ROSCon 2015
Hamburg, Germany

AUTOMATED DRIVING WITH ROS AT BMW.

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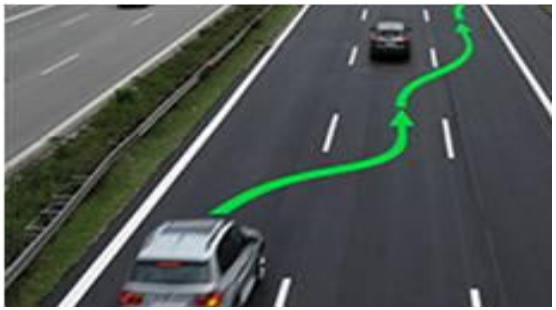
JULIAN THOMAS, OLIVER SCHEICKL.

BMW GROUP

HISTORY OF AUTOMATED DRIVING AT BMW.

BMW Track Trainer (2006).

Emergency stop assistant (2009).



Highly automated driving on the motorway (2011 / 2015)

Automated driving on the vehicle's limit (2014).

Fully automated remote valet parking (2015).

360° collision avoidance (2015).

Aeberhard et al., "Experience, Results and Lessons Learned from Automated Driving on Germany's Highways", IEEE Intelligent Transportation Systems Magazine, pp. 42-57, Spring 2015.

ADAPTIVE – EU RESEARCH PROJECT.

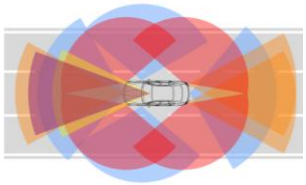
AdaptIVe
Automated Driving

- BMW is partner in the EU research project AdaptIVe.
- January 2014 – June 2017, €25 Million budget, 30 partners, 8 countries.
- Goal is the widespread application of automated driving to improve traffic safety, efficiency and comfort.
- BMW prototype will demonstrate urban (partial automation) and highway (conditional automation) automated driving functions.

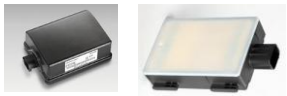
For more information, visit https://www.adaptive-ip.eu/.

ADAS VEHICLE FUNCTIONAL ARCHITECTURE.

SENSORS



Radar

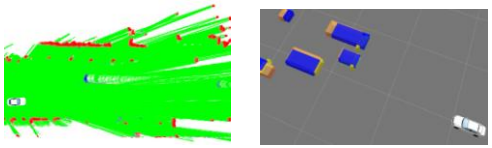


Cameras

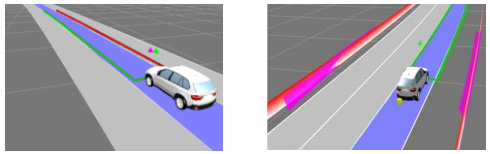
Laser scanner

ENVIRONMENT MODEL

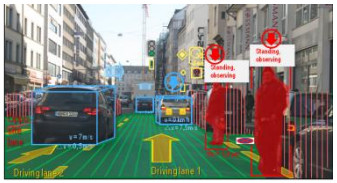
Representations and Fusion



Road Model and Localization

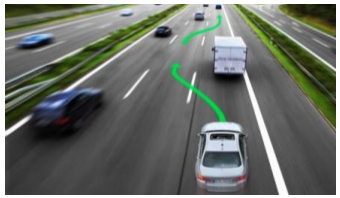


Situation Interpretation

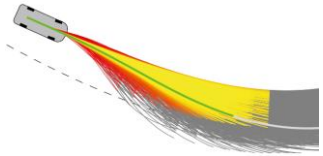


ADAS FUNCTIONS

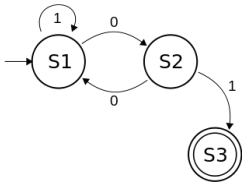
Maneuver Planning



Trajectory Planning



State Machine

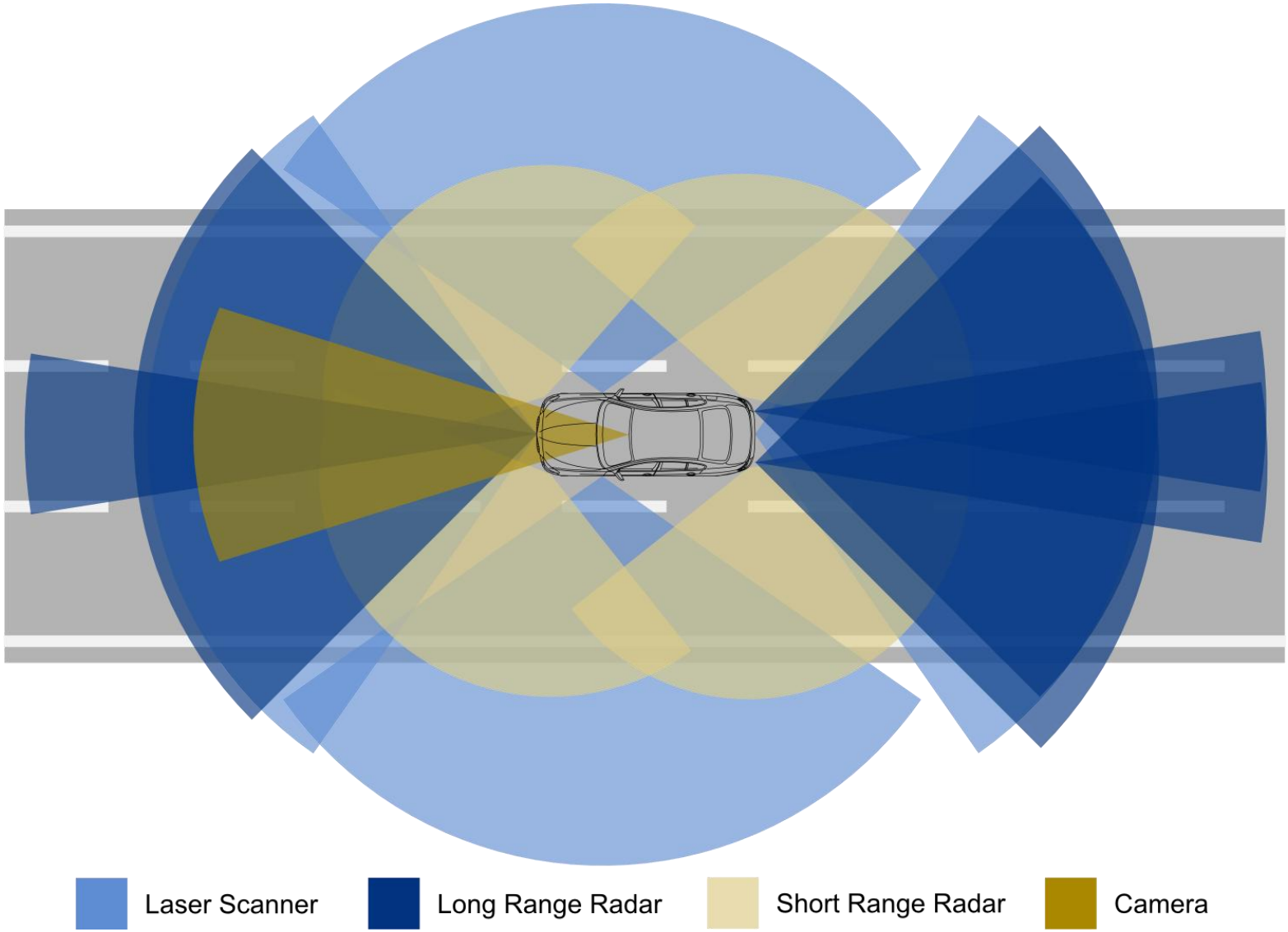


VEH CONTROL

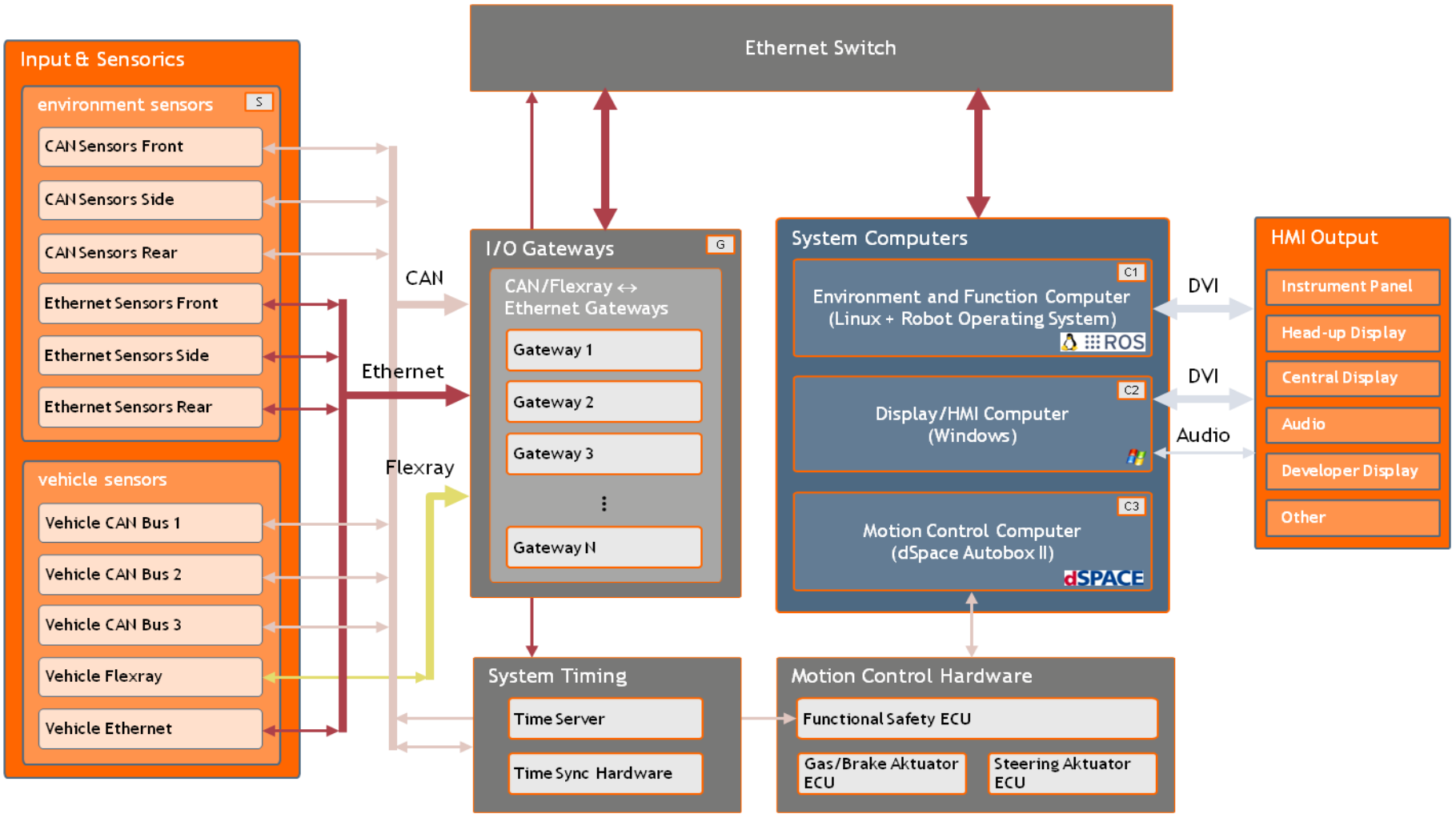
HMI

GEN2 RESEARCH PROTOTYPE.
BMW 335I GT.

SENSOR SETUP IN GEN2 RESEARCH PROTOTYPE.

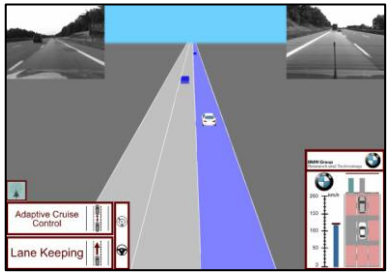


HARDWARE ARCHITECTURE.



CHOOSING A FRAMEWORK.

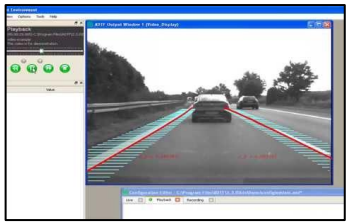
1 MicroFramework
BMW Group Research and Technology



- BMW internally developed Framework for prototyping ADAS.
- Shared memory transport mechanism.
- Synchronized execution of software modules.
- Internal development limited/complex.

2 EB Assist ADTF
Elektrobit Automtive

Elektrobit



- Commercial product popular within the automotive industry (OEMs/Suppliers).
- Readily available toolboxes to hardware used in the automotive industry.
- Easy to use GUI for manipulating various features and configuration a system.

https://www.elektrobit.com/products/eb-assist/adtf/

3 ROS
Open Source Robotics Foundation

ROS

- Popular open source robotics framework.
- Reliable distributed architecture.
- Wide use in the robotics research community.
- Huge selection of “off-the-shelf” software packages for hardware/algorithms/etc.

CHOOSING A FRAMEWORK.

MicroFramework BMW Grou 1

- BMW i
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- Shared
  mecha
- Synchr
  module
- Interna
  limited

EB Assist ADTF 2

https://www.elektrobit.com/products/eb-assist/adtf/

ROS 3

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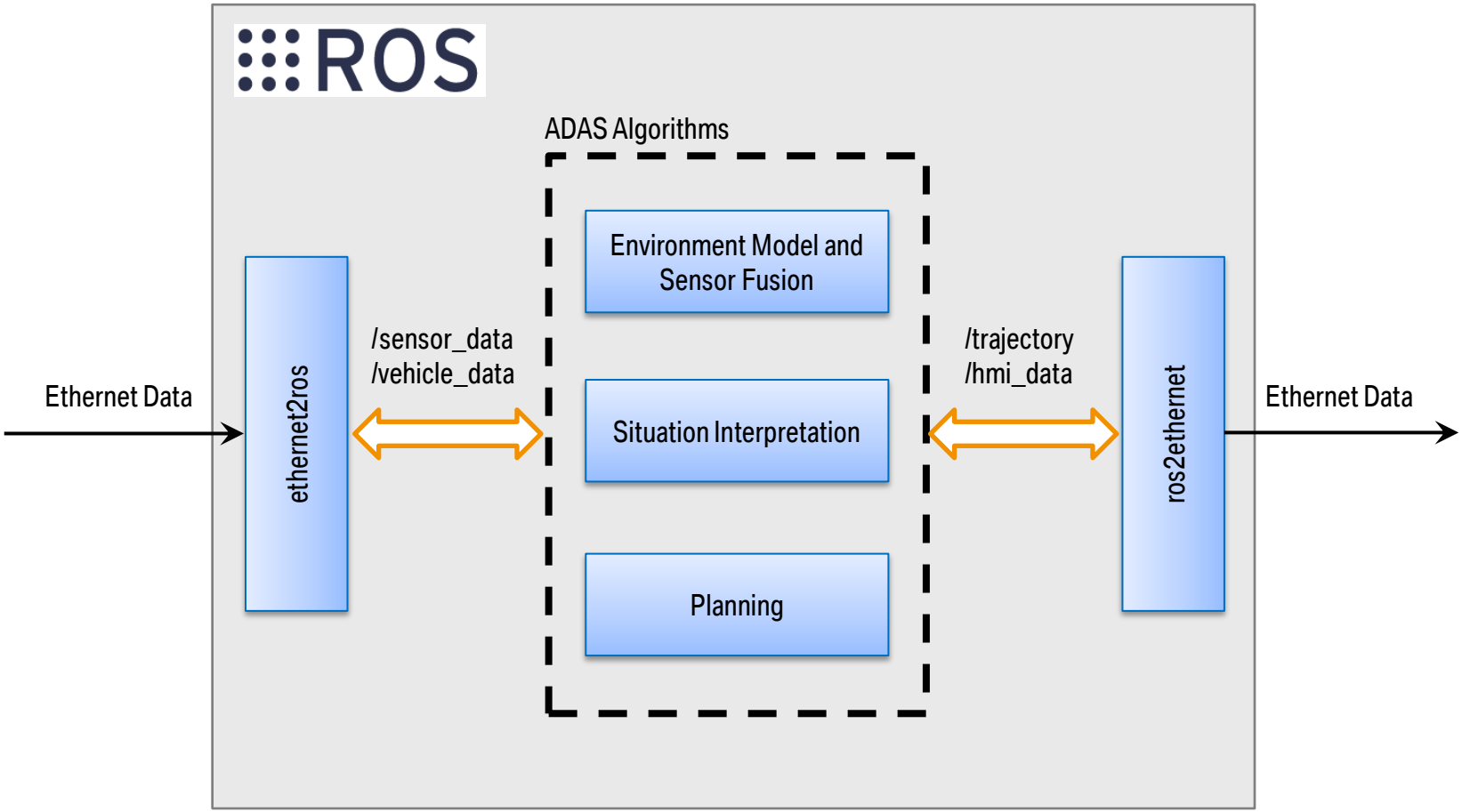
helf”

Why we ended up choosing ROS for the BMW research department:

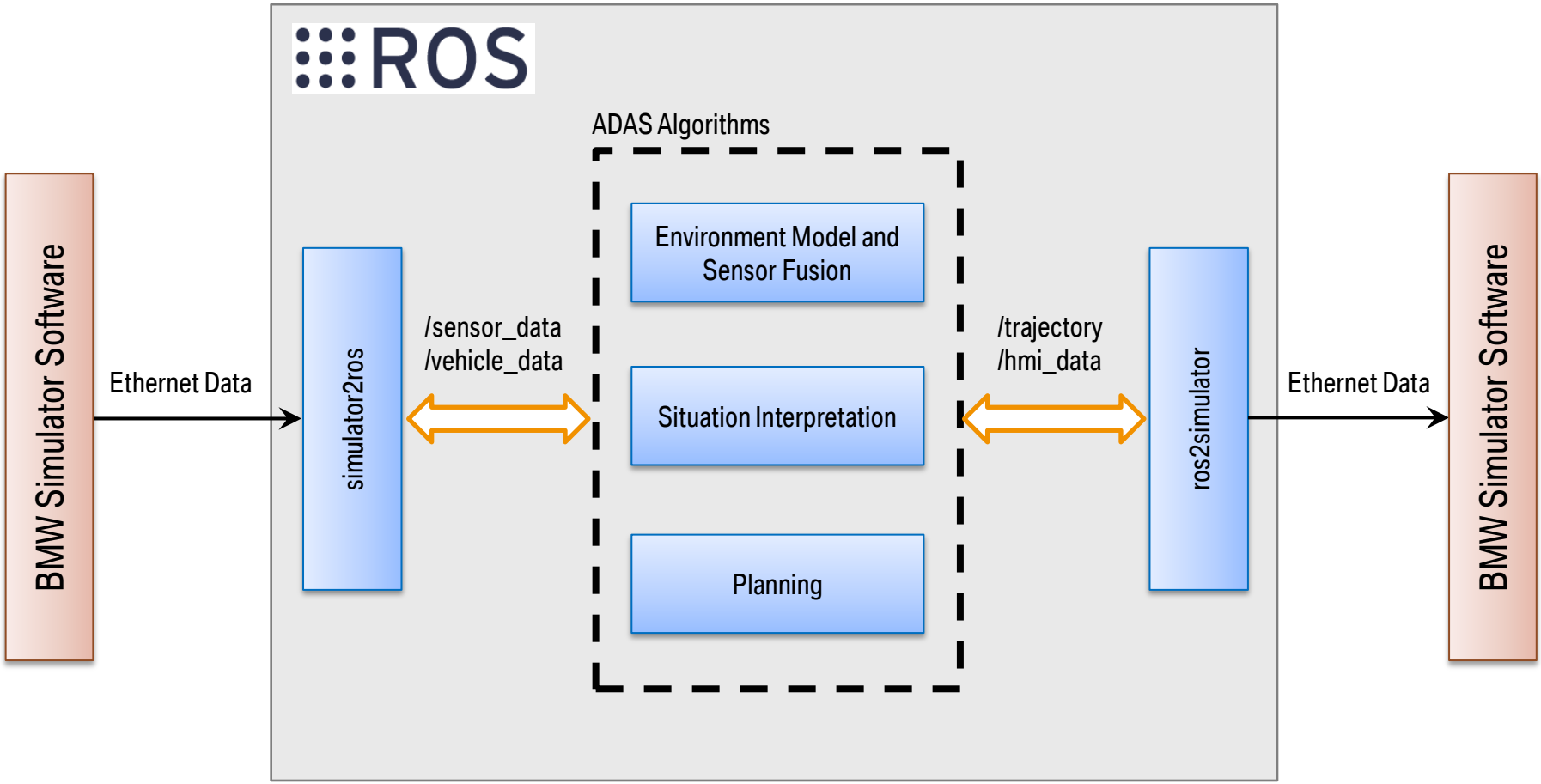
- Autonomous driving benefits from robotics research and ROS has been become very popular in the robotics community.
- Stability and reliability from a very large user-base.
- Quick tests and integration of already-available algorithms and software packages → saves development time.
- Open source.
- Easier cooperation with universities and other research institutes.
- Gain experience at BMW with using ROS and learn about its advantages /disadvantages with respect to other solutions → research department should try something new!

ROS ARCHITECTURE.



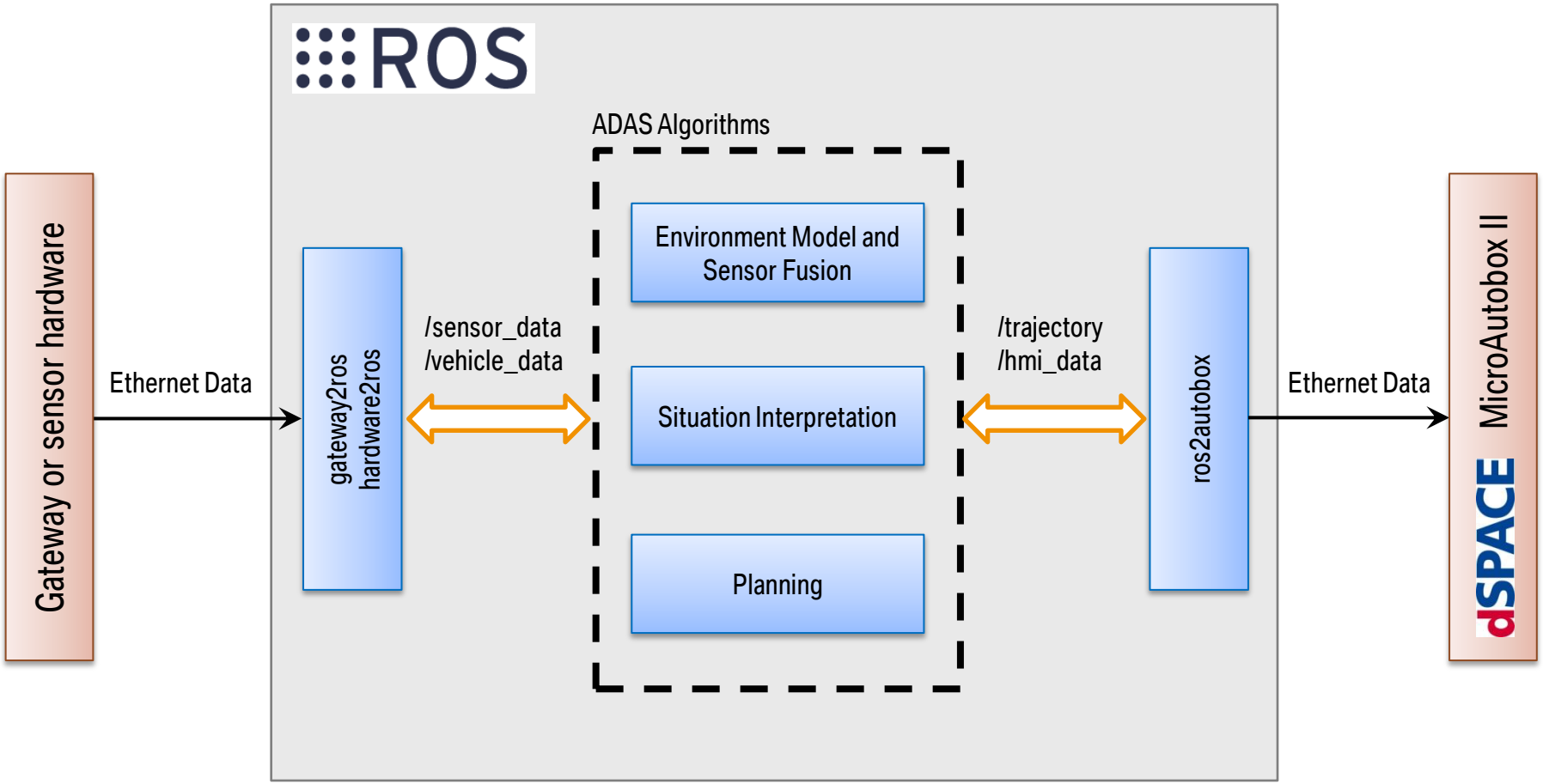
ROS ARCHITECTURE.

With the simulator:



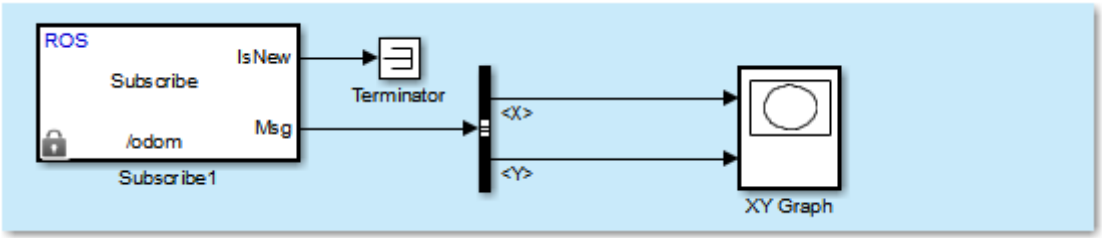
ROS ARCHITECTURE.

In the research vehicle:



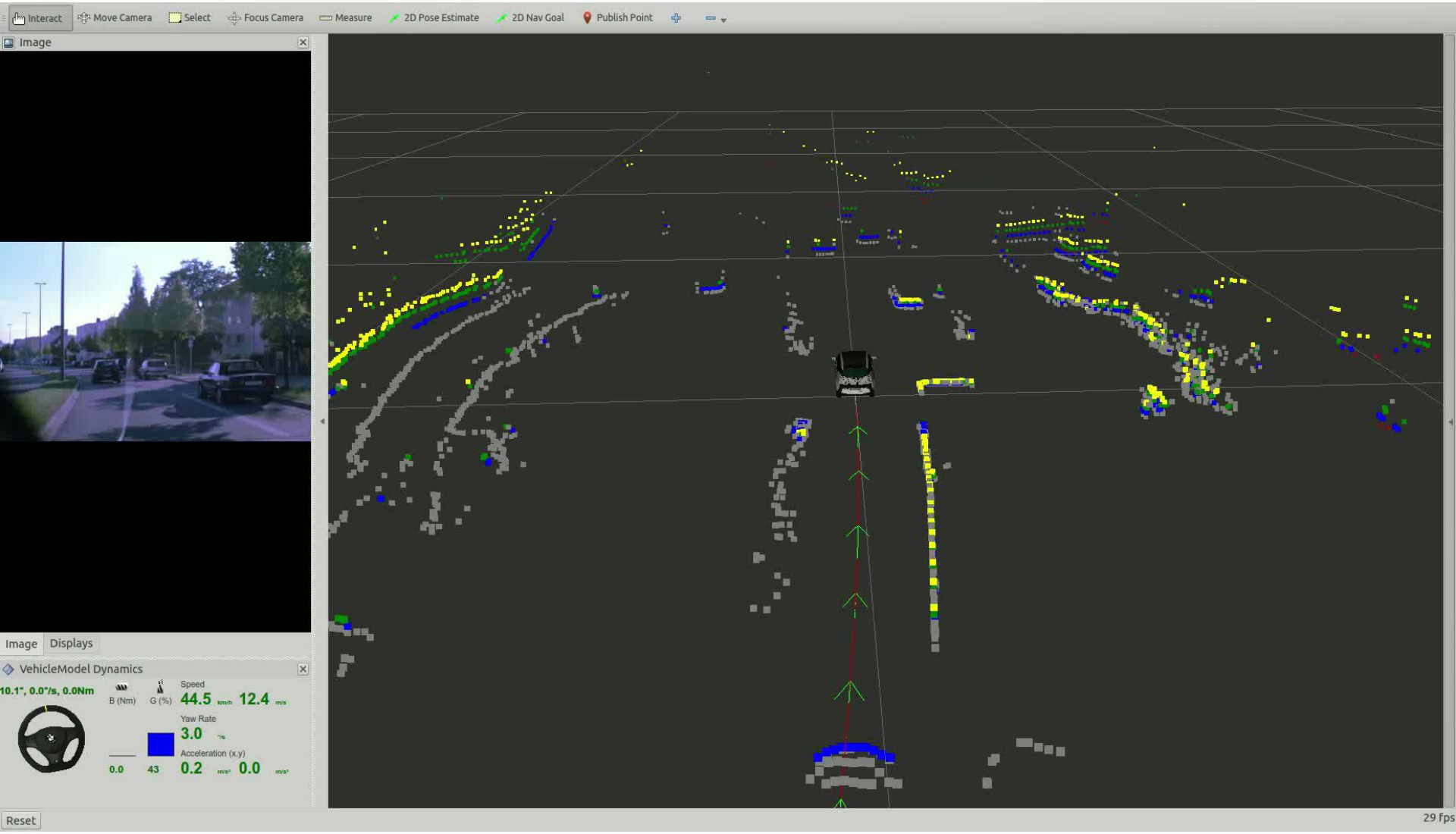
USING MATLAB/SIMULINK WITH ROS.

- MathWorks released the Robotics System Toolbox this year for ROS integration with Matlab/Simulink.
- Easily read and analzye data from ROS Bags → useful for evaluating the system.
- Some of our software is implemented as a Simulink model.
  - Use the Toolbox to easily integrated this software into the ROS eco-system:

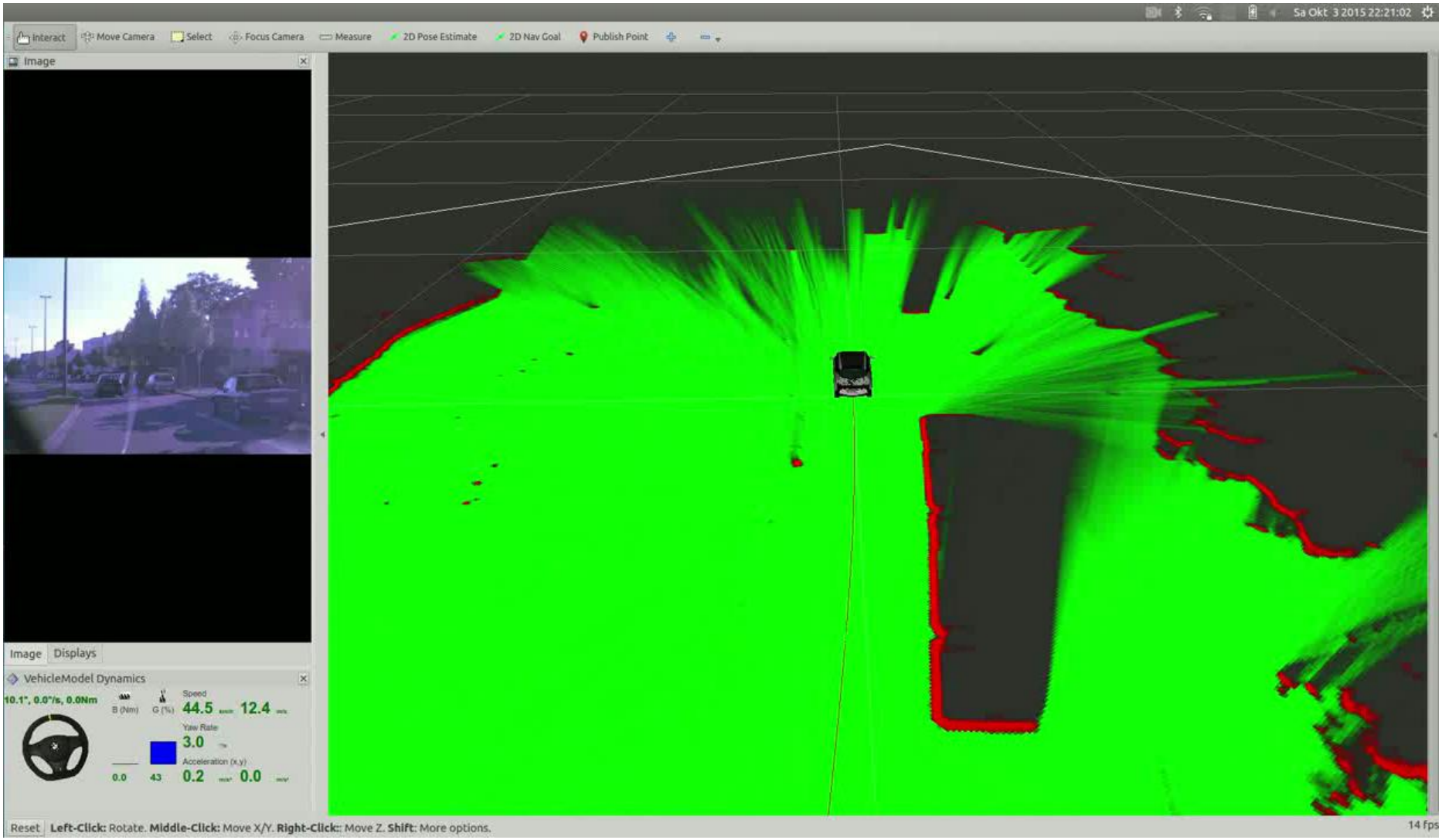


http://www.mathworks.com/products/robotics/

VIDEO – LASERSCANNER.



VIDEO – GRIDS.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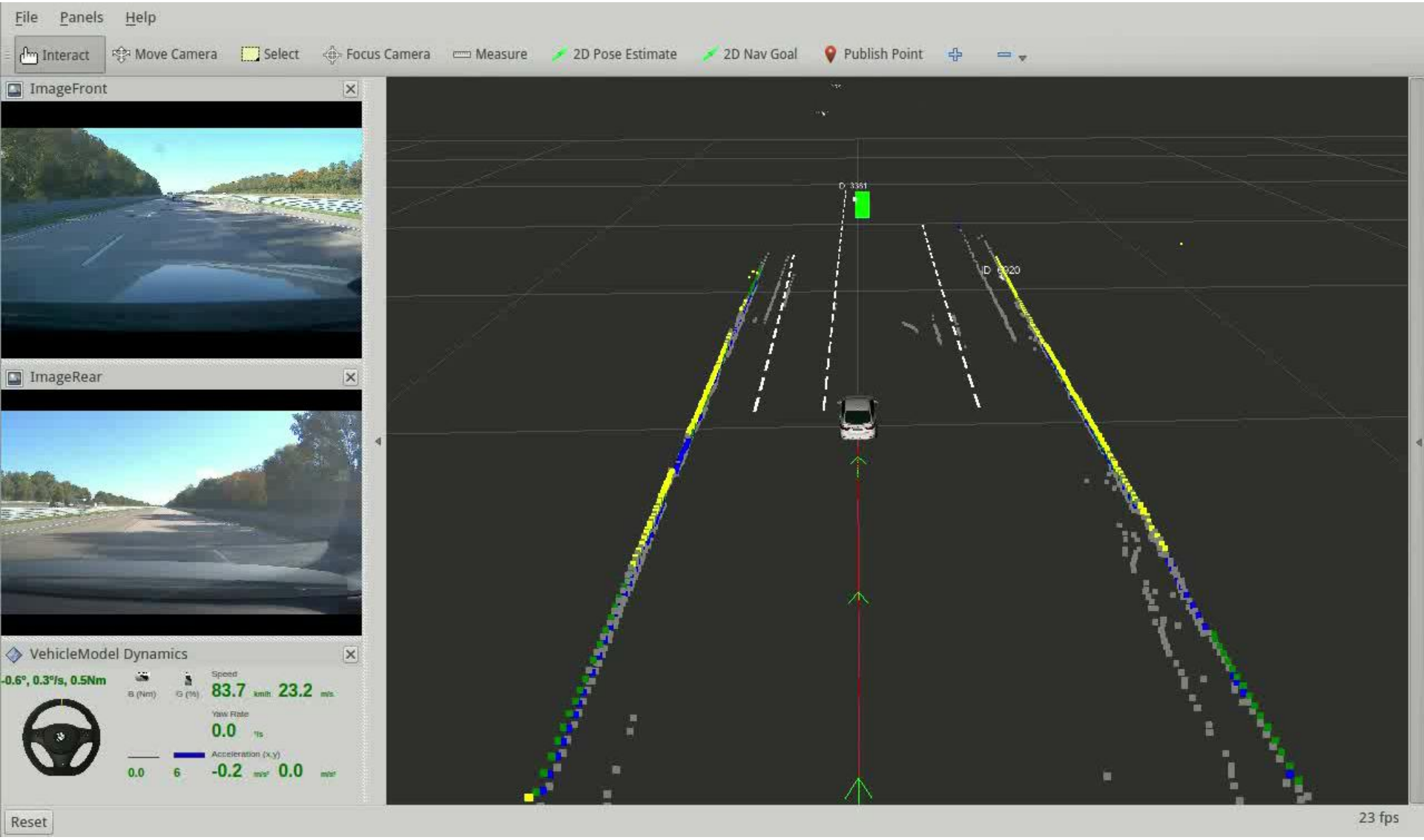
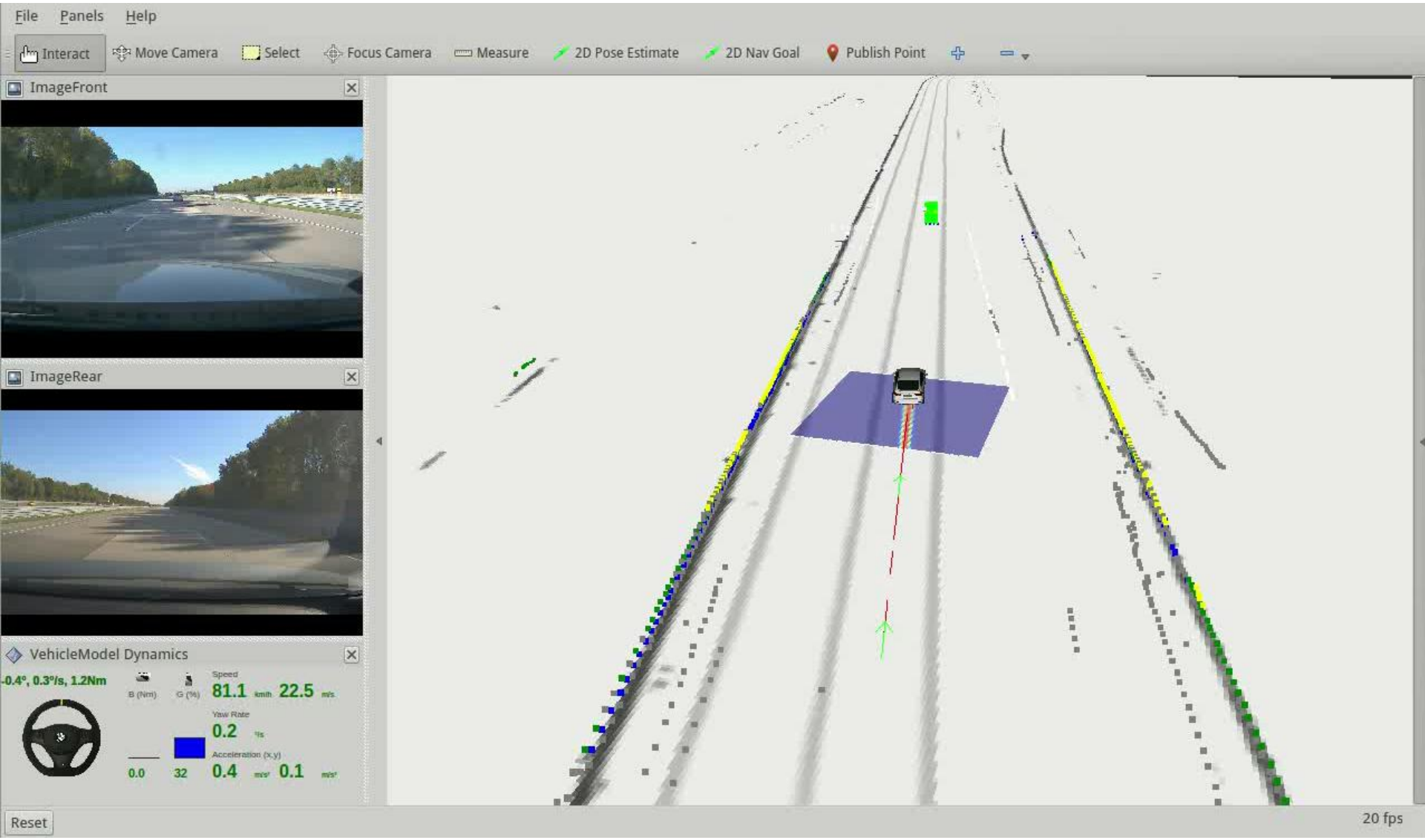
interact
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
2D Nav Goal
Publish Point
Image
Image
Displays
VehicleModel Dynamics
10.1°, 0.0°/s, 0.0Nm
B (Nm)
G (%)
Speed
44.5
12.4
Yaw Rate
3.0
Acceleration (x,y)
0.0
43
0.2
0.0
Reset
Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click:: Move Z. Shift: More options.
14 fps

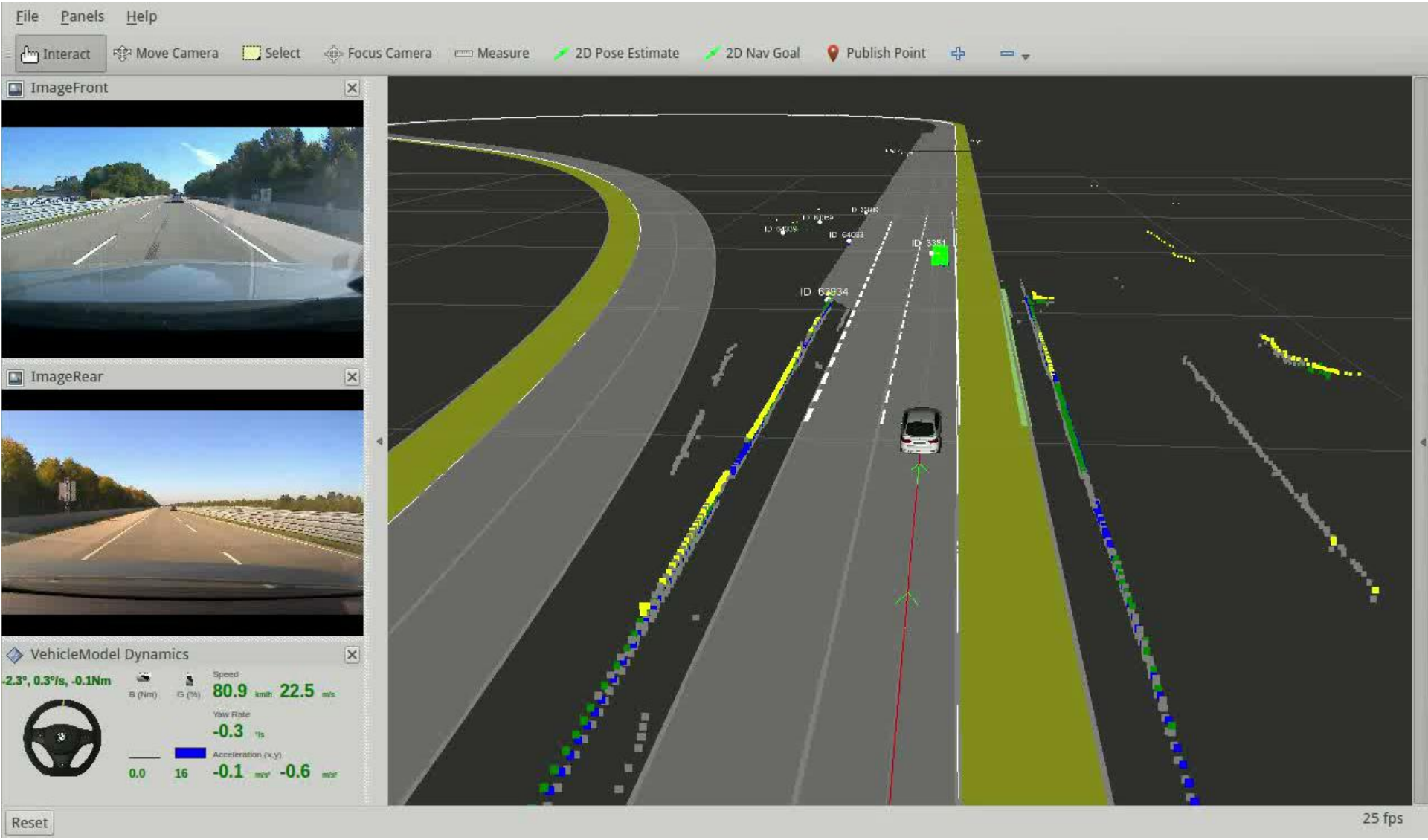
VIDEO – OBJECTS AND LANE MARKINGS.



VIDEO – LOCALIZATION.

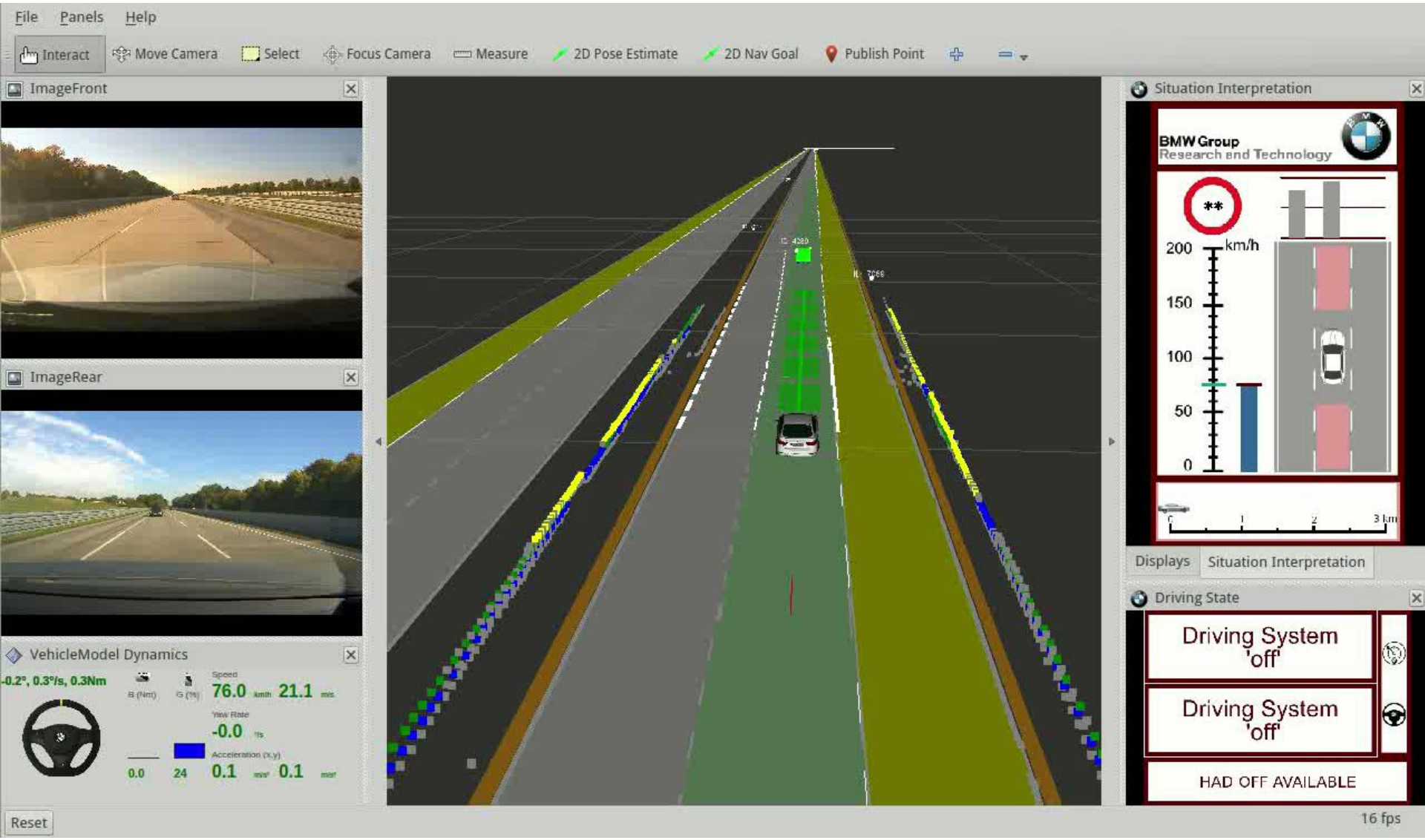


VIDEO – ENVIRONMENT MODEL.



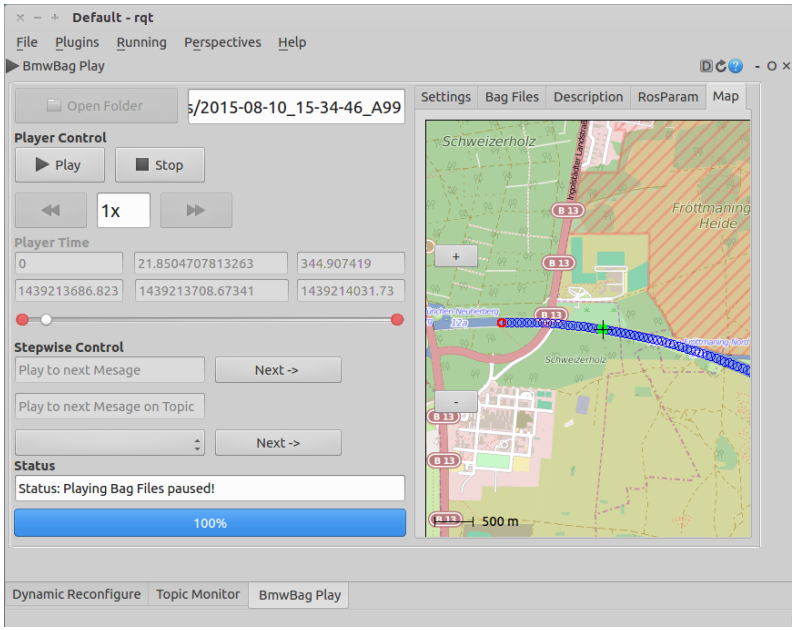
VIDEO – TRAJECTORY PLANNING.

VIDEO – AUTOMATED DRIVING FUNCTION.



DEVELOPED TOOLS.

- Several RQT Plug-Ins for various purposes:
  - Plug-Ins with specific functionality, for example simulating input and/or output for testing.
  - Improved Bag Record/Play Plug-In (rosparam dump/load, extra meta-data, map view, etc.).



- Lots of RViz Plug-Ins for visualizing our interfaces.
  - Avoid using markers to reduce traffic.
  - More flexibility with Ogre API.
  - Integration of selection mechanism for displaying object-specific data.

WHAT WE LIKE ABOUT ROS.

- Reliability and stability.
- Minimalism of a basic ROS node.
- Distributed architecture.
- ROS Message concept.
- “Off-the-shelf” tools such as RViz, RQT, Bag, diagnostics, etc.
- Future potential (ROS 2, ROS Industiral, new tools, etc.).
- Lots of software packages to try out!

THERE IS STILL A LOT OF POTENTIAL.

- More options in the message transport mechanisms.
  - ROS 2 with DDS could be a huge improvement.
  - GPU transport in order to minimize GPU → CPU data transfers.
- Easier ROS Message migration / compatibility (MD5 Checksum on .msg file maybe not the best solution?).
- Continue to improve the already very useful tools.
  - RViz – plug-ins, labeling framework.
  - RQT – Topic Monitor, Plot, Bag, etc.
- Node Manager GUI (something similar to node_manager_fkie).
- Easy configuration management for different robots (currently a hodge-podge of launch files for different vehicles).
- Compliance to industry standards for software (ISO, AUTOSAR, etc.).

THANK YOU FOR YOUR ATTENTION.

Contact: michael.aeberhard@bmw.de