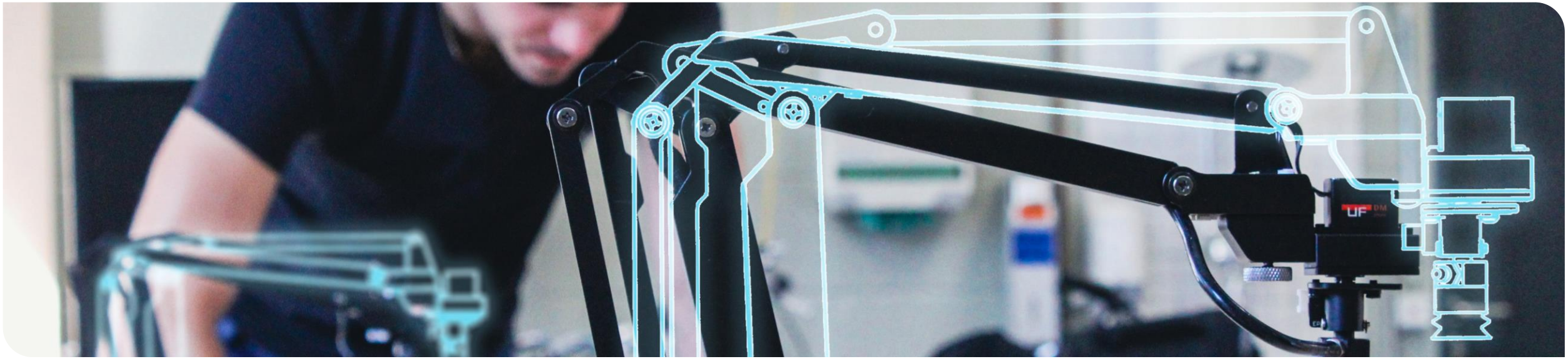
Karlsruher Institut für Technologie

Institut für Technik der Informationsverarbeitung

Seamless Engineering

1. Introduction Meeting



Institute for Material Handling and Logistics

Prof. Dr.-Ing. Kai Furmans

- 30 PhD Candidates in 4 Departments

- **Focus:**
  - Sensor Technologies
  - Object Detection
  - Indoor/Outdoor Navigation
  - Embedded Systems
  - AGV
  - Picking Robots

Research Group Systems Engineering

Prof. Dr.-Ing. Eric Sax

Karlsruher Institut für Technologie

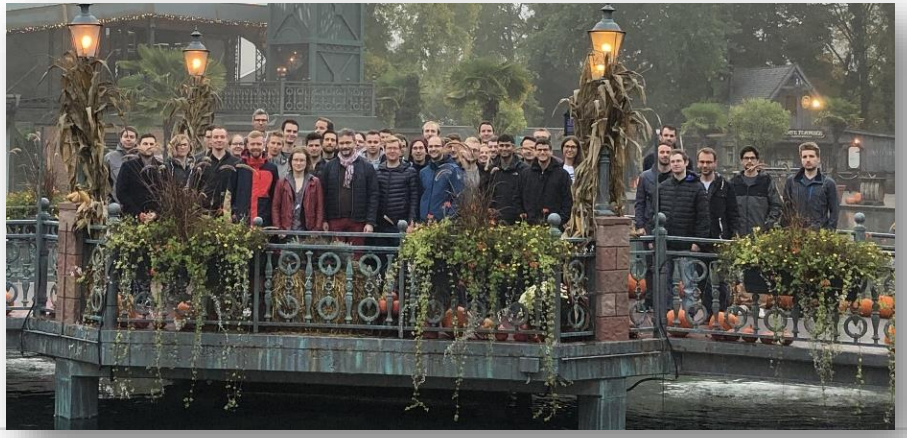
Focus:

- Processes and methods from "agile" to "V" for the design of embedded systems and system networks
- Validation up to approval (including hardware-in-the-loop testing) of embedded electronic systems, especially driver assistance systems
- Secure SW architectures and EE topologies
- Automated driving with special consideration of economic efficiency
- Big Data Analytics - Anomaly Detection and Data Evaluation in (Commercial) Vehicles

Establish/participate/contribute to strategic issues for

- Cross-entity processes from requirement to physical implementation
- Machine learning for applications in everyday situations
- Mobility 2025
  - especially in the commercial vehicle sector and public transport

Prof. Sax with his internal and external PhD Candidates (Oct. 2019)



The Seamless Engineering Team

M. Sc. Marc Schindewolf

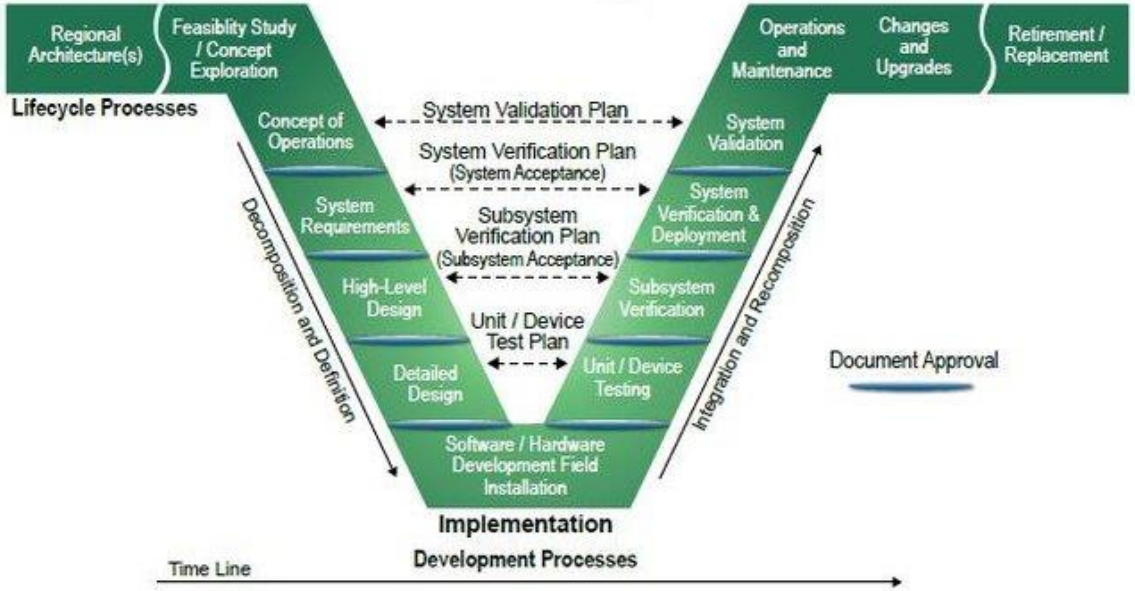
M. Sc. Martin Sommer

M. Sc. Maximilian Gilles

M. Sc. Lukas Müller

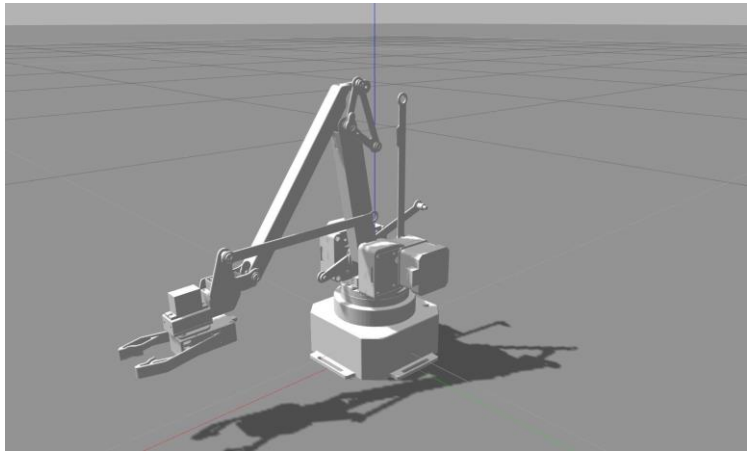
Teaching objectives Seamless Engineering

- Development of a heterogeneous integrated mechatronic system of systems in teams with different tasks
  - Integration
  - Process issues
  - Component development
- Practical experience
  - Concrete application
  - Demonstratable and applicable
  - Focus on availability and maturity
- Process oriented
  - Planned
  - Controlled
  - Quality-assured



Motivation

- During this workshop you will develop a material flow system that must be able to adaptively deal with different incoming orders
- In a first step you will create a digital twin of this system in simulation
- The second step includes the transfer from simulation to real world



Motivation – What is a digital twin?

- A digital twin…
  - Is a virtual model of a real system
  - Simulates both the physical state and behavior of the system
  - Shortens development cycles
  - Has the same interfaces as the real system
  - Provides value through visualization, analysis, prediction or optimization

Motivation – Digital Twins as Enablers

Hardware in the Loop Tests
- Testing systems under user specific constraints in simulation

Internet of Things
- Continuous collection of machine data

Artificial Intelligence
- AI can be used to make predictions about future scenarios

Cloud computing
- Large storage of machine data

Digital twins in logistics
In logistics, the ultimate digital twin would be a model of an entire supply chain network
Delivery Van
Train
Truck
Airport
Container
Vessel
Port
Shipment
Warehouse

Source: DHL

ORGANIZATIONAL ISSUES

Structure of the course Seamless Engineering

- The course is separated into a lecture and a practical course

Lecture	Learning the basics of systems engineering and the theory of material flow in logistics systems
Practical Course	Practical application of the knowledge by means of a larger project in group work

Procedure of the course (1)

- 19.10: 1. Introduction meeting
  - Organizational infos
  - Introduction to the task
- 26.10: 2. Introduction Meeting
  - Introduction to Gazebo and ROS
  - Introduction to hardware
  - GitLab
- 26.10 - 07.12.2021: Lectures
  - Every Tuesday, 2-5 pm in the Selmayr Hörsaal at IfL
- Tbd (17.12.2021): Exam of the lecture topics

Procedure of the course (2)

- 19.10 - 04.02: Working on the practical task
  - Working on milestones
- 07.02 - 11.02: Live Demonstration
  - The practical part of the event concludes with a live demonstration of your developed project with real hardware

Exam

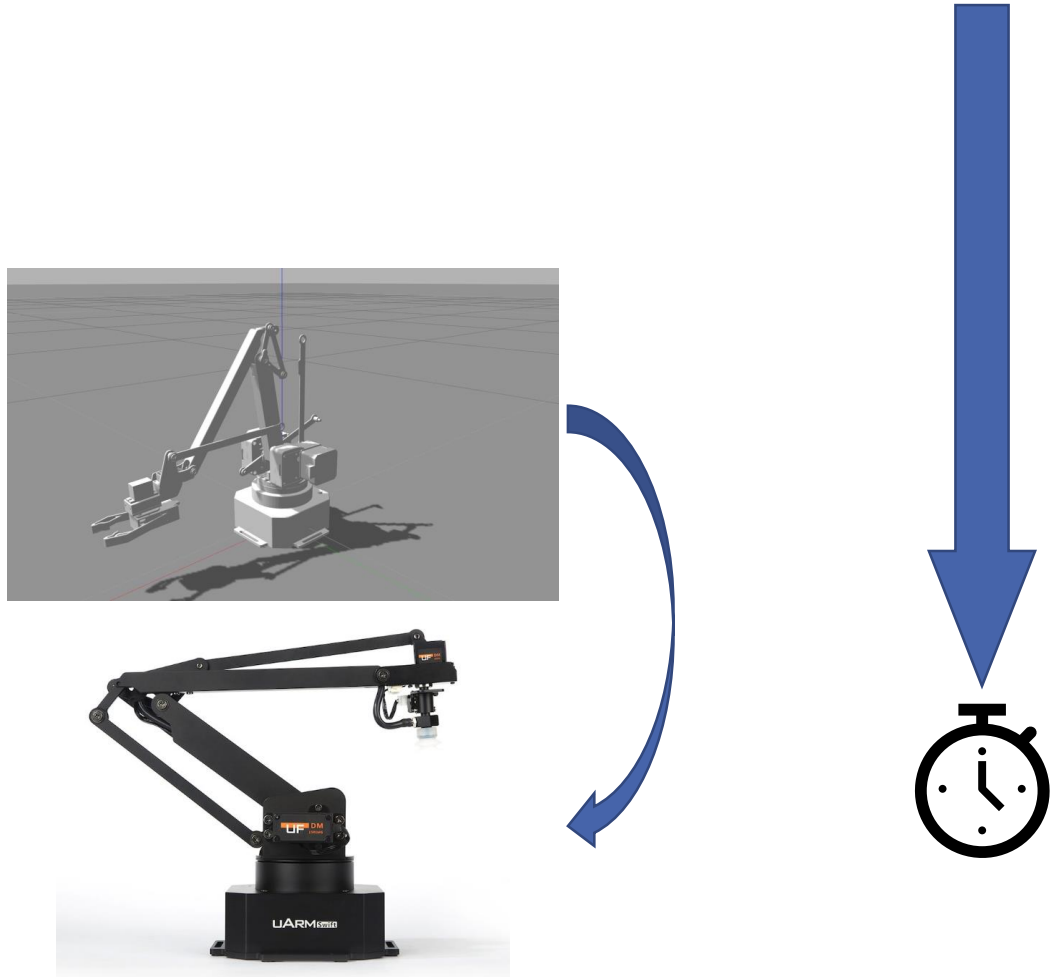
- Registration for the examination in the Campus Management System
- The workshop is only held in winter term (exam only in WT)
- Credit Points: 9 ECTS
- Graded Examination
  - Written exam of the lecture content: 50 % of whole grade
  - Milestones of practical course: 50 % of whole grade

Written Exam

- Review of the lecture content
  - The written examination before the winter break only tests the contents of the lectures.
  - Duration of the written exam: 60 minutes

Milestones during the practical course

- **0. Milestone**
  - SWOT Analysis and Project plan
- **1. Milestone**
  - Technical Report
- **2. Milestone**
  - Module Test
- **3. Milestone**
  - System Integration
- **4. Milestone**
  - System Acceptance



0. Milestone – SWOT Analysis and Project plan

- 1. Submission: SWOT Analysis
- 2. Submission: Project plan (Gantt Chart)
  - Creation of a project plan (MS Project or similar) for the individual work packages of the group members over the processing period

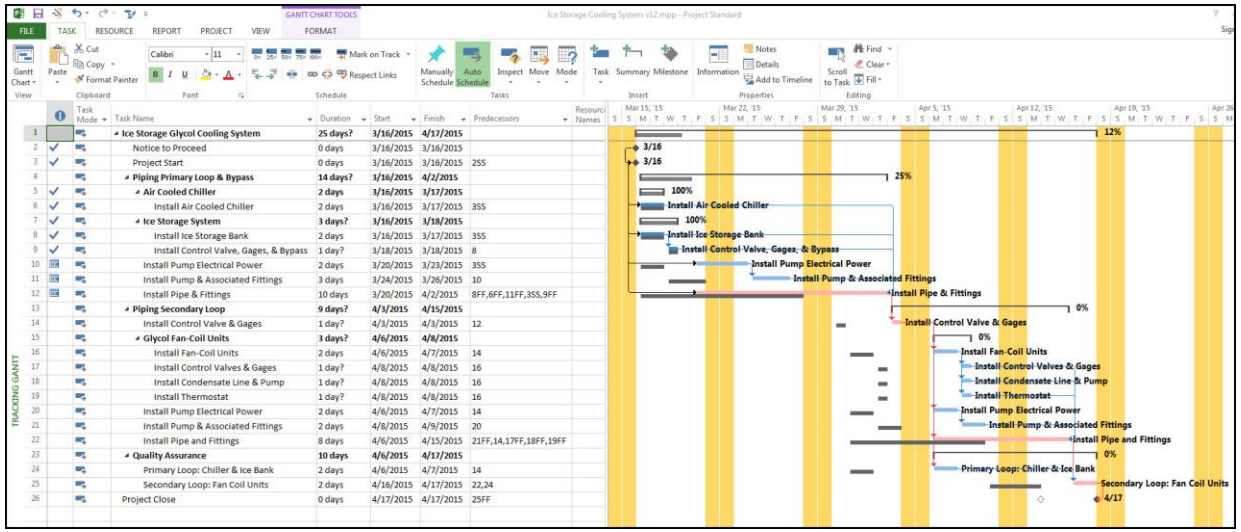
Submission of documents in ILIAS ->
No contribution to the final grade, but submission is mandatory

0. Milestone – SWOT Analysis and Project plan

SWOT Analysis

	Advantages over the competitor	Factors that hinder achieving your goals
Internal factors of influence can be directly influenced	Strengths	Weaknesses
External factors of influence cannot be directly influenced	Opportunities	Threats
	Factors that contribute to reaching your goals	Missing or ineffective factors

Project plan in MS Project



1. Milestone – Technical report

- Writing a technical report
  - System requirement specification
    - Transfer the product requirement specification defined by the client into a System requirement specification
  - Description of material flow

Submission of documents in ILIAS
-> 10% contribution to the final grade

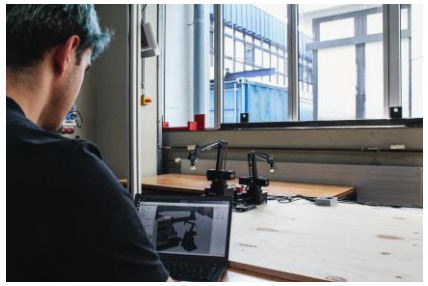
2. Milestone – Module Test

- Demonstration of the functionality of the sensors and actuators in the simulation environment (digital twin) in module tests
- Concrete tasks:
  - Turtlebot navigates autonomous between stations (video)
  - Turtlebot can position itself at station using markers (video)
  - Conveyor moves for specific length (video)
  - Preparation of the results in the form of a presentation (10-15 minutes)

Submission of documents in ILIAS
-> 10 % contribution to the final grade

3. Milestone – System integration

- Transfer from simulation to real hardware
- Concrete tasks
  - The flow of goods takes place autonomously in the simulation (video)
  - Transfer modules to real hardware (videos)
    - Turtlebot navigates between stations in real hardware
    - Turtlebot can position itself using markers
    - uArm can grasp different objects from Turtlebot and put them on conveyor
  - Preparation of the results in the form of a presentation (10-15 minutes)



Σ

Submission of documents in ILIAS
-> 10 % contribution to the final grade

4. Milestone – System acceptance

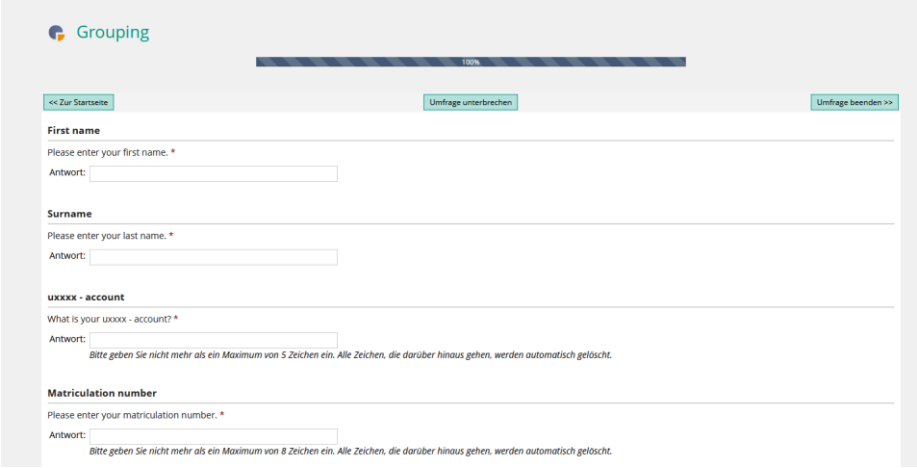
- During the system acceptance, you have the chance to show how you have implemented the logistic task using the real hardware on the workstation at the IfL
- Concrete tasks
  - Preparation of System acceptance test showing the whole flow of goods on real hardware at IfL work station

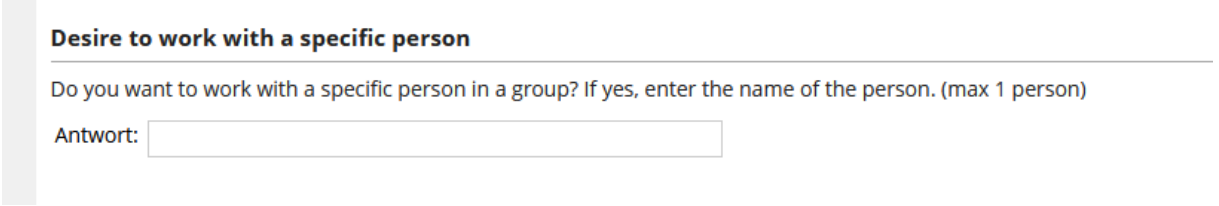
Submission of documents in ILIAS
-> 20 % contribution to the final grade

Exam

Grouping for the practical course

- Formation of groups of 5 to work on the practical course
- The grouping will be conducted on a survey in ILIAS based on your level of knowledge
  - At the beginning of the course you will have the opportunity to specify a desired teammate for your team
  - Grouping is mandatory for the entire course



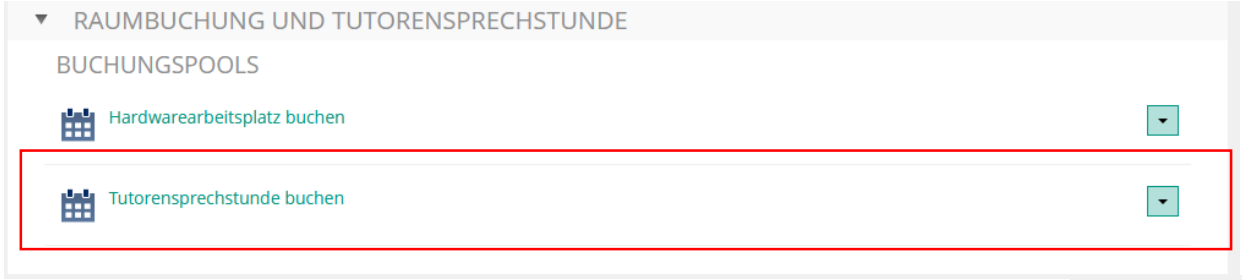


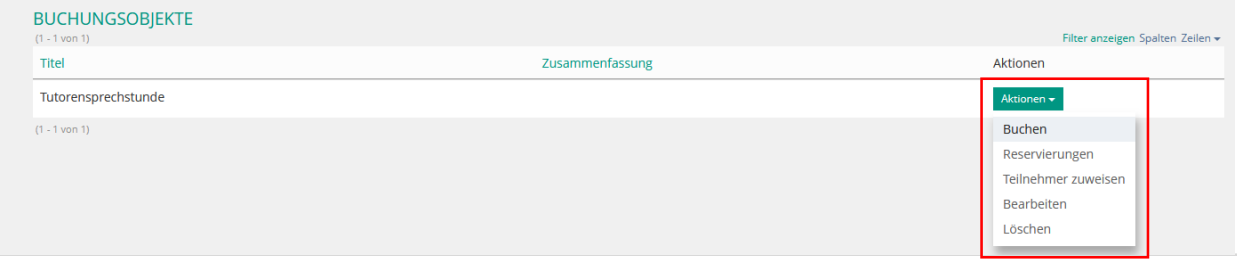
Consultation hours

- Carried out with Microsoft Teams:
  - Dates will be anounced in ILIAS
  - The use of the MS Teams app is mandatory
- Participation in consultation hours is voluntary, prior registration necessary (see next slides)
- Tutors help you with specific problems and questions
  - Read the manual and the documents carefully before you come to the consultation, your question may already have been clarified.
  - The tutor will give you tips but will not write the code for you!

Consultation hours – Registration (1)

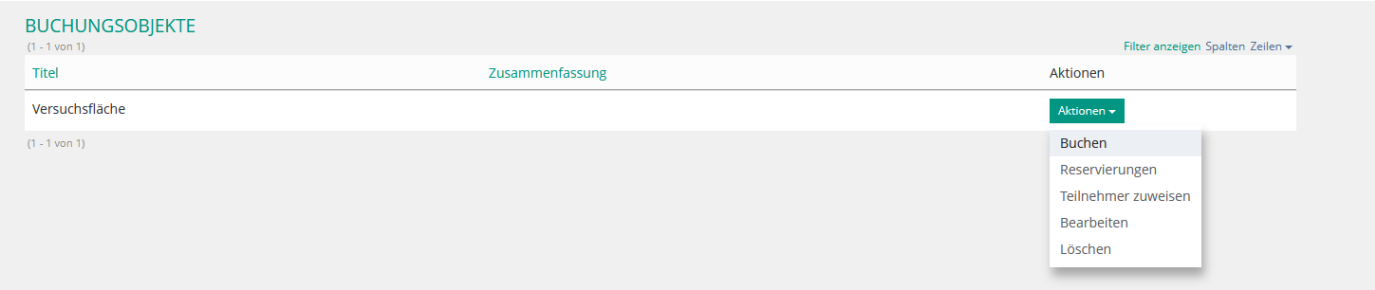
- Registration as a group with ILIAS (one registration per group):
- Separate registration is required for each date

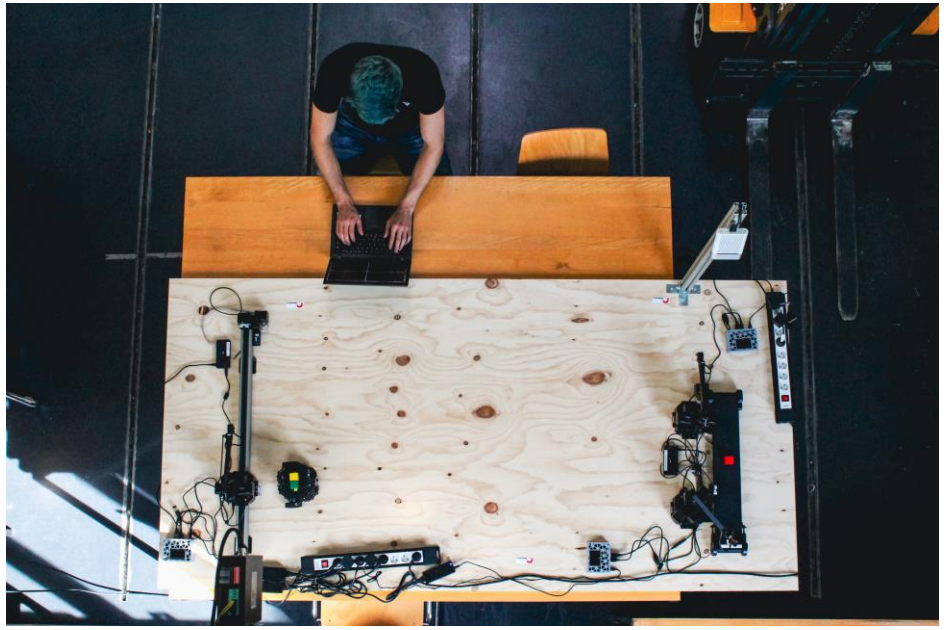




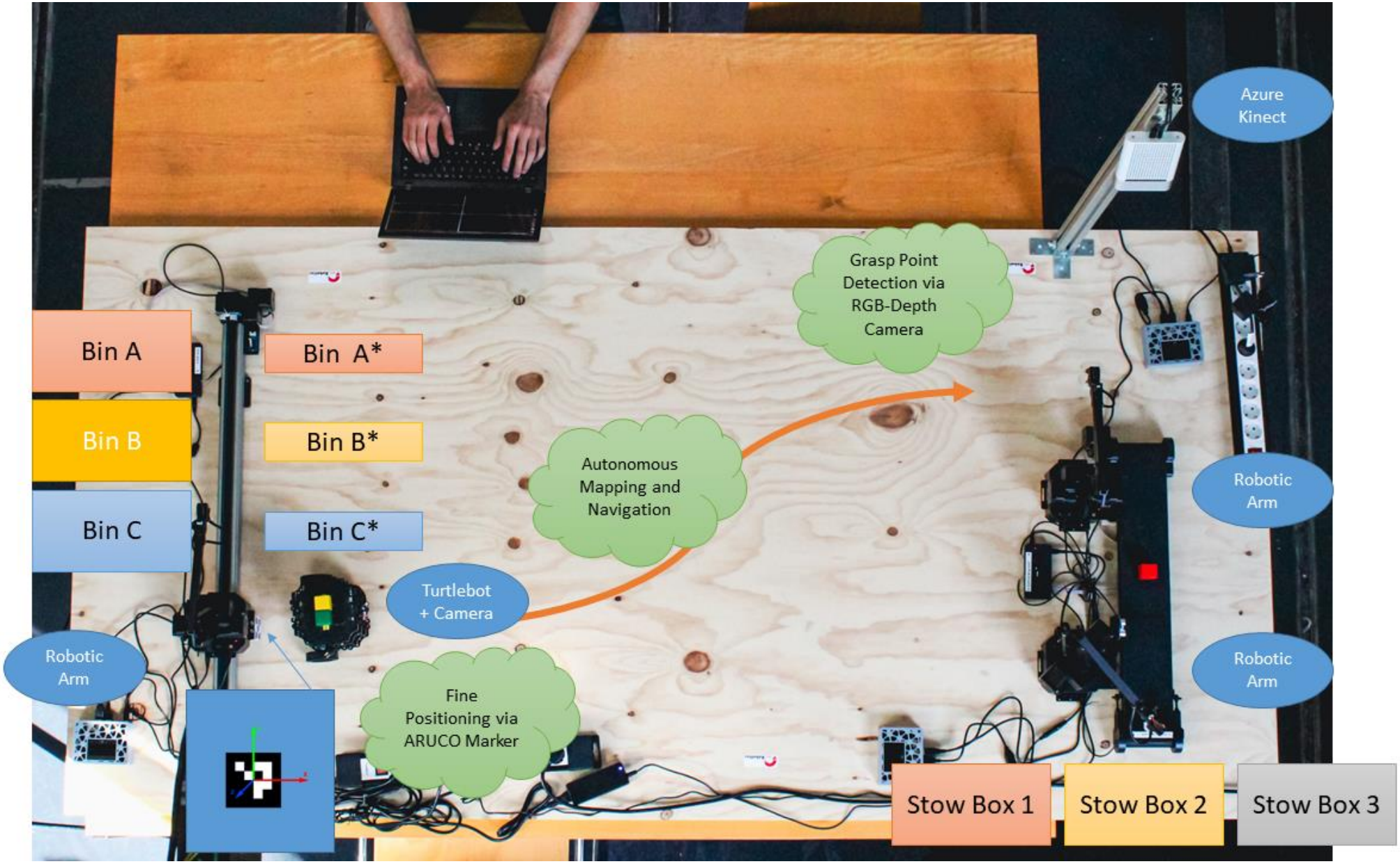
Booking of the hardware workstations

- You can transfer from the simulation to the real hardware on workstations set up for you at the IFL's experimental area.
- The booking of these workstations is also carried out via ILIAS





YOUR TASK

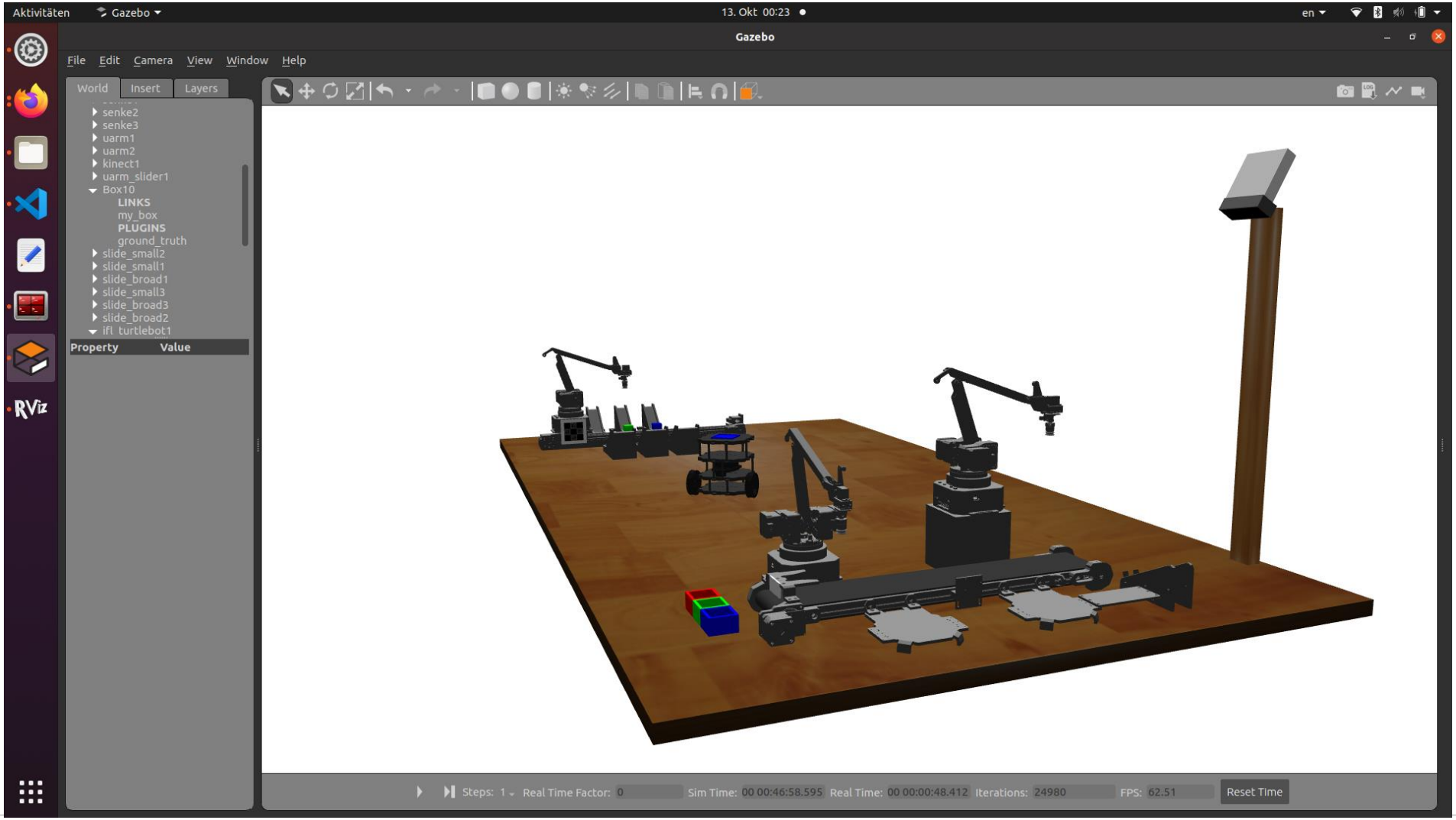

Azure Kinect
Grasp Point Detection via RGB-Depth Camera
Bin A
Bin A*
Bin B
Bin B*
Bin C
Bin C*
Autonomous Mapping and Navigation
Robotic Arm
Turtlebot + Camera
Robotic Arm
Robotic Arm
Fine Positioning via ARUCO Marker
Stow Box 1
Stow Box 2
Stow Box 3

Requirements

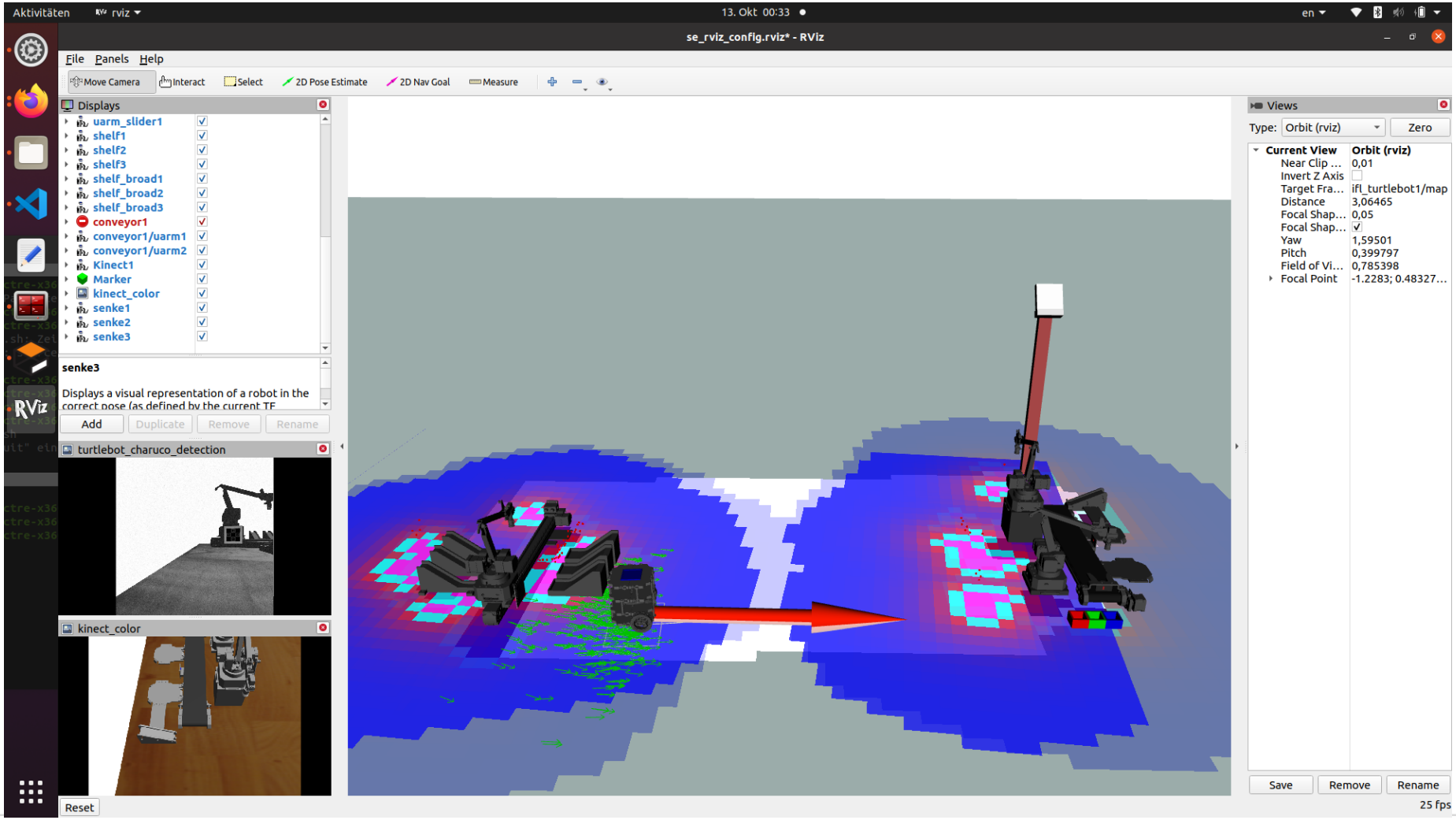
- The system to be developed has to fulfill Product Requirements specified in the manual of the workshop
  - These requirements serve as an evaluation basis for the Acceptance Test in Milestone 4
- The requirements are separated into functional and non-functional requirements
- It is your task to create a System Requirement Specification (SRS) for the system you develop (See Milestone 0)

ID	Title	Description
F1	Throughput	The throughput of the system should be at least xx
F2	Reliability	Objects must not be lost or damaged
F3	Customer satisfaction	The system must deliver the requested objects correctly
…	…	…

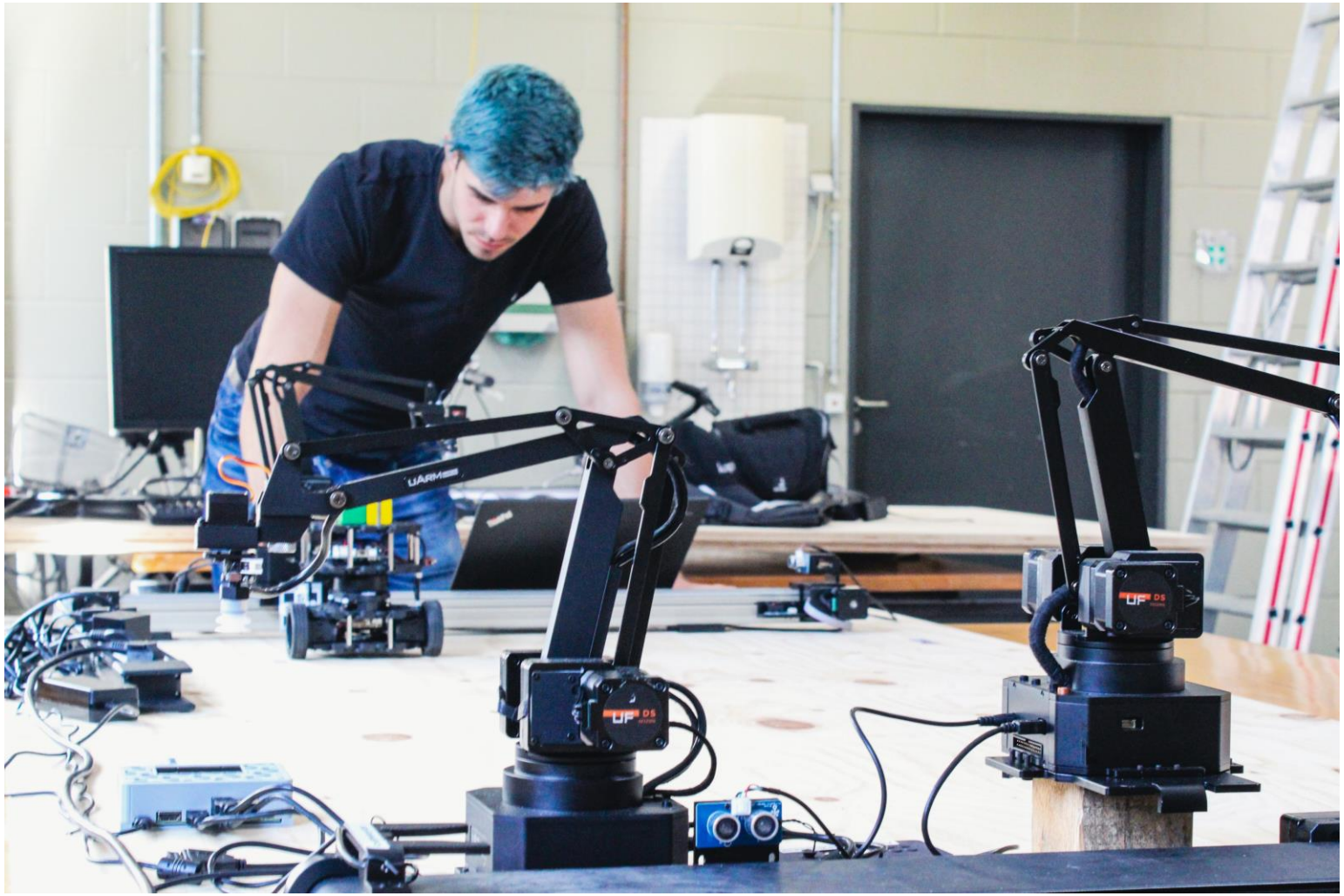
Simulation Environment



What you will see in the simulation environment



Transfer to real hardware



The manual

- The manual gives you a good overview about everything you need to know to finish the workshop successfully
- The manual gives deeper insights into the different topics than the introduction meeting

How can i find infos or help?

- More detailed description of the task in the "Seamless Engineering Manual
- Consultation hours and tutoring
- „Search engine of your trust!“

Outlook to the next introduction meeting

- Setting up bwLehrpool
- Introduction to Linux, ROS and Gazebo with Live demo
- ROS-Tutorials

- After that, you know all the basics and can start with the tasks!

Todos until next meeting

- Sign up to ILIAS course „Seamless Engineering“ and participation in the survey „Grouping“, so that we can create groups
- Sign up for the exam „Seamless Engineering“ in CAMPUS
  - 76-T-MACH-111401-Seamless Engineering
- Take a look in the „Manual Seamless Engineering“