applications considering the social impact together with a real project sponsor. Projects are multidisciplinary, so you work together with students from other programs.
TOPICS OF THE HZ AUTONOMOUS TRANSPORT CHALLENGE PROJECTS
DEVELOP A TECHNICAL SOLUTION
DEVELOP A TRANSPORT SOLUTION
Situational Awareness
User Needs
5g Communication
Social Acceptance
Object Detection
Business Process Redesign
Machine Learning
Business Case
System Integration
Safety
Collision Avoidance
Changes To Infrastructure
Productivity
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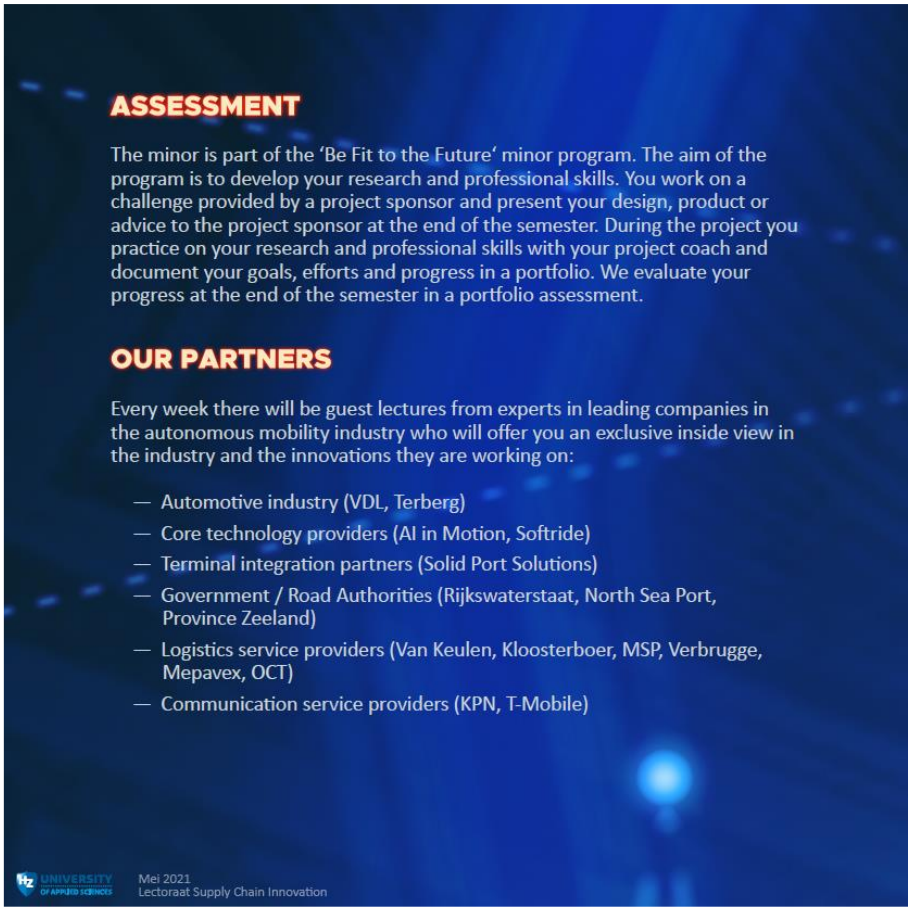
ASSESSMENT
The minor is part of the 'Be Fit to the Future' minor program. The aim of the program is to develop your research and professional skills. You work on a challenge provided by a project sponsor and present your design, product or advice to the project sponsor at the end of the semester. During the project you practice on your research and professional skills with your project coach and document your goals, efforts and progress in a portfolio. We evaluate your progress at the end of the semester in a portfolio assessment.
OUR PARTNERS
Every week there will be guest lectures from experts in leading companies in the autonomous mobility industry who will offer you an exclusive inside view in the industry and the innovations they are working on:
— Automotive industry (VDL, Terberg)
— Core technology providers (AI in Motion, Softride)
— Terminal integration partners (Solid Port Solutions)
— Government / Road Authorities (Rijkswaterstaat, North Sea Port, Province Zeeland)
— Logistics service providers (Van Keulen, Kloosterboer, MSP, Verbrugge, Mepavex, OCT)
— Communication service providers (KPN, T-Mobile)
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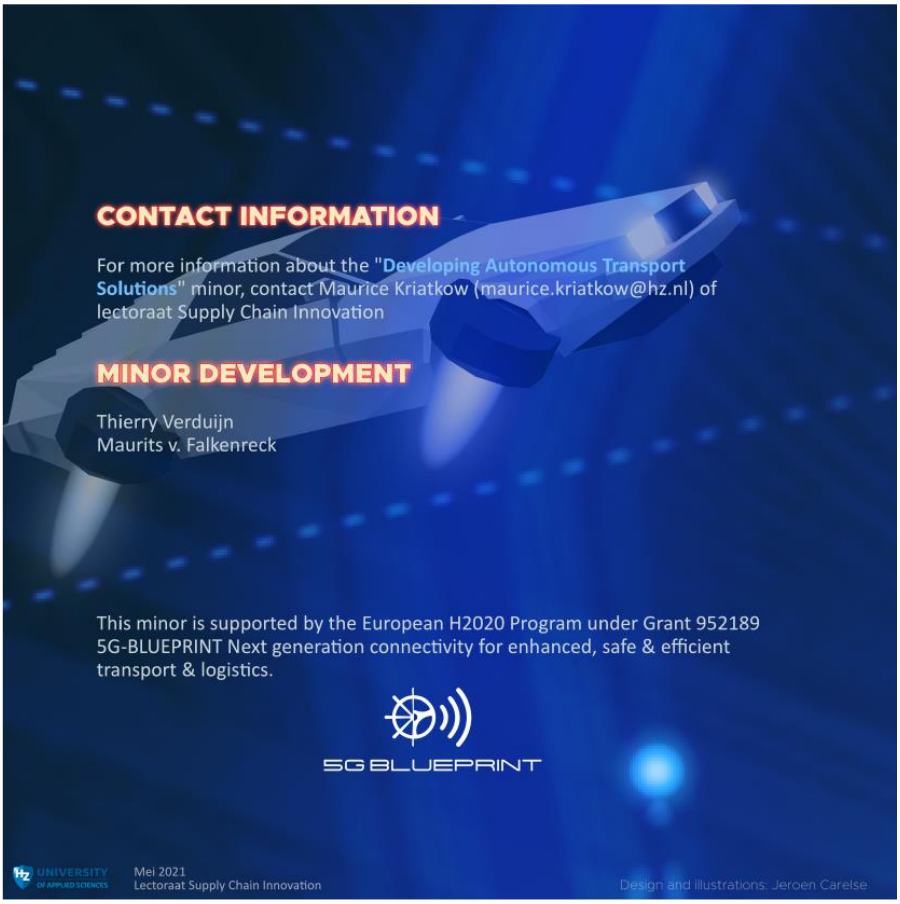
CONTACT INFORMATION
For more information about the "Developing Autonomous Transport Solutions" minor, contact Maurice Kriatkow (maurice.kriatkow@hz.nl) of lectoraat Supply Chain Innovation
MINOR DEVELOPMENT
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Maurits v. Falkenreck
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5G BLUEPRINT
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