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Fraunhofer-Institut für Materialfluss und Logistik IML

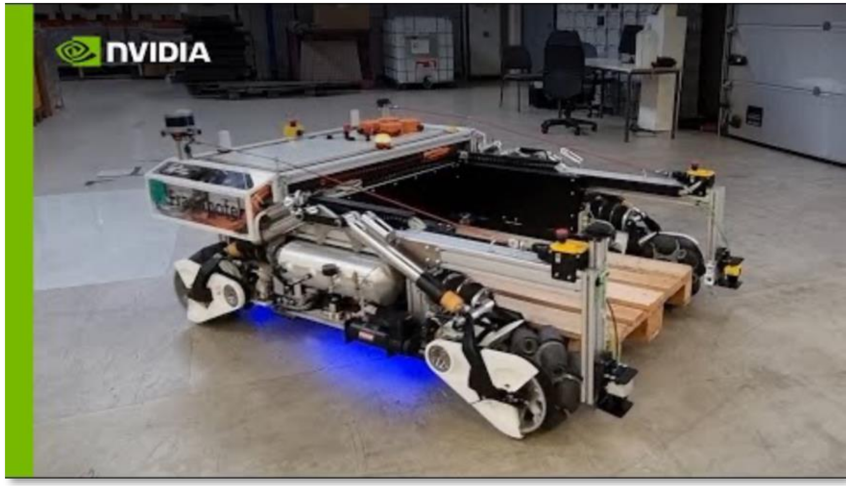
ROSCon DE + FR 2025

Anwendungsbeispiel Intralogistik: Simulation in der Robotik zwischen Anspruch und Wirklichkeit

Application Example Intralogistics: Simulation in Robotics Between Expectation and Reality

Marvin Wiedemann

Omniverse, Digital Twins and New Simulation Capabilities
Simulation is Hyped (Again)!



digital_twin omniverse
openusd
isaac
nvidia
simulation
robotics
physical_ai
embodiedai
cosmos

  Open

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2023

2025

Opportunity

—

Simulation-based Development


silicon economy
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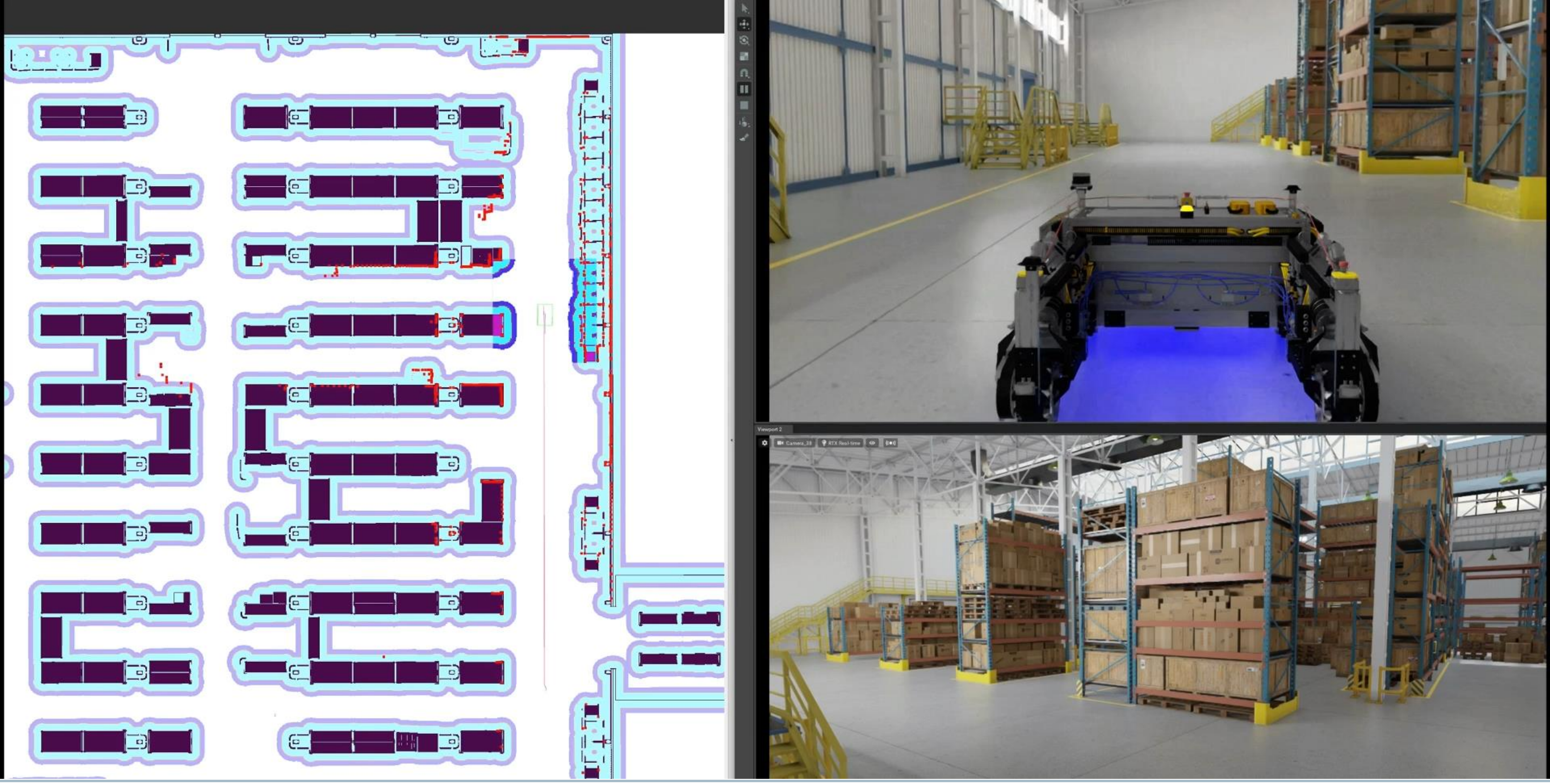
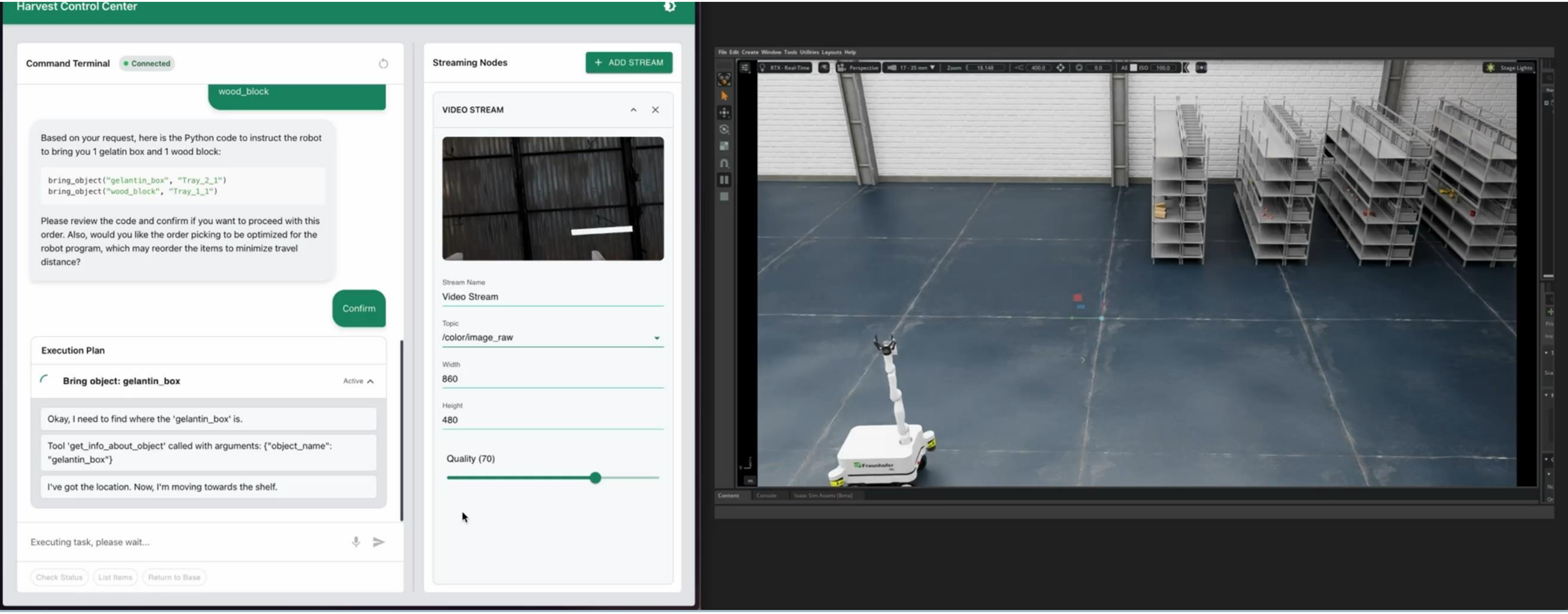

Viewport 2

Opportunity: Simulation-based Development
Mobile Manipulation for Autonomous Commissioning



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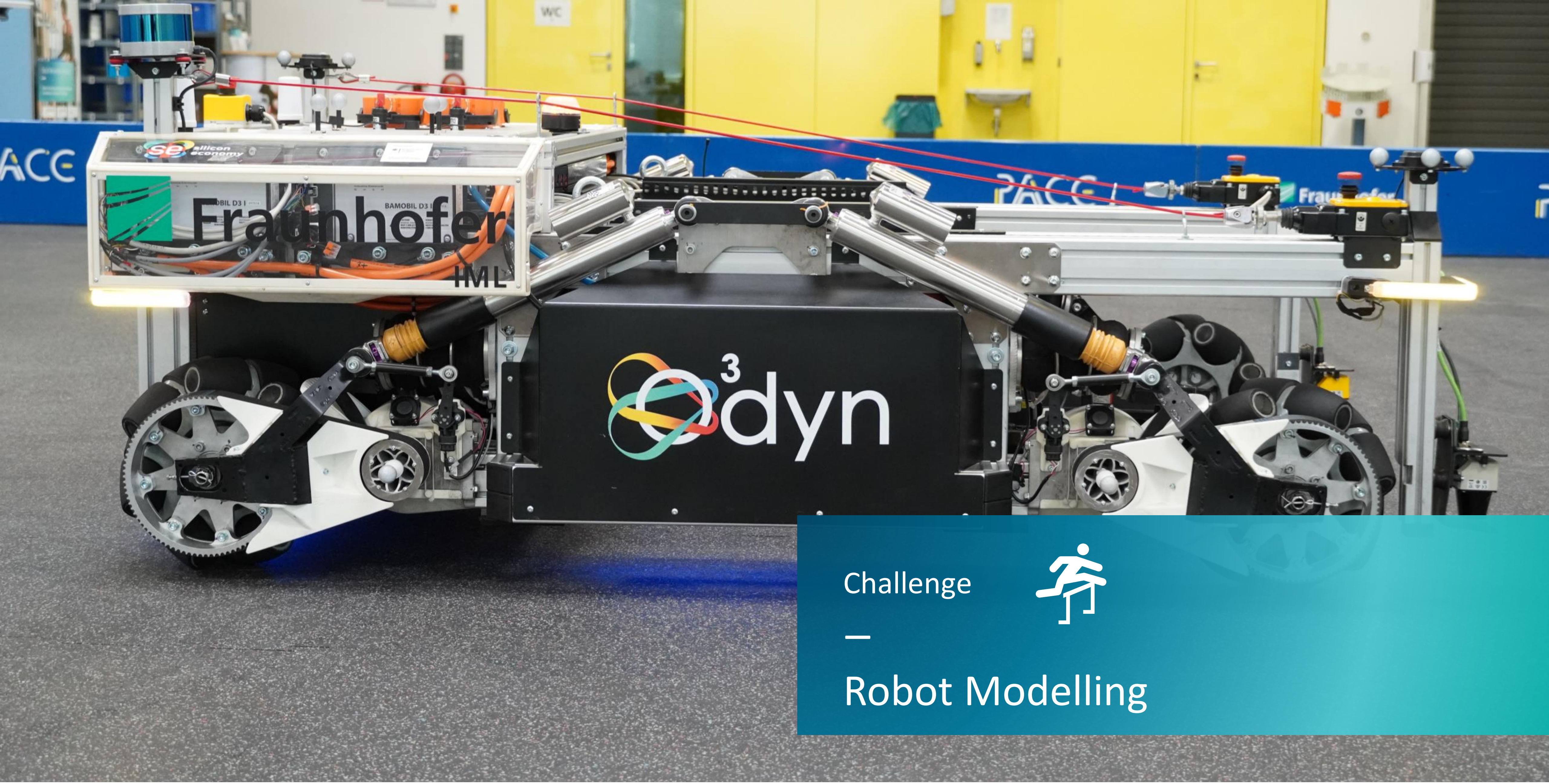

Challenge

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Robot Modelling

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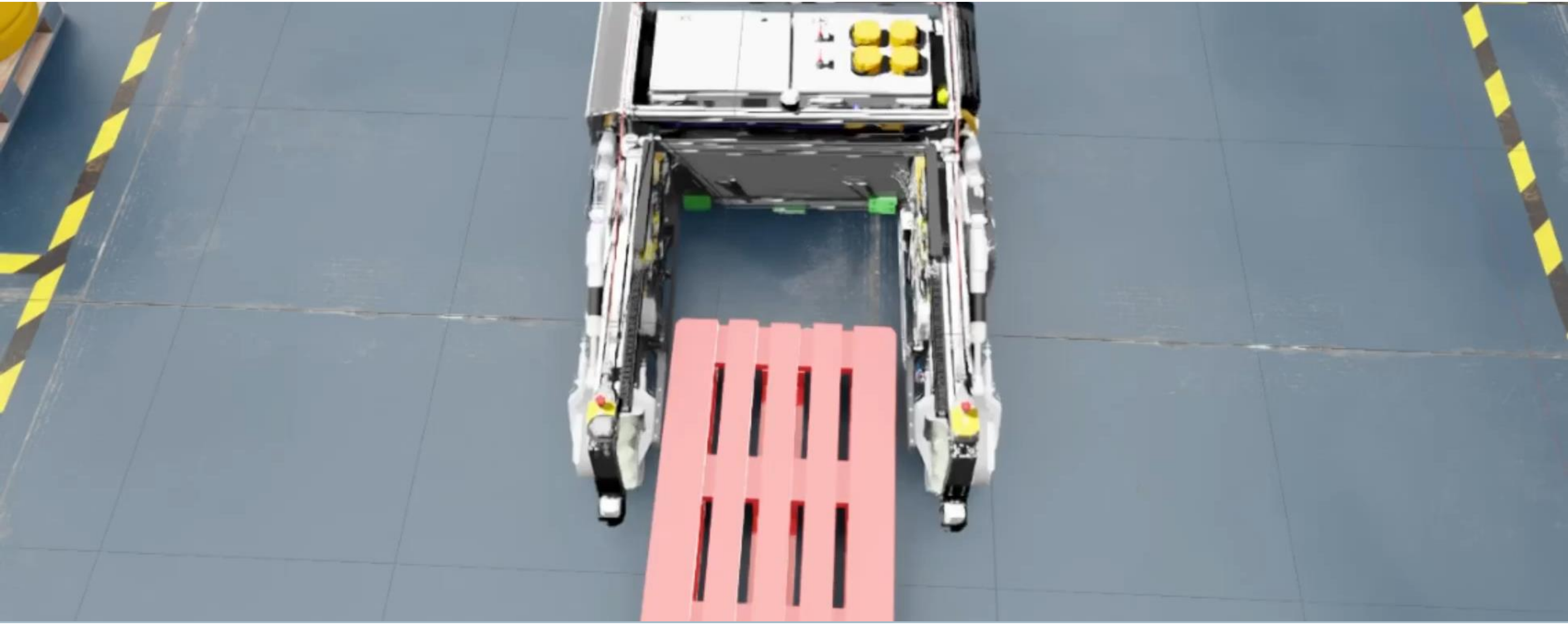
Challenge: Robot Modelling
When Things Don't Go Quite as Planned…



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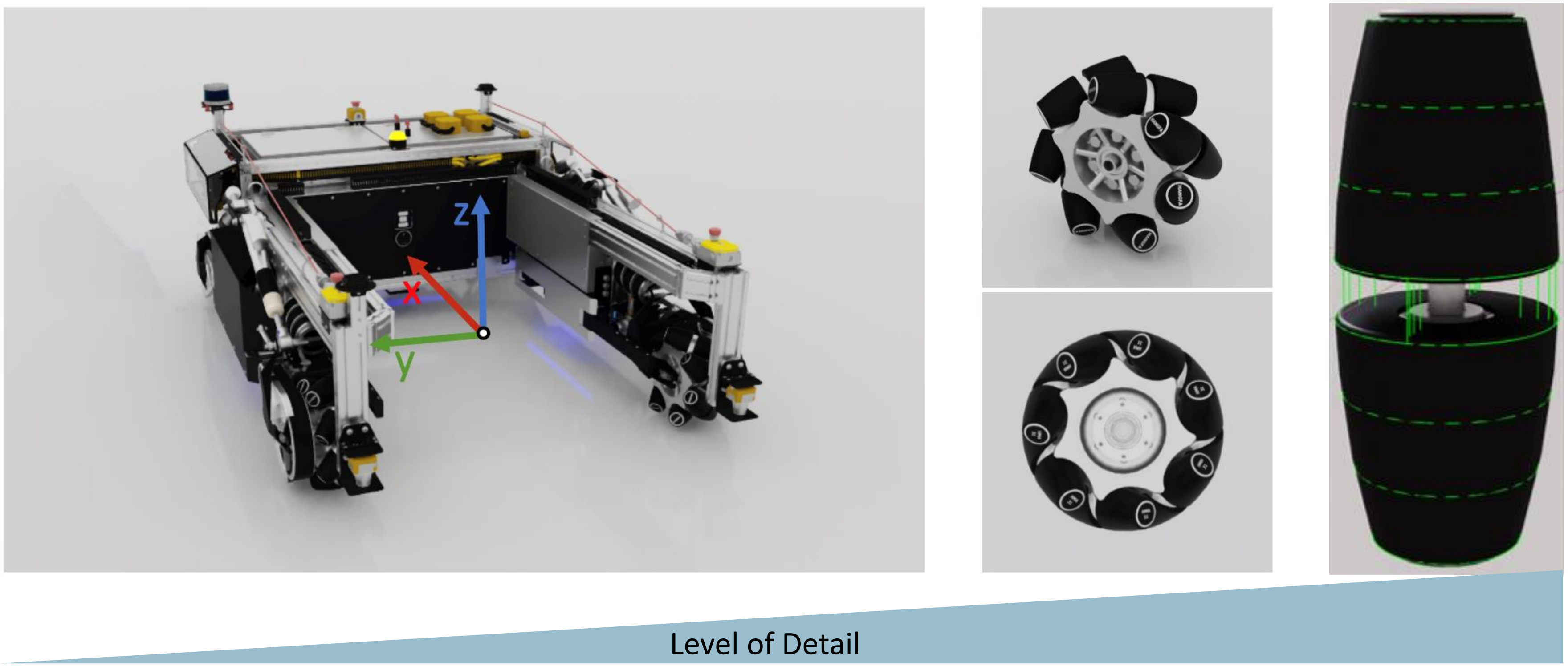
Challenge: Robot Modelling
Modelling of Omnidirectional Robots

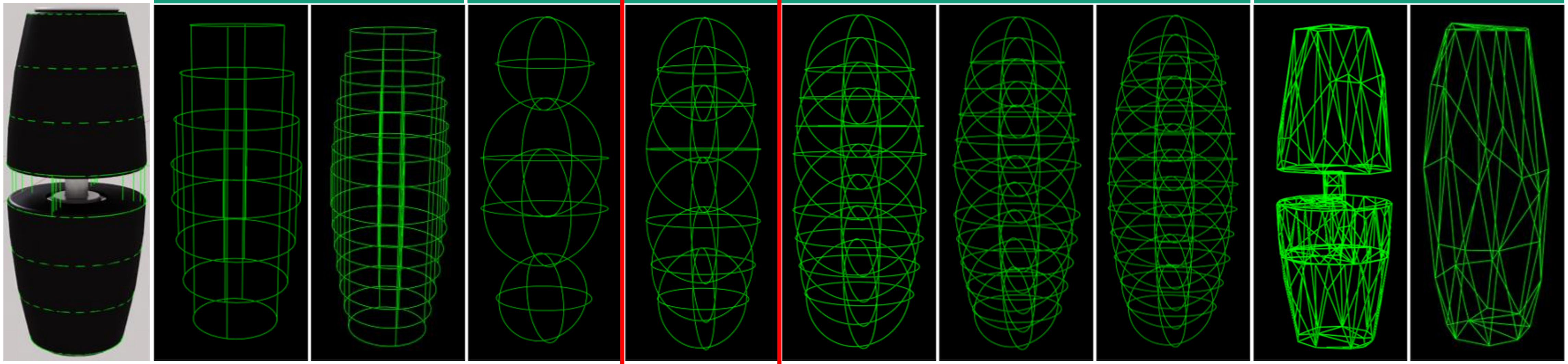


Overall System

Wheel Roller Colliders

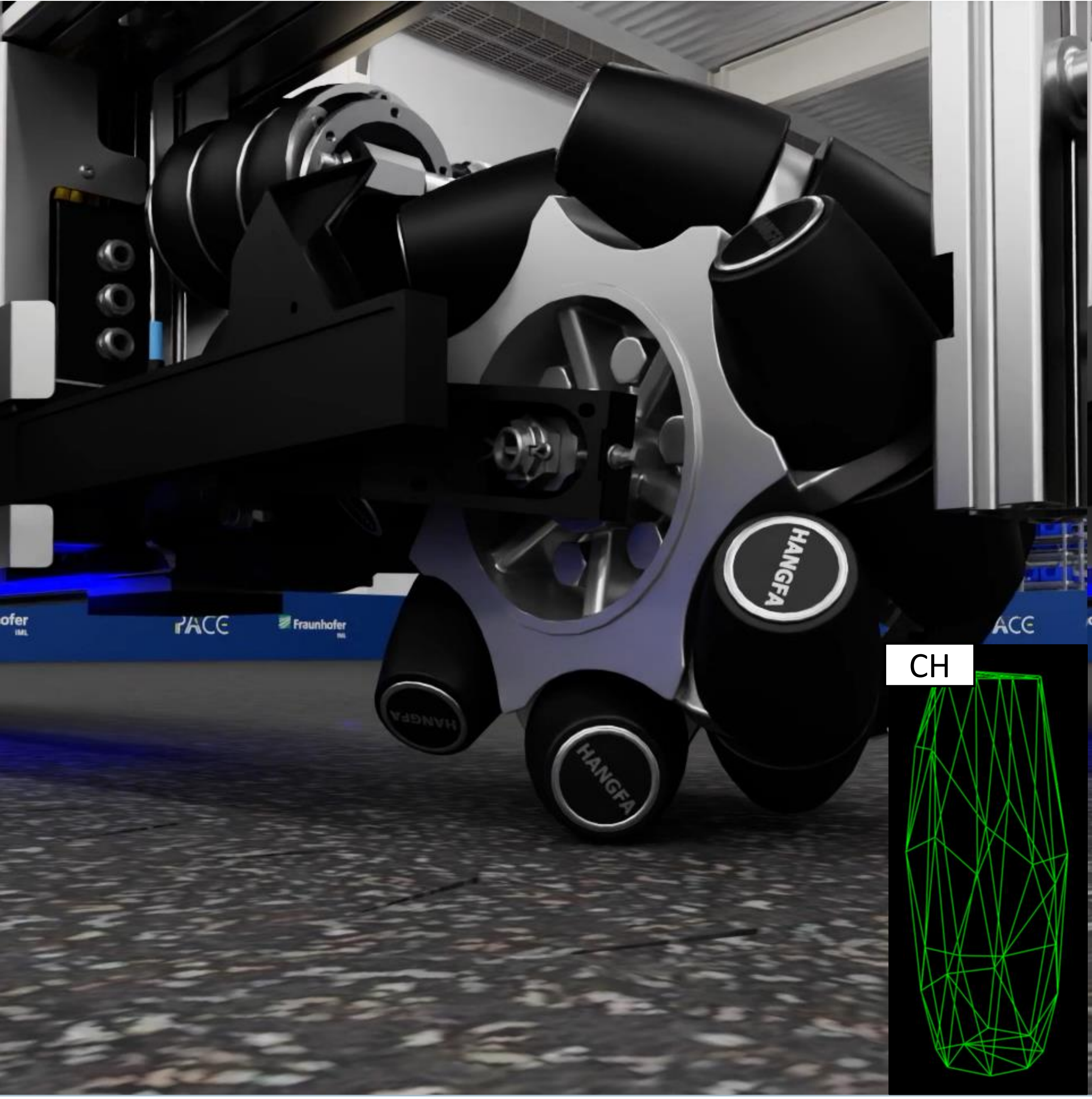
Reference: M. Wiedemann, O. Ahmed, A. Dieckhöfer, R. Gasoto and S. Kerner, "Simulation Modeling of Highly Dynamic Omnidirectional Mobile Robots Based on Real-World Data," *2024 IEEE International Conference on Robotics and Automation (ICRA)*, Yokohama, Japan, 2024, pp. 16923-16929, doi: 10.1109/ICRA57147.2024.10611459.

Challenge: Robot Modelling
Collider Modelling for Omnidirectional Robots



	Cylinders		Spheres					Auto-generated	
	C4	C7	S4	S6	S8	S10	O	CD	CH
Longitudinal Drift	o	++	o	+	++	++	++	-	--
Lateral Drift	+	o	++	++	+	+	+	-	--
Computational Costs	o	--	++	+	-	-	--	+	++

Reference: M. Wiedemann, O. Ahmed, A. Dieckhöfer, R. Gasoto and S. Kerner, "Simulation Modeling of Highly Dynamic Omnidirectional Mobile Robots Based on Real-World Data," *2024 IEEE International Conference on Robotics and Automation (ICRA)*, Yokohama, Japan, 2024, pp. 16923-16929, doi: 10.1109/ICRA57147.2024.10611459.


HANGFA
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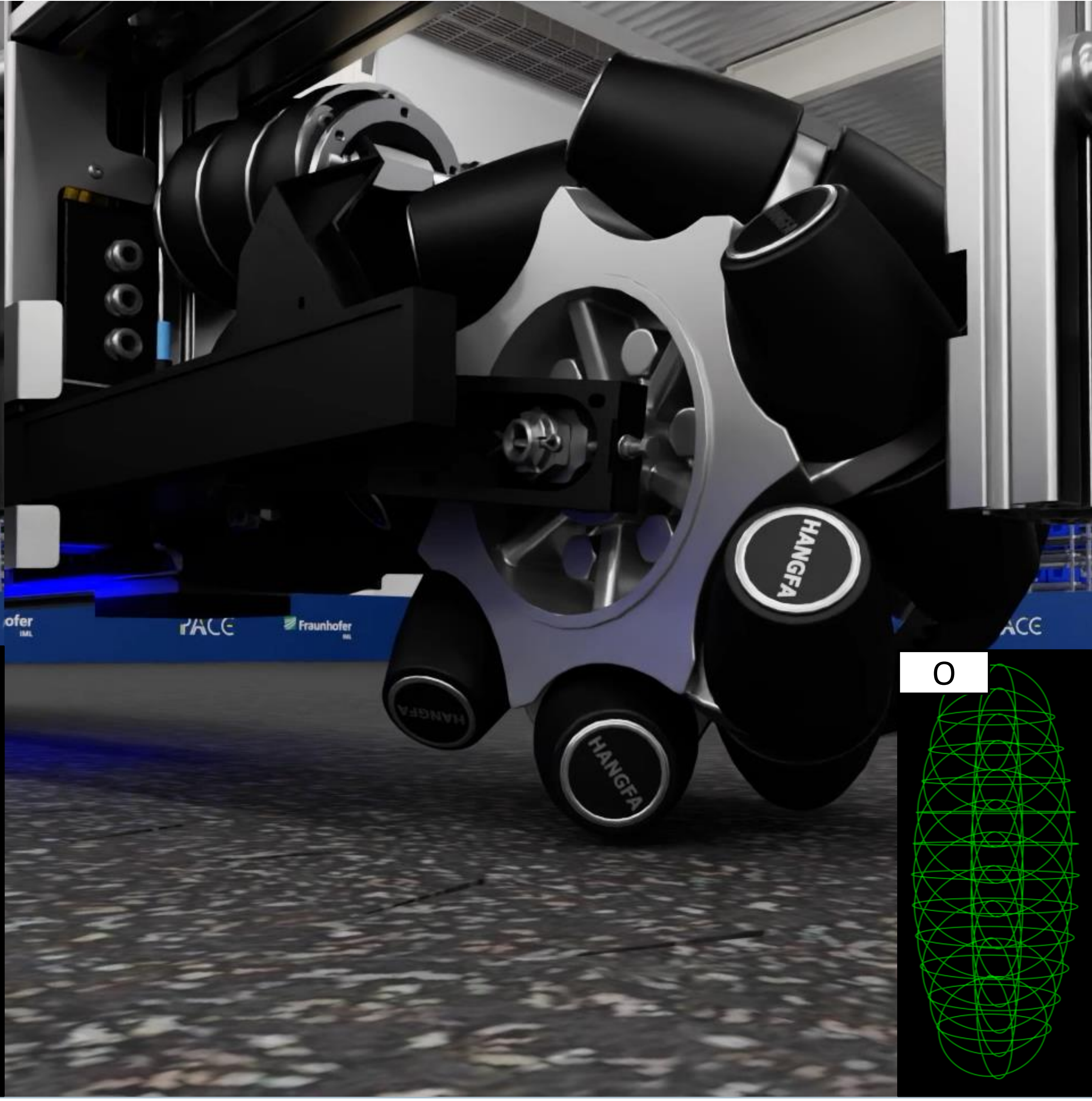
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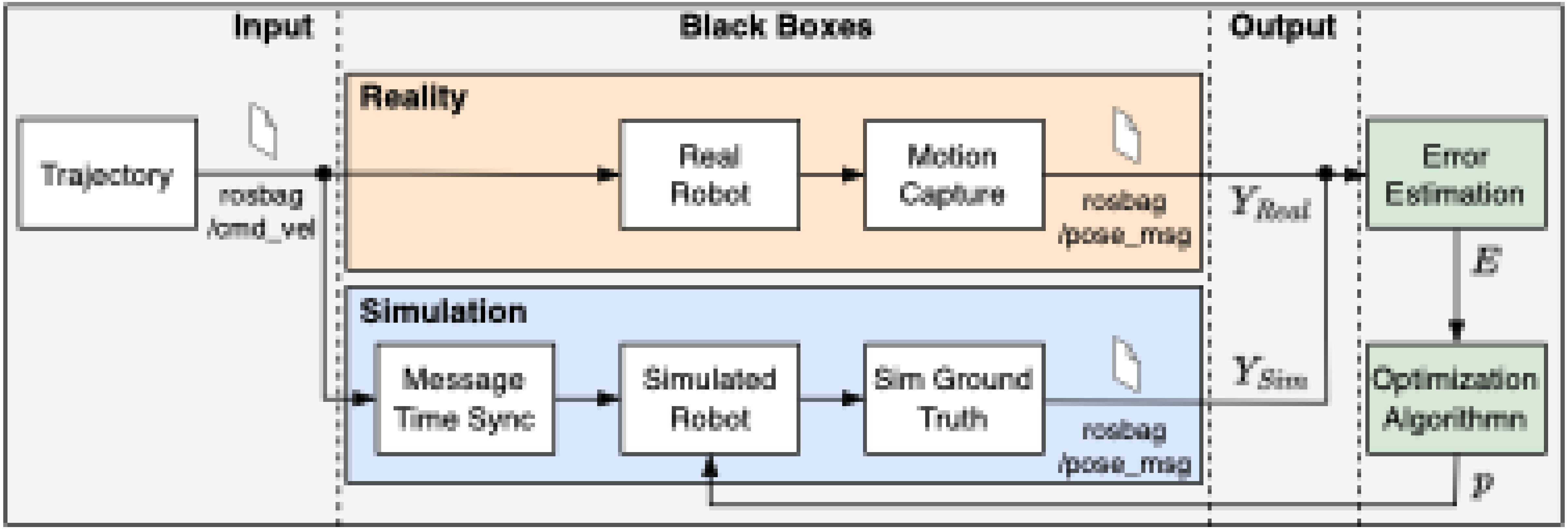
Challenge: Robot Modelling
Automated Model Tuning: The Pipeline



Reference: M. Wiedemann, O. Ahmed, M. Hatwar, R. Gasoto, P. Detzner and S. Kerner, "Automated Tuning of Non-Differentiable Rigid Body Simulation Models for Wheeled Mobile Robots," *2025 IEEE 21st International Conference on Automation Science and Engineering (CASE)*, Los Angeles, CA, USA, 2025, pp. 2436-2443, doi: 10.1109/CASE58245.2025.11163879.

Approximation of real-world trajectory marked in green

Generation 1/5

Generation 2/5

Generation 3/5

Generation 4/5

Generation 5/5

Tunde model: test runs

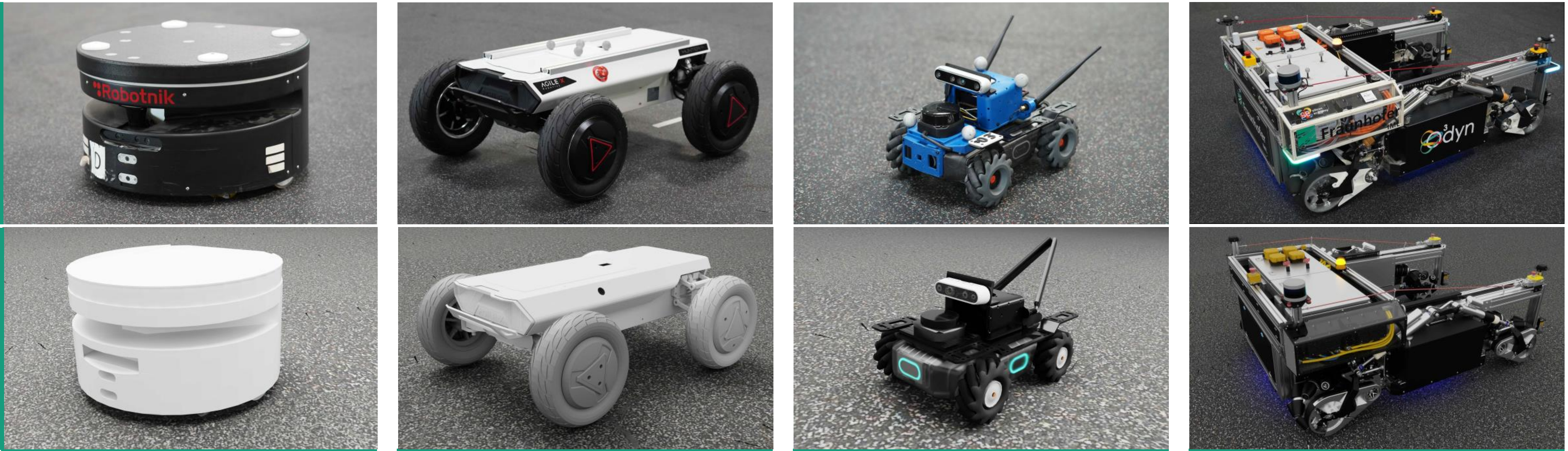
Tuning for O^{3}dyn Longitudinal Motion ($v_{x,max}$ = 3 m/s, a_x = 3 m/s^2, Length: 20 m)

Video Speed x50

Challenge: Robot Modelling
Automated Model Tuning: Wheeled Mobile Robots Examples

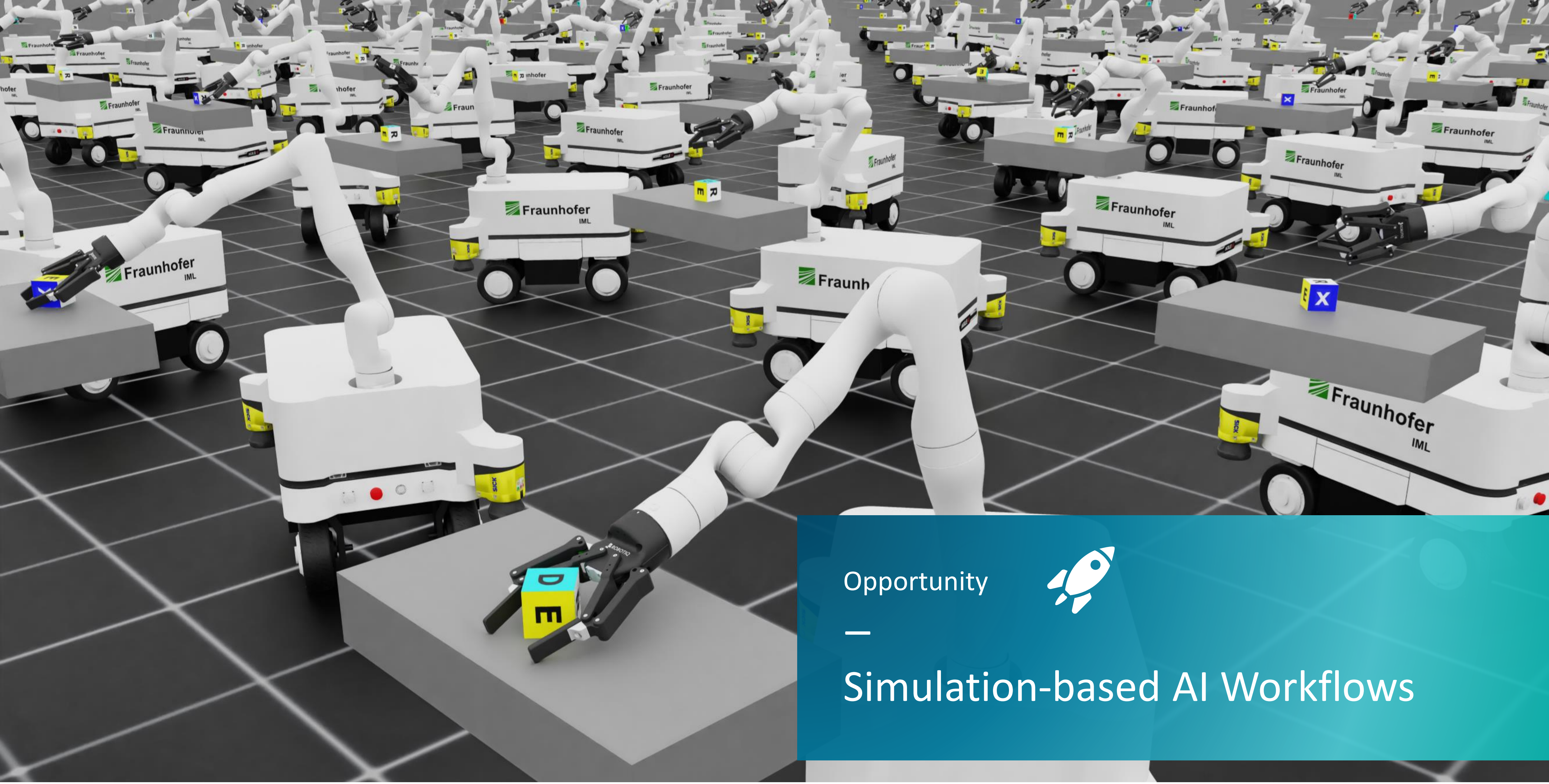
Real Robot

Simulation



Robotnik RB-1	AgileX Hunter SE	DJI RoboMaster S1	O^{3}dyn
Differential	Ackermann	Omnidirectional	

Reference: M. Wiedemann, O. Ahmed, M. Hatwar, R. Gasoto, P. Detzner and S. Kerner, "Automated Tuning of Non-Differentiable Rigid Body Simulation Models for Wheeled Mobile Robots," *2025 IEEE 21st International Conference on Automation Science and Engineering (CASE)*, Los Angeles, CA, USA, 2025, pp. 2436-2443, doi: 10.1109/CASE58245.2025.11163879.



Opportunity

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Simulation-based AI Workflows

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Learning System: Real Systems Learn New Behaviours in a Virtual World

Challenges

—

- AI methods needed for advanced environment understanding and interaction
- Dependency on high-quality training datasets

Advantages

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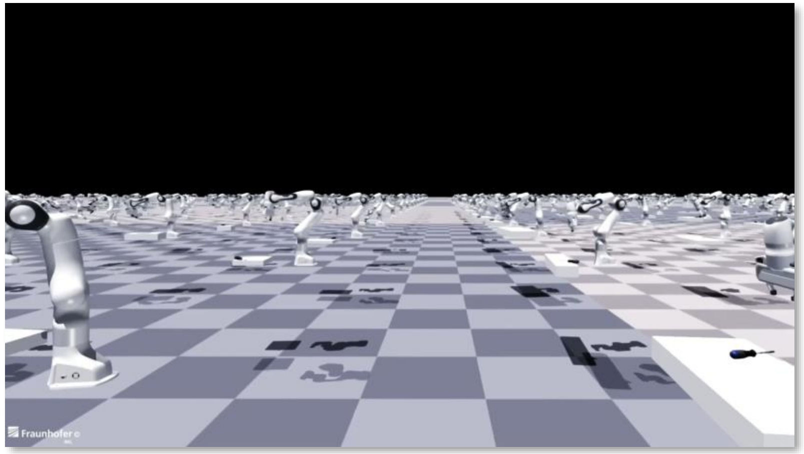
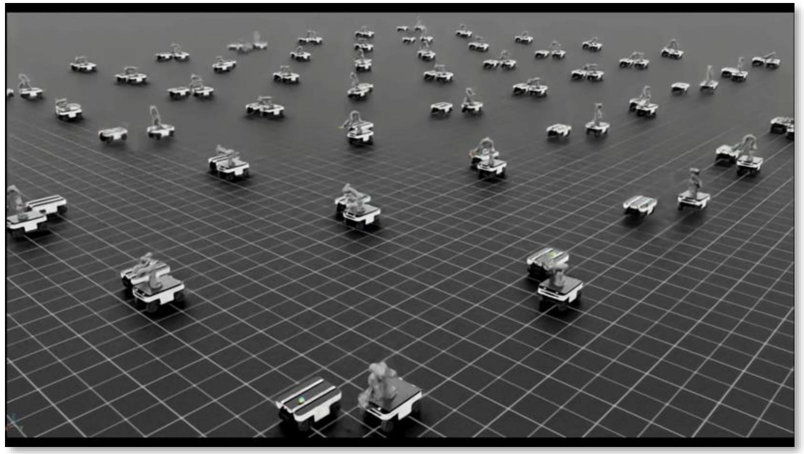
- Scalable generation of thousands of diverse synthetic images
- Safe, cost-free training and validation of new, robust system functions in a virtual environment





Challenge

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Environment Modelling

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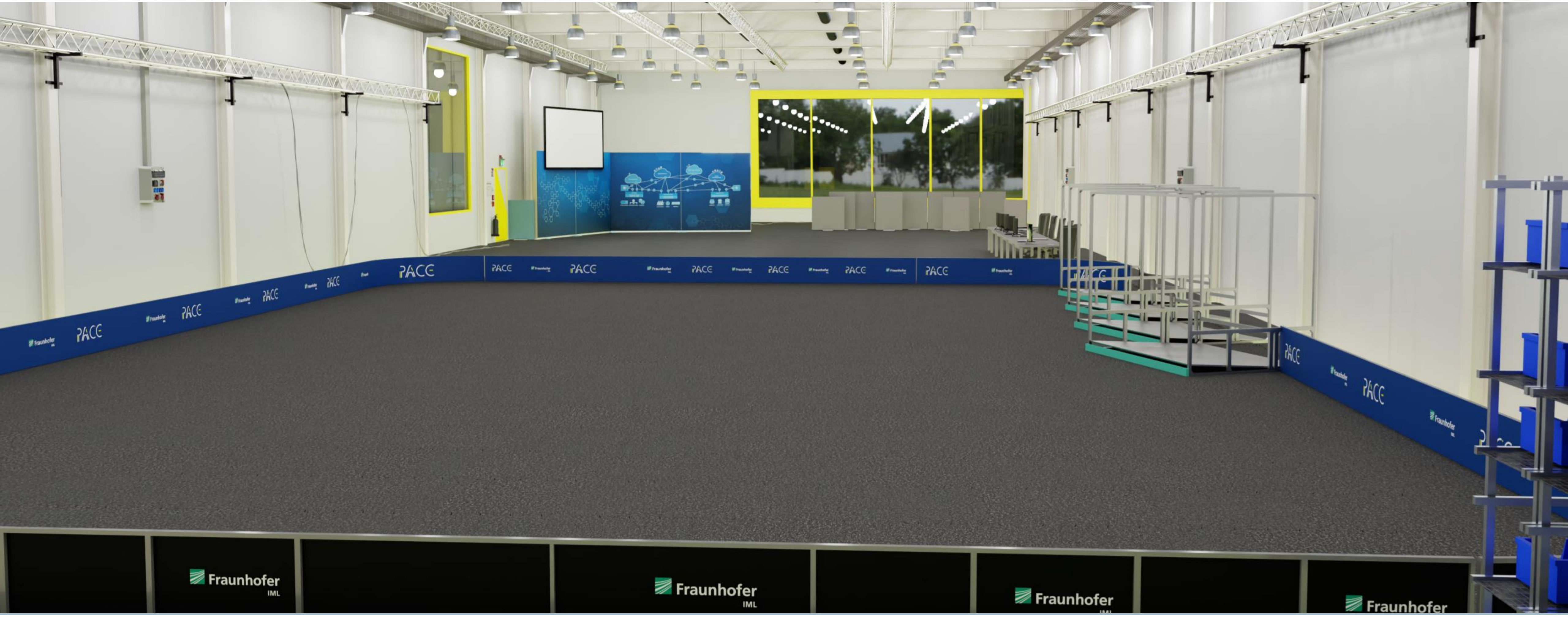
Challenge: Environment Modelling
Manual Environment Modeling



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Challenge: Environment Modelling
Environment Models based on 3D-Scans

Use Cases

—

- Building accurate simulation environments quickly
- Virtual deployment of robots and automation hardware

Used Approaches

—

- Meshing a 3D point cloud for improved performance
- Extracting individual objects as assets
- Using scanned simulation environment for synthetic sensor data

Challenge: Environment Modelling
Environment Models based on 3D-Scans

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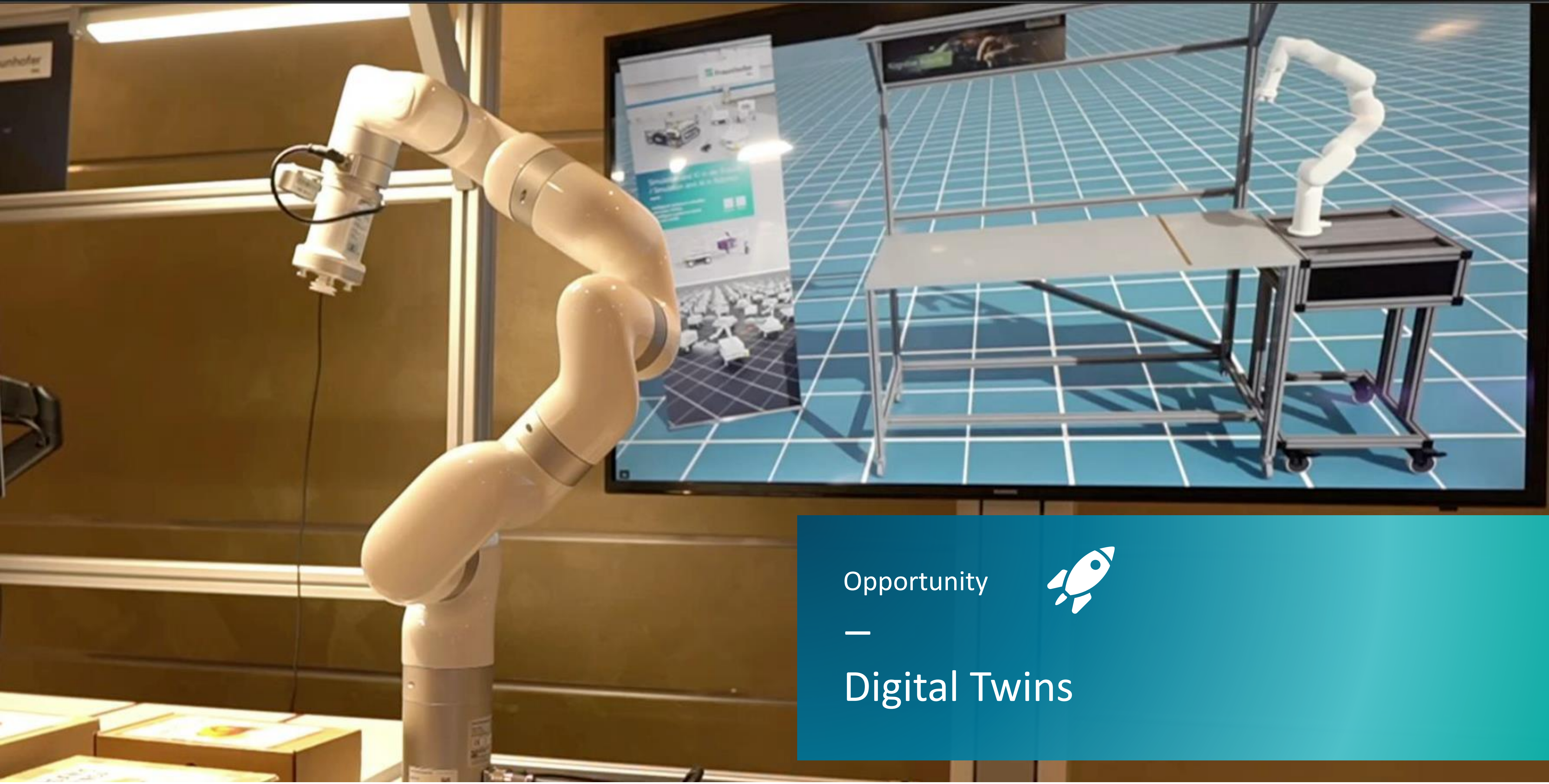

Opportunity

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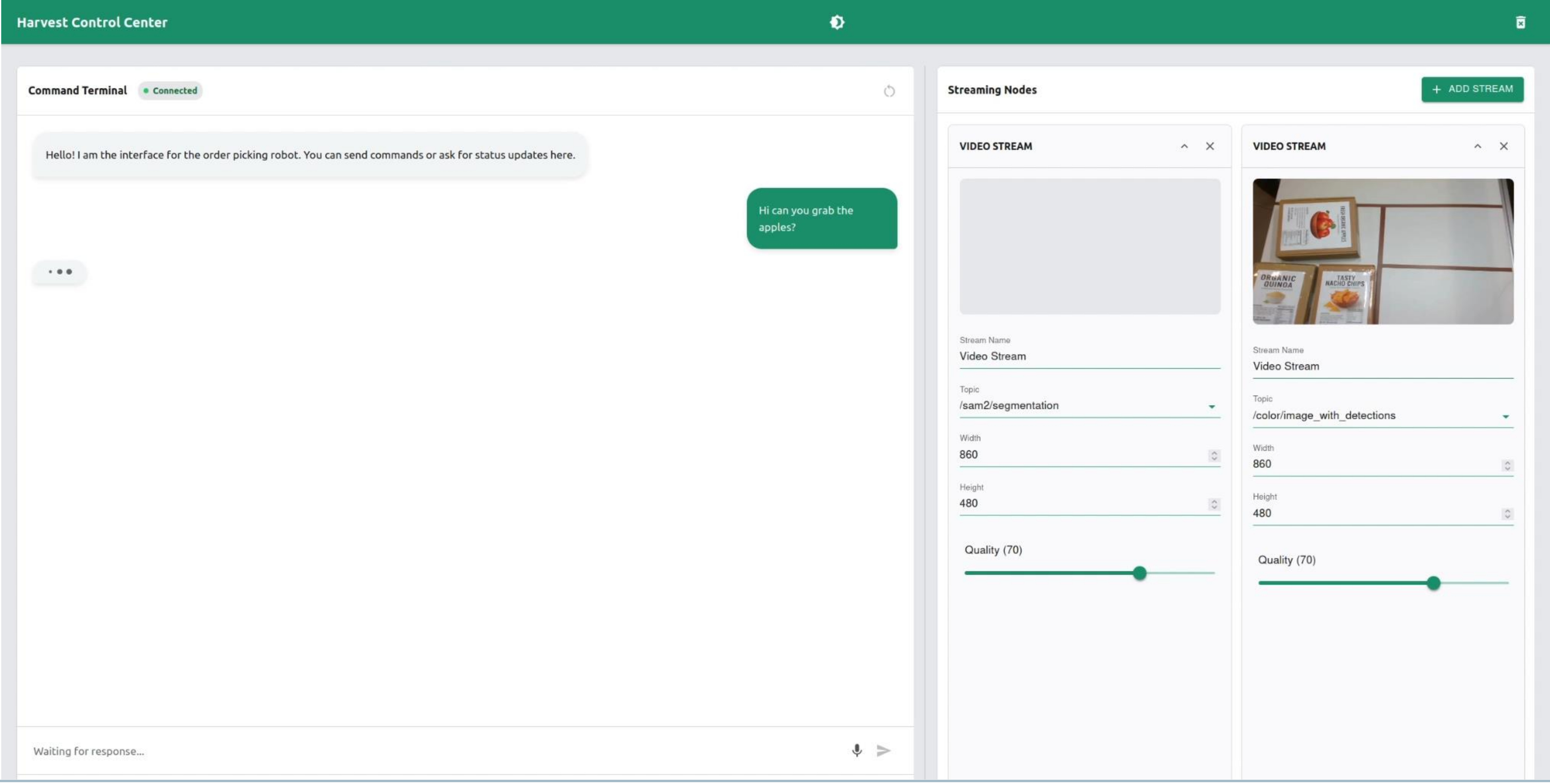
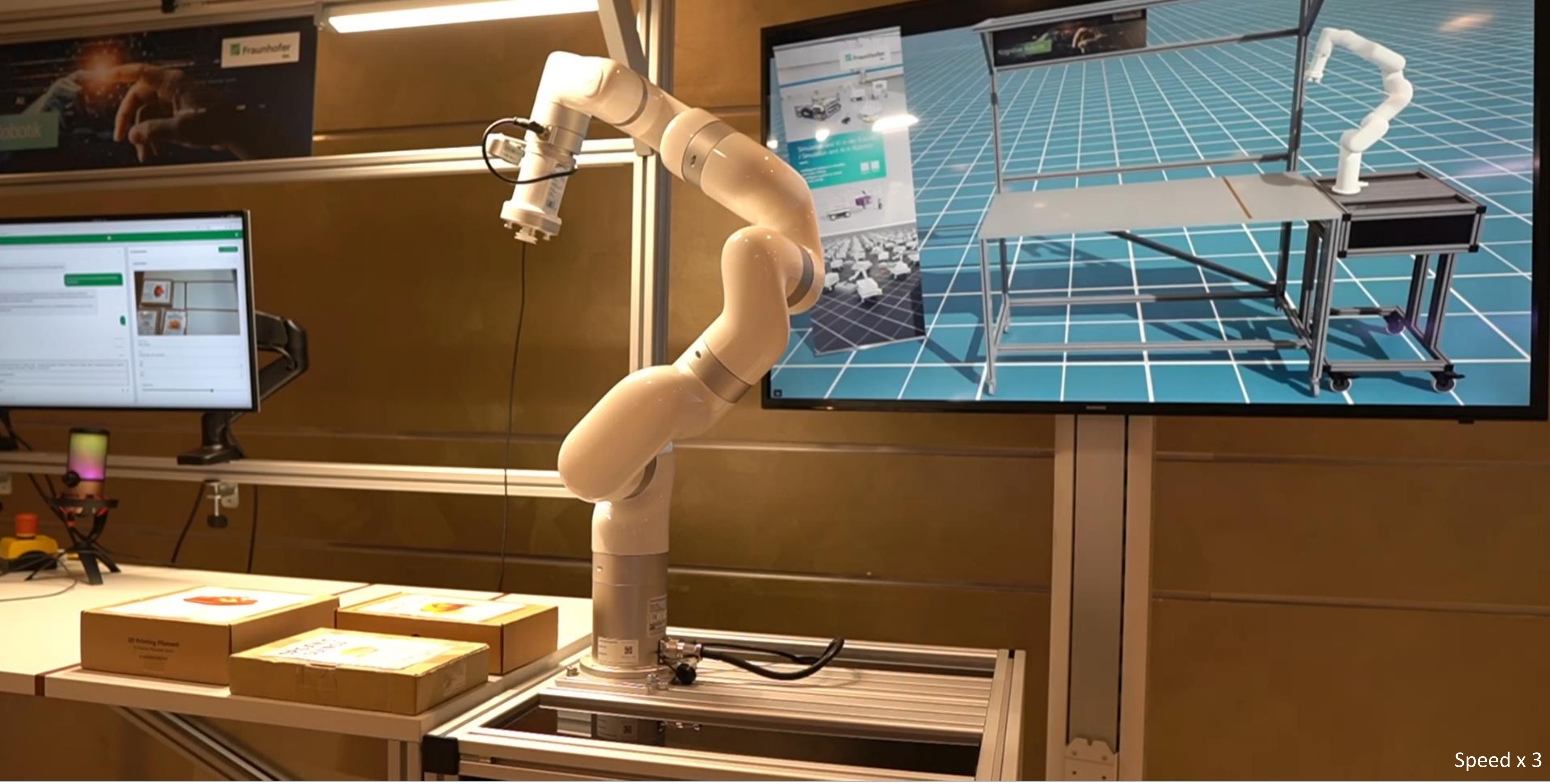
Digital Twins

Opportunity: Digital Twin
RoboAgent



Harvest Control Center
Command Terminal
Connected
Hello! I am the interface for the order picking robot. You can send commands or ask for status updates here.
Hi can you grab the apples?
Waiting for response...
Streaming Nodes
+ ADD STREAM
VIDEO STREAM
Stream Name
Video Stream
Topic
/sam2/segmentation
Width
860
Height
480
Quality (70)
VIDEO STREAM
ORGANIC QUINOA
TASTY NACHO CHIPS
Stream Name
Video Stream
Topic
/color/image_with_detections
Width
860
Height
480
Quality (70)



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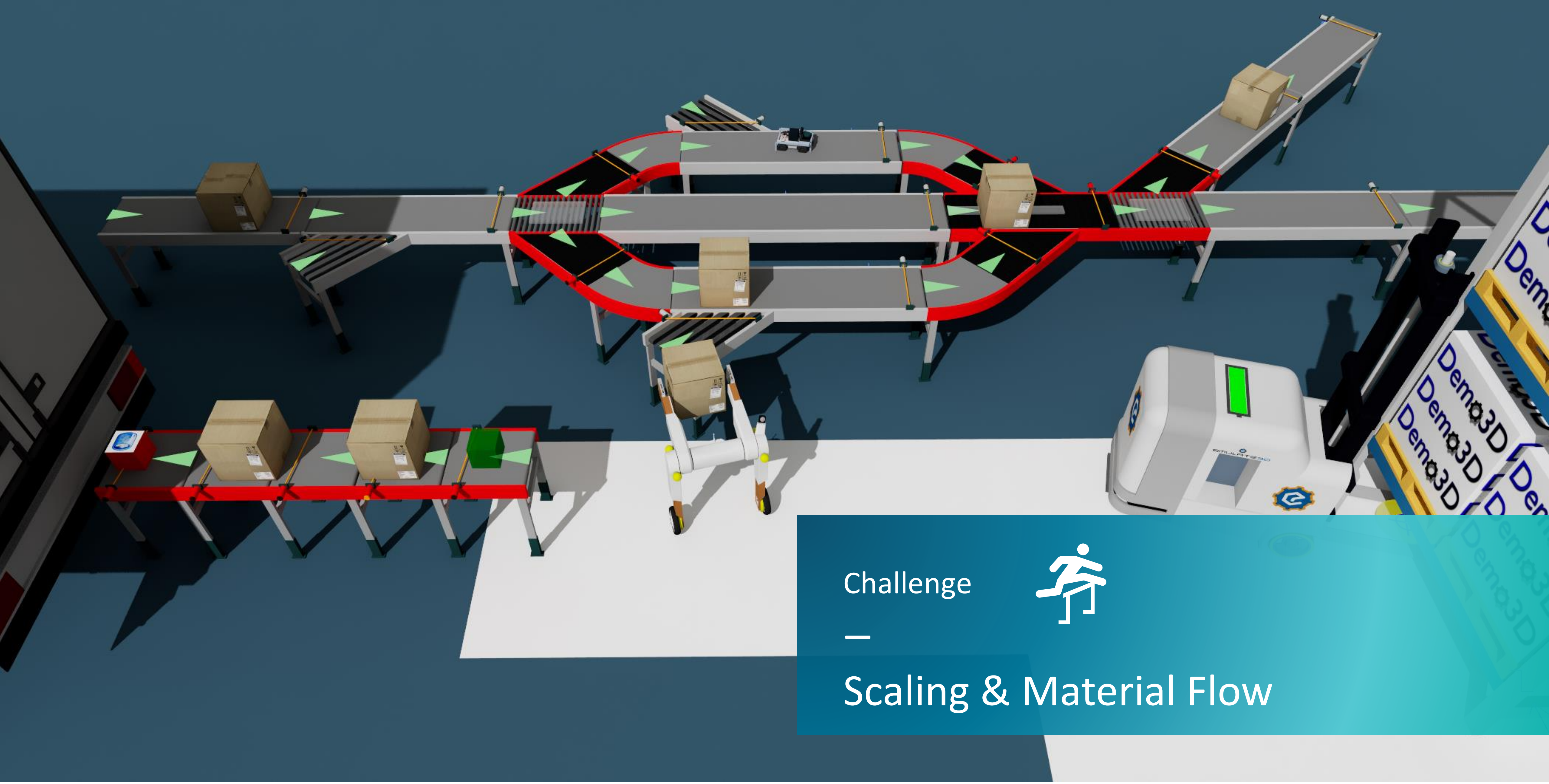
Speed x 3



Challenge

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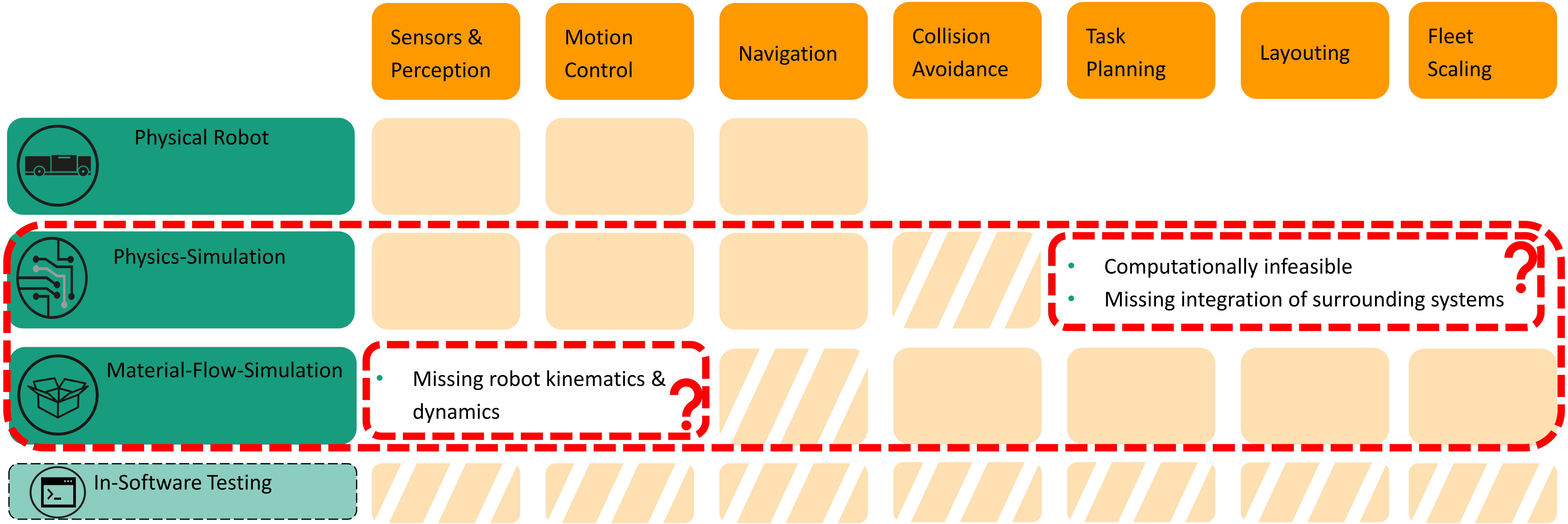
Scaling & Material Flow

Development Platforms



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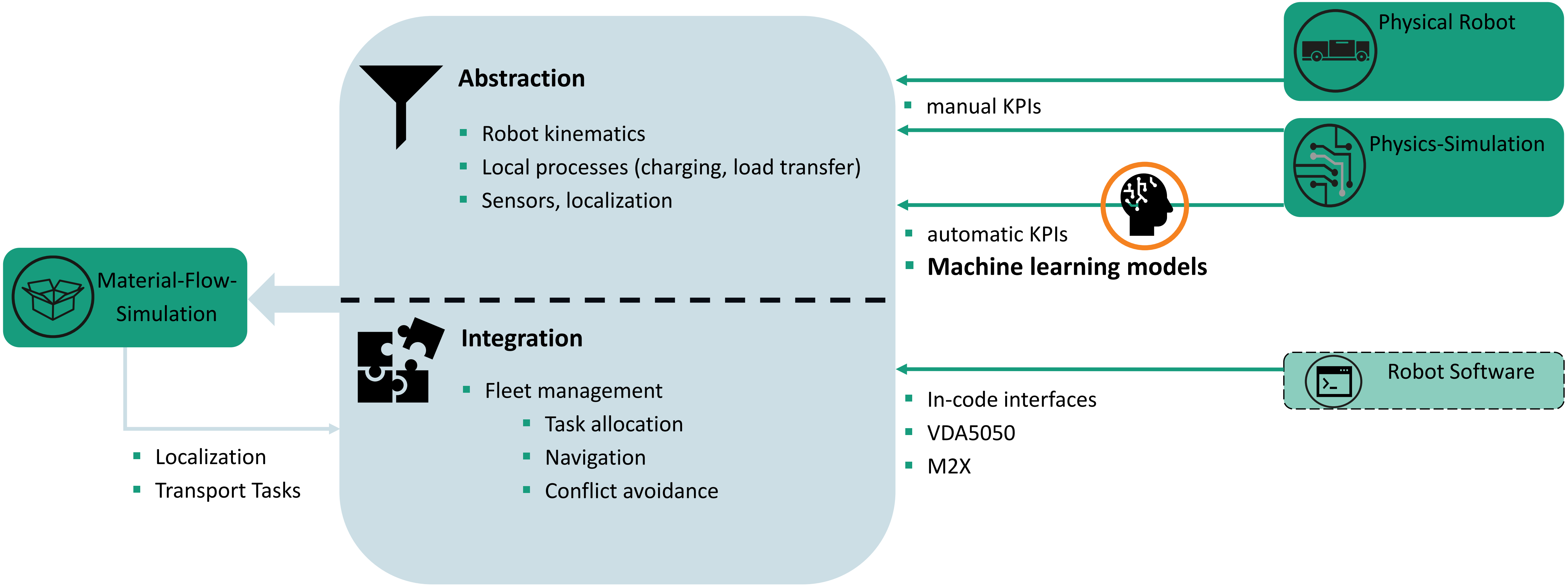
Abstraction Layer for Bridging the Gap

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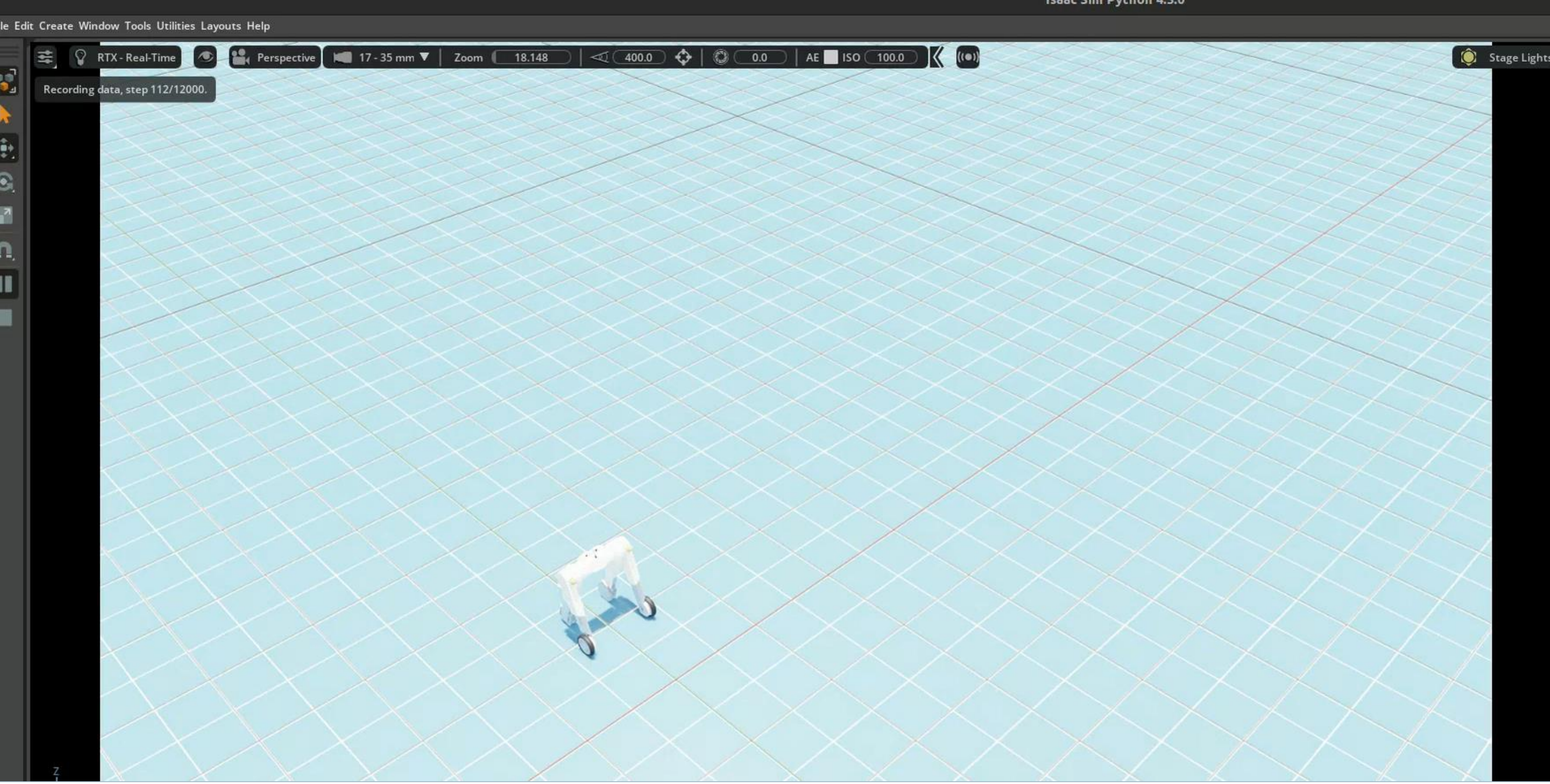
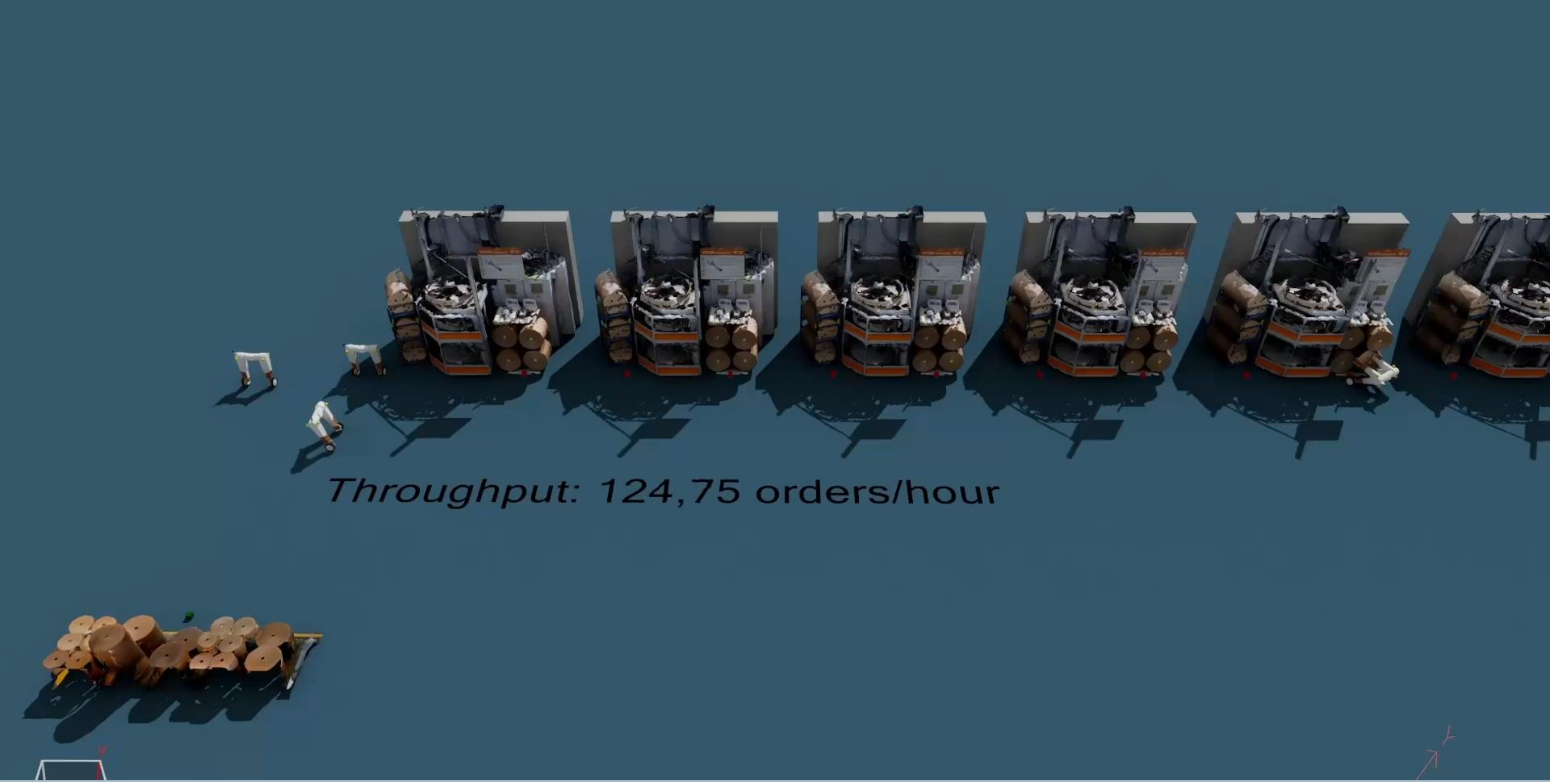

Edit Create Window Tools Utilities Layouts Help
RTX - Real-Time
Perspective
17 - 35 mm
Zoom
18.148
400.0
0.0
AE
ISO
100.0
Recording data, step 112/12000.


Throughput: 124,75 orders/hour

Key Takeaways

1. Simulation offers enormous potential, especially for AI and robotics development
2. Powerful tools exist, but there is no one-size-fits-all solution.
3. High-quality simulation requires significant effort and expertise nowadays, but there is on-going work on lowering the barrier.
4. Simulate as much as necessary, but as little as possible.
5. Explore the variety of simulation tools for broader capabilities and your demands.

Contact

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