Distance learning in undergraduate control systems labs by virtual twins

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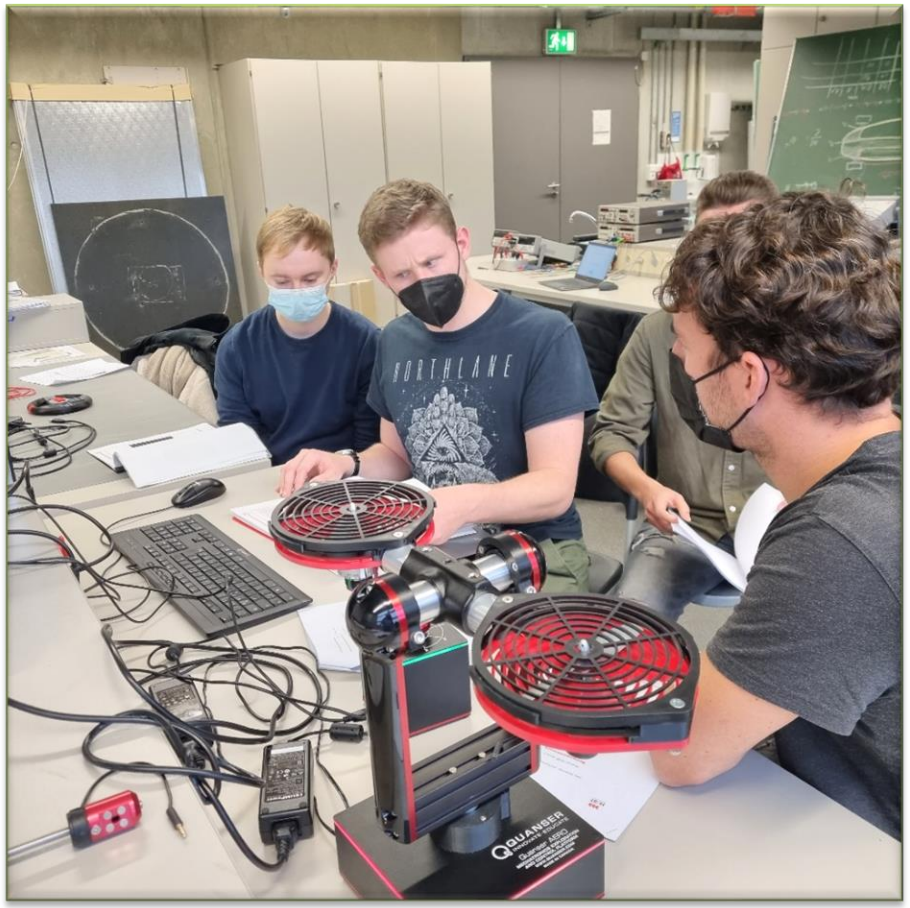
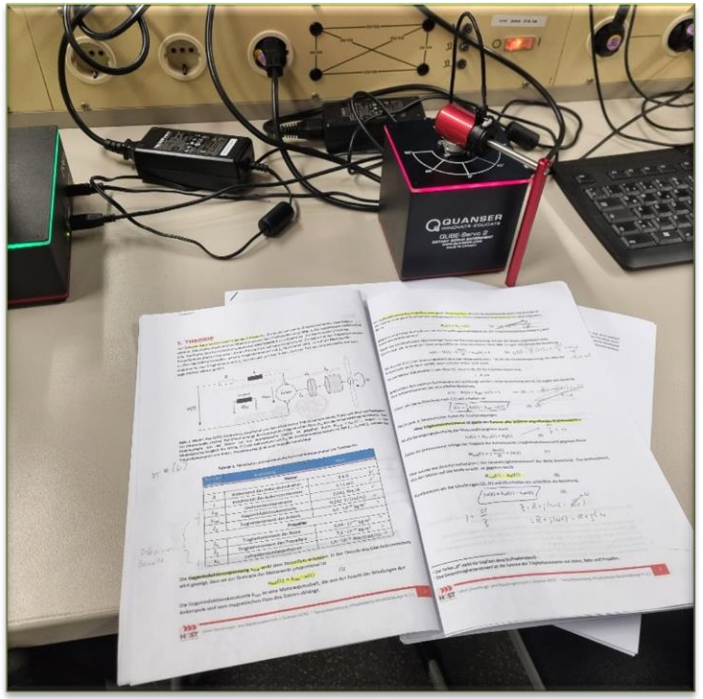
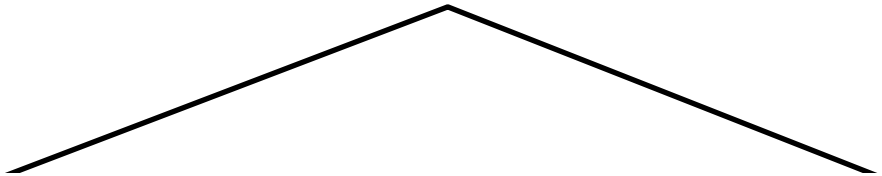
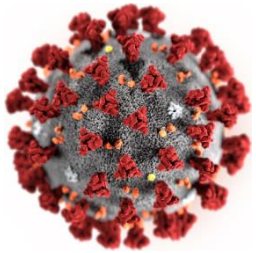
Hands-on labs are an indispensable part of the education of engineering students

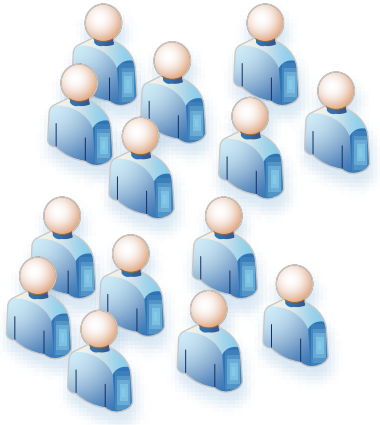




The Corona pandemic has largely kept students out of lecture halls and lab rooms.
This calls for putting more emphasis on solutions such as distance learning.







The DistLab project at Stralsund University focuses on distance learning in control systems labs and in robotics labs. It is currently going to be implemented by two faculties.

School of Mechanical Engineering

Control systems lab
Virtual twins

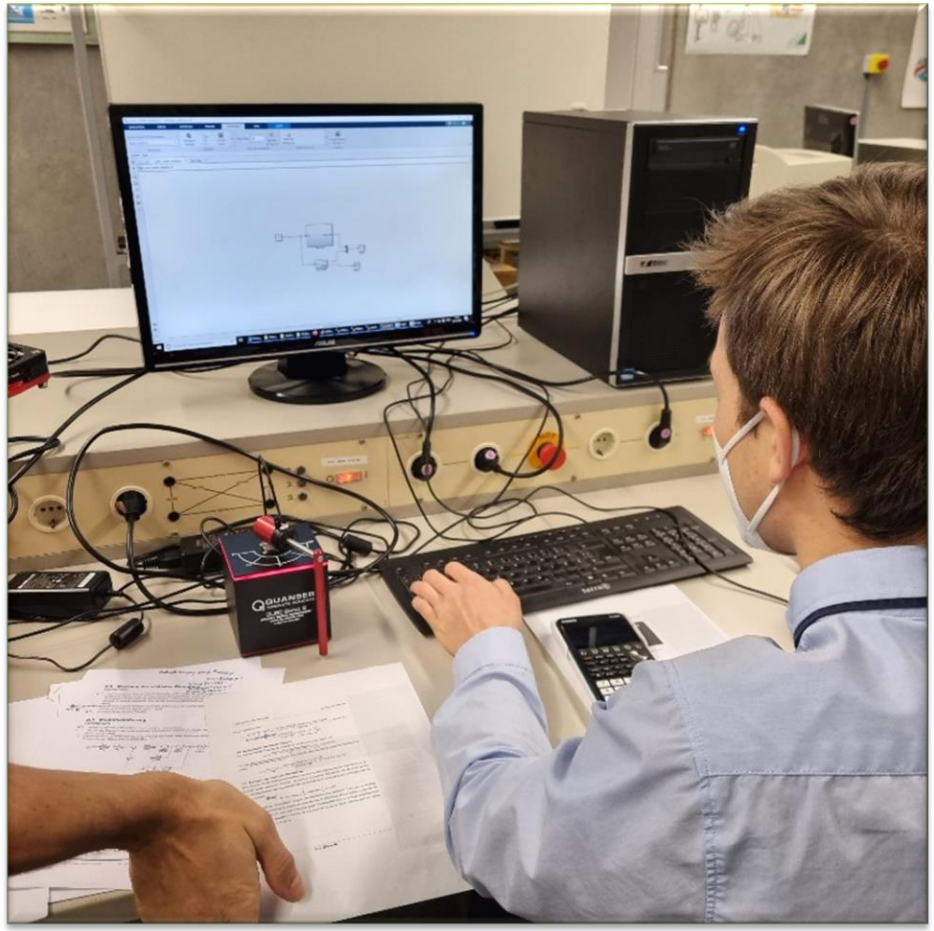
QUANSER
INNOVATE·EDUCATE

Manufacturing technology lab
Virtual twin

School of Electrical Engineering and Computer Science

Robotics lab
Remote labs

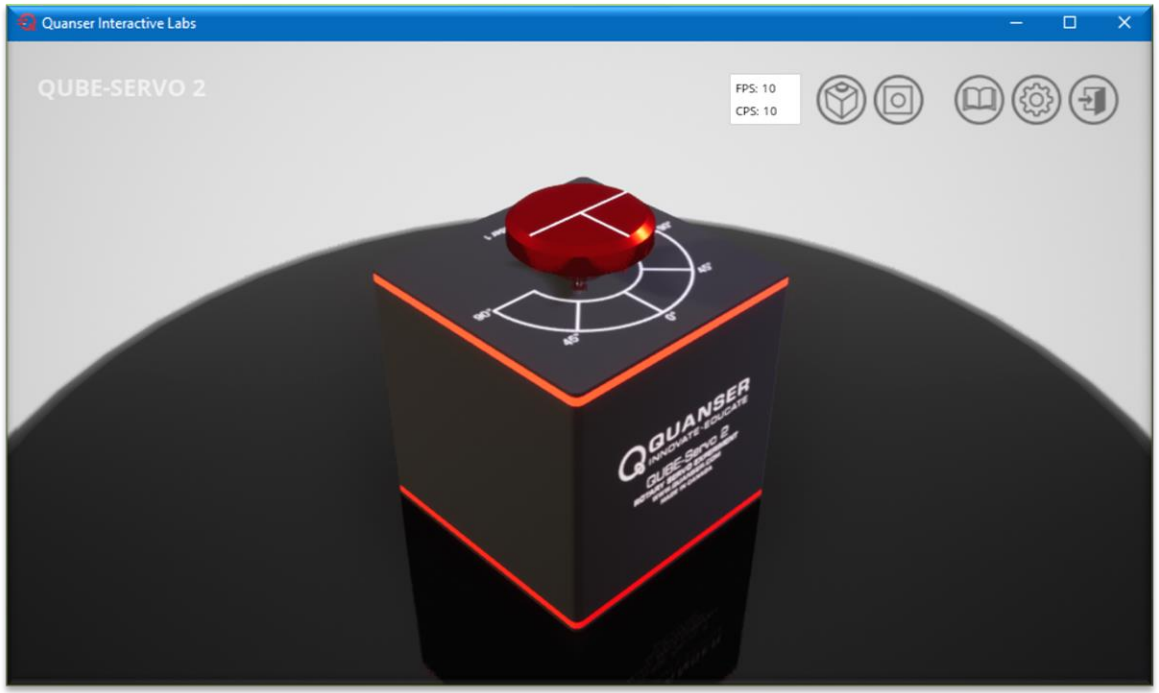
Control systems labs are a vital part of the mechanical engineering curriculum. They are mandatory for all undergraduate students in the 5th semester.



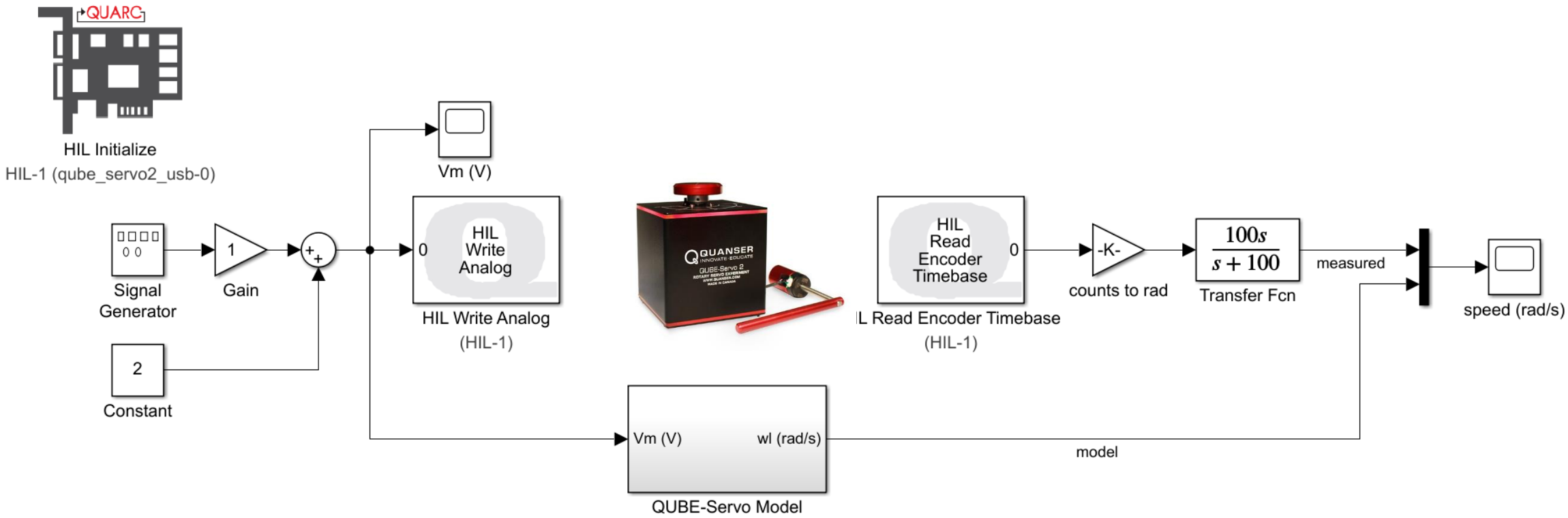
A virtual twin is a high-fidelity digital copy of a real lab experiment, such as a servo motor that rotates a shaft. A virtual twin behaves almost identically as its counterpart

real twin

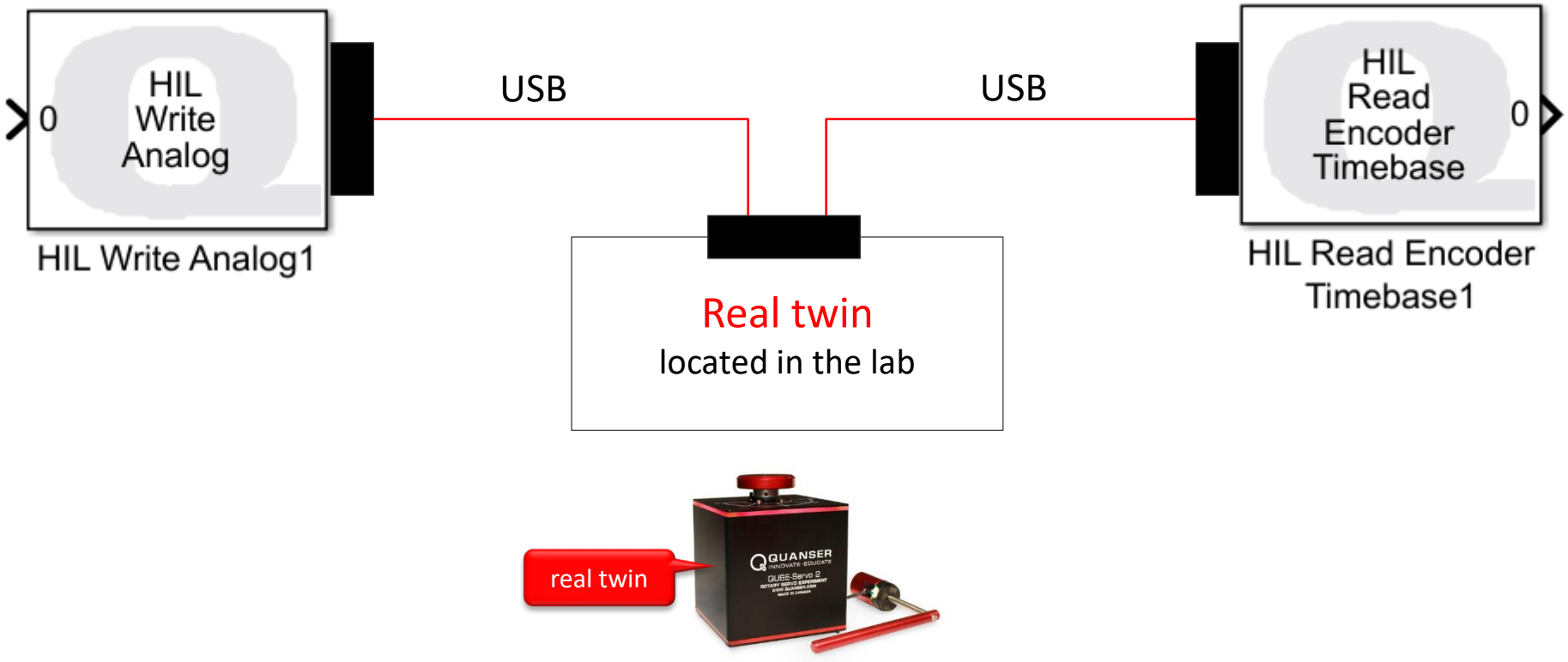
virtual twin



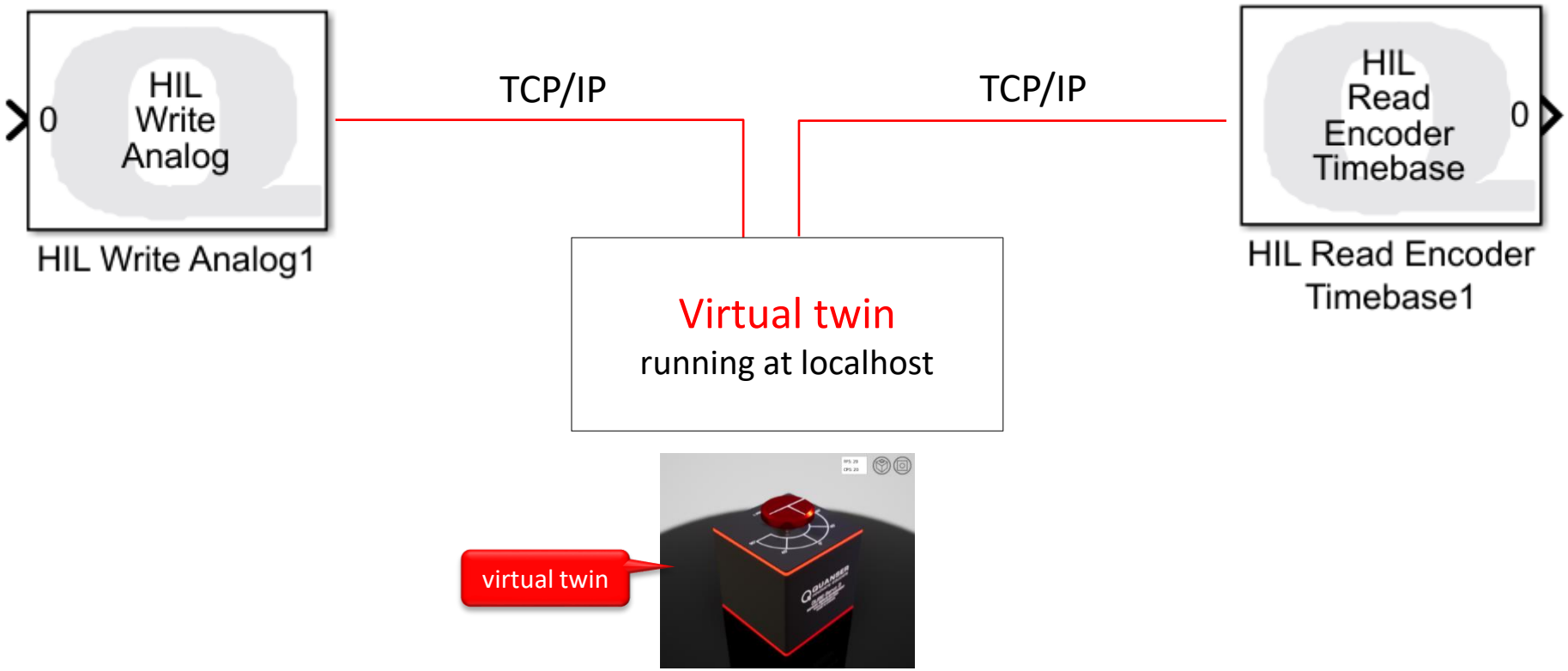
In classical hardware-in-the-loop systems (HiL), the hardware – such as servo motor rotating an inertia disk – is placed between the HiL write and the HiL read block



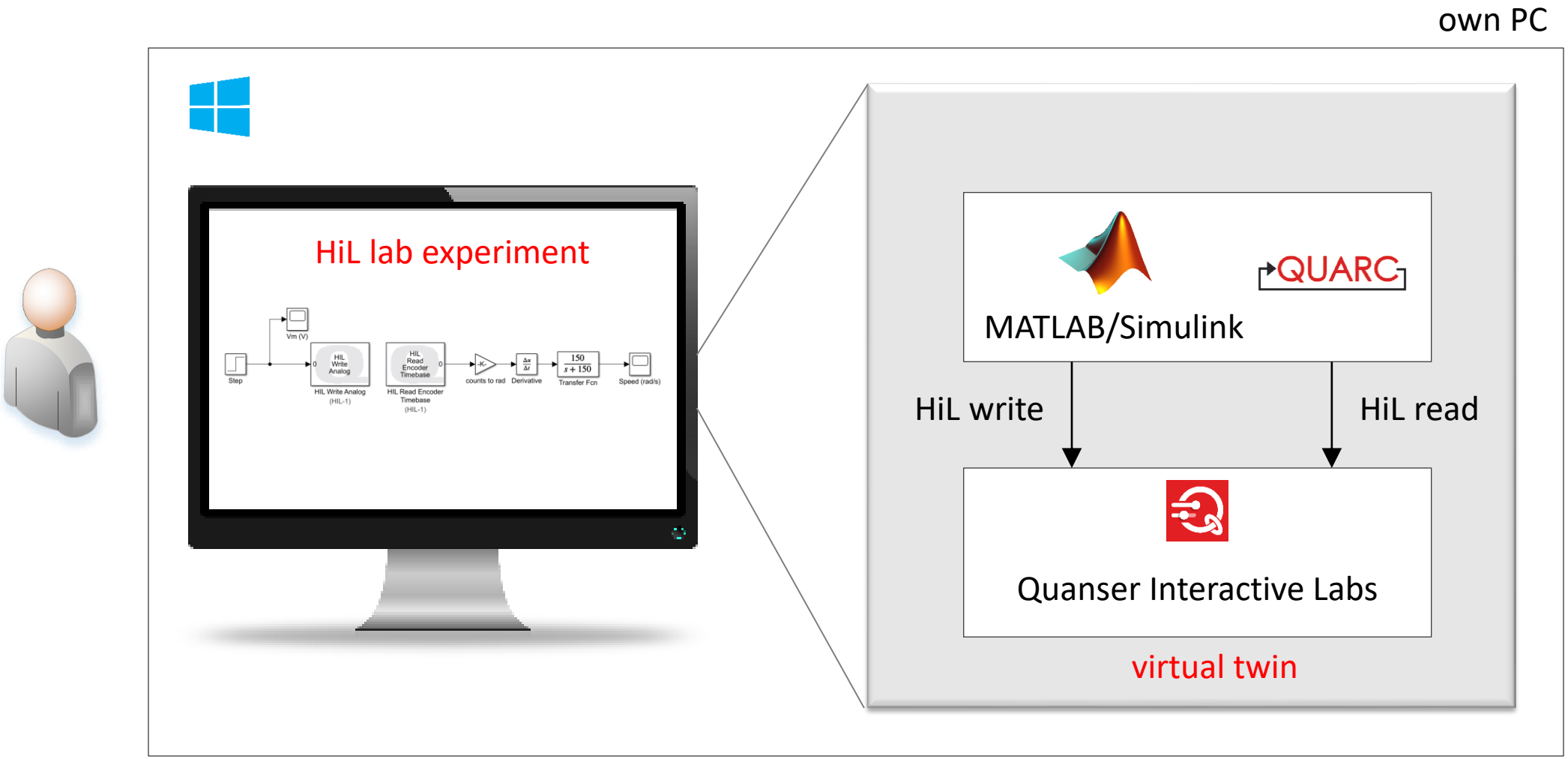
When on-campus, HiL write and read calls are executed via a USB interface against the real twin



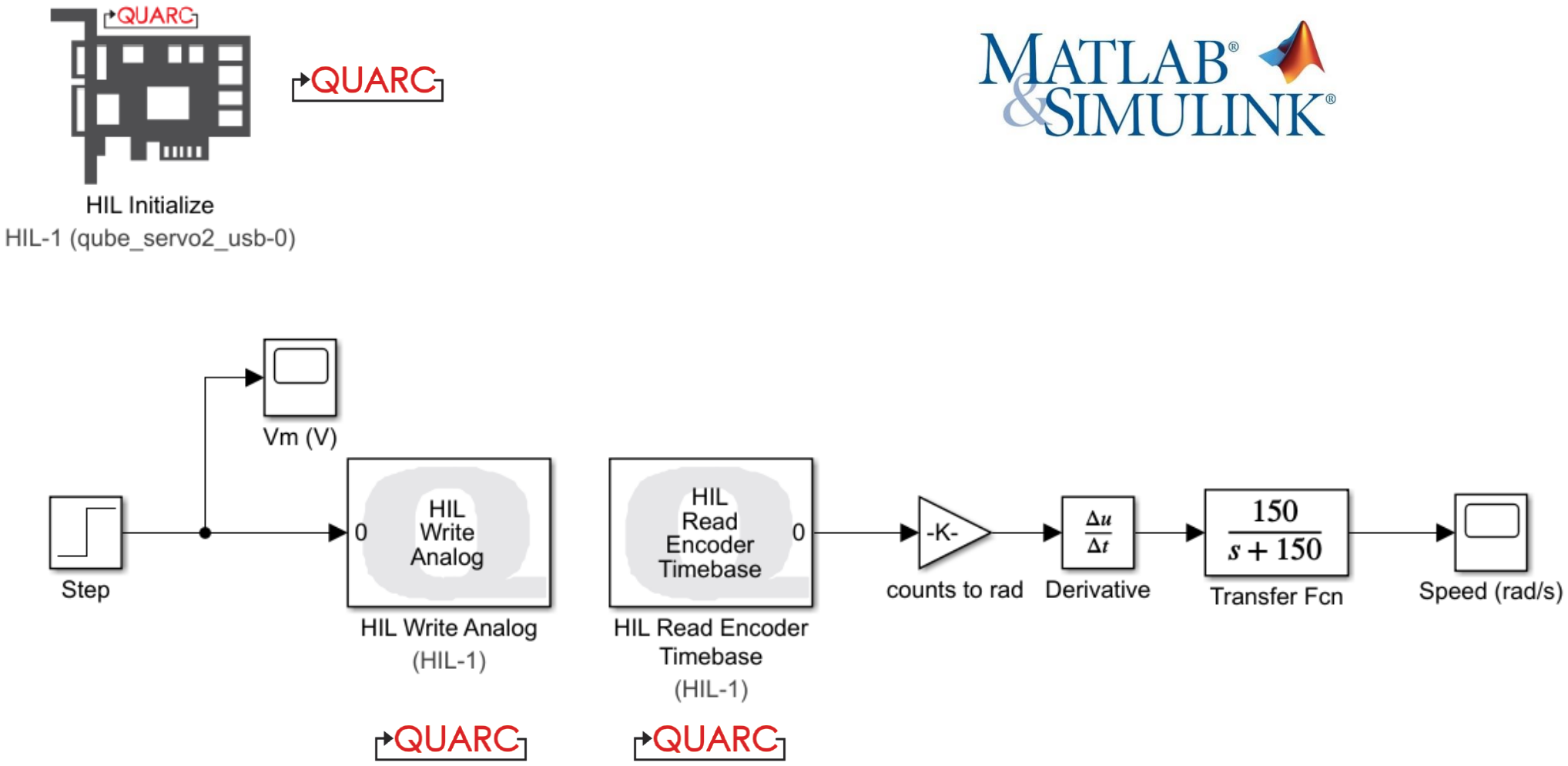
For distance learning, the situation is different. HiL write and read calls are executed via the TCP/IP protocol against the virtual twin running on the local machine



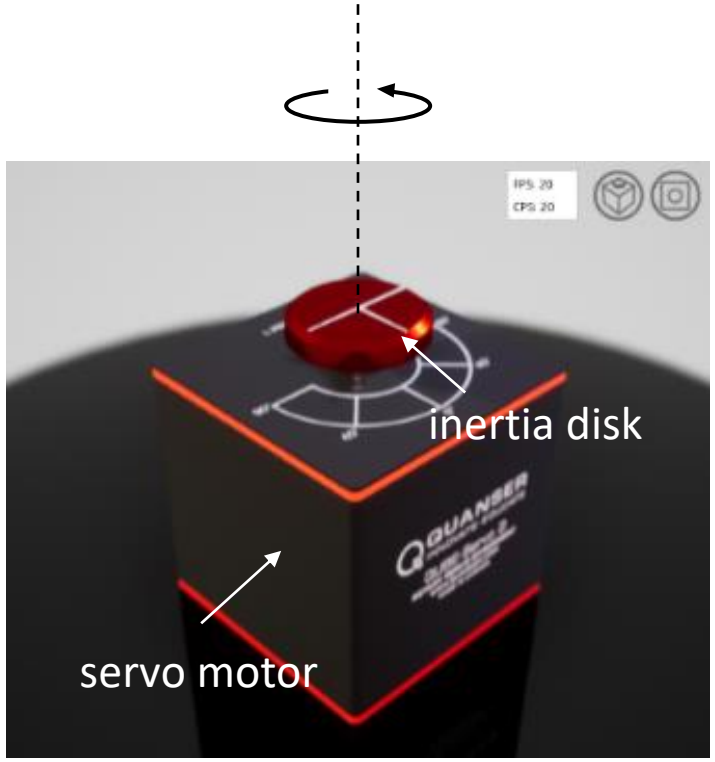
To run virtual labs off-campus, each team member has to install software, including a virtual twin, on his or her own PC



For the virtual labs, students must also install QUARC – a real-time control software running on top of Simulink



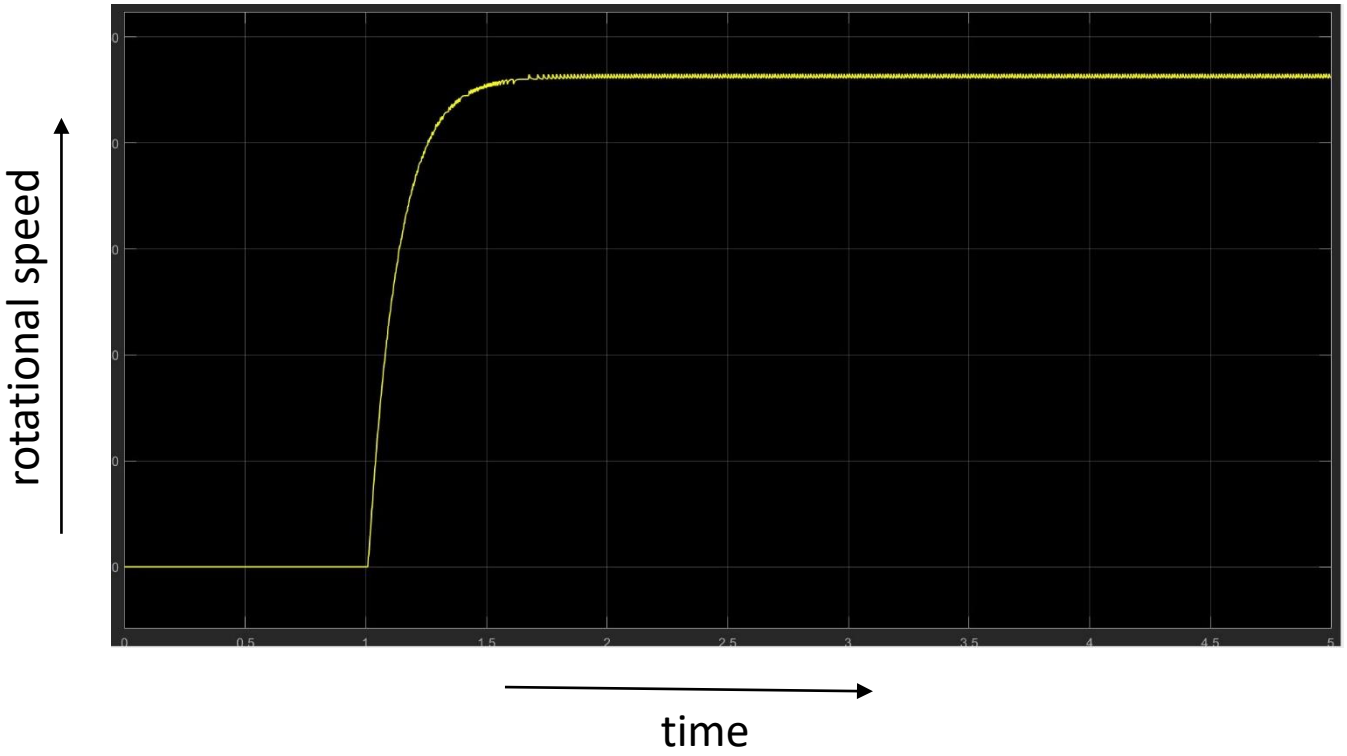
The virtual twin of the Quanser QUBE contains a servo motor and an inertia disk

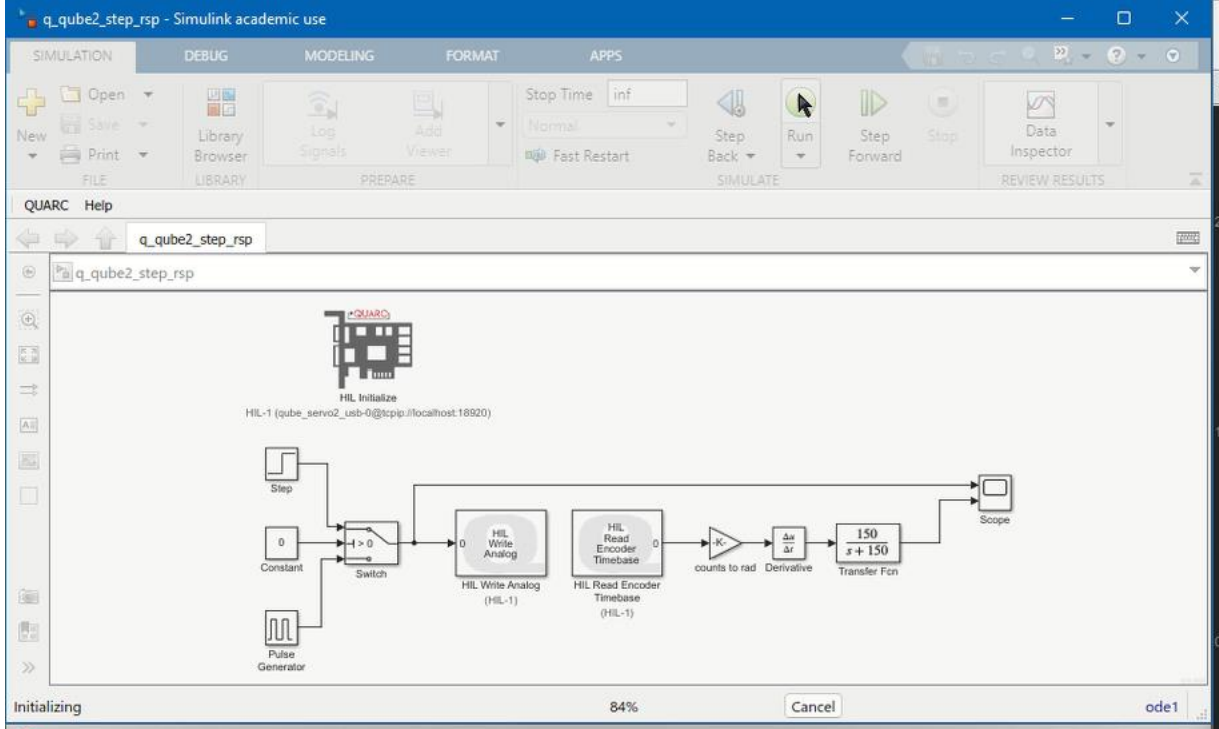


virtual twin

In the lab, students investigate the first order step response of the servo motor

step response

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Quanser Interactive Labs
QUBE-SERVO 2
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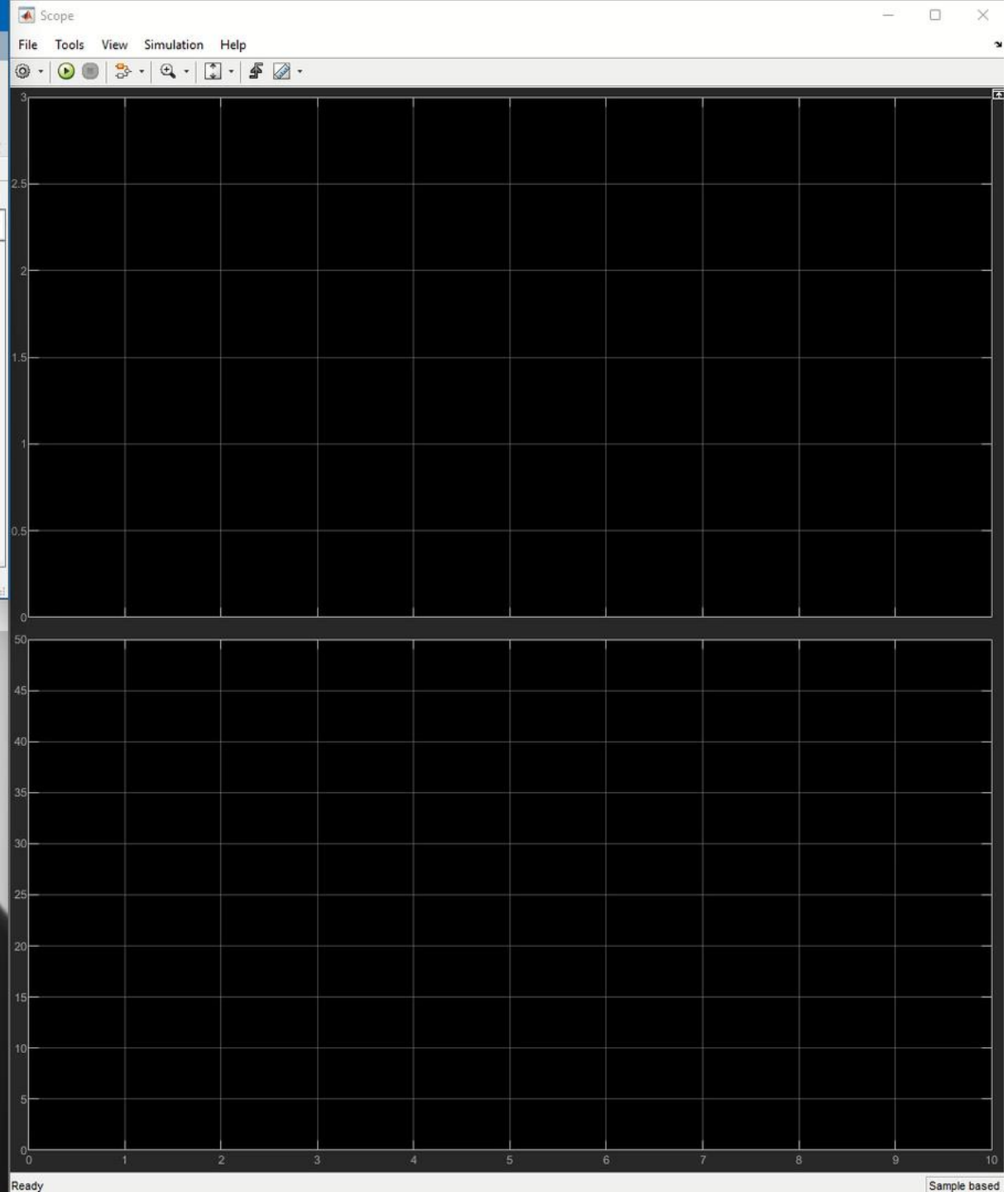
QUBE-Servo 2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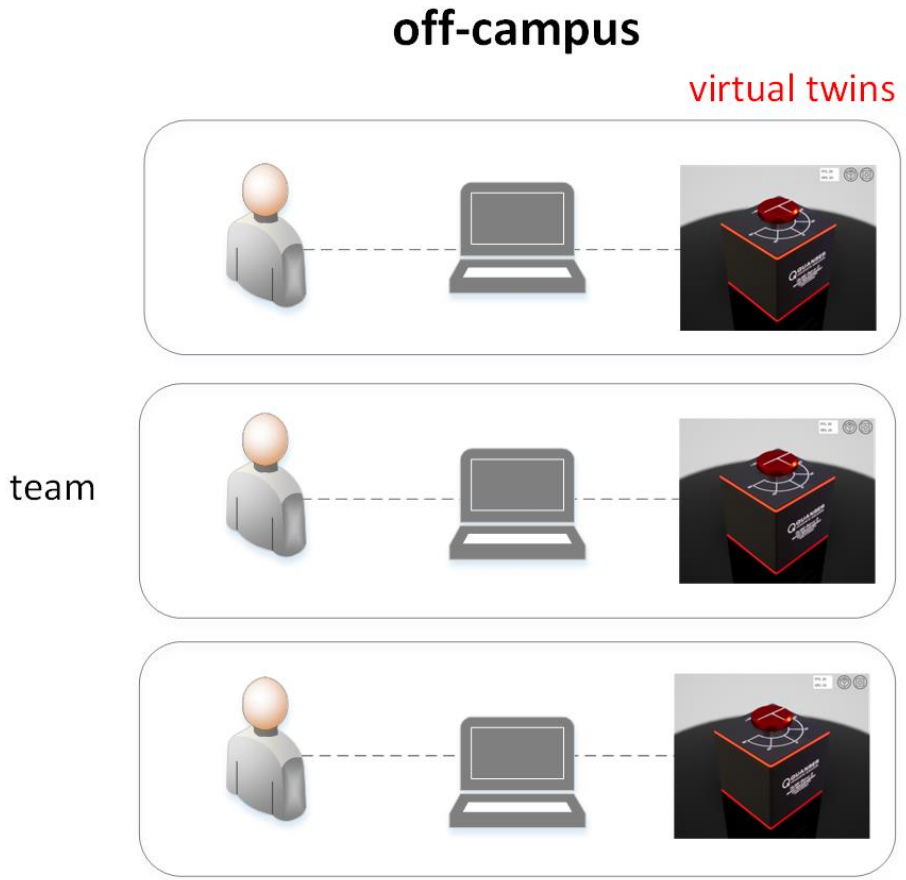
Sample based

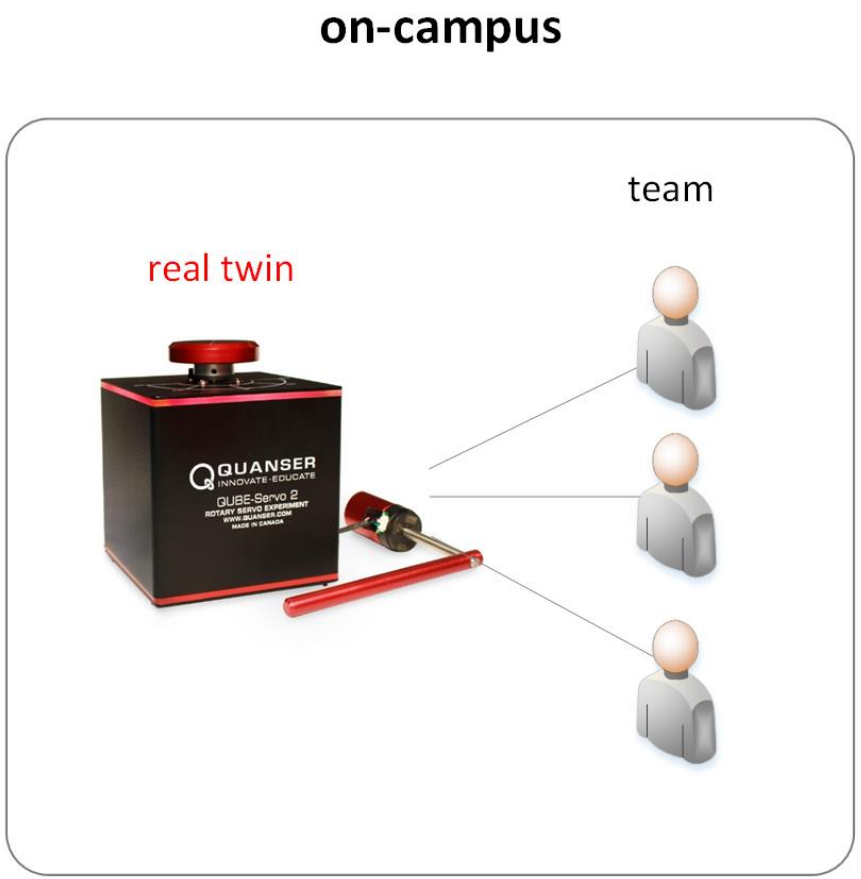
When off-campus, each team member carries out the labs against a virtual twin. This gives a number of benefits, such as self-determined learning pace



- self-determined learning pace
- better understanding of controls concepts
- no risk of hardware breaking

Once on-campus, the team repeats the labs that have been worked out earlier by using the virtual twin. Real and virtual twin behave almost identically

- Virtual and real twins interoperable
- Hands-on experience on hardware
- Single hardware device shared by each team



Key findings I

- In times of the pandemic, distance learning by means of virtual twins allowed for a significant reduction of lab attendence time without sacrificing content depth.
- On-campus lab experience is effectively supplemented by off-campus learning
- Students acquire experimental expertise at self-determined learning speed.
- Experience from two semesters has shown, that students very much welcome the distance learning format as a supplement to hand-on labs. This is why distance leaning via virtual twins will be kept even if the pandemic is over and no lab access restrictions apply.
- The DistLab project at Stralsund University is set to significantly expand the idea of distance learning by remote labs and virtual twins.

Students provided valuable first feedback on the conversion of the control systems lab to include virtual twins for distance learning

»Virtual eperience good as supplement to hands-on labs, but not as a replacement«

»Distance labs provide a convenient learning environment with sustainable outcomes.«

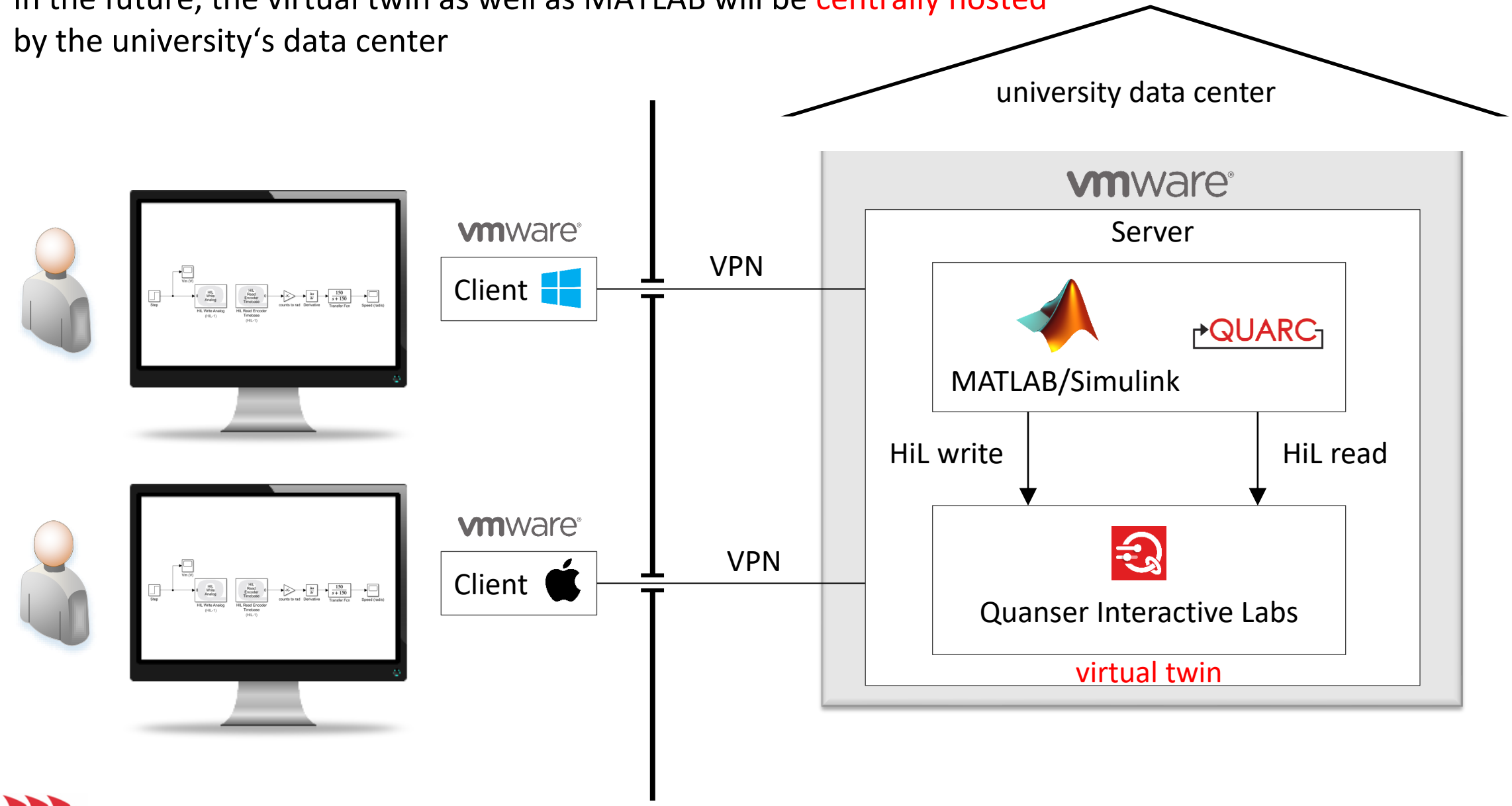
»I know what I have done in the lab.«

»With virtual twins, the learning effect is greater than with conventional labs because the acquisition of the material is distributed over the whole semester.«

»Off-campus learning is appreciated. Should be continued even after the end of the pandemic.«

»The software could not be installed on my PC.«
»The performance was very poor on my PC.«
»8 GB RAM was not sufficient.«
»Had installation issues, but could be rectified.«

In the future, the virtual twin as well as MATLAB will be centrally hosted by the university‘s data center



In the future, DistLab will extend the ideas of distance learning in control systems labs by implementing further pairs of real and virtual twins from Quanser

Pairwise real & virtual twins to be implemented

Key findings II

- In the current implementation, each student must install MATLAB/Simulink, QUARC and QLabs – the software for running the virtual twin – on his or her own PC. This leads to a number of issues:

  a) QLabs requires Windows operating system. However, many students are running MacOS or Android, which are both incompatible.

  b) The performance of the virtual twin has been found to strongly depend on the individual configuration of the team member‘s computers. This sometimes leads to dissatisfactory results. It may happen that two students, running the same Simulink code, are getting different outputs from the scopes.

- These issues call for a revised solution where all of the software is centrally hosted such that students only require a virtualization client – such as VMWare – to use these ressources.

Thanks to the whole DistLab team at Stralsund University of Applied Sciences

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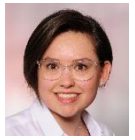

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Thank you