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| Technische Hochschule Ulm |
| Digital Twin of Kuka KR3 |
| Customer Requirements |

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| Ibrahim Almohamed, Ahmed  12.08.2024 |

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# Version and Control

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| Version | Name of Editor | Notes | Date |
| 1.0.0 | Ahmed Ibrahim Almohamed | n/a | 12.08.2024 |
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# Glossary

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| Term | Description |
| DT | Digital Twin |
| KukaDigitalTwin | A Digital twin system of the Kuka KR3 using ROS and Gazebo (simulation tool) . |
| AKL | “Automatisches Kleinteilelager” (DE) or “Automated small parts warehouse” (EN) |
| ROS | Robot Operating System |
| Kuka KR3 |  |
| KVP | KUKAVARPROXY |
| OPC-UA |  |
| SoftRealTime | system where deadlines are important but missing them occasionally does not result in system failure.(average delay of 5ms-30ms) |
| BiDirectionConnection | A connection between the physical and digital robots where commands can be sent from either robot to control the other, and the state information (such as position, velocity, sensor data, etc.) is continuously exchanged. |
| MoveIt2 | A robotic manipulation platform for ROS 2 and incorporates the latest advances in motion planning, manipulation, 3D perception, kinematics, control, and navigation |
| RosInterface | A software interface for the Ros2 to connect the Controllers and the simulation of Gazebo with the KVP protocol. |
| GUI | Graphical User Interface |
| RoboticsLab | A Laboratory at the THU that is used for running experiments of robotics. |
| KukaDigitalTwinDashboard | A Dashboard which is a part of the KukadigitalTwin GUI , used for control and monitor the digital twin and the real twin. |
| RosTasks | A RosTask is a software that aims to create a simple or complicated task for the KukaDigitalTwin , where the user writes a RosNode ,that is runnable on both the physical and digital twins. |
| RQT | RQT is a graphical user interface (GUI) tool for ROS 2. Everything done in RQT can be done on the command line, but RQT provides a more user-friendly way to manipulate ROS 2 elements. |
| RosNode | A node is a participant in the ROS 2 graph, which uses a client library to communicate with other nodes. Nodes can communicate with other nodes within the same process, in a different process, or on a different machine. Nodes are typically the unit of computation in a ROS graph; each node should do one logical thing. |

# Initial Customer Requirements

From the email exchange with Prof. Ollinger, we were able to gather the initial customer requirements. These requirements will also be expanded in this file and broken down into finer customer requirements. Then the customer, i.e. Prof. Ollinger, has to approve them (and the system requirements).

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| Requirement ID | InitCus\_Req\_1 |
| Description | Connection of the Kuka KR3 to ROS |

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| Requirement ID | InitCus\_Req\_2 |
| Description | Specification of an integrated ROS controller for a robot cell |

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| Requirement ID | InitCus\_Req\_3 |
| Description | Further development of the ROS laboratory test for physical Kuka KR3 |

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| Requirement ID | InitCus\_Req\_4 |
| Description | Analyzing application scenarios for digital twins and industrial robots:   * Exchange of experience with Sven Völker (DT application for AKL) |

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| Requirement ID | InitCus\_Req\_5 |
| Description | Implementation of a DT application:   * Coupling virtual with real robot via OPC-UA |

# Customer Requirements

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| Requirement ID | Cus\_Req\_1 |
| KukaDigitalTwin connectivity | The KukaDigitalTwin shall connect to the physical robot controller of the Kuka KR3. |

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| Requirement ID | Cus\_Req\_2 |
| SoftRealTime system | The KukaDigitalTwin shall run a SoftRealTime simulation of the Kuka KR3. |

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| Requirement ID | Cus\_Req\_3 |
| BiDirection-Connection | The KuKaDigitalTwin shall connect the physical and the digital robots in a BiDirectionConnection. |

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| Requirement ID | Cus\_Req\_4 |
| KukaDigitalTwin controller | The KukaDigitalTwin shall control physical and digital robots using MoveIt2 controller. |

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| Requirement ID | Cus\_Req\_5 |
| KukaDigitalTwin RosInterface | The KukaDigitalTwin shall integrate the RosInterface to the already developed simulation and controller. |

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| Requirement ID | Cus\_Req\_6 |
| KukaDigitalTwin Dashboard | The KukaDigitalTwin shall have an GUI as a Dashboard for the RoboticsLab at the THU. |

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| Requirement ID | Cus\_Req\_7 |
| KukaDigitalTwin Dashboard -Backend | The KukaDigitalTwin shall have a database to store information about the system and the user. |

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| Requirement ID | Cus\_Req\_8 |
| KukaDigitalTwin  Dashboard – control | The KukaDigitalTwinDashboard shall allow the user to control the physical and the real twin . |

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| Requirement ID | Cus\_Req\_9 |
| KukaDigitalTwin  Dashboard – monitor | The KukaDigitalTwinDashboard shall allow the user to monitor the physical and the real twin . |

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| Requirement ID | Cus\_Req\_10 |
| KukaDigitalTwin  Dashboard –  Development | The KukaDigitalTwinDashboard shall allow the user to develop RosTasks for the physical and the real twin and run them. |

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| Requirement ID | Cus\_Req\_11 |
| KukaDigitalTwin  Dashboard –  Launcher | The KukaDigitalTwinDashboard shall allow the user to launch RosTasks, Simulation tools (Gazebo , Rvizz) , RQT tools and more(TBD) . |

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| Requirement ID | Cus\_Req\_12 |
| KukaDigitalTwin  Remote Access-  Dashboard | The KukaDigitalTwin shall allow the user to remotely access the Dashboard and all its functionalities. |

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| Requirement ID | Cus\_Req\_13 |
| KukaDigitalTwin  Remote Access  Synchronization | The KukaDigitalTwin shall synchronize the physical and the digital twin by using OPCUA. |

# Templates

Requirements table

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| Requirement ID |  |
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