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High Performance Real Time Lab

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A2RL — Abu Dhabi Autonomous Racing League

INDY Autonomous Challenge

F1 TENTH

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The Lab

meets Automotive/Racing

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High Performance Real Time Lab

✓ Complex **workload-intensive** tasks
   ○ Perception, planning, ML/DNN

✓ **Latency-critical** control tasks
   ○ Cyber-physical interaction
   ○ Tight actuation loops

https://hipert.unimore.it/

Embedded boards

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F1tenth

Indy Autonomous Challenge - High Speed

Indy Autonomous Challenge - Road Course

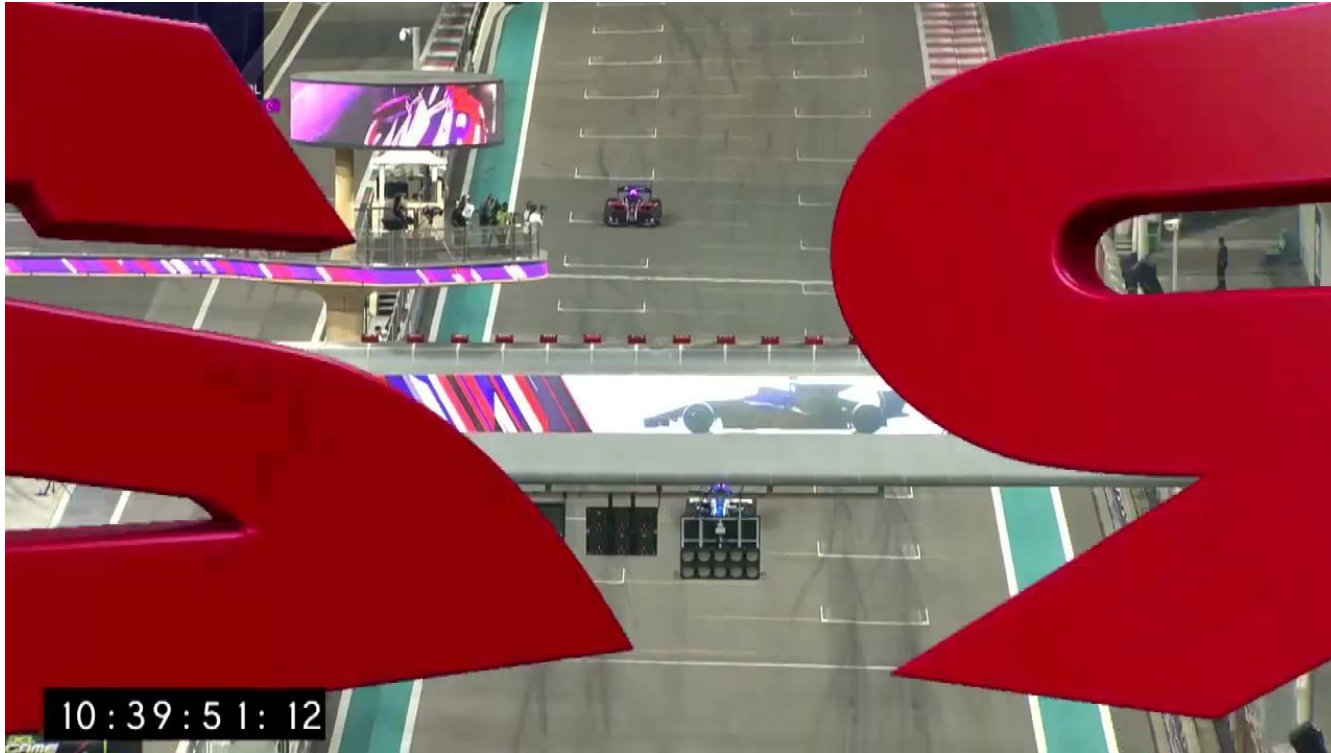# Indy Autonomous Challenge - Head to Head

Dallara AV-24

- **Dallara Indy Lights** (IL-15) chassis
- Honda K20 engine **480hp** - **7500rpm**
- **Top speed:** Close to 300 km/h (185 mph)
- dSPACE AUTERA
- Sensors:
  - 2 Novatel GPS
  - 1 Vectornav VN-310
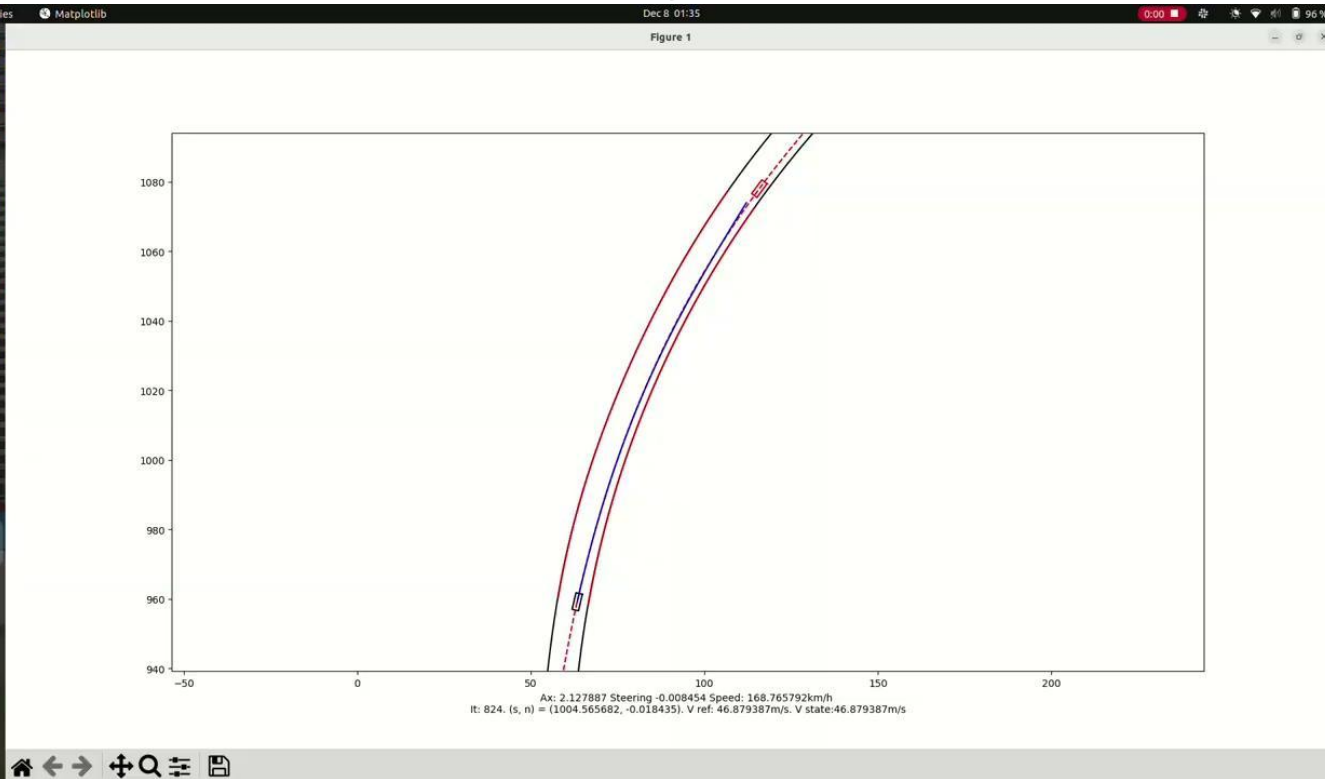 - 2 Radars
  - 3 Luminar LiDARS
  - 6 cameras

A2RL - Abu Dhabi Autonomous Racing League

10:29:06:22
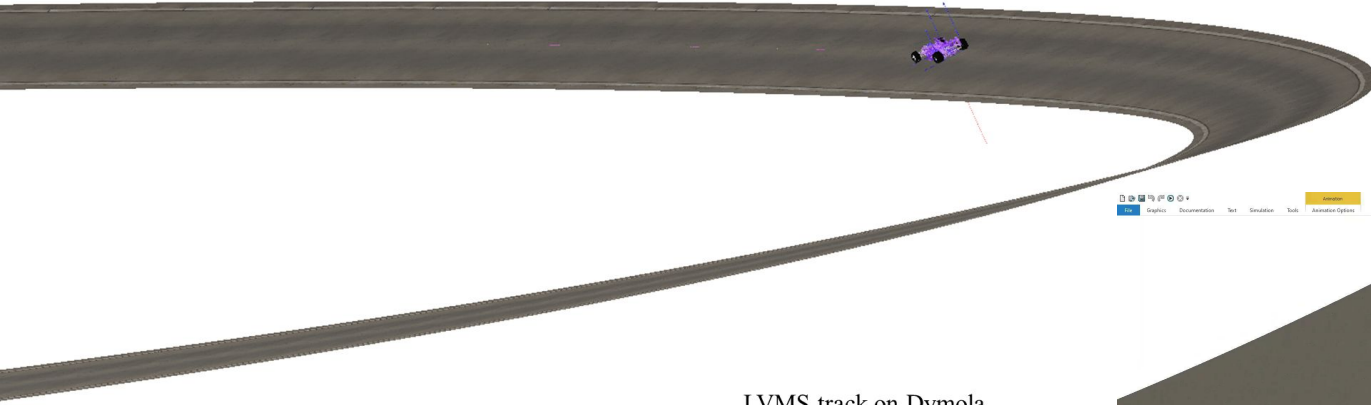
A2RL - 4 cars race

10:39:51:12

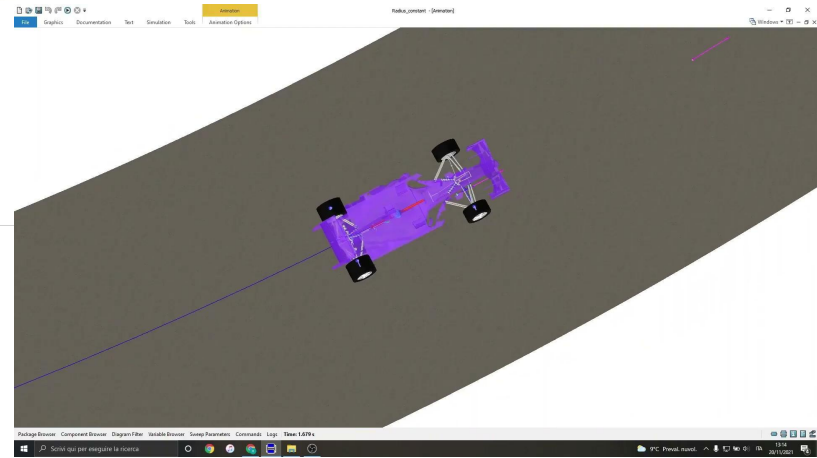# Research - Planning, Control

- Path tracking and Planning with Model Predictive Control (MPC) and Linear Quadratic Regulator (LQR).
- Hierarchical and/or combined controllers.
- Accurate vehicle models for real-time control.
- State estimation: sideslip angle/lateral velocity

Research - Vehicle Dynamics

LVMS track on Dymola

- Accurate multibody model fitting and simulation
- Road model
- Functional Mockup Unit (FMU)

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Research - References

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- A. Raji et al., **"A Tricycle Model to Accurately Control an Autonomous Racecar with Locked Differential,"** 2023 IEEE 11th International Conference on Systems and Control (ICSC)
- A. Raji et al. **"er.autopilot 1.0: The full autonomous stack for oval racing at high speeds"**, 2024, Field Robotics, 4, 99–137.
- A. Toschi et al., **"Guess the Drift with LOP-UKF: LiDAR Odometry and Pacejka Model for Real-Time Racecar Sideslip Estimation,"** 2024 IEEE Intelligent Vehicles Symposium (IV)
- F. Prignoli et al., **"RADAR-Based Safe Pull-Over of Autonomous Racing Cars in Localization Failure Scenarios"** 2024 European Control Conference (ECC)
- A. Raji, **"Model Predictive Planning and Control for Autonomous Racing, from HPC to Embedded Platforms"**, PhD Thesis, Unipr, 2024
- A. Remonda et al. **"A Simulation Benchmark for Autonomous Racing with Large-Scale Human Data"**, arxiv, accepted to Neurips 2024