OPENADX "AUTONOMOUS DRIVING SIMULATION" TESTBED

INTRODUCING RENESAS HARDWARE INTO THE SIMULATION LOOP

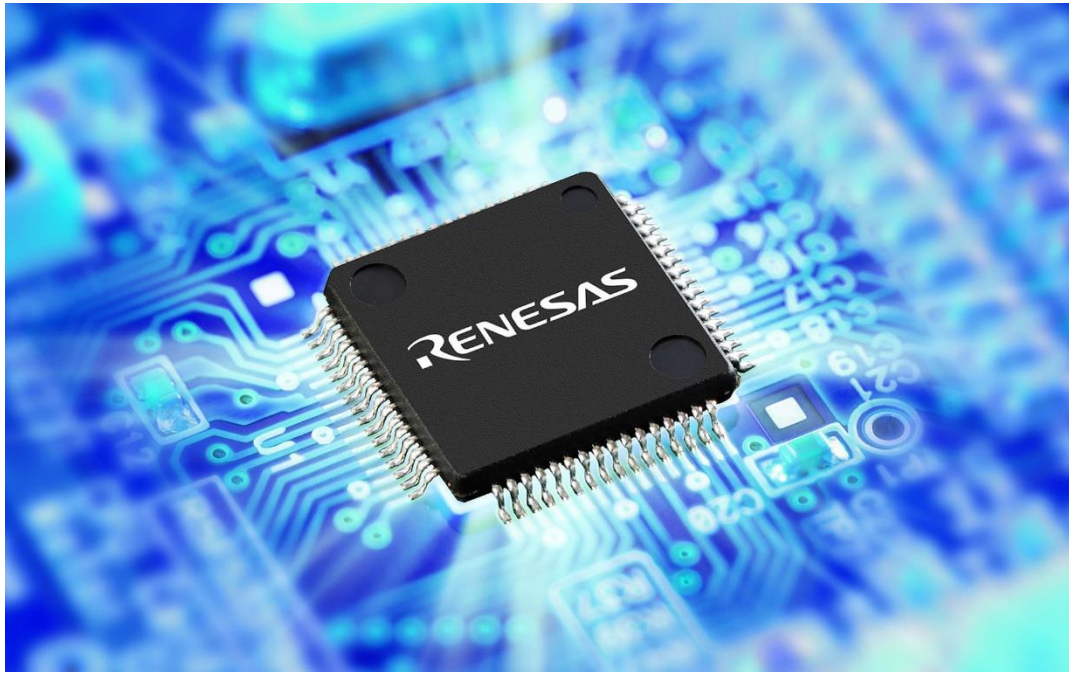
BIG IDEAS
FOR EVERY SPACE

RENESAS

WHO ARE RENESAS

THE WORLD'S LEADING EMBEDDED SOLUTION PROVIDER

- Renesas is a global semiconductor company built on a strong historical foundation of technological innovation originating from Hitachi, Mitsubishi, and NEC.
  In 2017, Renesas acquired Intersil to become the world's leading embedded solution provider.
  - A global leader in microcontrollers, SoC, analog and power semiconductors
  - Focused on a broad range of Automotive, Industrial, Home Electronics, Office Automation and Information Communication Technology
  - 780.3 billion yen in net sales in 2017
  - Headquartered in Tokyo, Japan
  - 20,000+ employees worldwide*1



*1: Consolidated, as of March 31, 2018 / SoC: System-on-a-chip

WHAT IS OPENADX?

- It is an Eclipse Foundation project.

Purpose is to accelerate the development of autonomous driving (AD).

- Focus is on,
  - Defining reference architecture(s).
  - Specifying open interfaces.
  - Specifying autonomous toolchain.

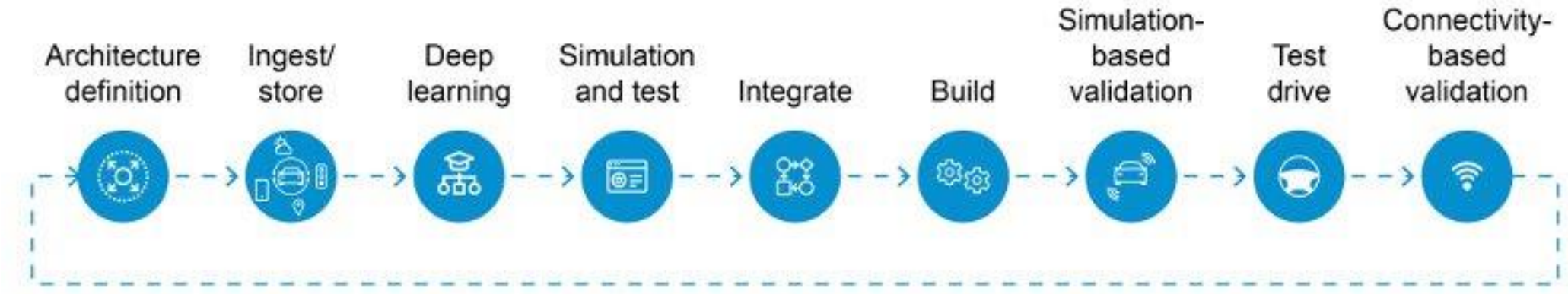
WHY OPENADX?

- The software and tooling requirements for Autonomous Driving (AD) are diverse and complex.
- Companies do not have the desire and in some cases technology to invest and build the entire AD toolchain themselves.
- The cost and resource to do so would be huge.
- Therefore consortiums, partnerships and open source development communities will be used to reduce the cost and entry to the market.
  - Specialist companies can focus on key areas of the AD toolchain, e.g. Simulation.
  - OEM’s can concentrate on differential areas to increase their business.

Collaboration via OpenADx for AD make sense for all companies involved!

HOW WILL OPENADX ACCELERATE DEVELOPMENT?

- Accelerate by - Enabling seamless integration of tools used in development.



  - Seamless integration both within and across the different development stages.
  - Also enables integration of tools supplied by multiple vendors.

- Accelerate by – Developing new tools and sharing through Open Source Software (OSS).

Removing barriers to share development across multiple vendors/stakeholders

OPENADX ACTIVITIES

- OpenADx activities will targeted at testbeds.
  - A testbed is based on an agreed use case.
  - Its about focusing collaboration on concrete use cases.
  - Should produce demonstrable results.

- Testbed activities at this time are,
  - Simulation Testbed.
    - Create framework to enable easy integration of tools and functions under test.
  - Massive Data Ingest and Management Testbed.
    - Collection and handling of sensor data needed for development/verification.

- The simulation testbed has adopted an open standard to connect tools and components.
  - This should allow local and remote connection of the various parts in a system.

- Our presentation today is focused around this simulation testbed activity and the interconnection of various components.

SIMULATION TESTBED COMMUNICATION

- DDS (Data Distribution Service) is to be used for data exchange between components.
  - Is an open, middleware, standard managed by OMG (Object Management Group).
  - Allows real-time applications to easily share information.
    - Information is ‘published’ as a ‘topic’ by a ‘node’.
    - And this ‘topic’ can then be ‘subscribed’ to by another ‘node’/application.

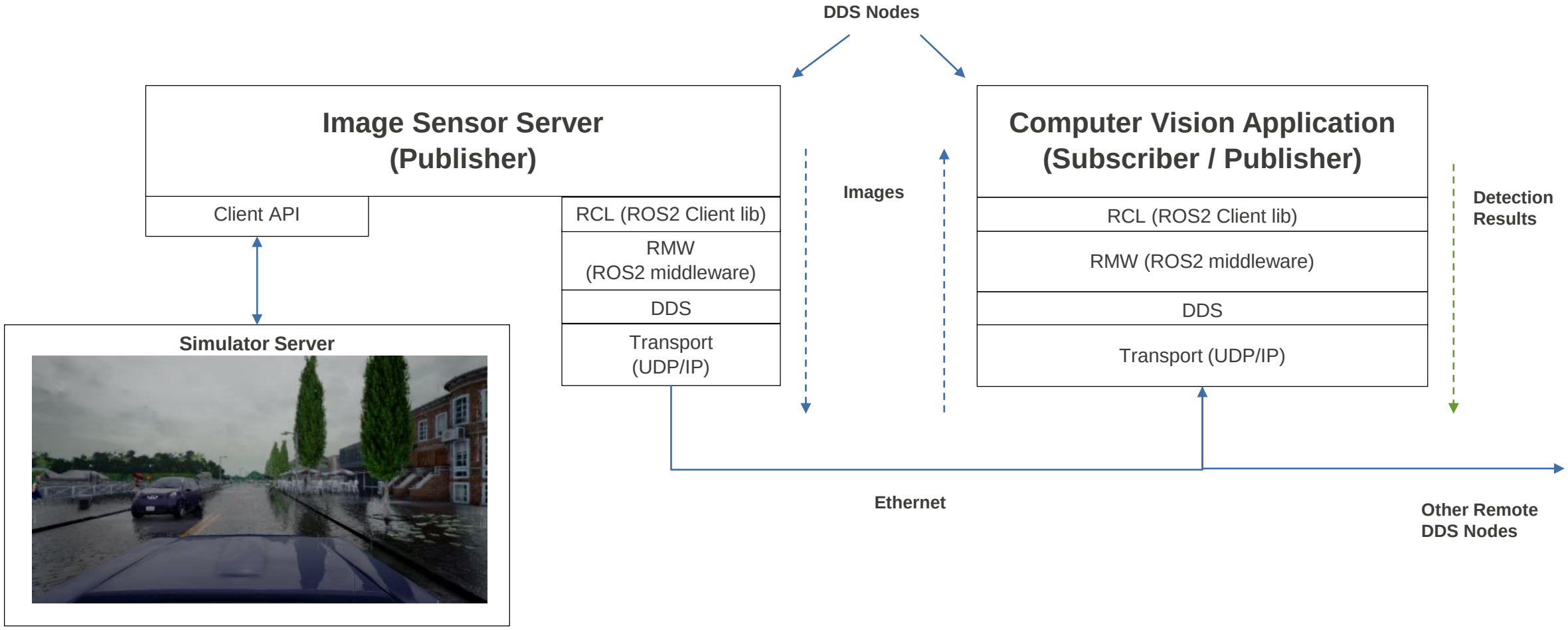
- The data exchange is then to be compliant with ROS2 (Robot Operating System 2).
  - ROS2 defines messages supporting various sensors, measurements and controls.

- This combination is then known as ROS2/DDS.
  - DDS being used as the underlying ‘middleware’ to exchange these ROS2 messages.

- There are different vendor implementations of DDS available, e.g.
  - FastRTPS, OpenSplice, Connext.

- Various transport layers can be supported, typically this is over an IP connection.

ROS2/DDS EXAMPLE



DRIVING SIMULATORS

- A key part to the simulation test bed is the driving simulator.
  - Allows testing of ADAS (advanced driver assistance systems) and AD systems.

- Some solutions are AirSim, CARLA, Deepdrive, Udacity, Tesis.

DRIVING SIMULATORS

- Multiple camera views, e.g. stereoscopic

They can replace some expensive road testing and provide reproducible test cases

WHERE DOES RENESAS FIT IN?

- Renesas R-Car is aimed at providing SoCs (system on chips) for ADAS and AD systems.
  - The V device family is for vision processing e.g. V3M or V3H.
- We need a reproducible test environment for this Renesas IP development.
  - E.g. Convolution Neural Networks (CNN) or Shader IP.
- Simulators then provide a useful source of test data for this IP development.
- OpenADx would then allow easy connection of a simulator and the IP under test.
  - Customers can test their actual software within a wider test environment.
- Continuous integration test systems can be built on this technology.
  - Cost effective way to provide regression testing.

OpenADx facilitates this easy connection of different simulation environments to Renesas IP

RENESAS OPENADX DEMO

- One key application for Renesas is the use of computer vision to create smart cameras.
  - R-Car product range supports this application.

- For the OpenADx simulation testbed we have focused on this smart camera application.
  - Using the Renesas IMP-X5 simulator and the R-Car V3M development board.

- The goal is to demonstrate the integration of Renesas technology into the OpenADx framework using ROS2/DDS.

R-Car OpenADx Demo

Manual Control (Steering wheel /pedals)

ROS2 Manual Input

Control Module

ROS2 Detected Object List Feedback

ROS2 Vehicle Control

Driving Simulator

ROS2/DDS Vehicle Control Server

ROS2/DDS Camera Image Server

ROS2 Camera Images

Target Simulator or Hardware

Renesas R-Car

ROS2/DDS Interface

Linux Application

Computer Vision & AI

CARLA

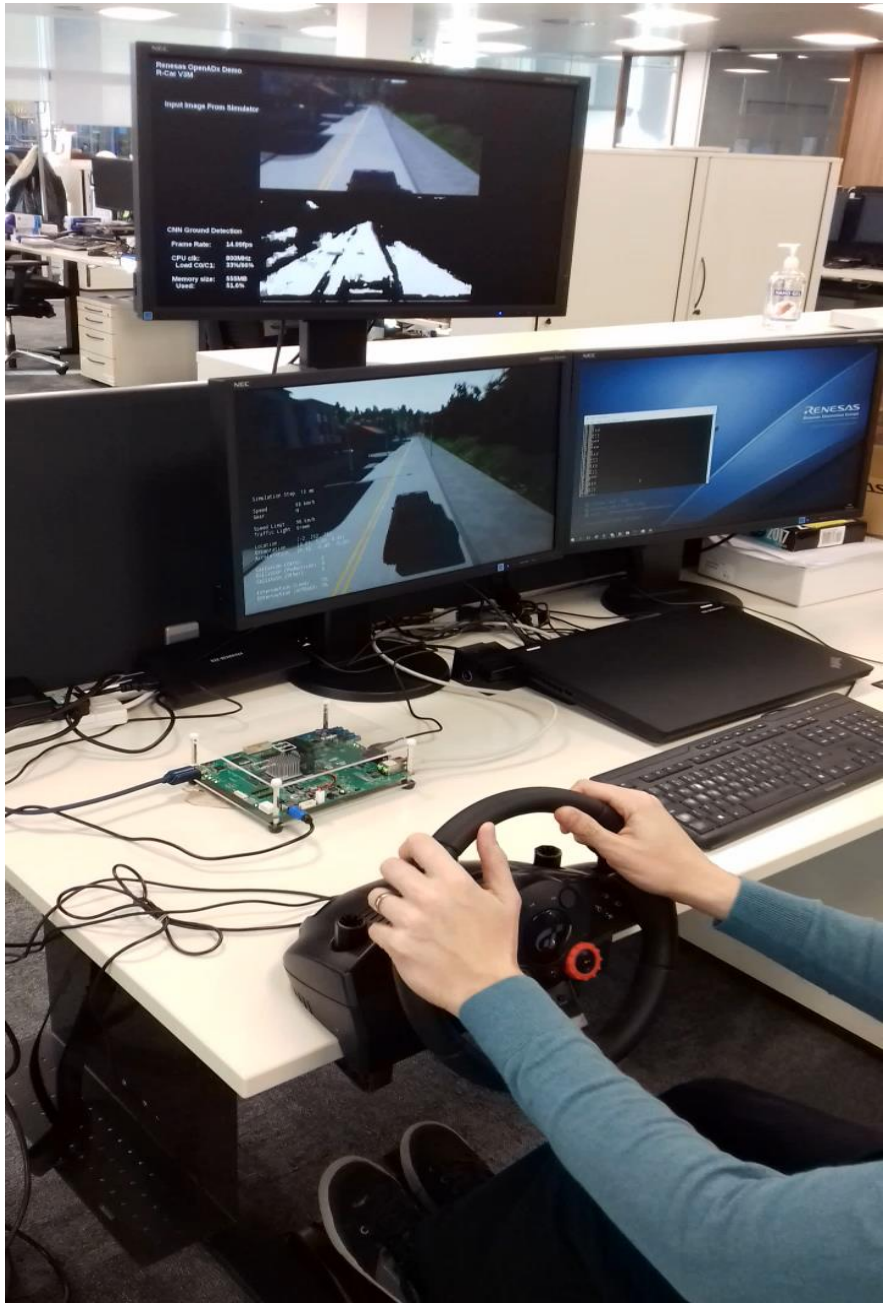
UNREAL ENGINE

ROS

DDS

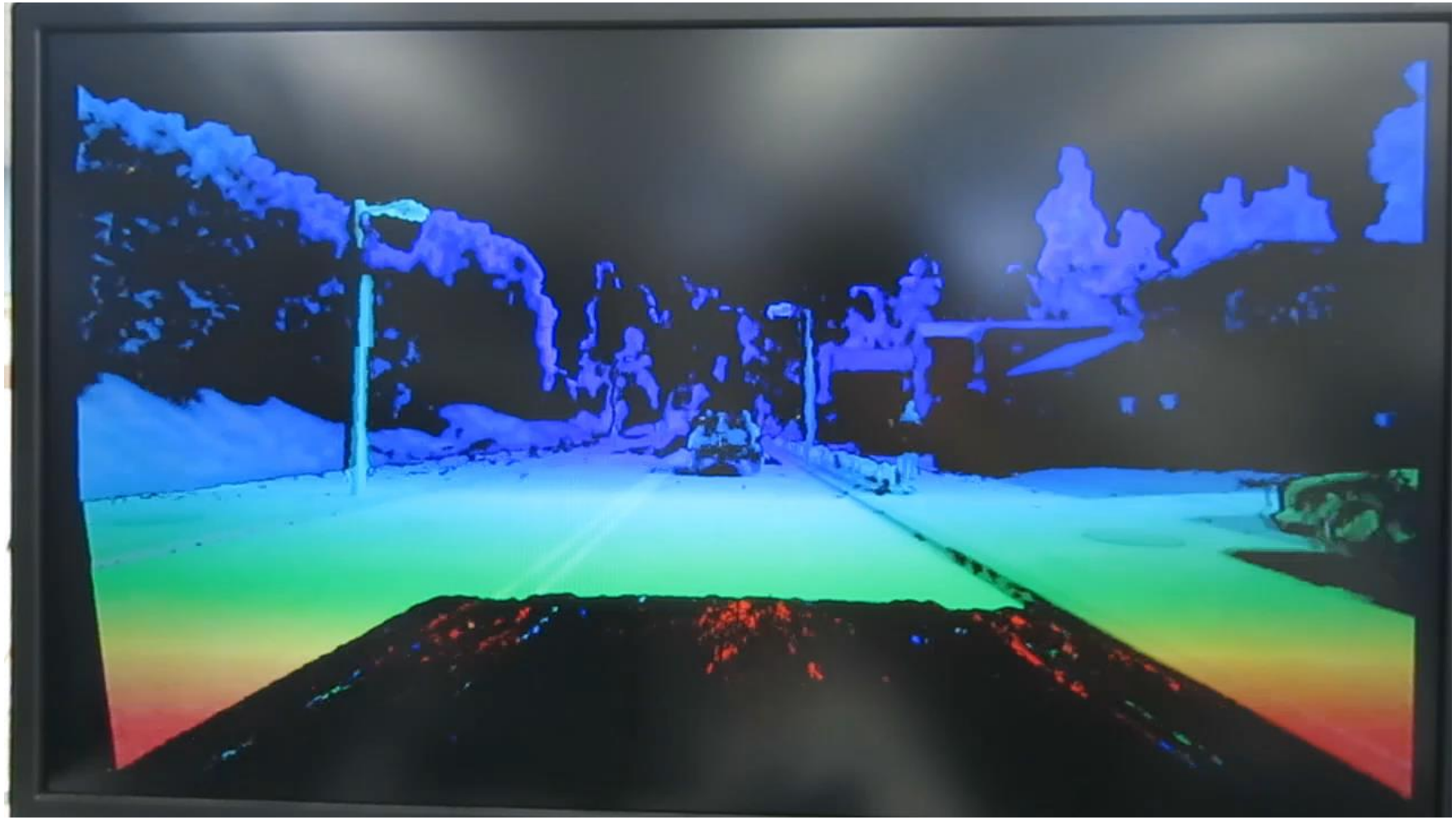
Demo Output via HDMI

OPENADX DEMO

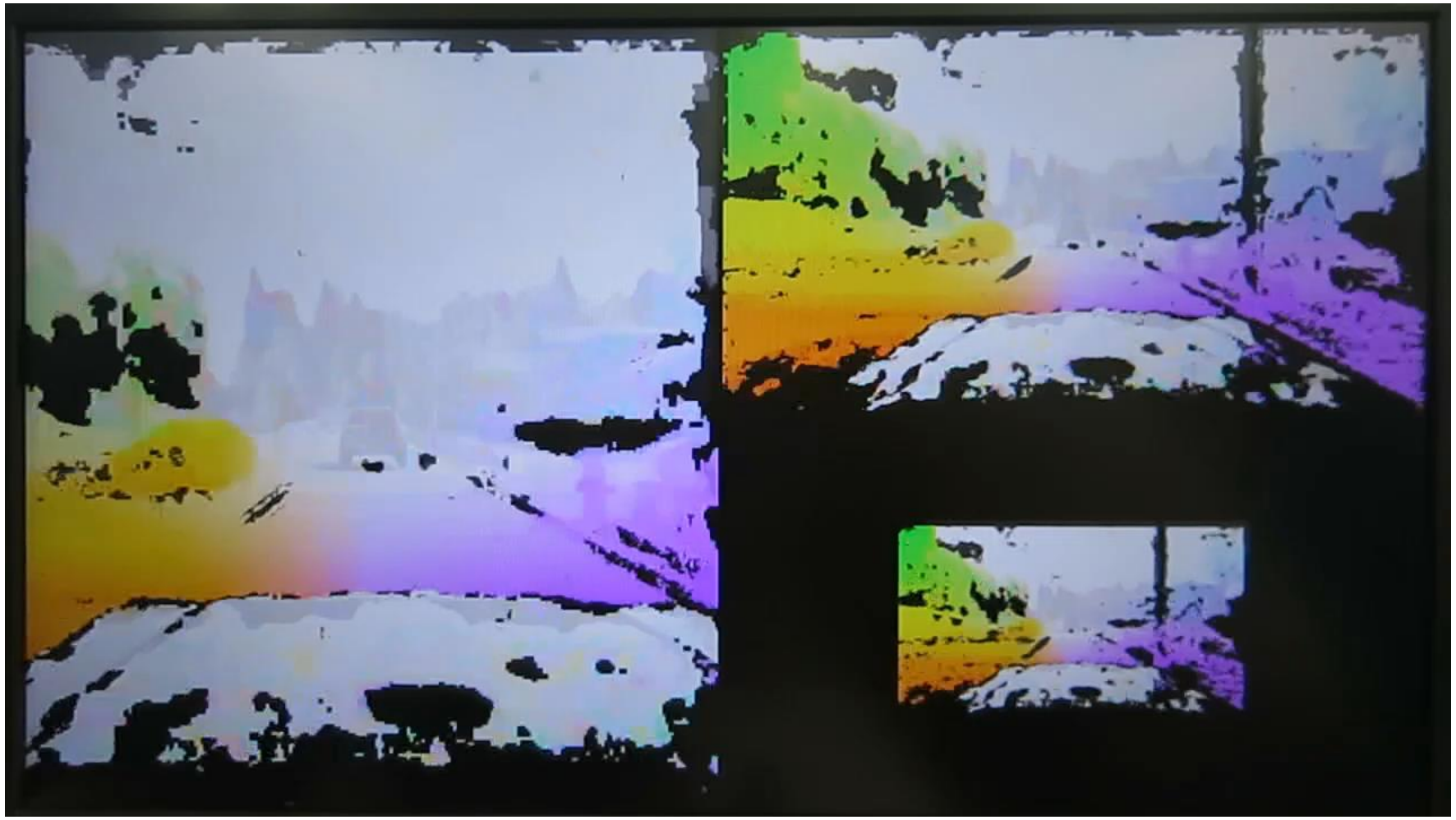


OPENADX DEMO - PROCESSED IMAGES

PROCESSING OF STEREOSCOPIC IMAGE SEQUENCE



PROCESSING OF IMAGE SEQUENCE



OPENADX COMPONENT SUBSTITUTION

- OpenADx has shown its benefit by allowing ROS2 compliant components to be easily interchanged.
- In this case,
  - The demo simulator was easily changed, substituting CARLA with AirSim.
  - The R-Car IMP-X5 virtual platform could be easily replaced with R-Car target hardware.

- Looped back AirSim image after IMP-X5 simulator annotates it with a white frame. --------->

DEMO PERFORMANCE

- While the demo today runs at 15FPS, some effort was needed to get to this level.
  - Images are 0.5Mpix (1024x512 RGB) and compressed for faster transfer.
  - Pipelining is used.

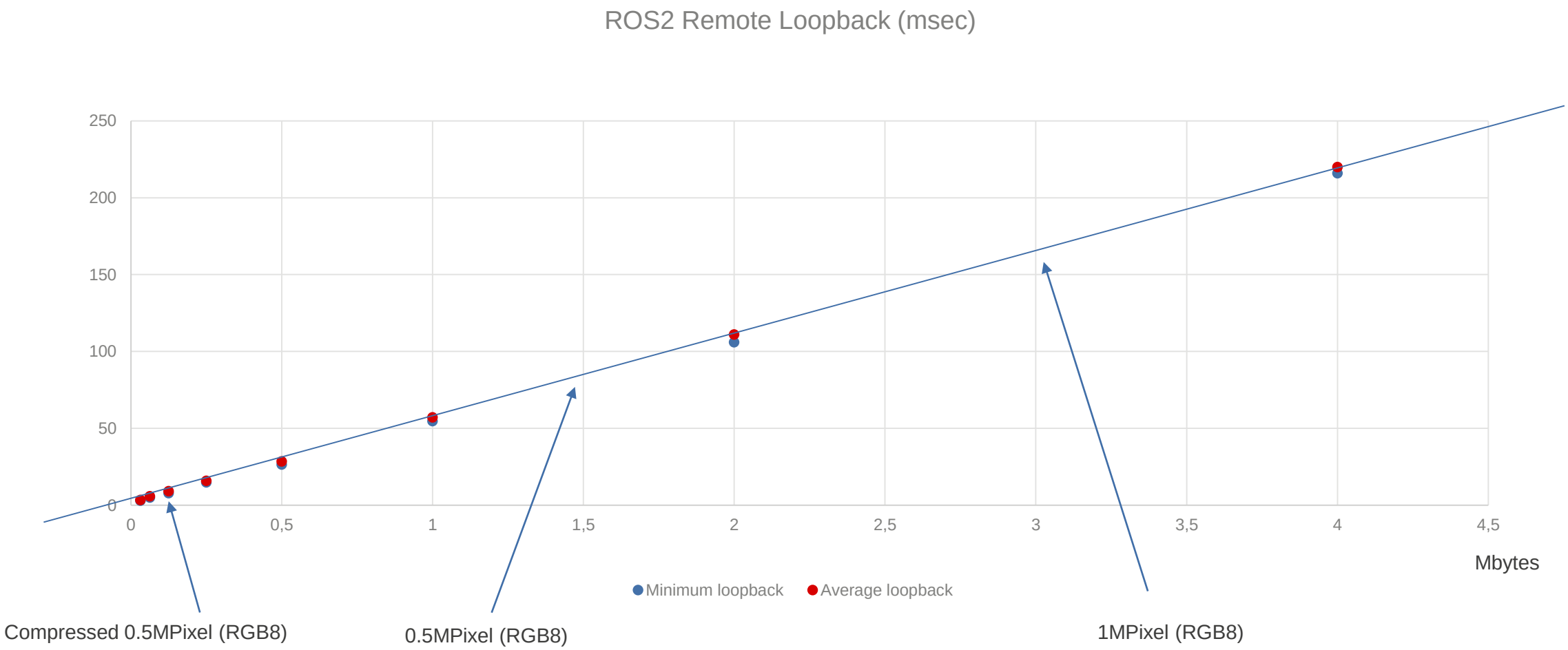
- Simulator camera sensors are a significant overhead.
  - Need to render an image for each sensor.

  - CARLA 0.8.4 simulation step (frame rate) timings (best case, default conditions),
    - Screen only -> 15msecs (66 FPS)
    - With 2 x 0.5Mpixel (RGB) -> 60msecs (15 FPS)
    - With 2 x 2Mpixel (RGB) -> 130msecs (7 FPS)

  - AirSim V1.1.10
    - 1 x 0.3Mpixel (RGB) -> +65msecs (15 FPS)

- Using “Hardware in the loop” was significantly faster than using the IMP-X5 IP simulator.

ROS2/DDS LOOPBACK TIMINGS – BENEFIT OF COMPRESSION



DDS EASE OF USE

- Using DDS was not quite plug and play.
- Corporate firewalls a problem.
- Routers/switches a problem.
  - Can block multicast, to prevent flooding of large networks.
- A functional DDS connection was no guarantee of a good image streaming rate.

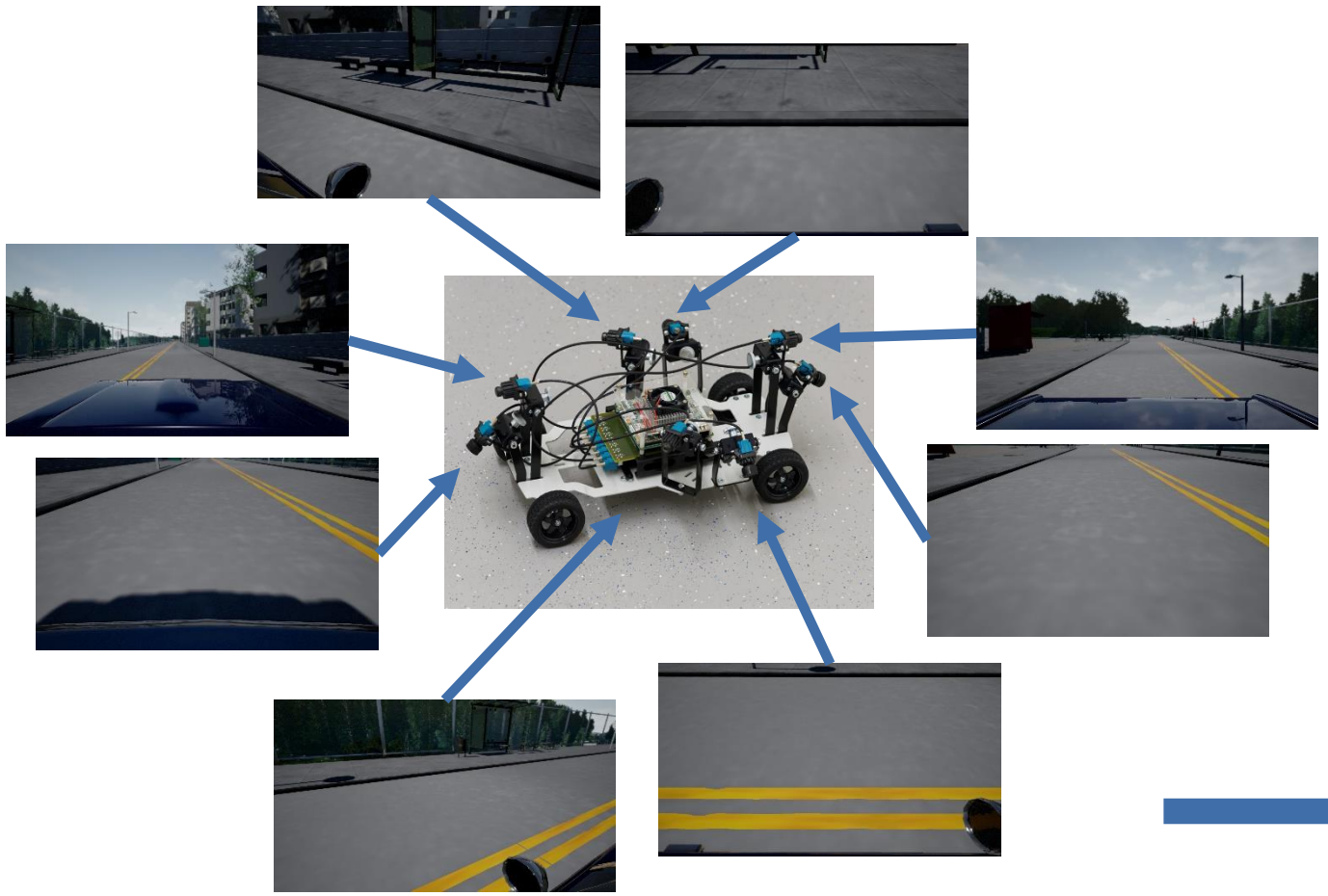
Once its working then its very easy to add / remove ROS2/DDS compliant components!

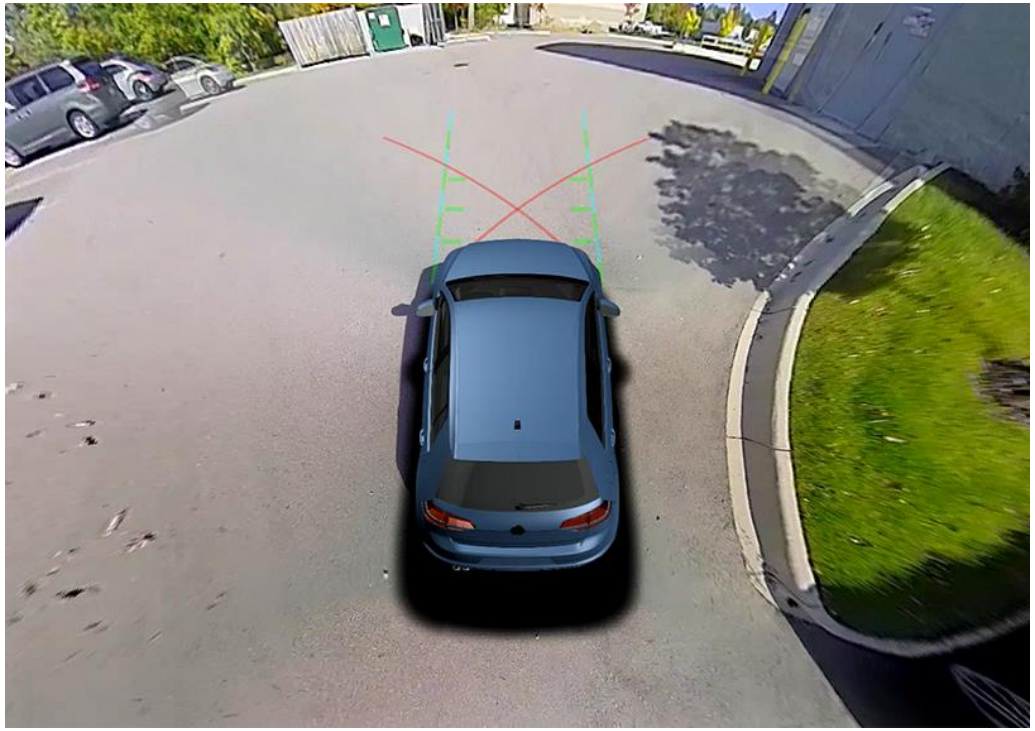
DEMO SUMMARY

Highly desirable to accelerate the simulation environment to “faster than real time”.

- Some simulators offer the ability to define the simulation step size (frame rate).
  - Depending on your processing performance you could run faster than real time.
- It was a challenge enough for us to run our simple scenario at real time on a laptop.
- AD is probably well over an order of magnitude worse requirement for simulation environment.
  - More cameras + higher resolution + other sensors.

SCALED UP ADAS SYSTEM





Multiple sensors morphed into 3D surround image.

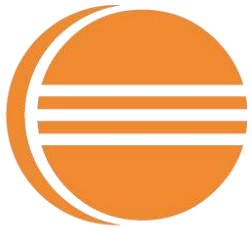
CONCLUSION

- OpenADx and ROS2/DDS has enabled easy substitution of components in a simulation environment.
  - It allows simulators or hardware to be tested in different simulation environments.
  - Open source software is a helpful medium to spread this.

Renesas see the value of Open Source Software and will continue to contribute.

- There are challenges in getting good image rates from simulators.
  - Need scalable simulators and compute platforms for multiple, high resolution sensors.
  - Building compression into the simulators can help.
  - The higher the frame rate the better, enabling accelerated testing.

Renesas are highly motivated to be part of the creation of scalable simulation environments.



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