

sea;me

Software Engineering in Automotive
and Mobility Ecosystems

Course Book



Overview

- 12-Month Advanced Studies to code the future of mobility
- Cost-free curriculum, learning environment, and equipment
- Direct connections to experts, mentors, employers
- Our fellow experts as core contractors represent Volkswagen, Microsoft, msg DAVID, MicroNova, MBition, CARIAD, IAV, NEC Laboratories and more

Course Book

SEA:ME means studying in a master-level curriculum focused on coding and mobility. It is the first applied curriculum that takes a 360° approach to mobility - training students in areas from in-vehicle circuitry programming to mobility ecosystems that guide and structure how we all move. We are looking for students with prior tech expertise - but also for students coming from mobility research backgrounds with beginning coding experience.

The primary audience of this course book is naturally one of potential students - but we aim to brief and inspire anyone with an interest in mobility and in the potential of software to shape its future.

The 12-month curriculum as we introduce it here - and in the first study season starting this July - will be a continuously evolving product. It is offered as an Open Educational Resource (OER) and lives and breathes based on the contributions of experts from mobility tech, research, and education. This first version already draws on expert knowledge and testing from project fellows. And we are constantly looking to recruit more expert supporters - from industry as well as from tech and social science, mobility research, consultancy and advocacy. And not least from the ranks of practitioners who shape

public application, management and policy around mobility.

By using peer-learning and hands-on projects, our students become job-ready in 12 months. And have direct access to career opportunities via expert supporters and company partners that are part of the SEA:ME learning community. During the program, they are included in growth-focused workshops and events as well as in direct feedback loops with supporting expert fellows.

Based on the non-profit nature of its initiators, and on support from a variety of sponsoring partners, this program is 100% tuition free.

Why Study SEA:ME?

This new curriculum is a one-of-a-kind opportunity to learn about software development for all types of mobility. We help you to educate yourself - to be a part of coding & shaping the future of how we all move. Also, it is completely cost-free.

There is nothing like this program yet - with its broad content, with your ability to choose which parts you focus on, and with our approach to learning that is community-based without teaching.

In just 12 months, you are trained job-ready - to start as a software developer in companies and institutions that provide software solutions for mobility. And you will already be connected with the partners that support our program - because they want to hire our graduates. This includes anywhere from traditional automakers, to new mobility / sharing providers, and to renowned global software companies that also provide backbone mobility software.

Our content is shaped by experts who work in the field - and who are a part of our community. This whole program is built around our learning community - built by us with students and with the experts that volunteer to support. We all boost each other in learning and innovating together.

While you are in the program, you learn from each other. Groups working on projects in their own focus areas help other groups understand what they are doing, and show each other their results and solutions. In this way, each student gets a broad overview of all mobility software areas even without working on all areas personally.

While you are acquiring technological expertise, we also introduce you to mobility concepts, how mobility affects our lives, what it currently looks like and how it can be changed for the better. Experts and a broad selection of learning materials will enable you to understand how different people in different places and circumstances experience mobility differently. And how you and all of us can leverage innovation and the potential of software to improve other people's lives and to make our own everyday lives more enjoyable through new types of mobility.

We are building a dedicated lab for this program that we will make available 24/7 to our students and to all contributors for shared learning, play, and social interaction. We are also building an online knowledge base around the program that will provide additional learning opportunities. And finally, we look forward to the input and feedback that our students provide - to learn from each other and to grow this new learning ecosystem together.

This program and learning community will be unique. We will share the learning content as an Open Educational Resource, for institutions worldwide to replicate. BUT, for the near future this program is the only one of its kind, in only one location: Wolfsburg. You can be the first to train in this way, by becoming a part of our first group of students starting in 2023 and graduating in 2024.

Why Study Mobility?

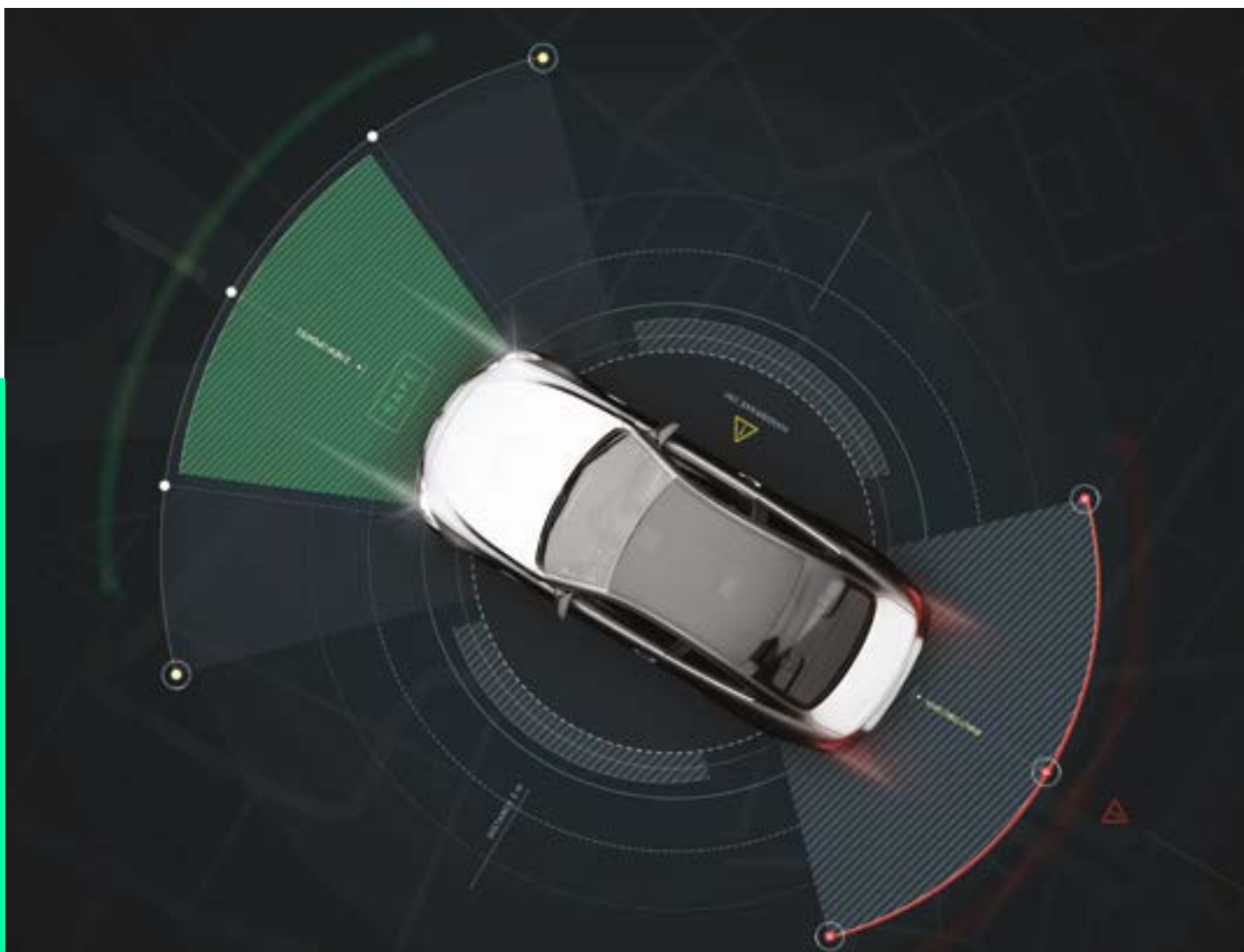
Mobility is one of the major factors shaping our lives and our surroundings. The future of our societies and how we live together. And not least how we can retain this planet as a living environment for all of us despite climate change.

At the same time, many improvements in mobility - for more access, choice, and freedom of movement - are becoming possible today by leveraging the innovative and disruptive potential of software.

Finally, the field of mobility software development offers some of the best career / personal development opportunities among any software-related fields of work. Today, companies and institutions in Germany and worldwide are competing with each other to hire, inspire, and

retain specialized software developers. Not least because they constantly lack developers.

In the "Soft Curriculum" part of this Course Book, we lay out examples of the inspiration and opportunities that await you. And how you can both change your own life and make an impact on shaping our shared living environments locally and globally for the better.



Why Study SEA:ME at 42 Wolfsburg?



At 42 Wolfsburg, students learn coding fundamentals at great speed and high quality. They become job-ready in 18-24 months by studying cost-free in a peer learning environment. Peer learning is a form of education where individuals learn from each other in a collaborative and supportive environment. The goal is to create a community of learners who share their knowledge, skills, and experiences to help each other grow and succeed. In the case of the SEA:ME Curriculum, this is further improved by including experts / practitioners who become part of the learning community and share their knowledge with students. And by scaling the timeline down to just 12 months of study.

42 Wolfsburg, with its downtown campus and its standalone mobility lab, provides a unique space for students to study, socialize, enjoy student-centered community events ranging from play to networking and skill-building, and can access pools of 200+ computers. All of this 24/7. At 42 Wolfsburg, students enter an environment in which they grow by learning about both tech content and life skills - as part of a community with their peers, staff, and supporters of the school.

Meanwhile, Wolfsburg as a city is the global brand name and focal point for mobility. As the hub of the global VW ecosystem and of a whole region hosting supplier and developer companies, it is at the heart of the change toward software-driven mobility both in Germany and within Europe.

In Wolfsburg and the larger region, there are a multitude of companies that are looking at Wolfsburg and our 42 Network campus, because we are the first institution worldwide that combines next-generation peer learning in software development with a dedicated curriculum for mobility. These industry players are looking toward getting to know our results both in terms of innovation and in terms of SEA:ME graduates whom they can recruit.

Within Germany and Europe, the brand name "Wolfsburg" creates instant attention and curiosity when anything related to mobility and innovation are discussed. This provides us and our students unrivaled opportunities to be at the heart of discussion, ideation, and joint innovation around mobility. Together with play-

ers ranging from car industry greats to software companies working on mobility solutions, to science, consultancy and advocacy around mobility. Students studying our curriculum in Wolfsburg are included in relationships and discourses that simply do not emerge in the same quick and organic way elsewhere.

The city, unlike larger ones, offers students ease of living, ease of renting, and a shared student community with the whole coding campus of 42 Wolfsburg. Here, it is possible to focus on study while having easy access to peers, community events and shared activities. Via 42 Wolfsburg relocation services and easy access to affordable accommodation of multiple types is provided. All in close proximity to the lab and the school's main campus.

Wolfsburg is located in the geographic middle of Germany, with easy train connections to Berlin in the East (1 hour), Hamburg up north (2 hours), Cologne and "Ruhrgebiet" region (3hrs), Munich or Amsterdam (4-5 hours).

Wolfsburg is a city that is set apart by the quality of everyday life it offers - with easy access to all services and places of daily need, much green space and areas for sport and relaxation. And with the shape of a walkable / bikeable city in which students can move around in an atmosphere that markedly differs from the ever-growing stress, rush, and risks in everyday traffic and life that large cities are known for. Life in Wolfsburg is easy. Relocating to Wolfsburg for 12 months of study is also easy. And finding inspiration and openings for your next steps, while taking our curriculum, is also easy.

How to Study SEA:ME

Below, we are providing in-depth information on the approach and on the modules / projects that form the new SEA:ME Curriculum.

Our students can choose which module to focus on. In groups and individually, you may cover as much of the content as you want and can within 12 months. And you can adjust your choice while in the program, based on new impressions.

Overall, the contents presented in this course book - and provided in our new curriculum - can provide you with a comprehensive understanding of software engineering in automotive and mobility ecosystems. All of the content is created for students with a focus on peer-learning - i.e. learning that is driven by community, mu-

tual inspiration, learning from experts and each other - but not from sitting in class listening to teachers.

By incorporating hands-on projects, case studies, and direct industry insights, you develop the skills and knowledge that you need to succeed in this dynamic and rapidly evolving field. Including the crucial job-related skills of a) learning how to learn, and b) learning how to work with others in order to innovate, ideate, and create.



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Mobility Software Development

This section focuses specifically on the development of software for the mobility industry, covering topics such as embedded systems, software architecture for vehicles, and safety-critical systems.

The development of software for the mobility industry requires a specific set of principles and considerations due to the unique nature of the technical environment. Some of these core principles are:

- 1. Embedded Systems:** Software for use in vehicles is often developed for embedded systems, which are small computer systems integrated into other products. The software must be optimized for low power consumption, small memory footprints, and real-time performance.
- 2. Software Architecture for Vehicles:** The software architecture for vehicles must be designed to accommodate the specific needs of the automotive environment. This includes considerations for networked systems, the integration of sensors and actuators, and the need for high reliability and safety.
- 3. Safety-Critical Systems:** Safety is a top priority in the mobility industry, and software for vehicles must be designed to meet the highest safety standards. This includes implementing fail-safe mechanisms, redundant systems, and rigorous testing and validation processes.
- 4. Functionality and Usability:** Mobility software must provide a high level of functionality and usability for drivers and passengers. This includes considerations for human-machine interaction, navigation and infotainment systems, and advanced driver assistance systems.
- 5. Interoperability:** The software must be designed to work seamlessly with other systems and technologies within the vehicle. This can be achieved by integration of different communication protocols and use of open standards where possible.
- 6. Security:** The software must be designed to protect against hacking and other security threats, as well as ensuring the privacy and confidentiality of sensitive data.
- 7. Scalability and Flexibility:** The software must be designed to accommodate future updates and changes to the vehicle, as well as the ability to easily integrate new technologies and features.
- 8. Robustness and Resilience:** All software has to operate reliably and consistently in any conditions, including extreme temperatures, vibration, and electromagnetic interference.
- 9. Certification and Compliance:** The software must meet industry standards and regulations for safety, security, and environmental sustainability. This includes certification from organizations such as ISO, SAE, and the European Union.

By following these core principles, software developers in the mobility industry can ensure that their systems are safe, reliable, and meet the highest standards of performance and quality.

Peer Learning Techniques

This section introduces you to the various methods and techniques for peer learning - including collaboration, teamwork, and mentorship - that you will use during your SEA:ME studies.

Peer learning is a form of education where individuals learn from each other in a collaborative and supportive environment. The goal is to create a community of learners who can share their knowledge, skills, and experiences to help each other grow and succeed. In the case of the SEA:ME Curriculum, this is further improved by including experts / practitioners who become part of the learning community and share their knowledge with students.

There are several methods and techniques for successful peer-to-peer learning, including:

- 1. Collaboration:** This involves working together with others on a common goal or project. Collaboration can take many forms, including group projects, study groups, and peer-reviews. This allows individuals to learn from each other's perspectives, skills, and experiences and to develop their teamwork and communication skills.
- 2. Teamwork:** Teamwork involves working together as a team to achieve a common goal. This can include sharing responsibilities, delegating tasks, and supporting each other. Teamwork helps individuals to learn how to work effectively with others, to develop leadership skills, and to build trust and cooperation.
- 3. Mentorship:** Mentorship is a relationship between an experienced individual and a less experienced individual. The mentor provides guidance, support, and advice to the mentee to help them achieve their goals. Mentorship can take many forms, including one-on-one relationships, group mentorship, and online communities. This helps individuals to learn from the experiences and insights of others and to develop their own skills and expertise. In the SEA:ME curriculum, we make use of dedicated fellows - practitioners from industry, science and mobility consulting - who are volunteering to support our students on their learning journey. This provides direct access not just to expertise and feedback, but also to learning about what is demanded in real-life work environments where software for mobility is produced.
- 4. Learning Communities:** These are spaces - online, offline, or hybrid - where individuals can connect and collaborate with each other. They allow individuals to learn from a wider range of perspectives and to connect with others who share their interests and goals (. They allow for self-directed shared learning, by participants teaming up around shared interests and ideas, driving their own projects forward and sharing with each other.
- 5. Self-directed Learning:** Self-directed learning involves taking responsibility for one's own learning and development. This can include setting goals, creating a learning plan, and seeking out resources and support as needed. Self-directed learning allows individuals to develop their autonomy, creativity, and critical thinking skills.
- 6. Gamification:** Gamification is the use of game design elements in non-game contexts to engage and motivate individuals. This can include using points, badges, and leaderboards to create a competitive and fun learning experience. Gamification can help individuals to develop their motivation and engagement with learning.
- 7. Action Learning:** Action learning involves applying the knowledge and skills acquired in a learning experience to a real-world problem or challenge. This helps individuals to develop their practical skills and to gain experience in solving real-world problems.

By using these methods and techniques, peer-to-peer learning can help students to develop their knowledge, skills, and confidence in a supportive and collaborative environment. It also allows individuals to take an active role in their own learning and development and to connect with others who share their interests and goals. And it also trains students in how real-life work environments of software developers function - and in how they can succeed in collaborating and knowledge-sharing with their colleagues and become successful in what they do.

Reflective Practice and Self-assessment

This section provides students with opportunities for self-reflection and self-assessment, helping them to evaluate their own learning and progress and set goals for future growth.

Self-reflection and self-assessment are core aspects of peer-to-peer learning that allow students to evaluate their own learning and progress. These activities enable students to gain insight into their own strengths and weaknesses, identify areas for improvement, and set goals for future growth. The aim is to help students understand their own learning style, identify their individual learning needs, and develop effective strategies for meeting those needs.

Self-reflection involves taking time to think critically about one's own learning experiences and the outcomes of those experiences. It may involve asking questions like: What did I learn from this project? How did I approach this task? What could I have done differently? What worked well and what didn't? What can I learn by comparing my approach to that of other students, learning from each other?

Self-assessment, on the other hand, involves evaluating one's own performance against a set of criteria or standards. This may involve self-grading assignments, evaluating one's own work against a rubric, or using self-assessment tools like checklists or questionnaires.

The goal of self-reflection and self-assessment is to help students take ownership of their own learning and development. By critically examining their own performance, they can identify areas for improvement, set goals, and make changes that will help them achieve their goals. Additionally, these activities help students develop self-awareness, self-confidence, and self-efficacy, all of which are important skills that can be applied in various settings, both in and outside of the learning environment.



SEA:ME Warm Up

A 2-week intensive workshop to introduce peer learning and collaboration among students using GitHub is a great way to help students develop valuable skills in teamwork, software development, and open-source collaboration.

Goals:

- 1.** Introduce students to GitHub and how it can be used for collaboration and version control.
- 2.** Introduce students to the Qt framework and provide an overview of how it can be used to develop GUI applications using C++/Qt/Qml.
- 3.** Encourage students to collaborate with each other and to help each other learn.
- 4.** Provide students with the opportunity to practice open-source collaboration.
- 5.** Foster a sense of community and teamwork among the students.

Throughout the workshop, students should be encouraged to communicate with each other and to help each other learn. By the end of the workshop, students should feel more comforta-

Objectives:

- 1.** By the end of Day 1, students should be able to create their own GitHub accounts, create repositories, and make commits.
- 2.** By the end of Day 2, students should have a basic understanding of the Qt framework and be able to create a simple C++ application.
- 3.** By the end of Week 1, students should be able to work in pairs or small groups to develop a Qt application, and should be comfortable using GitHub to collaborate on their project.
- 4.** By the end of Week 2, students should have joined an open-source project on GitHub that uses Qt, and should have made contributions to the project.

ble collaborating with others and should have a greater appreciation for the value of peer learning.



Tech Curriculum

This section gives an overview of how you can apply your knowledge and skills in real-world scenarios through solo/group projects and case studies focused on software engineering in mobility ecosystems. Students choose which projects in which of the 3 below focus areas they want to work on. For this, students form teams, switch teams, and collaborate in and between teams from project to project. In so doing, students tailor their own learning path and what / how much they learn within 12 months.

Module 1: Distributed Embedded Systems

Distributed embedded systems in the mobility industry are complex systems that combine hardware, software, and networking components to create advanced and highly integrated systems for vehicles. These systems typically include a wide range of components, including microcontrollers, sensors, actuators, and communication networks.

One of the key features of distributed embedded systems is their use of multiple microcontrollers, each of which is responsible for a specific function or task. For example, one microcontroller may be responsible for controlling the engine, while another may be responsible for controlling the infotainment system. These microcontrollers are connected through a communication network, such as Controller Area Network (CAN) or Local Interconnect Network (LIN), which enables them to exchange data and collaborate to achieve the desired behavior of the vehicle.

Another important aspect of distributed embedded systems is the use of software. This includes both low-level software, such as drivers and firmware, and high-level software, such as user interfaces and applications. The software used in these systems must be highly reliable and performant, as it is responsible for critical functions such as safety and performance.

The use of networking technologies, such as Ethernet and SOMEIP/CommonAPI, is also critical for distributed embedded systems in the mobility industry. These technologies enable vehicles

to connect to other vehicles, to infrastructure, and to the internet, creating a highly connected and intelligent mobility ecosystem.

The development of distributed embedded systems in the mobility industry requires a deep understanding of a wide range of technologies, including hardware, software, and networking. Additionally, it requires close collaboration between hardware and software engineers, as well as designers and testers, to ensure that the systems are reliable, performant, and meet the complex requirements of the industry and users.

Overall, distributed embedded systems in the mobility industry are critical components of the modern vehicle, and play a key role in enabling the development of advanced and highly integrated systems for vehicles. Whether it is for safety, performance, connectivity, or entertainment, these systems are essential for delivering a high-quality and innovative driving experience.

Learning distributed embedded systems in the mobility industry through peer-to-peer educational projects is a great way to gain hands-on

experience and to develop practical skills that are highly relevant to current and future industry requirements. The following steps can be taken to get started:

- 1. Familiarize yourself with the fundamentals:** Start by learning the basics of distributed systems, embedded systems, and the automotive industry. This may include topics such as automotive communication protocols (e.g. CAN, LIN, Ethernet), embedded software development (e.g. RTOS, programming languages, debug techniques), and automotive industry trends and requirements (e.g. autonomous vehicles, connectivity, electrification).
- 2. Form a group:** Find other students with similar interests and form a group to work on educational projects together. Having a group can provide a supportive environment, facilitate collaboration, and provide opportunities to learn from one another.
- 3. Identify project ideas:** Choose a project idea that aligns with your interests and skills, and that is relevant to the current or future requirements of the automotive industry. Some possible project ideas include developing a digital twin of a vehicle, building an autonomous vehicle control system, or designing a networked system for electric vehicle charging.

- 4. Divide tasks:** Divide the project into smaller tasks that can be worked on by individual team members. This will make it easier to manage the project, keep track of progress, and ensure that everyone has a clear role to play.
- 5. Start coding:** Start coding and implementing the project using the tools, technologies, and platforms that are relevant to the automotive industry (e.g. Qt, Wayland, VSOMEIP/CommonAPI, etc.).
- 6. Test and refine:** Regularly test the project and refine it based on the results. This will help to identify and resolve issues, improve performance, and ensure that the project meets industry requirements.
- 7. Present and share:** Once the project is complete, present it to others and share your experience and learning. This will provide an opportunity to showcase your work, receive feedback, and connect with others in the industry.

By following these steps, students can develop a deeper understanding of distributed embedded systems in the mobility industry and to gain practical skills that are in high demand in the job market. Additionally, working on peer learning educational projects can help to foster a sense of community and provide opportunities for collaboration and networking.

Project Descriptions

Hosted as Open Educational Resource [OER] on GitHub

DES Project 1 - DES Project - PiRacer Assembly



The purpose of this project is to provide students with hands-on experience in assembling and testing a PiRacer, a small, single-board computer-based racing car. The project will cover the basics of electronics, programming, and robotics, and will provide students with a foundation in these important areas of technology.



DES Project 2 - DES Project - Instrument Cluster



The PiRacer instrument cluster Qt application project is aimed at creating a real-time speedometer for a racing car. The application will run on a Raspberry Pi and receive speed data from a speed sensor via the Controller Area Network (CAN) protocol. This project will provide an opportunity for students to gain practical experience in software engineering, specifically in the areas of embedded systems, software architecture, and communication protocols. The project will also allow students to apply their knowledge of the Qt framework, which is widely used in the automotive industry for developing embedded applications. The successful completion of this project will demonstrate the students' ability to design and implement a real-world software solution, and their ability to effectively communicate their results.



DES Project 3 - DES Project - Head Unit



This project aims to develop a Head Unit Qt application running on a Raspberry Pi (RPI) alongside the previously developed PiRacer Instrument Cluster Qt application. The Head Unit application will provide additional features like ambient lighting, gear selection, and a media app. The project will use Yocto as the build system for the RPi.



DES Project 4 - DES Project - PDC System



The goal of this project is to enhance the Piracer by integrating a Park Distance Control (PDC) system, running on a Raspberry Pi (RPI) inside the head unit. The PDC system will utilize ultrasonic sensors to detect the distance between the vehicle and any obstacles, and provide an audible response to the driver. In addition, the full stack feature development will be integrated into the existing Yocto image, creating a comprehensive and fully functional system. The project aims to provide hands-on experience in developing and integrating advanced driver-assistance features, as well as provide a deeper understanding of the software and hardware involved in modern vehicles. The following sections will provide further details on the technical requirements, system architecture, software design, implementation, results, and references for this project.



DES Project 5 - DES-ME Project - SDV



In this project, you will learn how to design an SDV using Kubernetes/clusters by creating a network of nodes that run the hardware, software, and network components of the vehicle, and managing and orchestrating these components using Kubernetes. You will explore the different hardware and software components of an SDV, and learn how to integrate them using Kubernetes. You will also learn how to manage and orchestrate the network components of an SDV, ensuring that the different software components can communicate with each other and with other systems. Overall by the end of this project, you will have a solid understanding of how to design an SDV using Kubernetes/clusters.



Module 2:

Autonomous Driving Systems

The term autonomous driving systems refers to advanced technology that allows vehicles to drive themselves without human intervention. These systems are designed to provide a high degree of safety, comfort, and efficiency, and to make driving more convenient and accessible for people.

Autonomous driving systems typically consist of a combination of hardware and software components. The hardware components include sensors, such as cameras, radar, and lidar, that are used to gather information about the vehicle's surroundings. This information is processed by the system's control unit, which includes a central computer and various microcontrollers. The software components of the system include algorithms that use the information gathered by the sensors to make decisions about the vehicle's movements and behavior.

Autonomous driving systems use various technologies and techniques to enable vehicles to drive themselves, including machine learning, computer vision, and control systems. Machine learning algorithms are used to analyze the vast amounts of data generated by the sensors and to make predictions about the behavior of other road users and the environment. Computer vision algorithms are used to interpret the images captured by cameras and to detect objects and features in the environment. Control systems algorithms are used to control the vehicle's movements, including steering, acceleration, and braking, based on the information gathered by the sensors and the predictions made by the machine learning algorithms.

The development of autonomous driving systems requires a multidisciplinary approach, bringing together expertise from fields such as computer science, electrical engineering, mechanical engineering, and more. The development process involves a combination of simulation, testing, and real-world deployment, as well as close collaboration between software engineers, hardware engineers, and designers.

Overall, autonomous driving systems have the potential to transform the mobility industry, providing safer, more convenient, and more accessible driving experiences for people. However, the development of these systems is complex and challenging, requiring close collaboration

between various disciplines and a deep understanding of the technologies and techniques involved.

Learning autonomous driving systems through peer learning educational projects can provide students with hands-on experience and a deeper understanding of the current and future industry requirements. In this type of educational approach, students work together in small teams to design and develop projects related to autonomous driving systems. These projects are designed to be closely aligned with current and future industry requirements, ensuring that students gain the skills and knowledge that are most relevant and in-demand.

Here are a few steps that could be involved in learning autonomous driving systems through peer learning educational projects:

- 1. Familiarization with key technologies:** Students start by gaining an understanding of the key technologies and concepts involved in autonomous driving systems, such as computer vision, machine learning, and control systems. Students also familiarize themselves with opportunities, limits, and ethical / governance questions around the use of autonomous vehicles.
- 2. Team formation and project selection:** Students then form teams and select a project that they want to work on. The project should be relevant to autonomous driving systems and aligned with current and future industry requirements.
- 3. Project planning and development:** Teams then plan and develop their projects, working together to integrate the various components of the autonomous driving system, such as sensors, control units, and software algorithms.
- 4. Testing and validation:** Teams then test and validate their projects, both in simulation

and in real-world environments, to ensure that the system meets the desired requirements.

- 5. Presentation and reflection:** Teams then present their projects to their peers and instructors, reflecting on what they learned and what could be improved.

Peer-to-peer educational projects provide students with the opportunity to work on re-

al-world projects, develop their technical and team-working skills, and gain hands-on experience in developing autonomous driving systems. This approach also provides students with an understanding of the current and future industry requirements and helps to prepare them for careers in the mobility industry.

Project Descriptions

Hosted as Open Educational Resource (OER) on GitHub

ADS Project 1 - ADS Project - Autonomous Lane Detection with PiRacer



"Autonomous Lane Detection with PiRacer: A Hands-On Approach to Self-Driving Vehicles" is a peer-to-peer educational project aimed at introducing students and hobbyists to the exciting world of autonomous vehicles. The project focuses on using the Raspberry Pi and various sensors and actuators to build a low-cost yet powerful autonomous vehicle. The goal of the project is to demonstrate how a simple computer like the Raspberry Pi can be used to develop an autonomous vehicle that can detect lanes and maintain its position within them. With a hands-on approach, participants will learn about the fundamentals of autonomous vehicles and gain practical experience in building one themselves.



ADS Project 2 - ADS Project - Object Detection and Avoidance with PiRacer



In this peer learning project, you will learn how to build a state-of-the-art autonomous vehicle that can detect and avoid obstacles using the Raspberry Pi and various sensors. The PiRacer is an open-source platform designed to introduce you to the principles of robotics and computer vision, as well as the latest advancements in artificial intelligence and machine learning. Whether you are a beginner or an experienced engineer, you will find this project to be both challenging and rewarding, as you gain hands-on experience in the design, construction, and programming of autonomous vehicles.



ADS Project 3 - ADS Project - Road Surface Segmentation using PiRacer



Road Surface Segmentation is a crucial task in the development of autonomous vehicles. Accurate road surface segmentation is essential for maintaining the stability and safety of self-driving vehicles by providing a clear understanding of the available driving space in real-time. In this peer learning educational project, participants will develop an algorithm for road surface segmentation using the Piracer platform.

The objective of this project is to create an algorithm that can accurately segment the road surface in real-time video streams captured from a moving vehicle. The algorithm will be evaluated based on its ability to segment the road surface in various lighting and weather conditions, its computational efficiency, and its accuracy in the presence of complex objects, such as trees, buildings, and other vehicles.

Participants will use a combination of computer vision techniques and deep learning to develop their solution. They can use open-source tools and libraries, such as OpenCV, TensorFlow, and PyTorch, to implement their algorithm. The project will provide participants with hands-on experience in developing real-world computer vision applications, and it will help them build their skills in image processing, deep learning, and software development.



ADS Project 4 - ADS Project - Self-driving mail delivering PiRacer



The project will be structured as a competition, where teams of participants will work to build the best PiRacer for delivering mail within a simulated environment. Using Raspberry Pi computers, motors, wheels, and other off-the-shelf components, participants will write software to control their vehicles and complete various challenges, such as delivering mail accurately, navigating through obstacles, and avoiding collisions.

Throughout the project, participants will gain hands-on experience with cutting-edge technology in the field of autonomous driving, including computer vision, machine learning, control systems, and robotics. They will also develop valuable skills in software engineering, project management, and teamwork as they work together to build their PiRacer and compete against each other.

This peer learning project is an exciting opportunity for anyone interested in autonomous driving, robotics, and technology to learn, experiment, and have fun. Whether you are a student, hobbyist, or professional, this project is a great way to expand your knowledge and skills, and be a part of the future of autonomous driving.



Module 3:

Mobility Ecosystems

Mobility ecosystems refer to the various components, technologies, and services that come together to enable safe, convenient, and efficient transportation. This includes everything from the vehicles themselves, to the infrastructure, services, and regulations that support them.

It also includes how environments in which mobility takes place are shaped and can be reshaped to enable different and new mobility offers and opportunities. Including by use of new opportunities provided by the power of software.

The following are some key components of a mobility ecosystem:

- 1. Vehicles:** Automated, connected, and electrified vehicles are increasingly becoming the norm, and are a critical component of the mobility ecosystem. These vehicles are equipped with advanced technologies that support autonomous driving, vehicle-to-vehicle communication, and more.
- 2. Infrastructure:** Infrastructure plays a critical role in enabling safe and efficient mobility. This includes everything from roadways and highways, to charging and fueling stations, to parking facilities.
- 3. Services:** A wide range of services are essential for supporting the mobility ecosystem, including ride-sharing services, real-time traffic and navigation systems, and predictive maintenance services.
- 4. Regulations:** Regulations play a crucial role in shaping the mobility ecosystem, including everything from vehicle safety and emissions standards, to licensing and liability laws.
- 5. Data:** Data is increasingly becoming a key component of the mobility ecosystem, as it enables real-time monitoring, analysis, and prediction of various aspects of the transportation system, such as traffic patterns, vehicle performance, and more.
- 6. Stakeholders:** A wide range of stakeholders are involved in the mobility ecosystem, including mobility service providers, auto-

makers, technology companies, government agencies, smart city builders, and more.

The mobility ecosystem is constantly evolving and changing, driven by technological innovation, changing consumer preferences and evolving needs of both individual users and transportation / freight companies. As such, it is important for students and professionals in the mobility industry to have a deep understanding of the mobility ecosystem, as well as the various components and technologies that make it up. This knowledge can help them to develop new solutions and services that support the evolving needs of mobility providers and users.

Learning about mobility ecosystems, including Vehicle-to-Vehicle (V2V) communication, Vehicle-to-Infrastructure (V2I) communication, the Internet of Things (IoT), and other related technologies, can be done through a variety of peer learning educational projects that are close to current and future industry requirements. These projects can help students and professionals to develop a deep understanding of these complex systems and the challenges they face, and to gain the skills and knowledge necessary to innovate and contribute to the development of new and improved mobility solutions.

Here are a few suggestions for peer learning educational projects that can help students and professionals to learn about mobility ecosystems in the mobility industry:

- 7. Developing a V2V or V2I communication system:** Students can work in teams to design, build, and test a V2V or V2I communication system that uses real-world data and simulates the interactions between vehicles and infrastructure in a complex transportation network.
- 8. Creating an IoT-enabled vehicle monitoring system:** Teams can work on a project that involves building a monitoring system that

uses IoT technologies to collect data from vehicles, such as speed, location, fuel efficiency, and more.

9. Building a connected and automated vehicle platform: This project can involve designing, building, and testing an autonomous vehicle platform that integrates with various components of the mobility ecosystem, including V2V and V2I communication systems, IoT technologies, and more.

10. Developing a predictive maintenance system for vehicles: Teams can work on a project to build a predictive maintenance system that uses real-world data to identify and predict potential problems with vehicles, and to recommend actions to prevent them. This encompasses both vehicles transporting individuals, vehicles of ride-sharing / public transport, and vehicles of freight transport on roads and rail.

11. Designing and building a traffic management system: This project can involve developing a real-time traffic management system that uses data from various sources, such as sensors, cameras, and GPS, to monitor traffic patterns and make predictions about traffic flow, congestion, and more. The traffic management system needs to include both individual mobility, shared / public mobility, and transportation / freight management - linking and syncing all of the participants and modes of mobility into an efficient network that considers all users / stakeholders.

By working on these types of peer learning educational projects, students and professionals can gain hands-on experience with the technologies and systems that make up the mobility ecosystem, and develop the skills and knowledge necessary to contribute to the development of innovative solutions in the mobility industry.

Project Descriptions

Hosted as Open Educational Resource (OER) on GitHub

ME Project 1 - ME Project - Digital Trip Book

The use of technology in the automotive industry has revolutionized the way we drive, providing drivers with new tools and insights to make their journeys safer, more efficient, and more enjoyable. The DriveScore TripBook project takes this to the next level, by combining two innovative approaches to automotive software engineering: digital trip books and driving score assessments.

The digital trip book component of this project allows drivers to keep track of their driving history, including information about the routes they have taken, the distances they have traveled, and the driving scores they have received. This information can be used to identify patterns and trends in their driving behavior, and to make data-driven decisions about how to improve their driving style and reduce their carbon footprint.

The driving score component provides drivers with real-time feedback and recommendations on how to improve their driving style, based on the data collected by a Controller Area Network (CAN) Bus data recorder and analyzed using Artificial Intelligence (AI) / Machine Learning (ML) techniques. This innovative approach helps drivers to optimize their driving efficiency, increase road safety, and reduce their carbon footprint.

By combining these two approaches, the DriveScore TripBook project provides drivers with a comprehensive and data-driven view of their driving behavior, allowing them to make informed decisions about how to improve their driving style and enhance their overall driving experience.



ME Project 2 - ME Project - IoT-Enabled Fleet Management



In the rapidly evolving world of logistics and supply chain management, new technologies are emerging that have the potential to revolutionize the way goods are transported and delivered. One such technology is IoT-enabled fleet management, which involves using connected devices and real-time data to optimize vehicle routes, reduce fuel consumption, and improve delivery times.

CARLA is a powerful simulation platform that provides a realistic environment for testing and developing autonomous vehicles. In this peer-to-peer educational project, participants will use telemetry data generated from CARLA simulations to explore the potential of IoT-enabled fleet management for improving logistics and efficiency.

The project will involve designing and implementing algorithms for IoT-enabled fleet management and evaluating their performance using the telemetry data. Participants will have the opportunity to work on real-world problems and gain hands-on experience with data analysis, simulation, and fleet management.

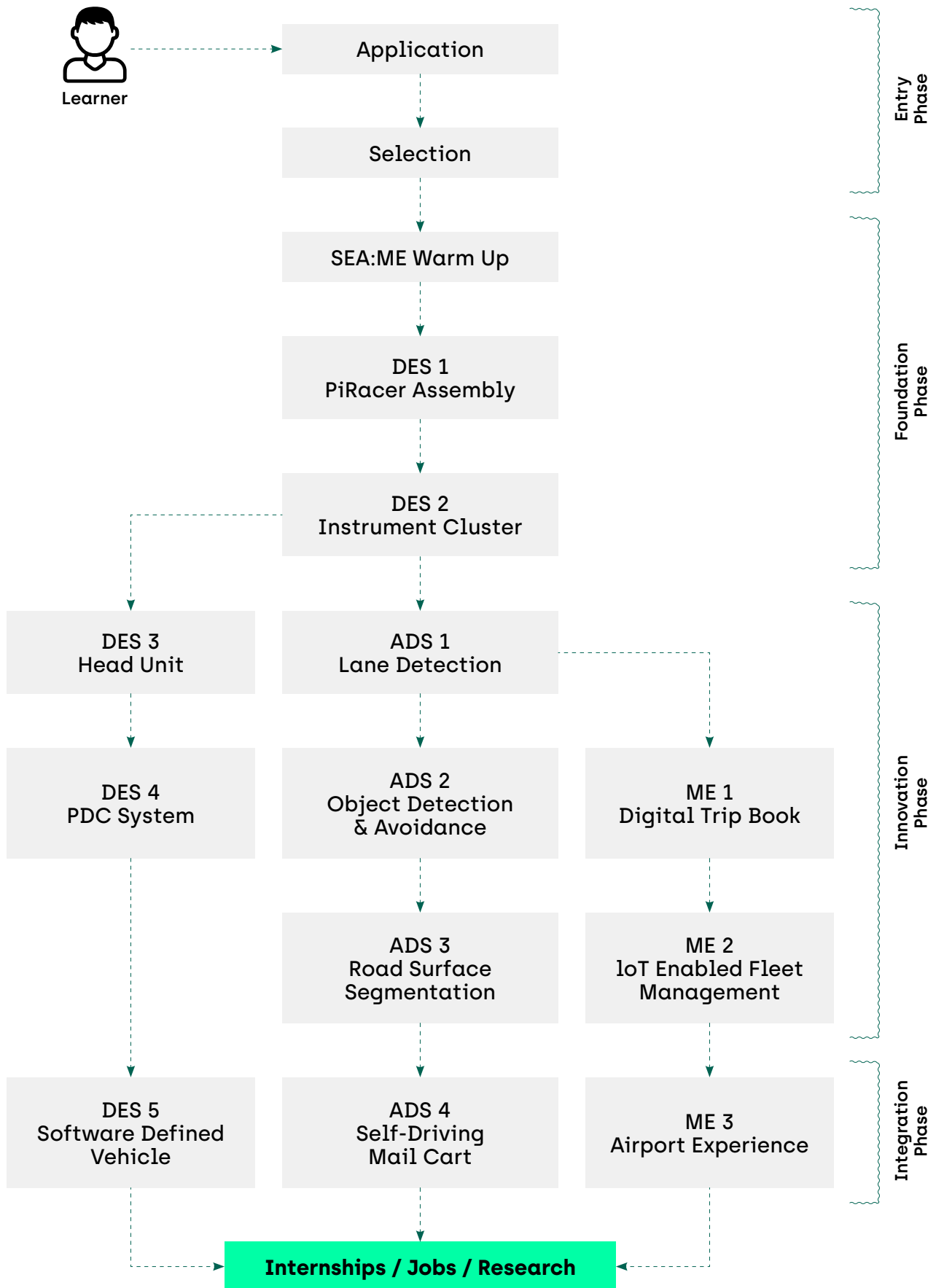
Through this project, participants will gain a deeper understanding of the benefits of IoT-enabled fleet management and the challenges and opportunities of implementing these technologies in the logistics and supply chain industries. They will also develop valuable skills in data analysis and simulation, making them well-prepared for careers in these exciting and rapidly evolving fields.



ME Project 3 - ME Project - Airport Experience



Study Roadmap



Soft Curriculum

This section features learning content about the current state and future trends and opportunities in mobility. It explores how software can be used to help create new modes and ecosystems of mobility, to increase access to mobility, and to make mobility more useful and beneficial for everyone. It also focuses on what career paths mobility software developers can take and how our learning content can be put to work at work.

Building your Professional Network / Learning from Experts

The SEA:ME Curriculum features a diverse range of experts from the mobility industry, science, advocacy, consultancy, and politics as guest speakers, workshops leads and individually approachable mentors / fellows. They share their knowledge and advice and engage in discussion with us - providing students with insights into how mobility is shaped and why, into innovation and new ideas, and into best practices and opportunities for software development for mobility. Guest speakers and workshop leads will introduce different perspectives on mobility, as well as different ways of thinking about and imagining mobility and the role(s) it plays in our lives and in how we live together and relate to each other. They will provide our students with opportunities to re-imagine mobility and their own career and life opportunities.

Mobility Knowledge-Base

For the SEA:ME Curriculum, we are building an online knowledge-base of learning materials around mobility, together with experts. Once you have started in our curriculum, you will be part of growing this 360° compendium of expert knowledge around mobility. In addition to the tech fundamentals, this learning ecosystem provides you with multi-angle insights on what mobility is, how it has evolved, how it currently presents itself, and what are ideas for upcoming innovation and re-shaping of mobility solutions that will change how all of us use, access and benefit from mobility.

You will be able to access this learning ecosystem 24/7 - and to contribute by suggesting new content that would be beneficial to our learning community. We want to actively inspire and empower you to contribute to the shared learning content and to the spectrum of ideas and inspirations that make up our community.

At the same time, any content that copyright allows will be made available open source online, so that anyone anywhere can benefit from the information and insight that we collect and share in our community. In this way, we all become creators together and share with the world at large.

Plan your Path - Career Opportunities and Professional Development

Mobility ecosystems are part of a rapidly growing and evolving industry that offers a variety of career paths and opportunities for software engineers. We will provide you with insights on possible career paths - and open up opportunities for you to participate in workshops / trainings / events that are provided at 42 Wolfsburg.

Some of the most common career paths and opportunities in mobility ecosystems include:

- 1. Embedded Systems Software Engineer:** Design, development, and testing of software for embedded systems in vehicles, such as infotainment systems, powertrains, and safety systems.
- 2. Vehicle Cybersecurity Software Engineer:** Design, development, and testing of software to ensure the security and privacy of connected vehicles.
- 3. Electric Vehicle Software Engineer:** Design, development, and testing of software for electric vehicles, including power management, battery management, and vehicle control systems.
- 4. Software Test Engineer:** Testing software for vehicles to ensure that it meets quality standards and requirements, including functional testing, performance testing, and security testing.

5. **Software Consultant:** Providing expertise and advice on software development and technology to organizations in the automotive and mobility industry, including helping organizations to adopt new technologies and best practices.
6. **Software Architecture Engineer:** Define the structure and organization of software systems in vehicles. These software engineers work on defining the high-level design of software systems, including the organization of components, interfaces, and data flows.
7. **Software Integration Engineer:** Integrate software systems in vehicles to work seamlessly with each other. These software engineers work on integrating software systems in vehicles to ensure they function correctly and communicate effectively with other systems.
8. **Human-Machine Interface [HMI] Software Engineer:** Design and develop software systems for the interaction between vehicles and their occupants. These software engineers work on systems that allow drivers and passengers to interact with vehicles through displays, buttons, and other input devices.
9. **Advanced Driver Assistance Systems [ADAS] Software Engineer:** Design and develop software systems for advanced driver assistance features in vehicles. These software engineers work on systems that assist drivers in tasks such as lane keeping, automatic braking, and adaptive cruise control.
10. **Automotive Cloud Software Engineer:** Design and develop cloud-based software systems for the automotive industry. These software engineers work on systems that allow vehicles to store and process data in the cloud.
11. **In-Vehicle Infotainment [IVI] Software Engineer:** Design and develop software systems for in-vehicle entertainment and information systems. These software engineers work on systems that provide drivers and passengers with audio, video, and other forms of entertainment and information.
12. **Vehicle Telematics Software Engineer:** Design and develop software systems for vehicle telematics, including GPS tracking, remote diagnostics, and over-the-air updates. These software engineers work on systems that allow vehicles to communicate with remote servers for various purposes.
13. **Mobile Application Developer for Mobility:** Develop mobile applications for the mobility industry. These software engineers work on developing applications that allow drivers and passengers to interact with their vehicles, access information, and perform various functions from their mobile devices.
14. **Vehicle Data Analyst:** Analyze data generated by vehicles and their systems. These analysts work on analyzing data to gain insights into vehicle performance, usage patterns, and customer preferences.
15. **Vehicle Software Support Engineer:** Provide technical support for software systems in vehicles. These engineers work on providing support to customers and users of software systems in vehicles, resolving issues, and answering questions.
16. **Software Development Operations [DevOps] Engineer:** Ensure the efficient and effective operation of software development processes. These engineers work on automating software development processes, ensuring software quality, and managing software delivery.

These are just a few of the many career paths and opportunities available to software engineers in mobility ecosystems. The industry is constantly evolving, and new opportunities are emerging as technology advances and new business models emerge. Software engineers with a strong foundation in software engineering principles, a passion for technology, and a desire to work in a fast-paced and dynamic industry are well positioned to succeed in this field.

Explore - Emerging Technologies and Trends

There are several new developments and innovations in mobility ecosystems that our students will explore and prepare to contribute to, including:

1. **Electric Vehicles [EVs]** - The increasing focus on sustainability and reducing carbon emissions has led to a growing demand for electric vehicles [EVs]. Software engineers play a crucial role in the development of EVs, working on battery management systems, charging infrastructure, and the vehicle's power electronics. They also develop software for the electric drivetrain, which includes the motor and the inverter, as well as the overall vehicle control systems.

2. **Autonomous Vehicles** - Autonomous vehicles have been a hot topic in recent years, and software engineers play a critical role in their development. They work on developing the perception, decision-making, and control systems that allow the vehicle to operate autonomously. This involves developing algorithms to detect and classify objects in the environment, make decisions based on the data collected, and control the vehicle's movements.
3. **Connected Cars** - The trend of connected cars is growing rapidly, and software engineers are working to develop new technologies to improve the driving experience. Connected cars use the internet to provide real-time traffic updates, entertainment systems, and other features, and software engineers work on developing the infotainment systems, the vehicle's internet connectivity, and the over-the-air update systems.
4. **Vehicle Cybersecurity** - With the increasing use of software in vehicles, cybersecurity has become a major concern. Software engineers are working on developing new solutions to protect vehicles against hacking, data theft, and other cyber attacks. This includes developing secure communication systems, secure boot processes, and secure data storage systems.
5. **Advanced Driver Assistance Systems (ADAS)** - Advanced Driver Assistance Systems (ADAS) are becoming increasingly common in vehicles, and software engineers play a key role in their development. ADAS systems, such as lane departure warning, adaptive cruise control, and automated emergency braking, use sensors and software algorithms to enhance safety and improve the driving experience.
6. **Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) Communication** - Software engineers are developing new technologies to enable communication between vehicles and between vehicles and infrastructure. This includes developing communication protocols, security solutions, and software systems for the exchange of information. The goal is to improve safety, reduce traffic congestion, and enhance the driving experience.
7. **Artificial Intelligence (AI)** - Artificial Intelligence (AI) is being used in the automotive industry to enhance the driving experience, improve safety, and optimize the perfor-

mance of vehicles. Software engineers work on developing AI algorithms for applications such as computer vision, natural language processing, and machine learning, as well as integrating these algorithms into the vehicle's control systems.

8. **Internet of Things (IoT)** - The Internet of Things (IoT) is being used to connect vehicles and other devices, enabling new services and experiences for drivers and passengers. Software engineers play a crucial role in developing IoT-based solutions, working on developing the communication protocols, security solutions, and software systems for connecting devices.

These are just a few examples of the latest developments and innovations in mobility ecosystems. As technology continues to evolve, the role of software engineers in this field will continue to grow and change.

Societal Context, Change, and Future of Mobility

This section explores the ways in which mobility affects our lives. What current mobility modes / offers / limitations look like. And what innovations, changes and improvements the future of mobility can hold. It introduces why it's both exciting and valuable to work on the future of mobility and to help improve all of our lives in this way.

Here, students are able to explore their own learning paths around how mobility is designed and how it could be improved. And they can be part of shaping our communal learning by adding their own research, inviting experts as guest speakers and inspiring each other by co-organizing talks and workshops around the future of mobility. We want the SEA:ME learning community to be an open forum and lab for innovation and the building of ideas around how software solutions can be used for future mobility. And our students will co-drive this.

Mobility as we currently experience it is defined by long standing characteristics and continuing trends. These form the current baseline from which our approach to mobility sets out, and they include the following examples and solution approaches:

1. A sharp divide between the availability of mobility offers / choices between urban and rural environments. With cities having been shaped around automobile traffic since the 1950s, and rural areas in many countries

having been increasingly cut off from public transport offers. Smart networks of various mobility services can offer access to mobility in urban and rural environments and begin to connect these by making use of the intermodal spaces between them.

2. Dominance of individual traffic in personally owned cars, as well as of freight transport on roads. Since the second half of the 20th Century, living environments across the globe have increasingly been shaped around individual vehicles on roads, with personal movement on roads defined along the lines of freedom. In smart software-driven environments of the 21st Century, thinking and action along the lines of freedom can be re-imagined and re-shaped as freedom of access and freedom of choice for everyone who needs or wants to consume movement options.
 3. Continued growth of car ownership in urban areas, and ongoing extension of road space. While science has identified this dynamic as one of "induced traffic", where increased road space repeatedly leads to more vehicles and traffic - and thus to new calls for yet more road space. Innovative 21st Century thinking and planning can make use of the powers of software to create efficient models and analyses of traffic flow, predictions of which effects which mobility modes can have, and help shape traffic in ways that adapts to the needs of residents more than residents continuing to adapt to assumed needs of traffic.
 4. Preventative pricing levels and complicated booking models for public transport. Software-driven, networked public transport offers - across vehicle types / sizes, roads and rail - can boost ease of use, speed and comfort of shared transportation offers. Integrated booking, navigation, and authentication apps can help users to easily combine different mobility modes, types of vehicles, and services - by identifying what is most efficient and comfortable for each single trip from Point A to Point B.
 5. Low availability of space for non-automotive vehicles, and large amounts of space dedicated to parked vehicles that have been averaged as being parked for 96% of time per day. More choice and easier access to different mobility modes can contribute to freeing up public spaces that have been increasingly used for parking over the last decades. Smart shared vehicles can also help avoid issues around parking in spaces that are not legal, where parked cars block weakest participants in mobility such as wheelchair users, blind citizens, physically frail / limited individuals or children on bikes.
 6. Lack of barrier-free access to public transport, which leads to exclusion even where mobility choice generally exists. Modern networked and user-oriented transportation networks can offer different types of vehicles and access modes, and make these easily available and identifiable to users with special needs. They thereby can boost freedom of movement and freedom of choice for individuals that so far are strongly limited in where they can move at which time and in which ways.
 7. Globally, there remains a constant increase in levels of emissions generated by traffic on ground, in water and in air. With these emissions (fine particles) being generated not just by combustion engines, but in large part by vehicle parts such as tires and brakes, overall volume of traffic / vehicles and efficient solutions for passenger and freight traffic are of importance. Smart mobility solutions can address emission levels, for example by easing use of low emission services (shared / rail) and by making trips in higher emission vehicles (individual / road) more efficient by use of shortest possible routes and efficient driving styles.
 8. Effects of globalized supply chains and of consumer trends toward online ordering and returning of products are continuing to fuel increases in freight transport.. Innovation in mobility management can help alleviate some of the effects. For example by addressing the "last mile" where shipments are brought to final recipients after long-haul transport, or by building efficient long-haul transport networks consisting of road and rail, in which goods are easily switched between vehicle types.
- Given that established characteristics and ongoing trends in mobility currently leave much to be desired, and given that traffic circumstances are getting ever more intense and difficult around us, it is only fortunate that at this point in time there is a whole set of new opportunities starting to open up. The opportunities provided by software are beginning to offer completely new ways of imagining and shaping mobility solutions. New ways of thinking about the kinds of mobility that would give more of us access,

and all of us more choice. So that each one of us could choose where and when we want to personally drive a car, or to sleep or work while riding in an autonomously driving vehicle, or to connect to public transport or ride-sharing, pick up a rental cargo bike, etc. etc. And how we could easily and cheaply combine any one of these modes and vehicles in one comfortable, quick and seamless trip from Point A to Point B.

At the same time, all of us living in cities will be able to benefit from more shared and diverse mobility options also in ways that transcend our own trips. For example, where space for individual parked vehicles becomes available again to all of us for use as an enjoyable public space for leisure, sports and play. Where more mobility choice and more shared mobility evolve, our shared urban spaces increase in size and the liveability of our environments increases. And where mobility choice increases in rural areas, people have more opportunities to connect with each other and to live in environments that are still different from cities but also easily accessible anytime.

Finally, with more mobility offers and choices available, all of us will be able to move anywhere anytime - including those of us who are limited in their mobility by health status, age, disability or other circumstances. And those of us who currently have to make the choice between a type of mobility that they feel uncomfortable with or no mobility at all can receive actual choice, safety and comfort.

The future of mobility looks bright because of the new potential that is emerging now for the first time in decades - a potential that is largely driven by what software can offer. Therefore anyone who becomes a software expert for mobility today not only has plenty of choice in terms of the direction / work area to go into, but also has plenty of opportunity to be a part of something that improves their own life and the lives of us all. Makes our lives both easier and more enjoyable - by leveraging the strengths of code.



Requirements - How to Apply

Applying to SEA:ME is easy. You can use the dedicated form on our website at <https://seame.space/study-seame/>

In order to join, you need basic coding skills and / or experience in mobility engineering. A background in mobility studies plus basic coding skills is especially appreciated.

We aim to build a learning community of diverse personal backgrounds and diverse focus areas. By having students with a strong interest in either embedded systems, autonomous driving, or mobility ecosystems - or any combination of these - we can build a community of knowledge sharing and mutual inspiration that maximizes your learning results and overall development as a professional in the field of mobility programming.

We are recruiting students for SEA:ME in what is called a rolling admissions process. This means that we constantly look at individual applicant profiles and determine whether a sufficient overall skill set is present in each candidate. Based on this assessment, we let you know whether you can safely expect to join us. So that you can timely know in advance and start planning your logistics.

If you are interested in joining the SEA:ME curriculum, but you are not sure about what it entails or whether your background is enough: Contact us and find out more at contact@seame.space



sea!me

software engineering in automotive
and mobility ecosystems



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