Autonomous Racing Car for Formula Student Driverless

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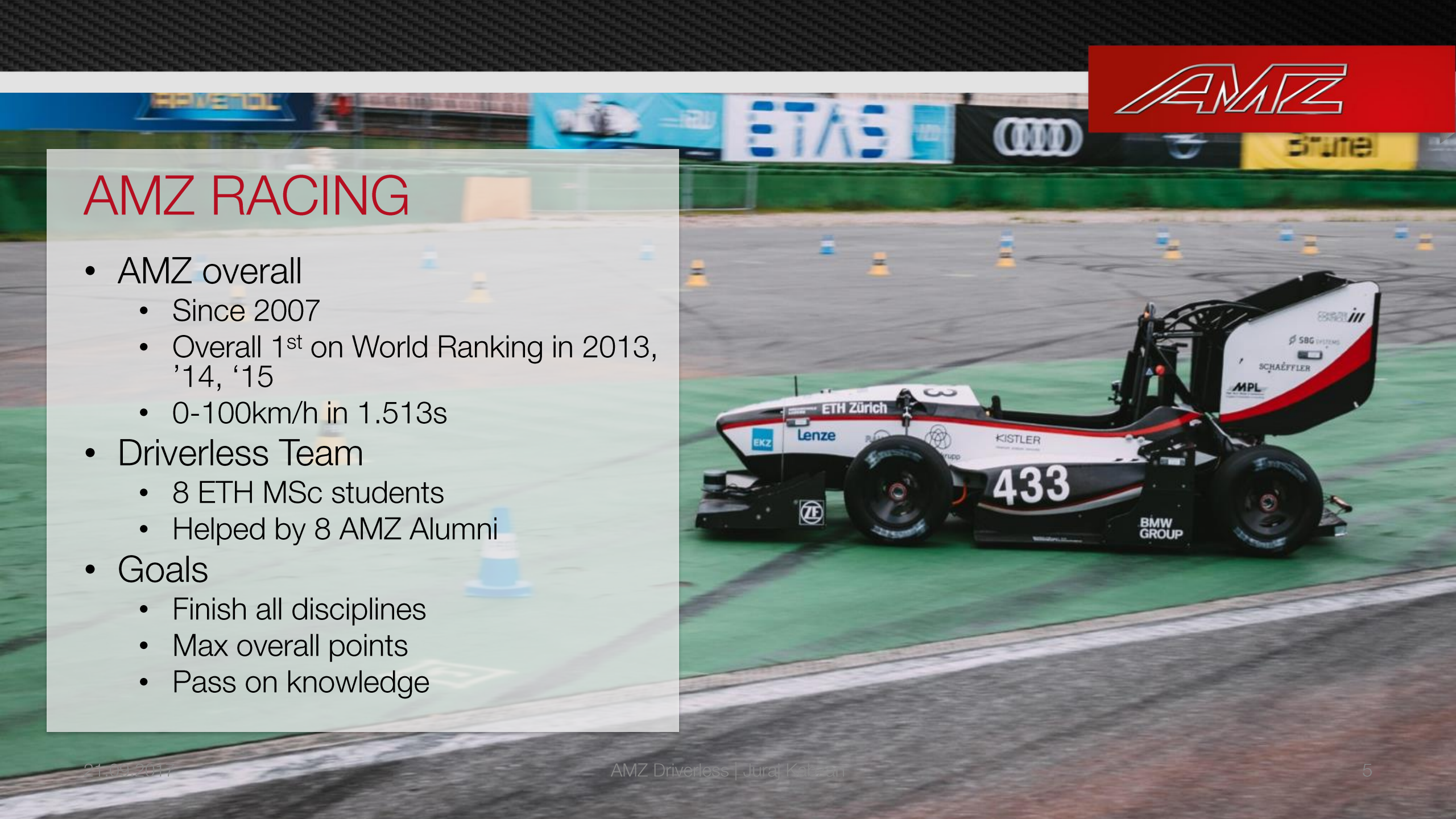
What to expect

1. AMZ Team
2. The Competition
3. Algorithms
4. Software Tools

AMZ RACING

- AMZ overall
  - Since 2007
  - Overall 1st on World Ranking in 2013, ’14, ‘15
  - 0-100km/h in 1.513s
- Driverless Team
  - 8 ETH MSc students
  - Helped by 8 AMZ Alumni
- Goals
  - Finish all disciplines
  - Max overall points
  - Pass on knowledge



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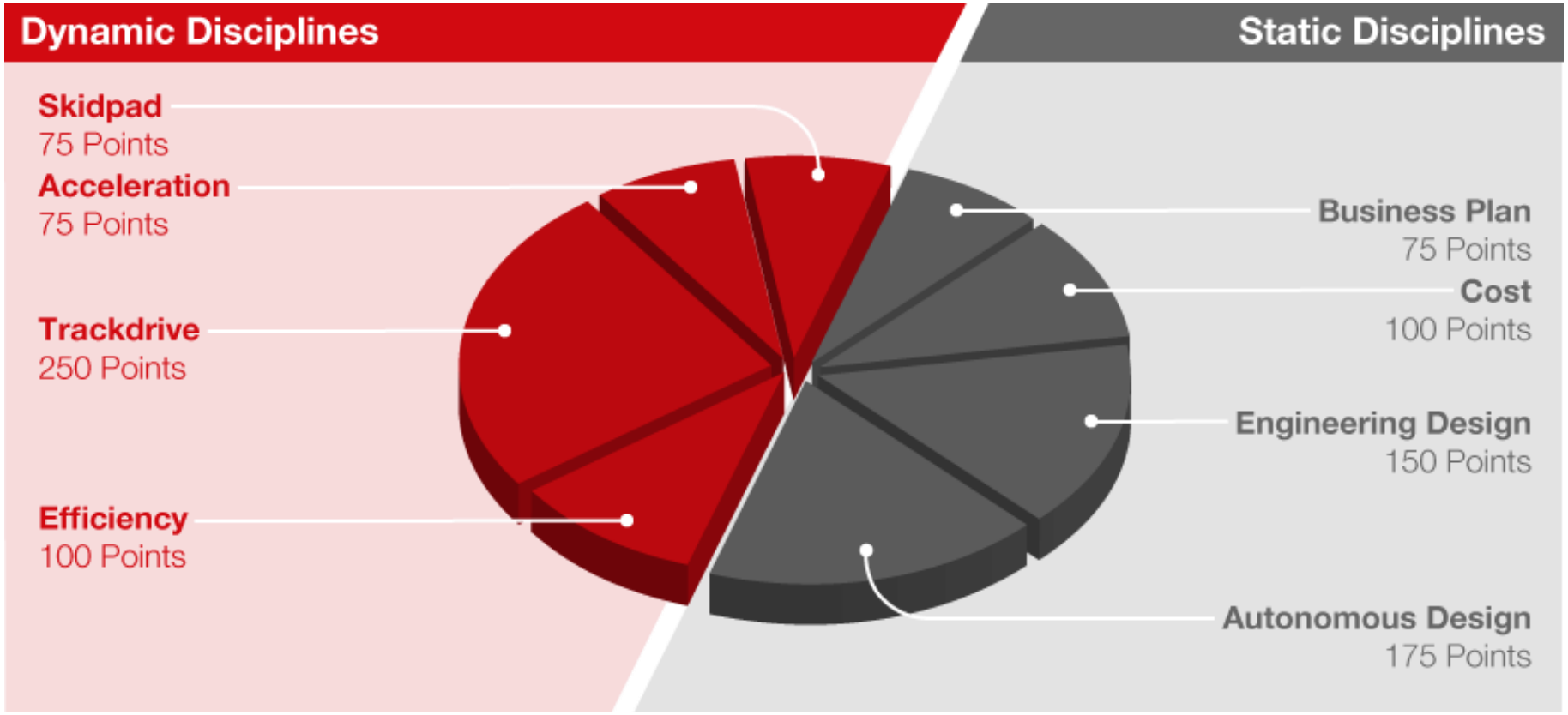
Formula Student Germany 2017

FSG Competition

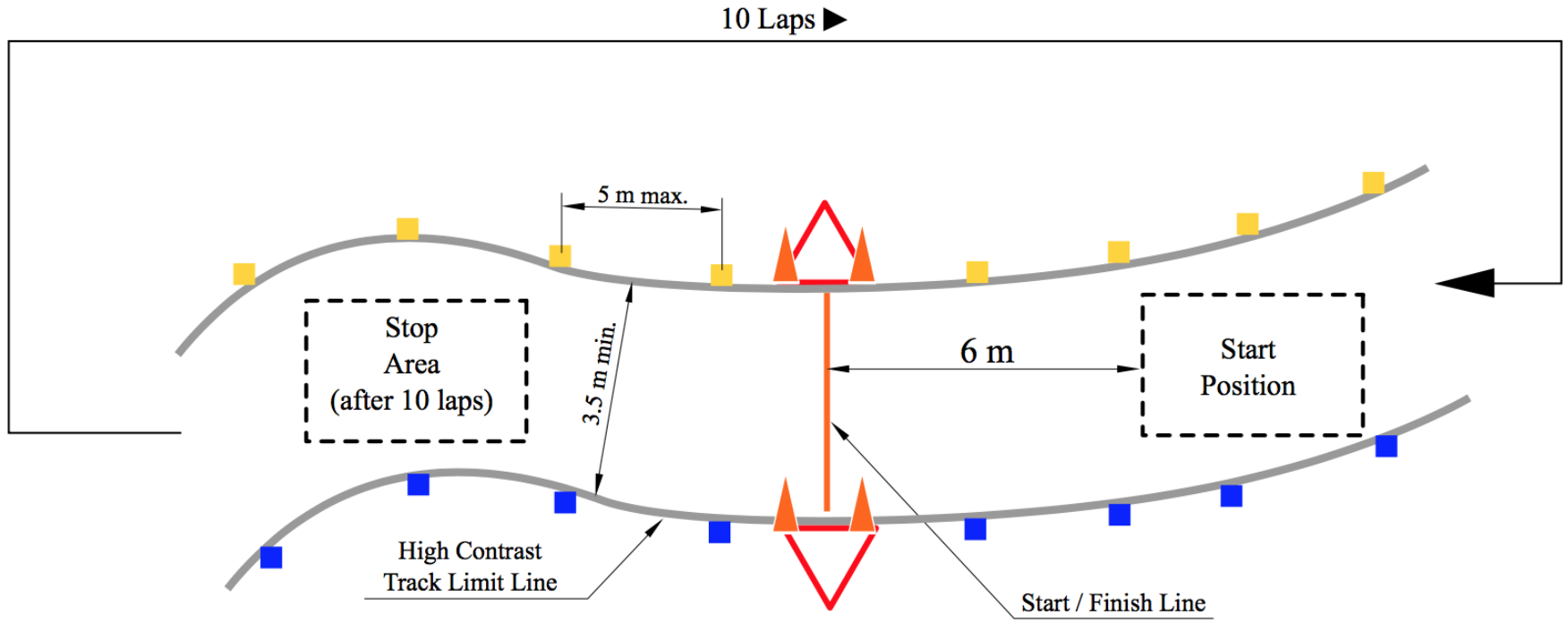


Trackdrive and Trackwalk

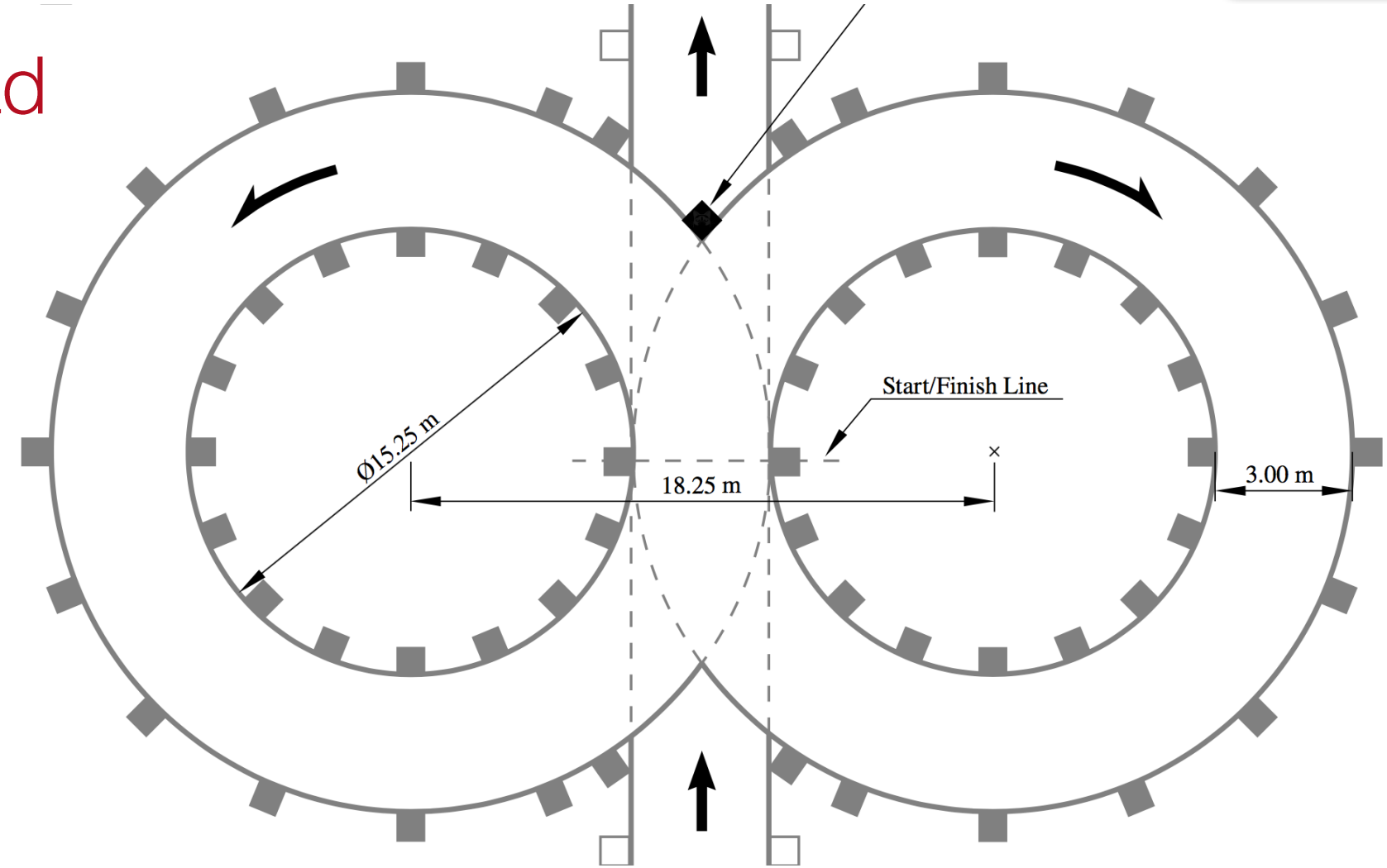
Yellow/Blue Cone

Small/Big Orange Cone

Red TK Marking & TK Equipment
(Shape undefined)

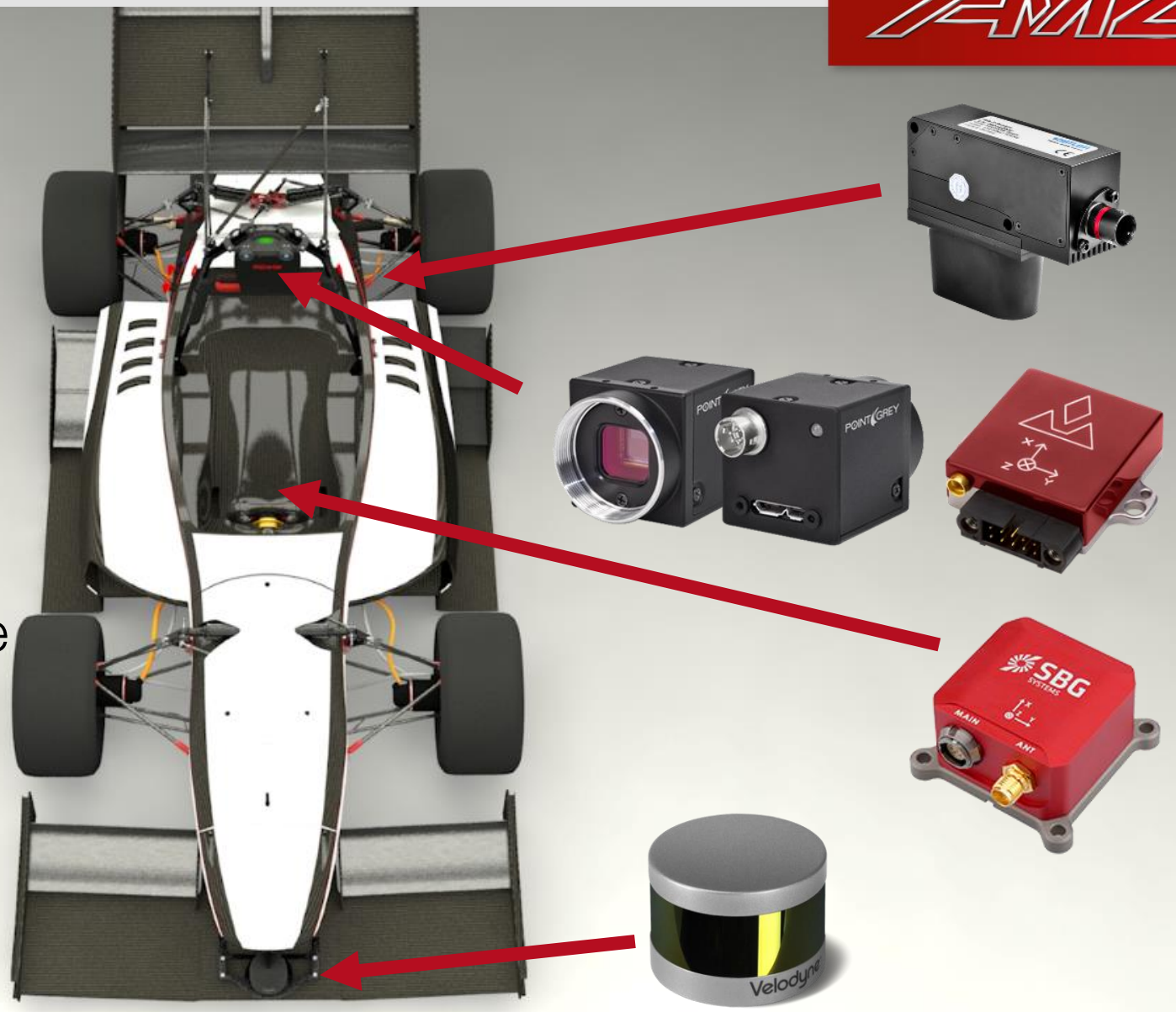


Skidpad



<<flüela>>

- Build for Formula Student Electric 2015
- 4WD electric
  - **Torque Vectoring**
  - Breaking by **Recuperation**
- Full aerodynamic package
- High wheel torque
- Lightweight



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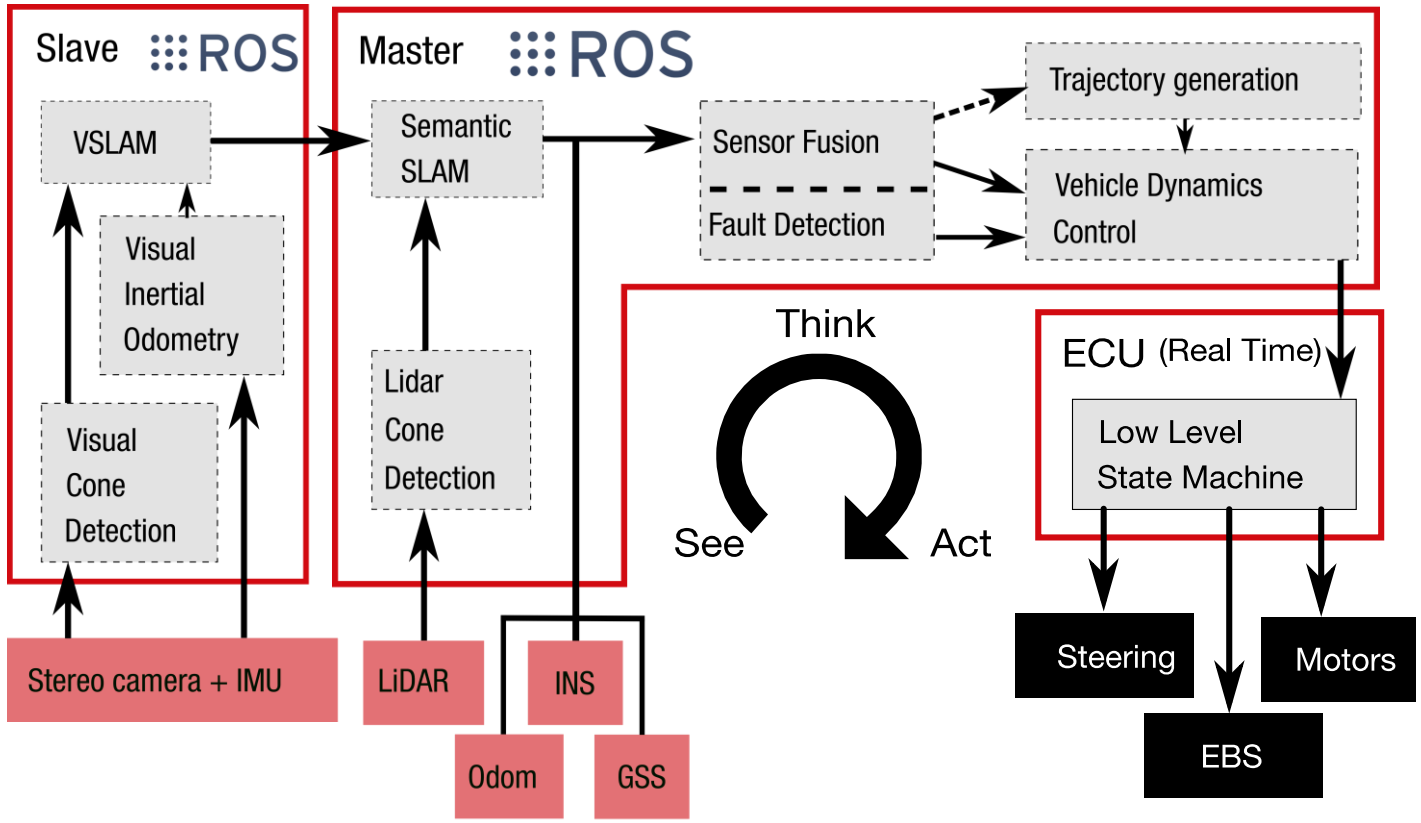
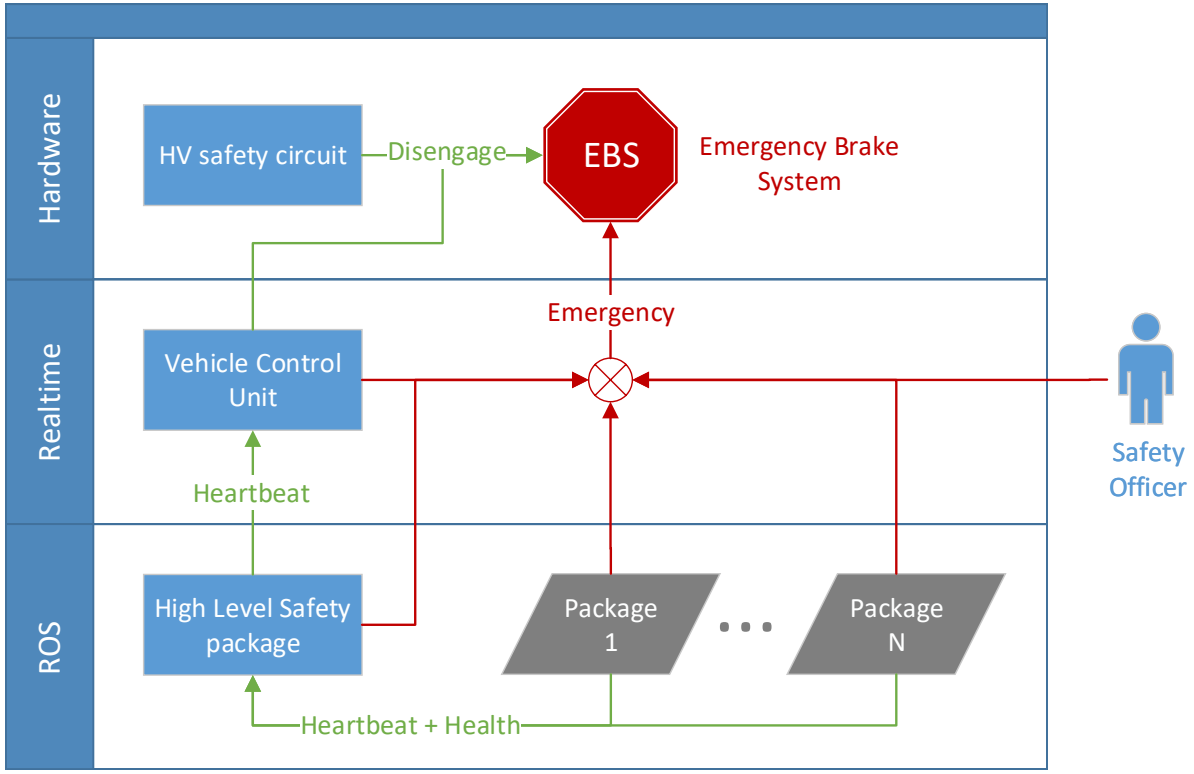
Overall Concept

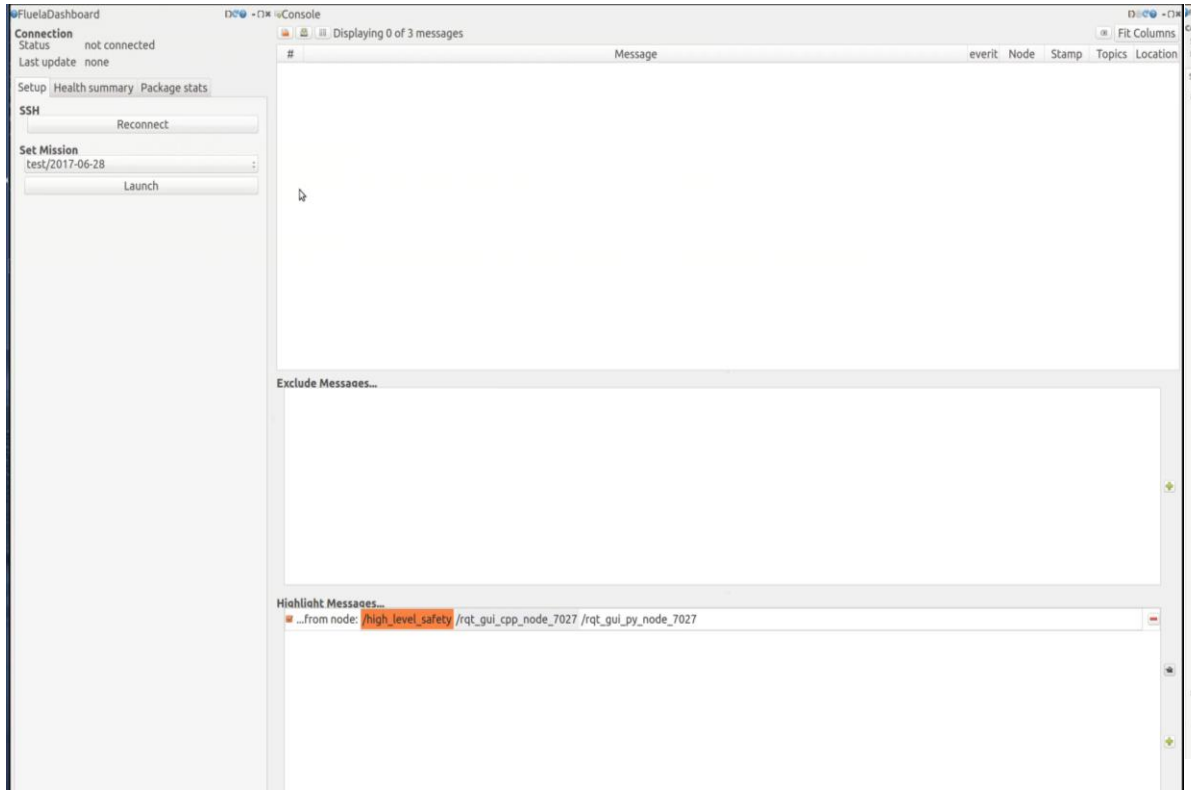


Automatic Launching

- Every discipline is launched from single launch file through `high_level_safety` package
  - Launches all required nodes
  - Monitors used resources
- Monitors `heartbeats` of every node and stops the car if too many are missing



Control Station and Diagnostics

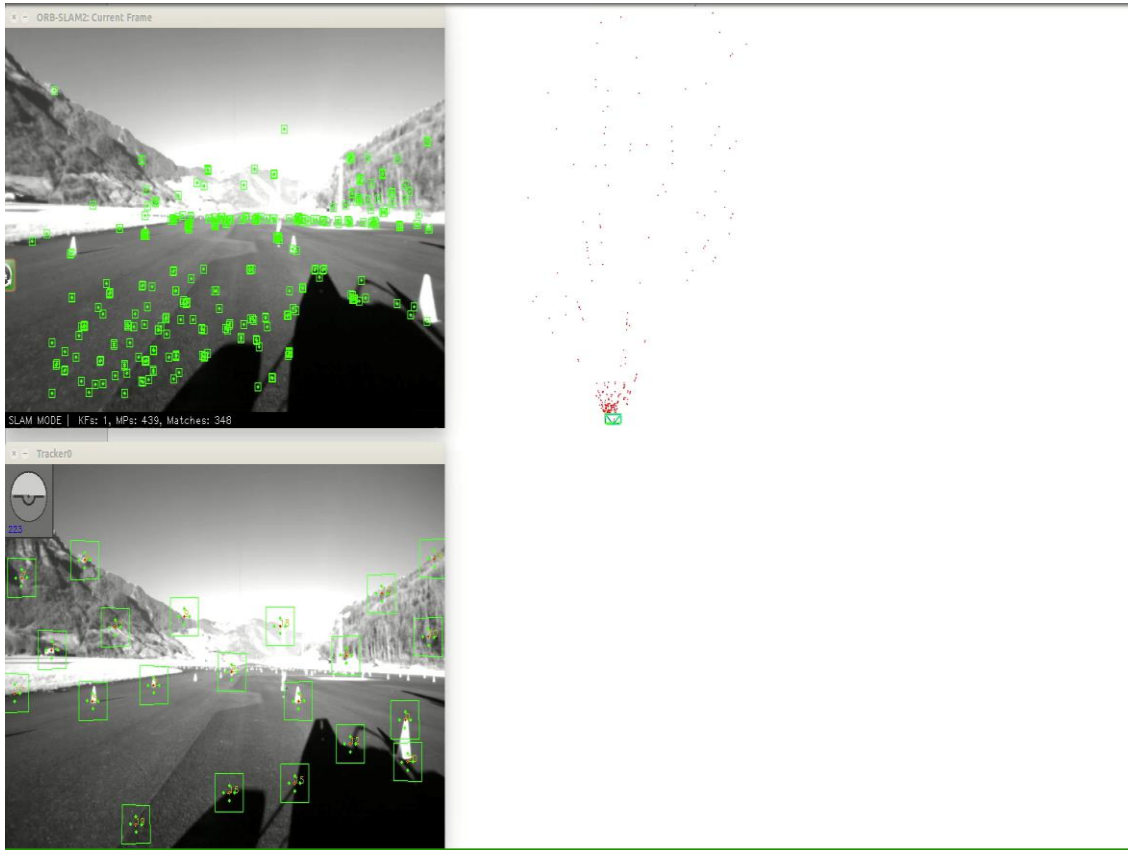


Open Source

https://github.com/grafue/SERVO

Slave: Visual Pipeline

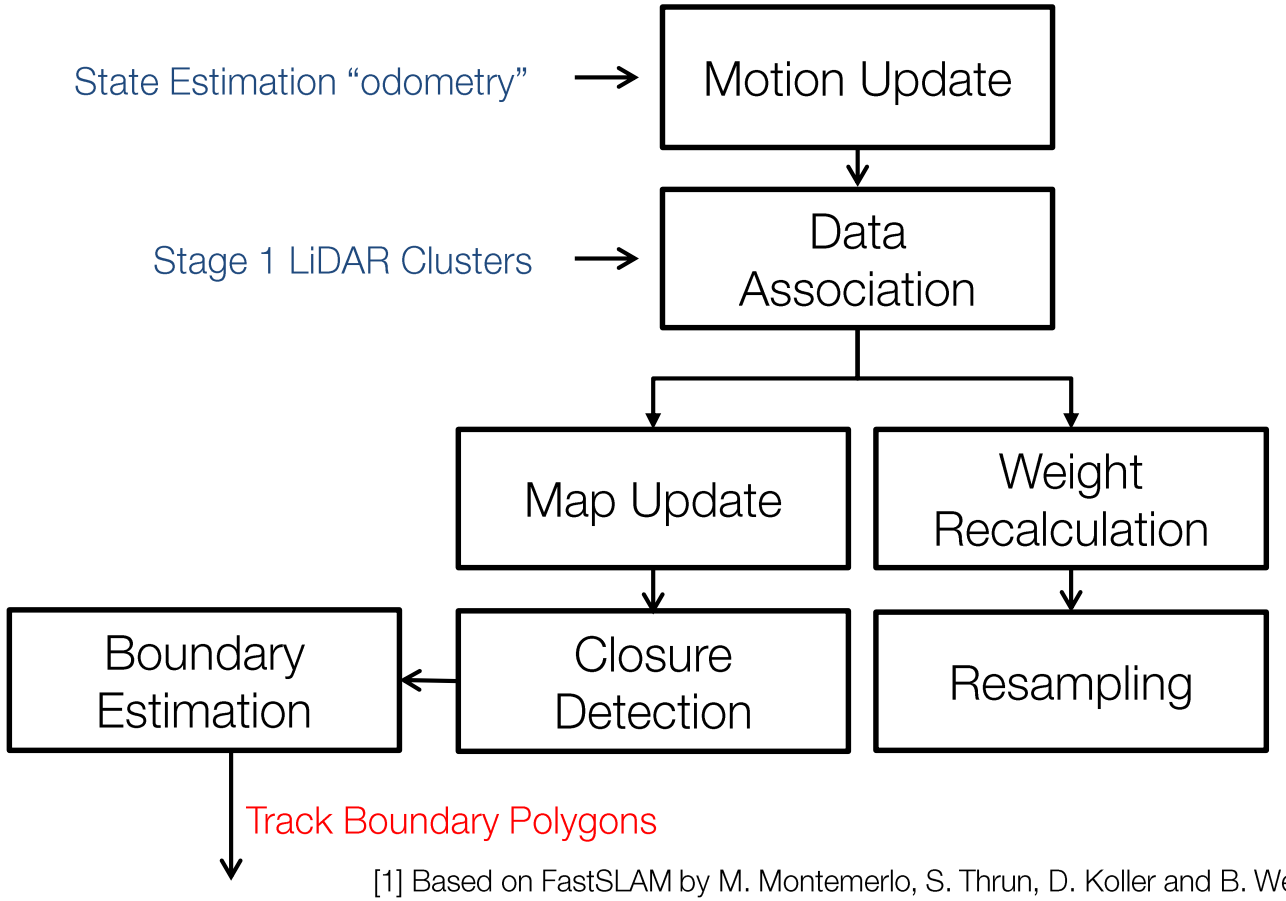
- Stereo camera (648 x 488) with INS
- Fusion of **ROVIO**[1] with **ORB_SLAM**[2] is open source with our dataset
- Cone detection is based on Cascade Classifier



- [1] Bloesch, Michael, et al. "Robust visual inertial odometry using a direct EKF-based approach." *Intelligent Robots and Systems (IROS), 2015 IEEE/RSJ International Conference on*. IEEE, 2015.
- [2] Mur-Artal, Raul, and Juan D. Tardós. "Orb-slam2: An open-source slam system for monocular, stereo, and rgb-d cameras." *IEEE Transactions on Robotics* (2017).

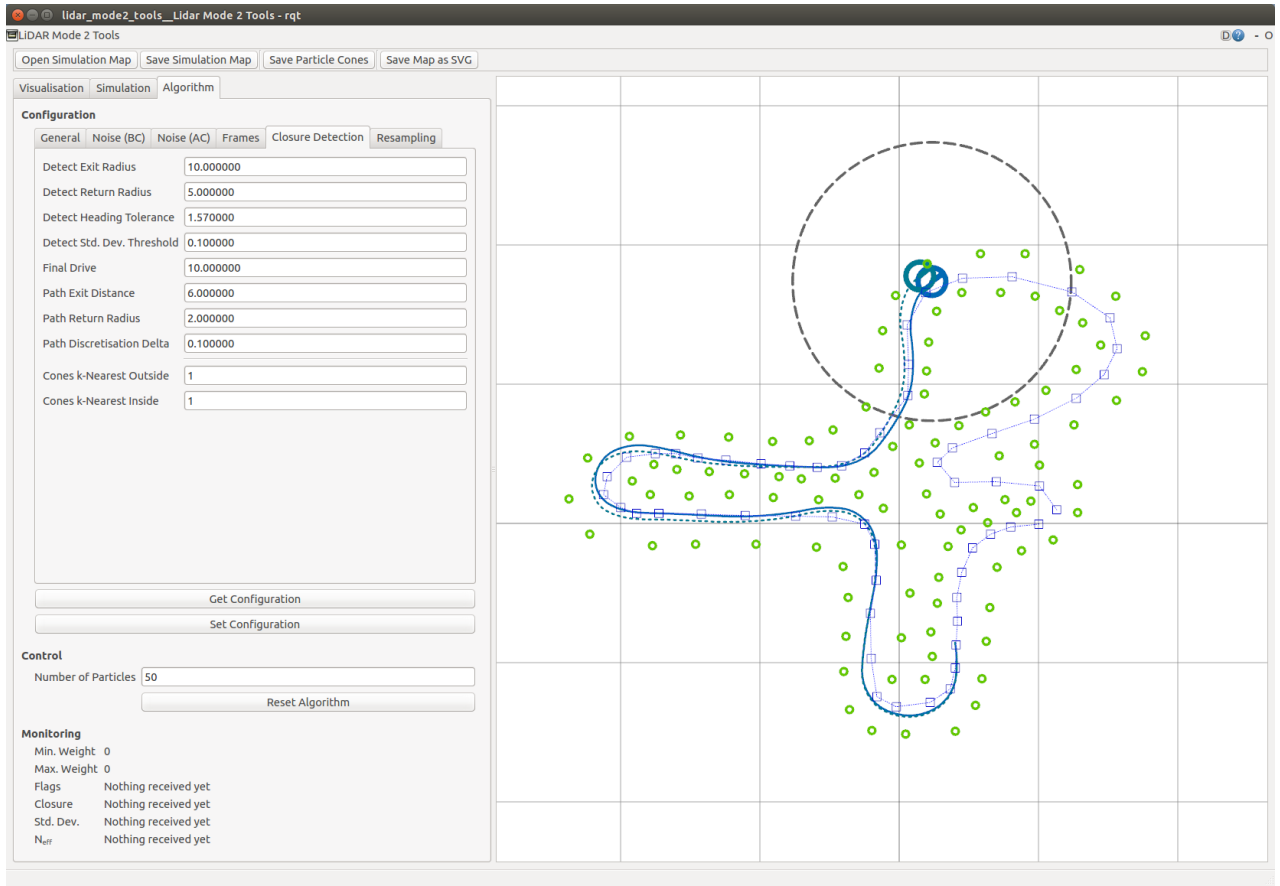
Master: Semantic SLAM (Fast SLAM [1])

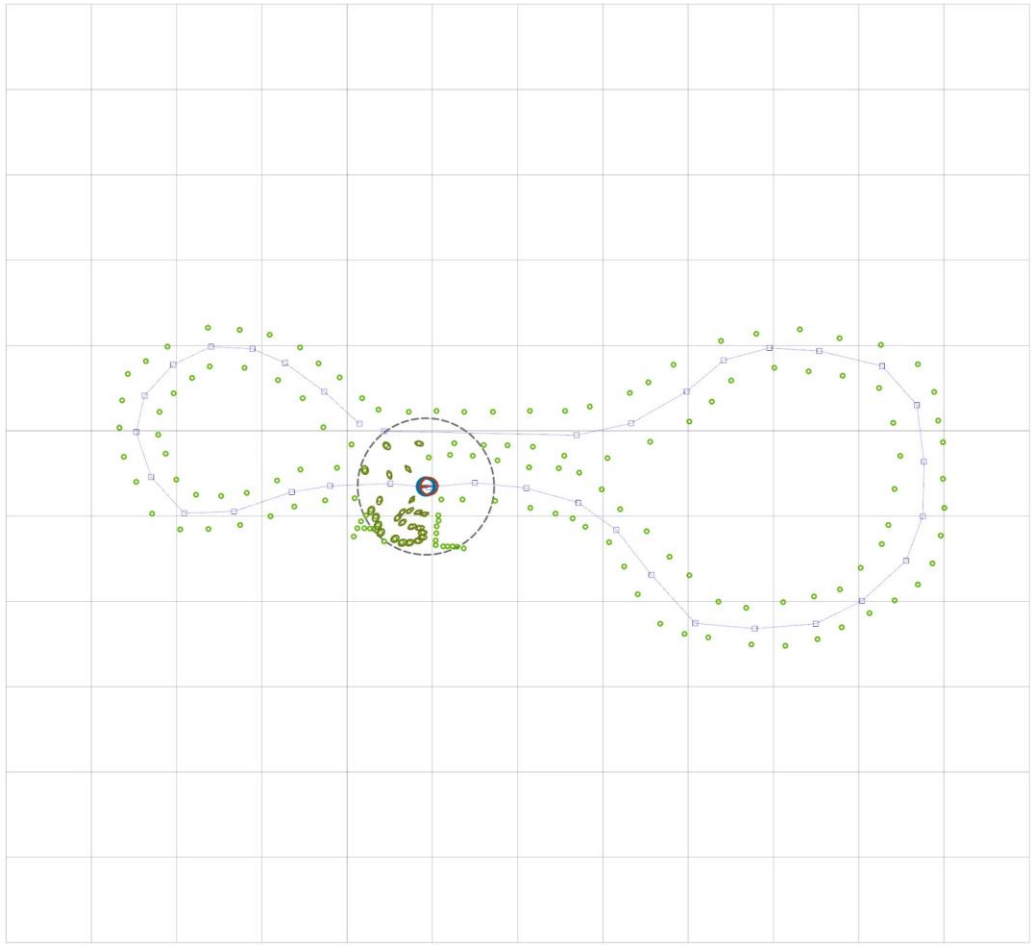
- Two main ROS package
  - Simulator, Configurator & Observer tool
  - SLAM/Localization Node (runs on car)
- Efficient workflow for testing
  - Importance of GUI tools



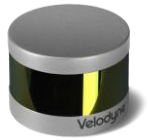
[1] Based on FastSLAM by M. Montemerlo, S. Thrun, D. Koller and B. Wegbreit

SLAM Simulator





Master: Sensorfusion



Pose in the Map

SLAM

INS

Velocity in Car frame

Wheel Odometry

EKF

Outlier rejection

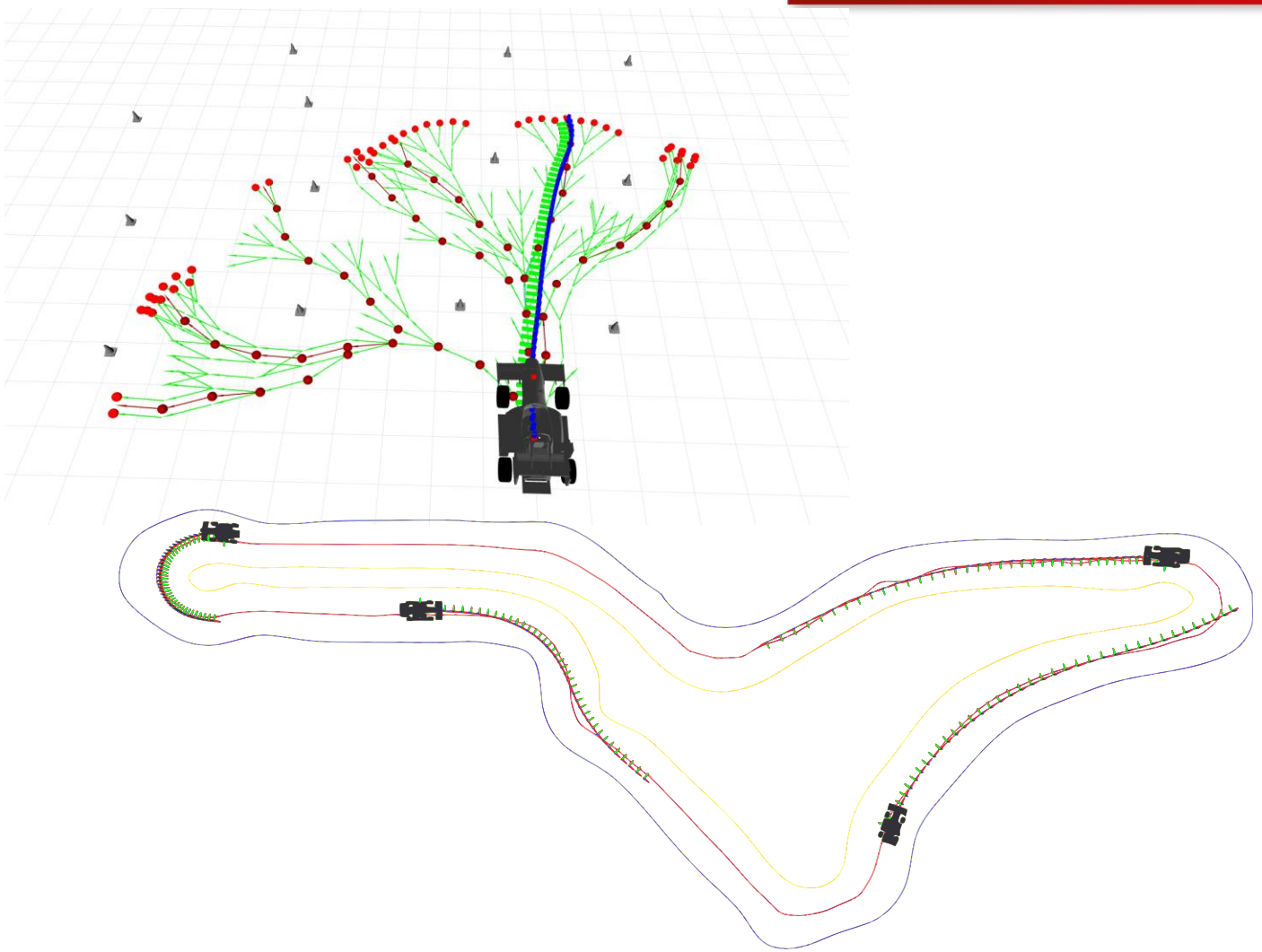
State

EKF Debugging

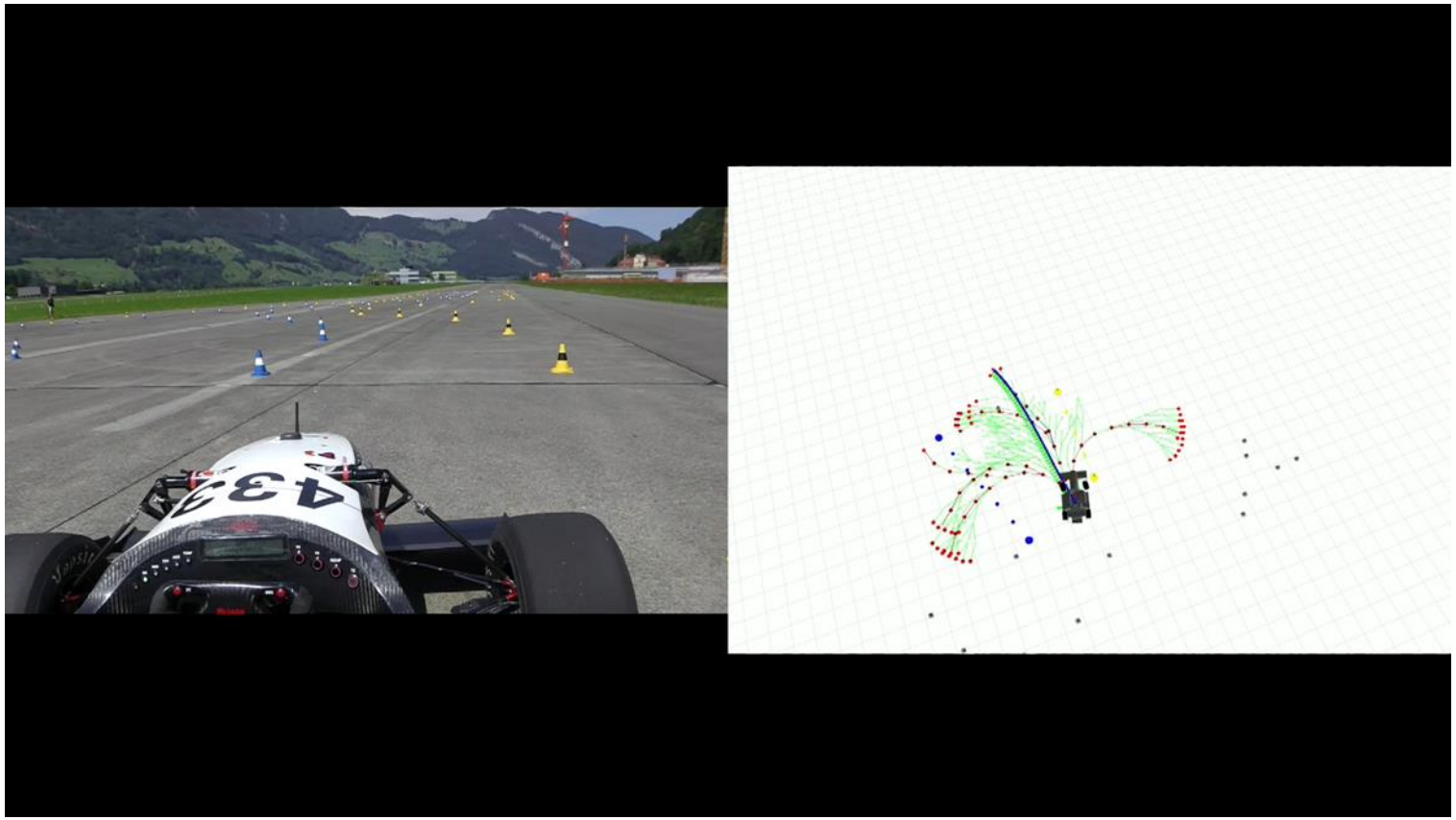
- Custom debug messages
- Extensive use of RQT Multiplot
- Use of RVIZ Plugins
  - IMU
  - Variance Plotting
- Gazebo Simulation

Two Modes

- Discovery mode:
  - No, or very little knowledge about the track
  - Very slow and map
- Race Mode:
  - Map must be available
  - MPC with dynamic vehicle model
  - Solved online with EMBOTECH Forces Pro at 20Hz

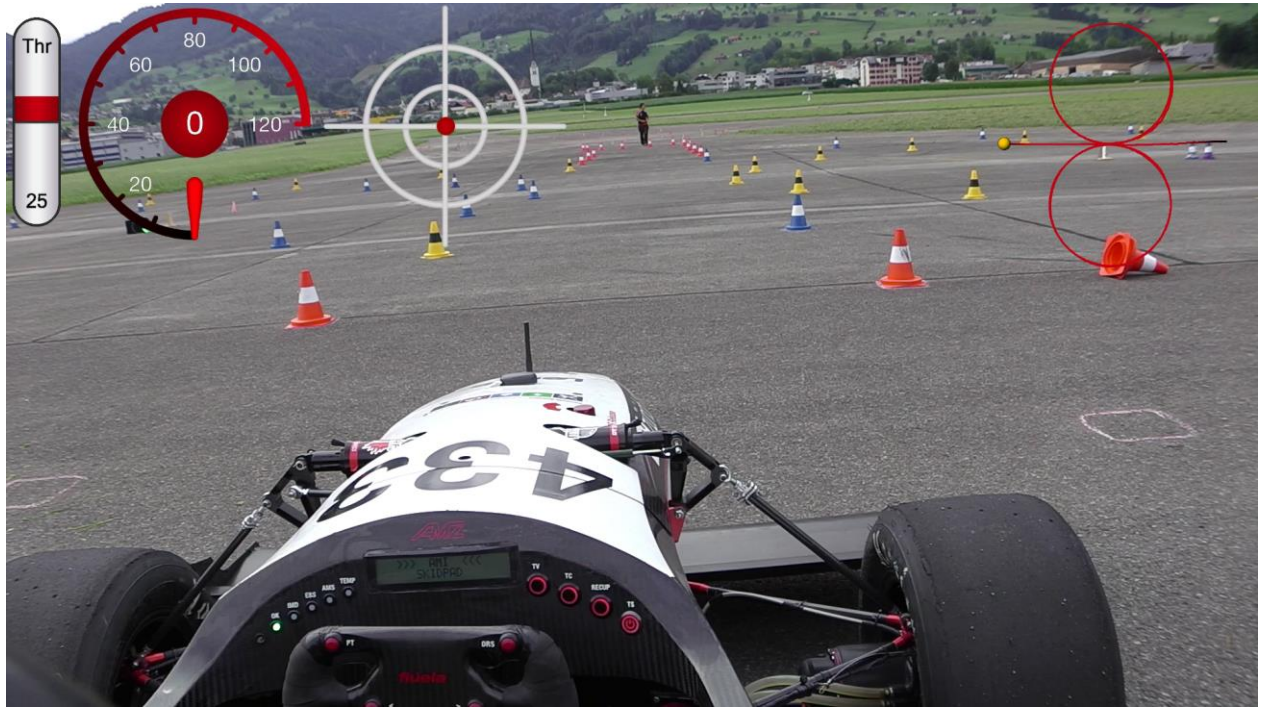


The Switch



Skidpad

- Localize in a predefined Map
- Maximize lateral tire force through a slip angle feedback control
- Faster than a human driver



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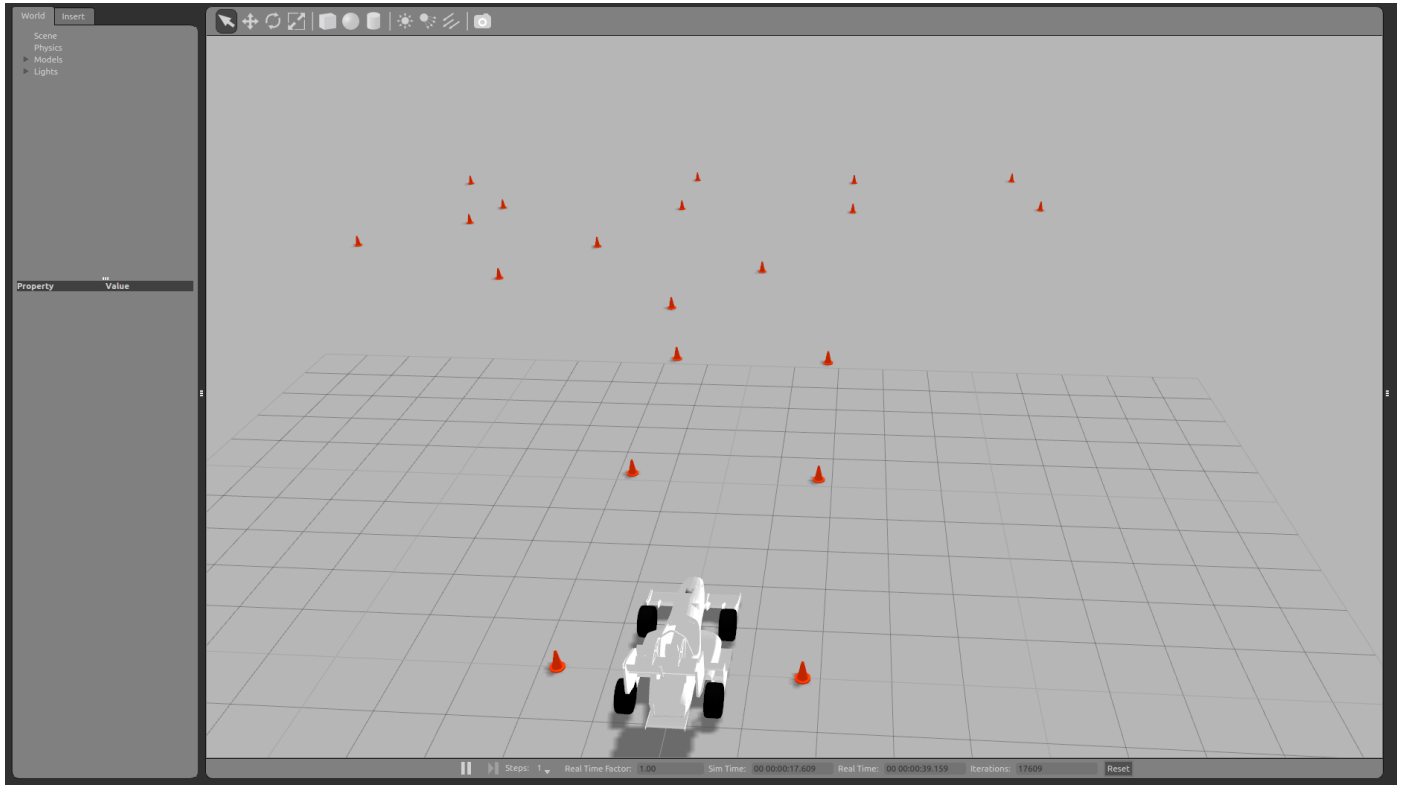
Simulation

- Closed Loop Simulation
- Sensors simulation
- Gazebo
- Use of gazebo sensors plugins
- Python model simulating precise vehicle dynamics

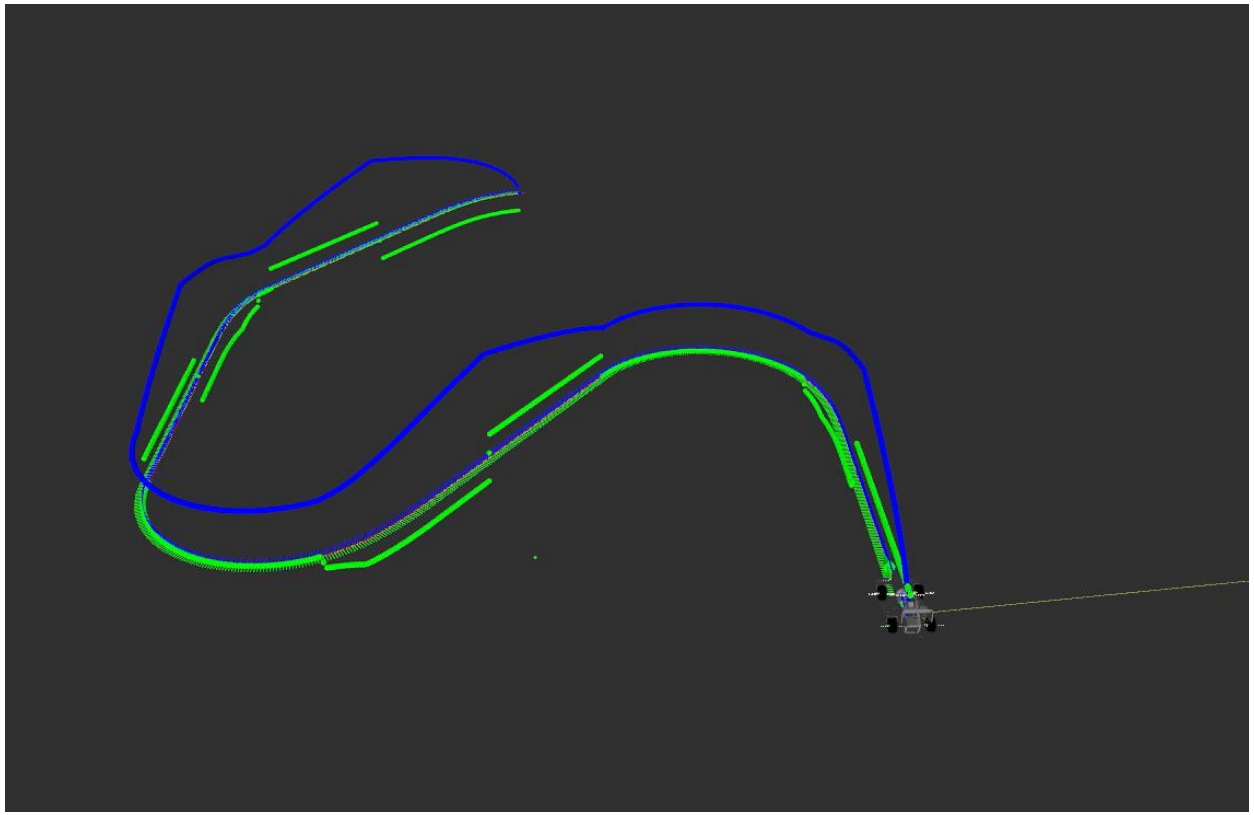


Results!


FORMULA STUDENT GERMANY
INTERNATIONAL DESIGN COMPETITION
ETH Zürich
Driverless
Student Driverless
YAMAHA

Software Tools or “How to Keep it Together”

- Ubuntu 14.04 LTS, ROS Indigo
- Software version control
  - Git
- Extensive use of simulation
- ! Visualizing as much as possible !



Software Tools or “How to Keep it Together”

- Lots of tests on hardware
  - Once a week testing on airports
- Continuous Integration:
  - Jenkins
- Nightly Simulations on a Server
- Logging:
  - Just the Important Information
  - TAKE CARE: Sometimes less is eventually more

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