Digital Twin Development for an Automated Robot Workcell

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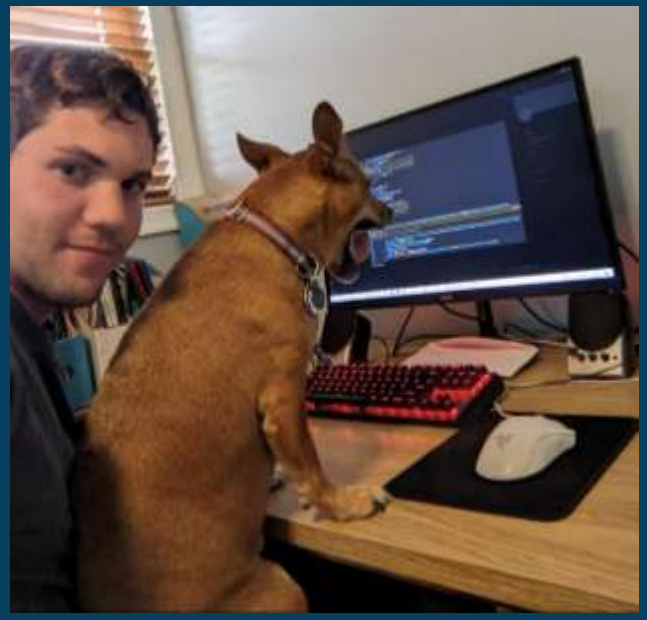
About Me

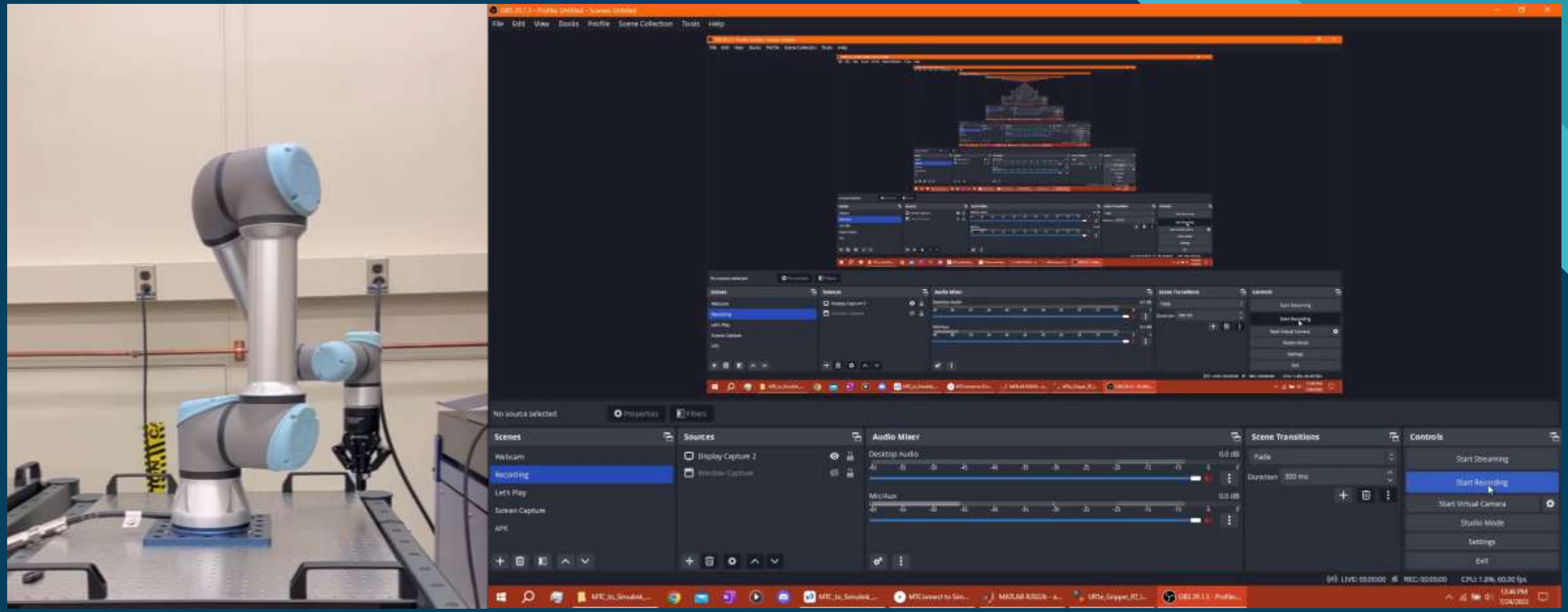
- UMD Senior
- Mechanical Engineering Major
  - Robotics Minor
- Baja SAE team - Terps Racing
- Game programming
- Dog!



Assembling Baja Car Transmission

My Project

- Digital twin of UR5e robot arm with a gripper



Outline

1. What is a digital twin?
2. Digital twin standard
3. Implementation
4. Lessons learned
5. Future work

Digital Twins

What? Why? How?

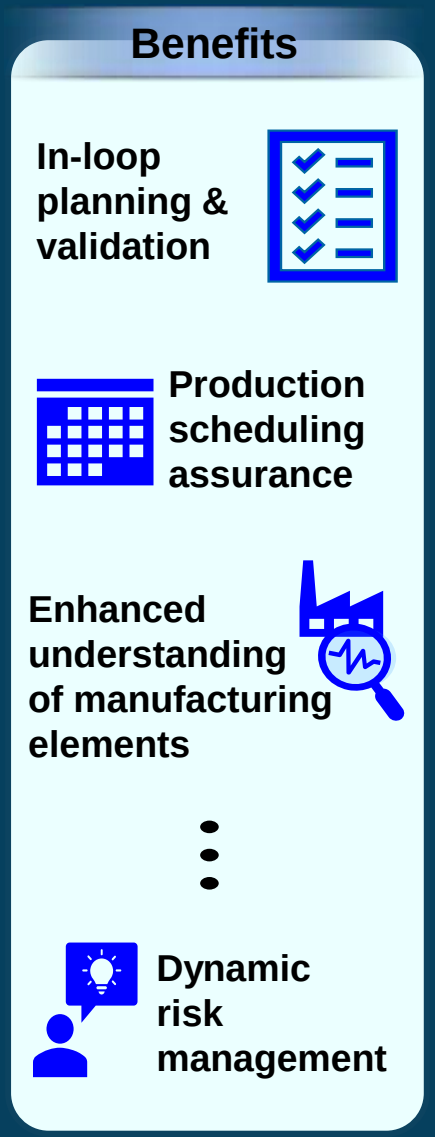
What is a “Digital Twin”?

“A fit for purpose digital representation of an observable manufacturing element with synchronization between the element and its digital representation.” (ISO 23247)

+ feedback loop

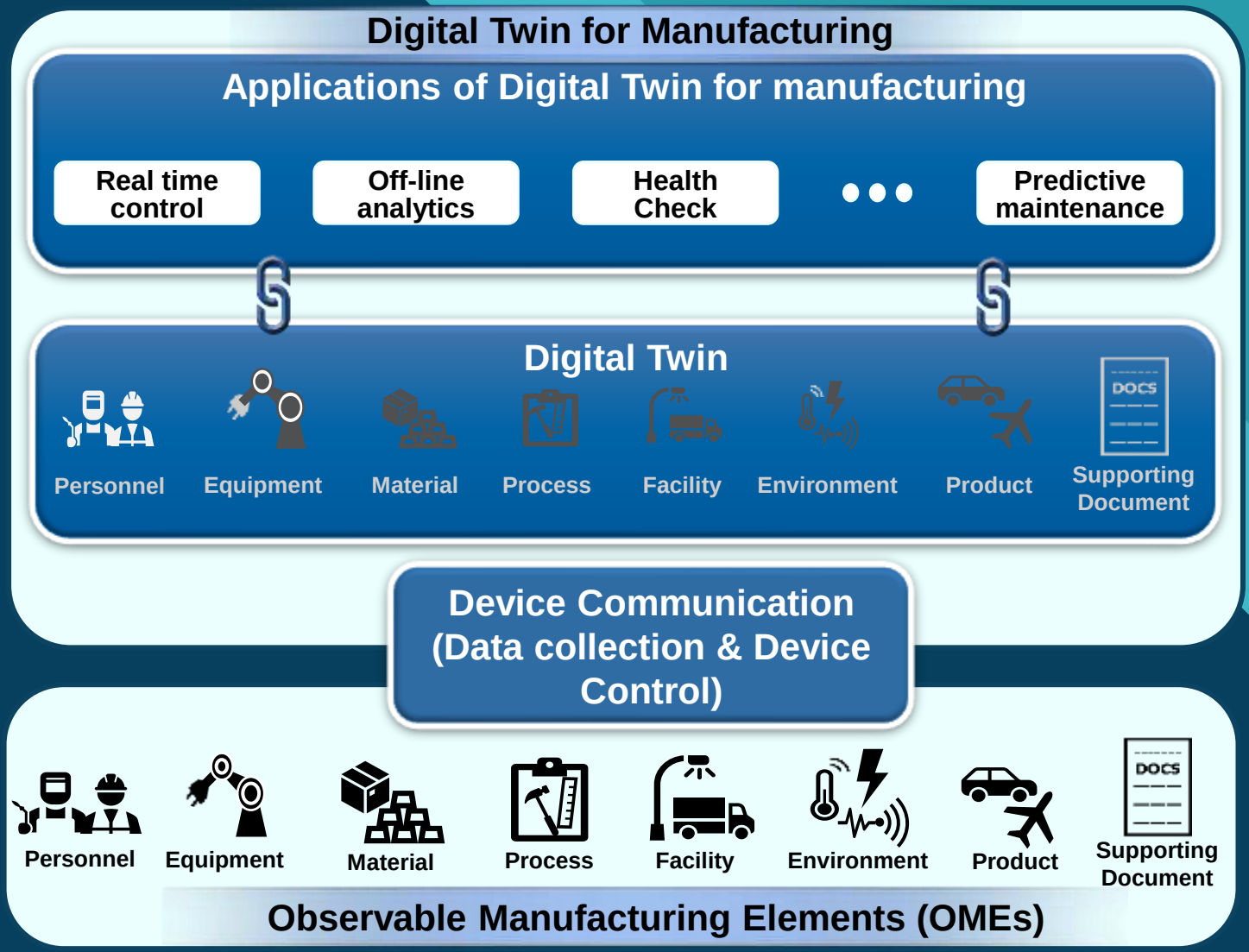
Why Digital Twins?

Analysis → Solve problems
Automation → Gain efficiency



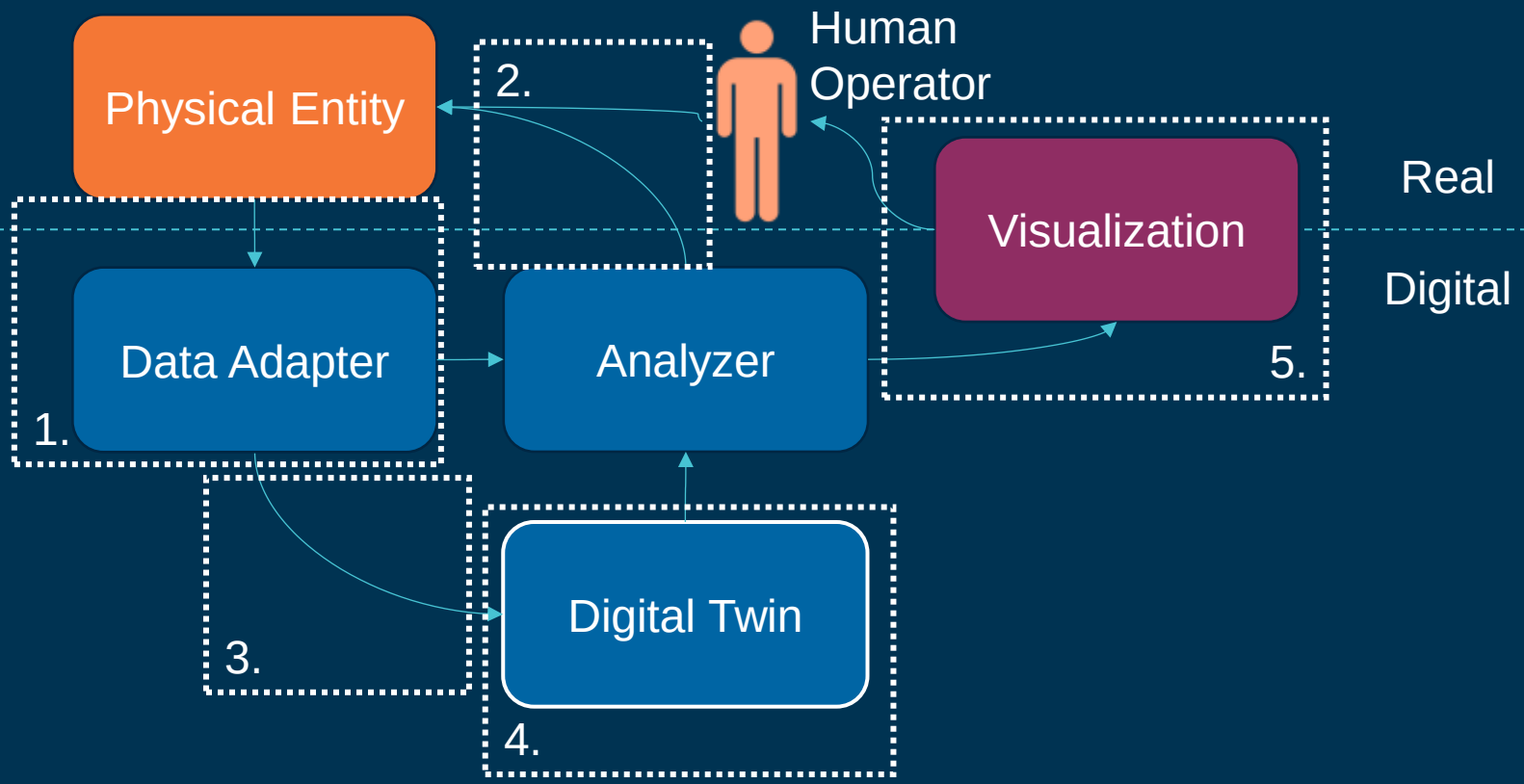
Why use ISO 23247?

- Definitions & vocabulary
- Framework for development
  - System structure
  - Encourages using existing standards
- Guide for my work

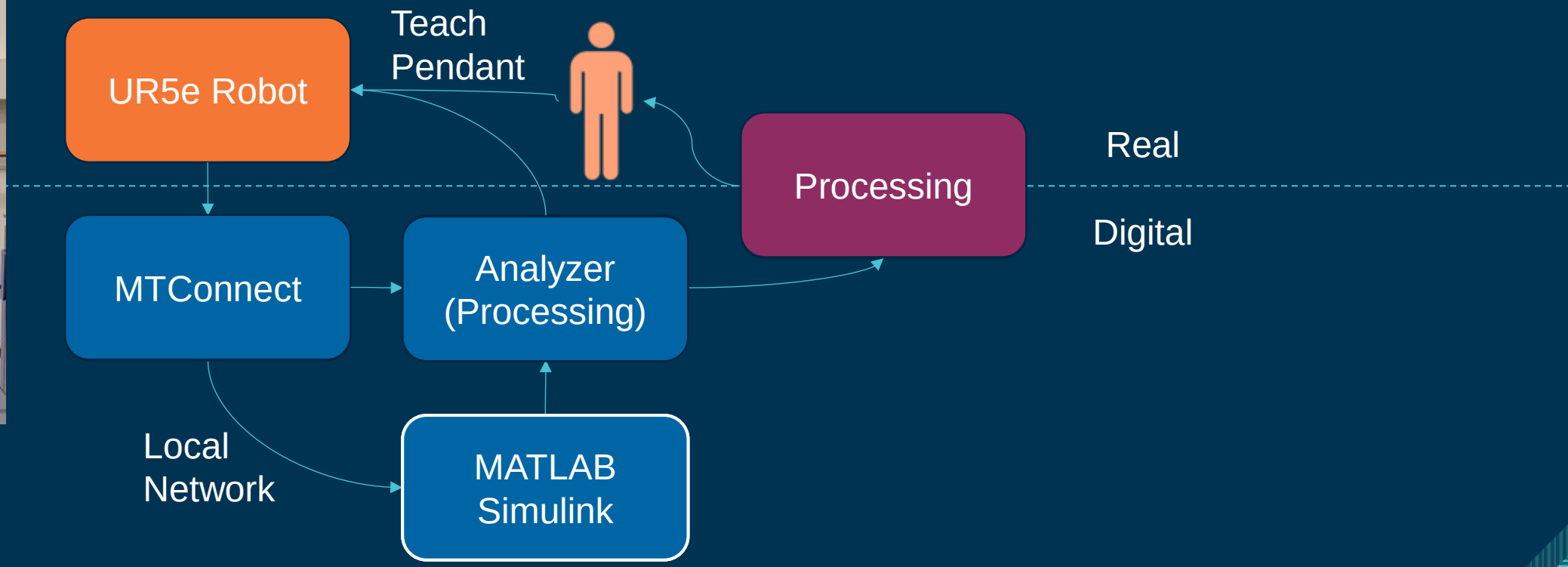


ISO 23247-1 (2021)

Using ISO 23247

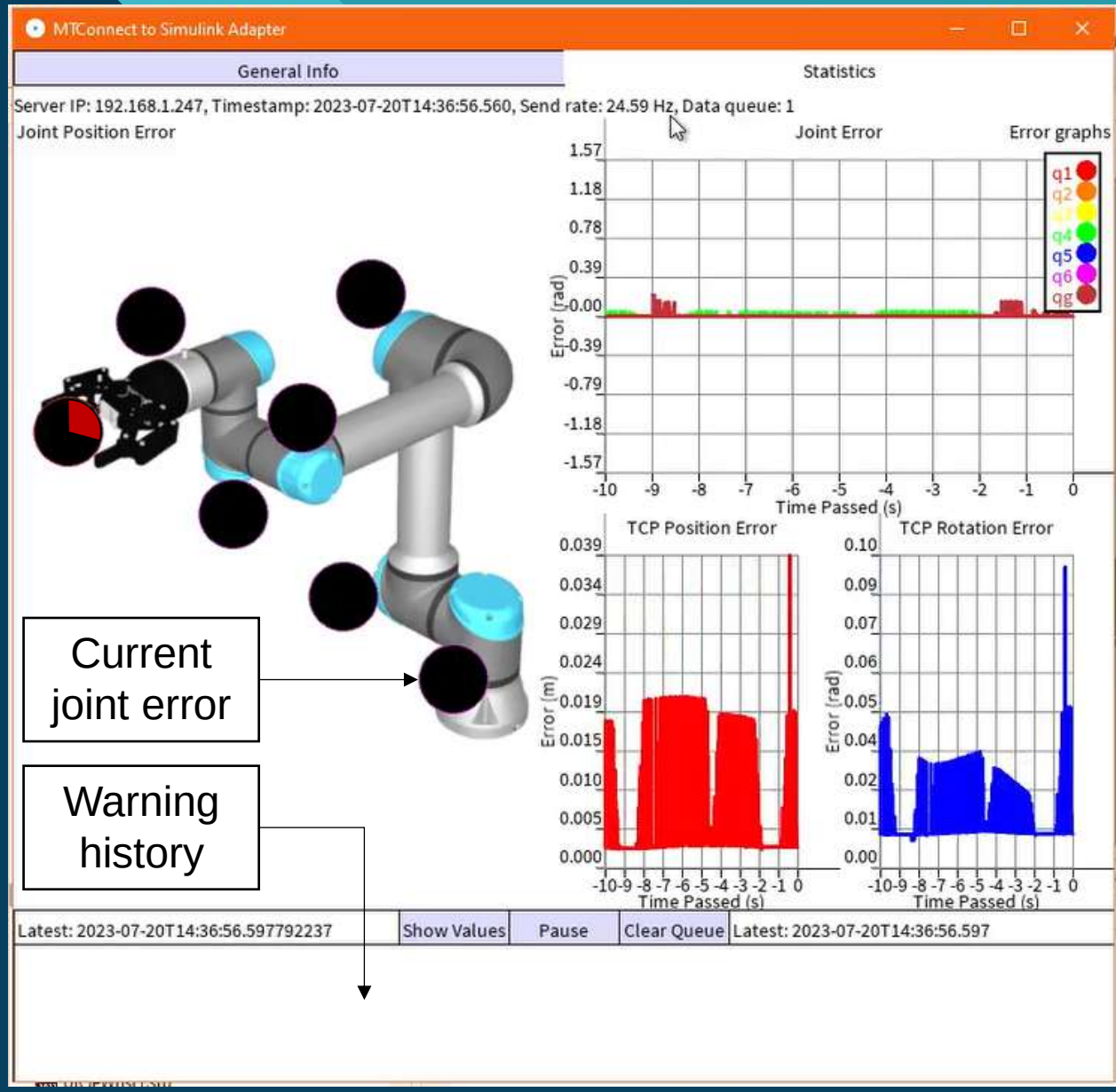


Applying ISO 23247



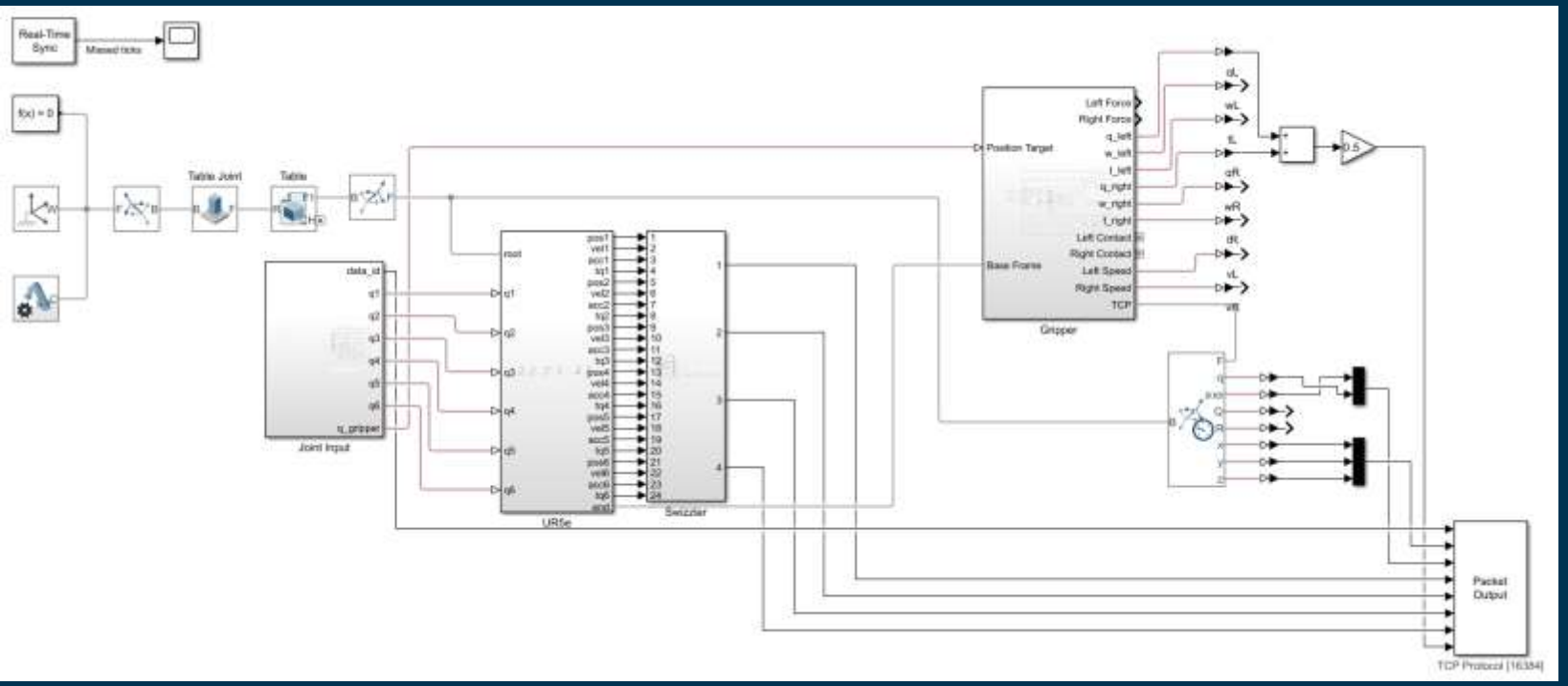
UR5e Twin Purpose

- Detect discrepancies
  - Joint states
  - Tool center position (TCP)
  - Gripper state
- Notify operator with on-screen warnings
- Data visualization
- Improve model

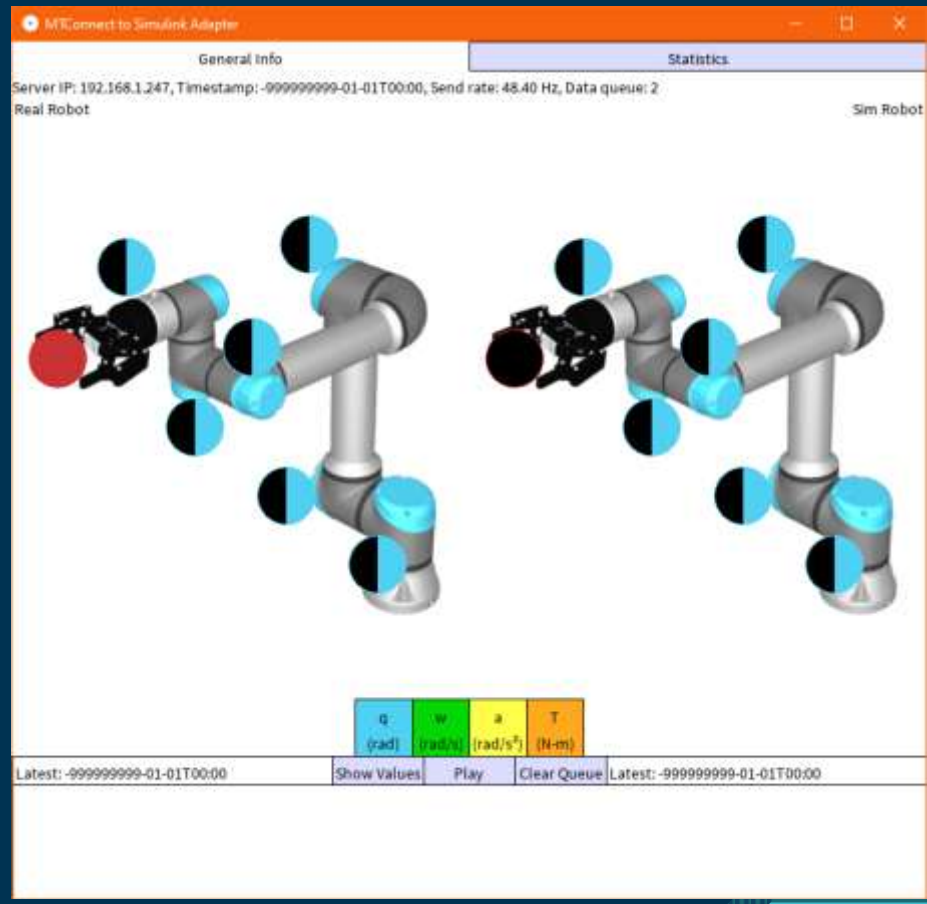


UR5e Twin Implementation

MATLAB Simulink model



Processing Program



Lessons Learned

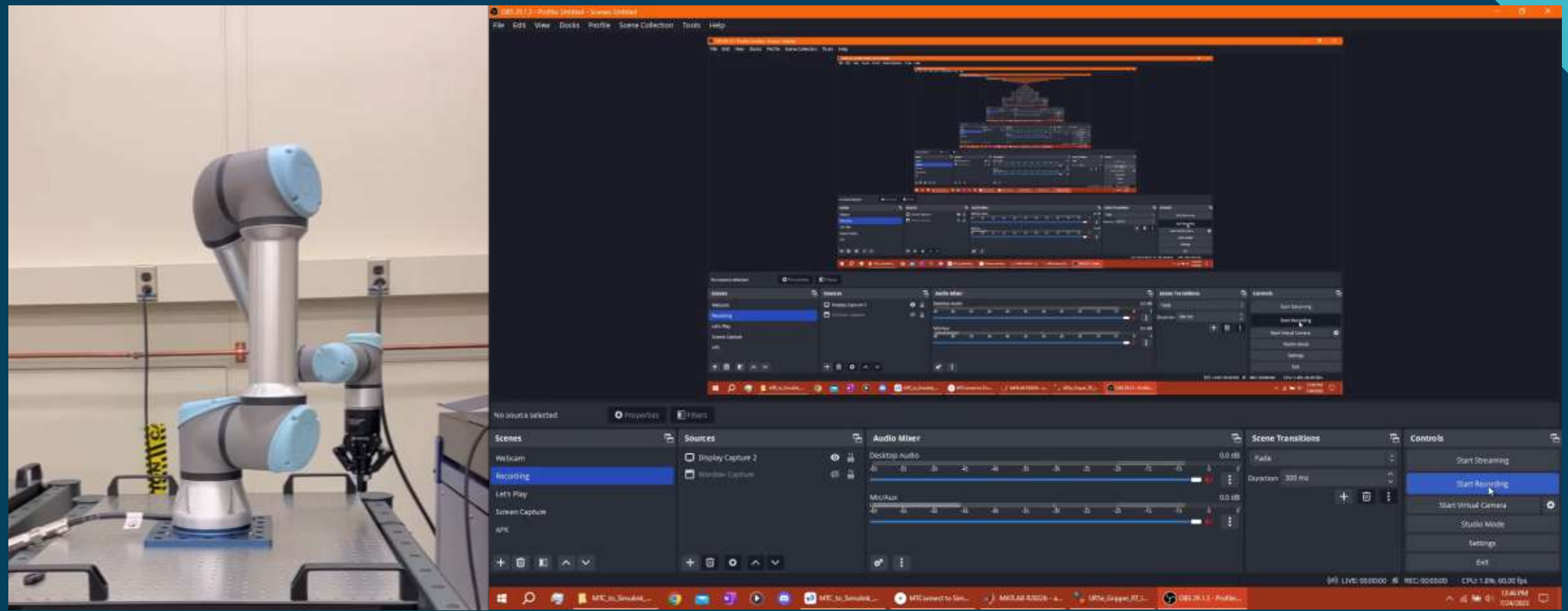
- Simulation accuracy is key
  - Verification & Validation
- Reduce complexity
  - Good software engineering practices
  - Fit for purpose
  - Use standards
- Implementation-specific considerations
  - Networking
  - Real-time simulation
  - Data formatting

Future Work

- Explore other physics simulators
  - ROS + Gazebo
  - Game engines
  - Other enterprise software
- Improve simulation accuracy
  - Use collected data
- Integrate UR5e digital twin with other twins:
  - CNC Mill & CMM

Conclusion

- Digital twins have big potential
- Digital twins are complicated
- Standards help with implementation



Thank you!

Acknowledgements

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References

International Organization for Standardization. (2021). *Digital twin framework for manufacturing* (Standard No. 23247).

Shao, G. (2021). Use case scenarios for digital twin implementation based on iso 23247. *National institute of standards: Gaithersburg, MD, USA*.