



virtual vehicle

Enabling future vehicle technologies

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Autonomous Driving Stacks

Autware Online Class

www.v2c2.at

Outline

Motivation to use AD Stacks

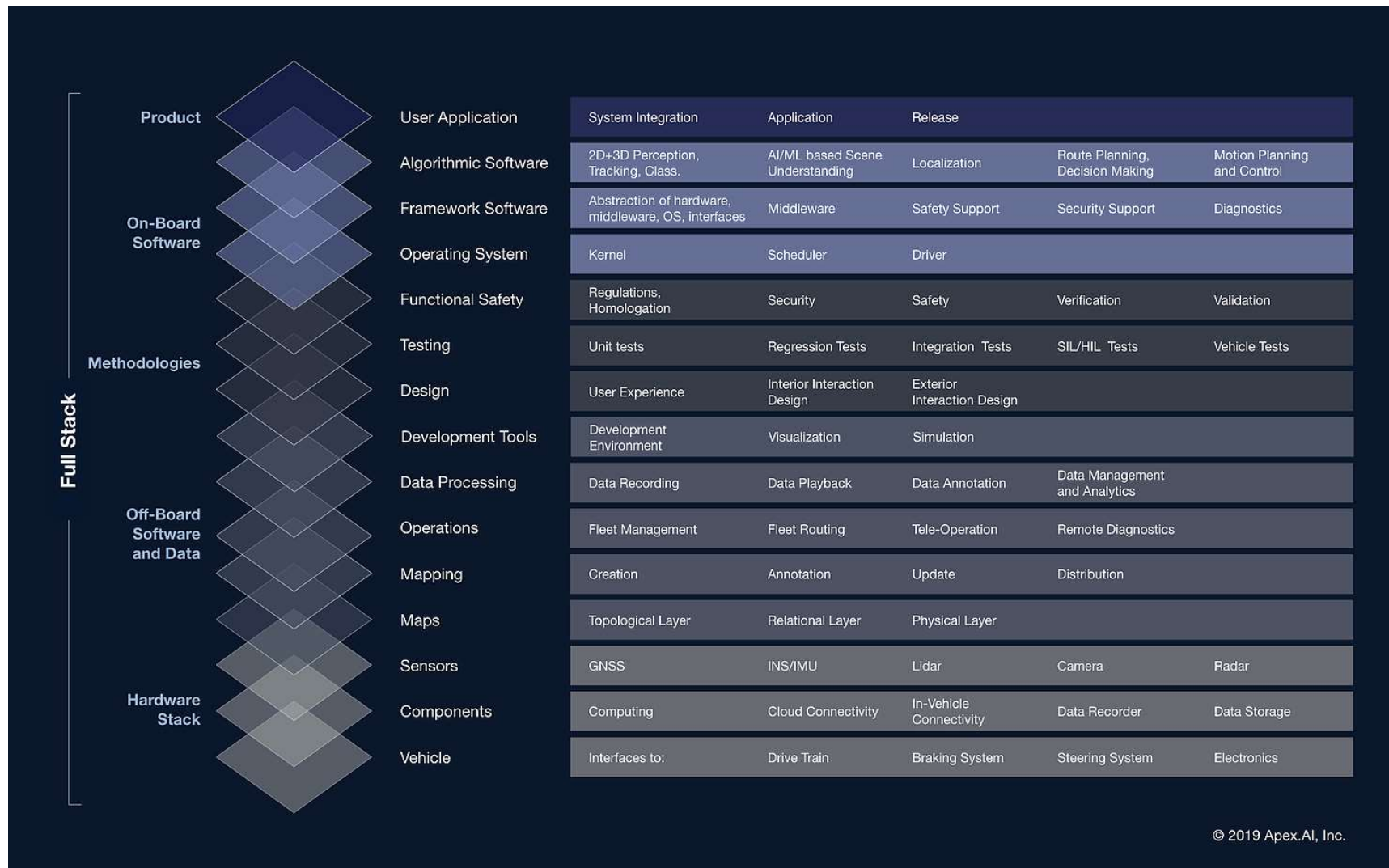
Architecture of AD Stack

Other AD Stacks

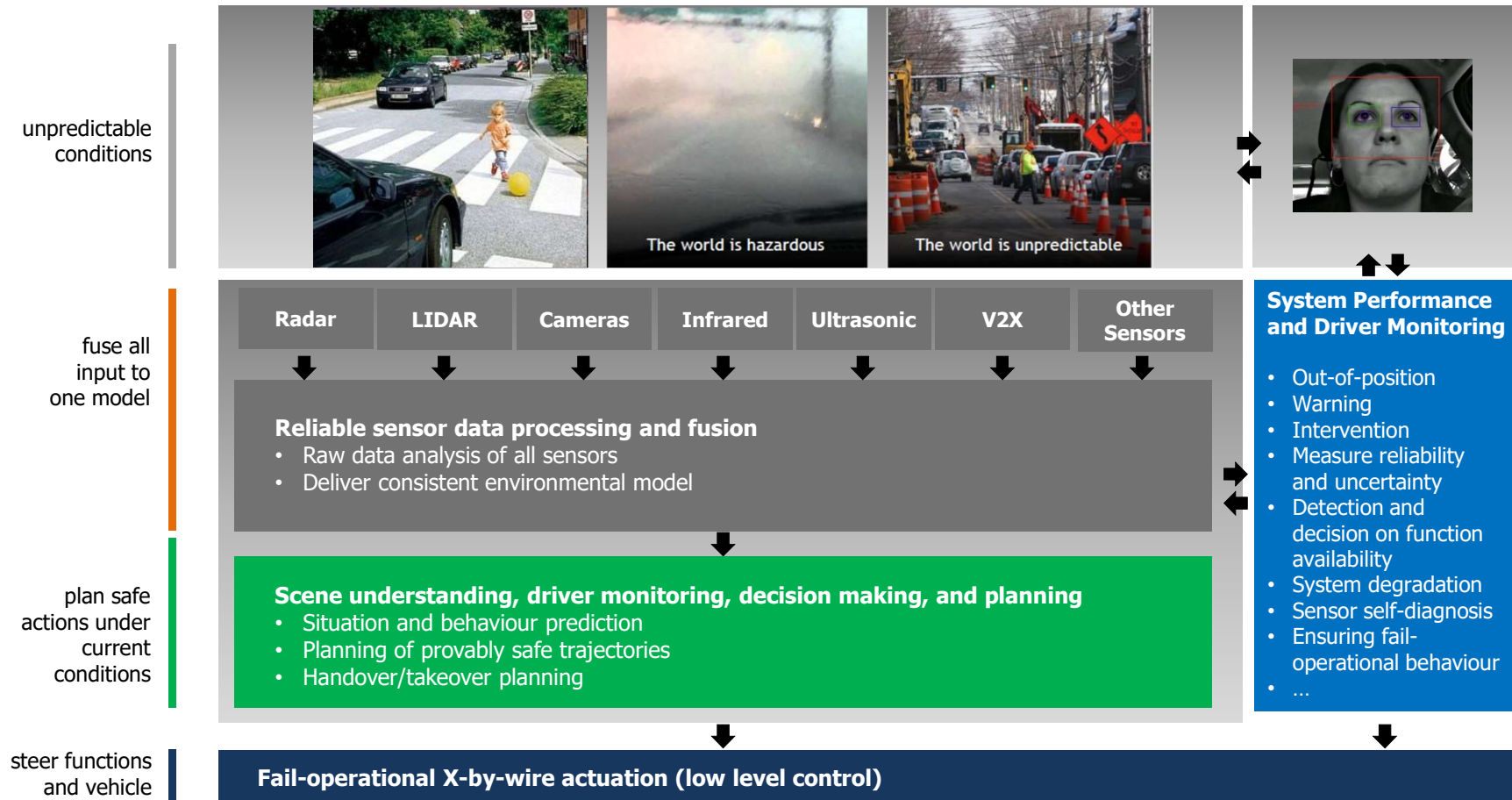
Integration of Autoware into a Research Vehicle

Autoware Use Cases

Autonomous stack / Motivation

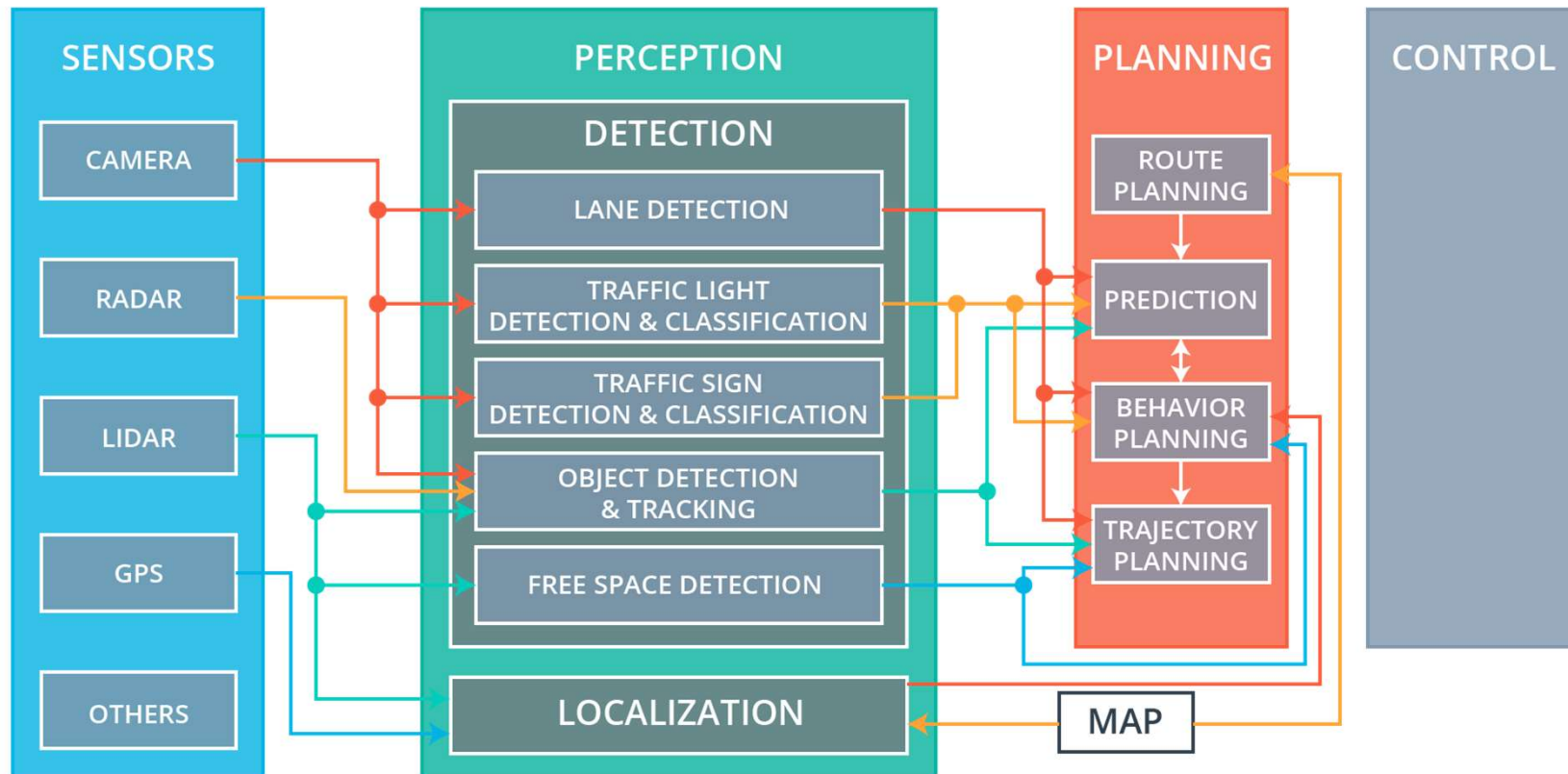


High-level architecture of an autonomous vehicle (AV)



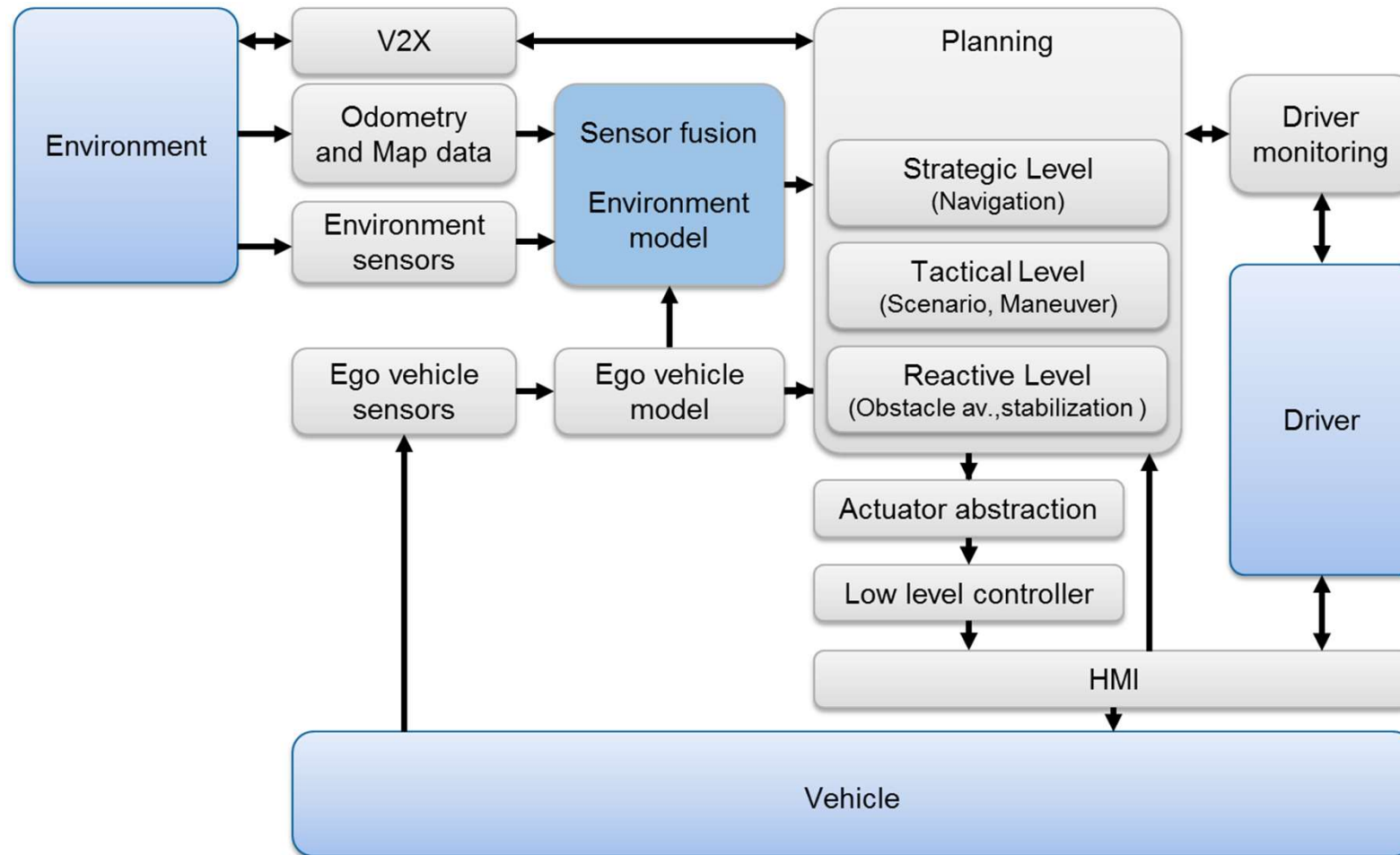
[Source: based on ECSEL Project RobustSense, 2016]

High-level AV signal flow



[Source: Udacity, 2019]

Interaction of AV building blocks



Strategic / Mission Level (~10+ sec)

Highest level task for planning a trip

- Route planning
- Comply to driving laws
- ...

Tactical Level (~1 to 10 sec)

Maneuvering the vehicle in traffic

- Lane following, merging...
- Object and event response execution
- ...

Reactive / operational level (~0.01 to 0.1 sec)

Split-second reactions and adjustments to lateral and longitudinal control

Active Safety (~0.1 to 15 sec)

Reaction to imminent threat

- Automated emergency braking
- Emergency maneuver
- ...

[Source: NHTSA, Framework for ADS testable cases and scenarios, 2018]

- **Safety-critical**

- Safety-critical system is the highest and most important criticality level
- If a safety-critical application or system fails it may cause injury or death to human beings
- Could for example be the controller that control the steering of a vehicle (**hard real-time**).

- **Mission-critical**

- The mission critical application has high priority but failure will not harm any human, if this application fails the mission or the purpose of the whole system will fail, e.g. navigation system (**soft real-time**).

- **Low-critical**

- Tasks which does not affect the mission or are dangerous but could affect the user experiences.

- **Mixed criticality systems (MCS)**

- Combination of hard RT, soft RT, and other tasks
- MCS: Integration of components with different levels of criticality into a common hardware platform.
- MCS is a system that has two or more distinct levels (i.e. safety-critical, mission-critical and low-critical) running on the same platform
- Examples: Automated vehicles, unmanned aerial vehicles (UAVs)

- Autoware was started 2015 by Shinpei Kato at Nagoya University.
- "All-in-One" open-source software for autonomous driving technology.



- Autoware Foundation launched in 2018.
- Non-profit organization supporting open-source projects enabling self-driving mobility.

PREMIUM

INDUSTRY & GOVERNMENT

ACADEMIC & NON-PROFIT MEMBERS





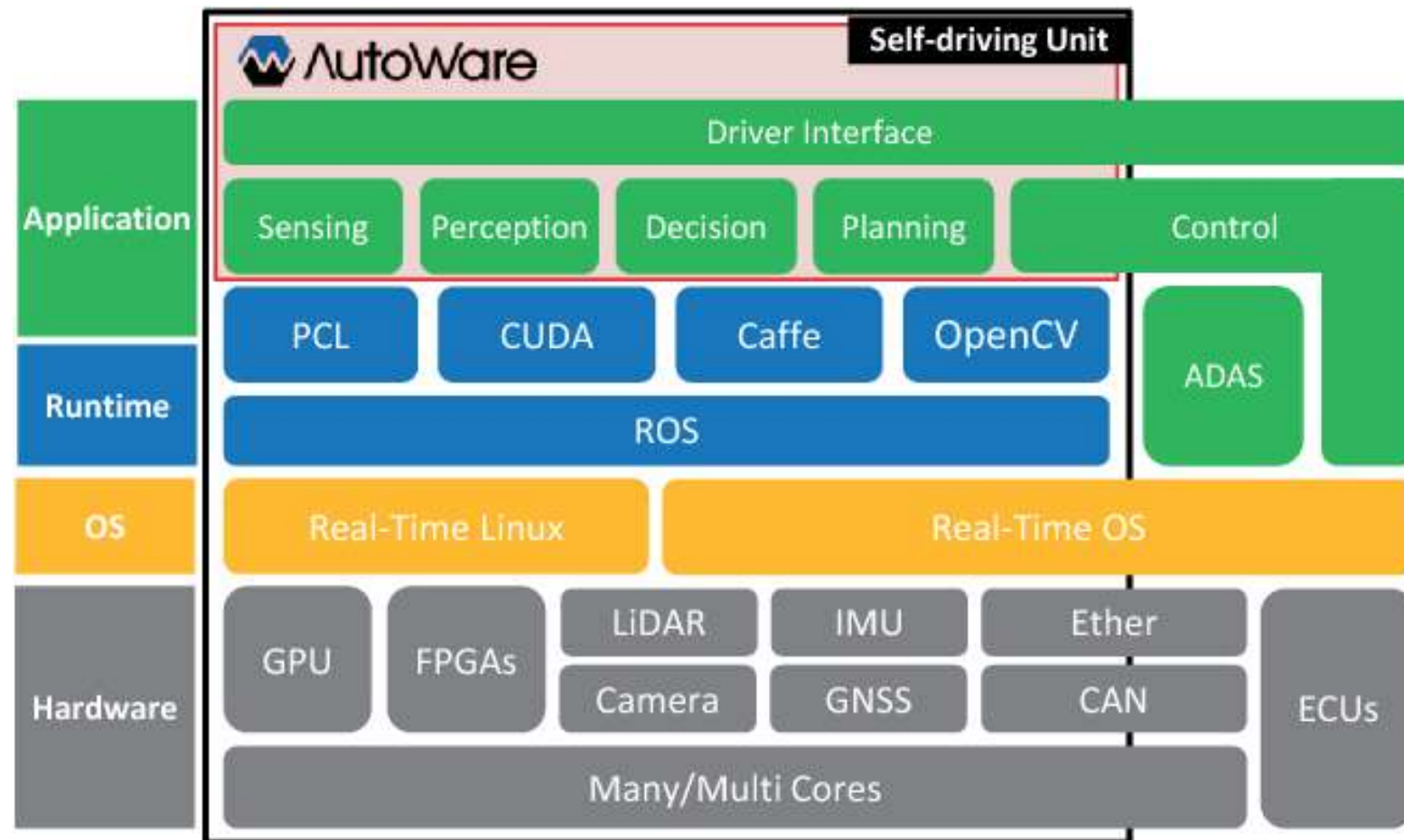
It is based on ROS 1 and available under Apache 2.0 license

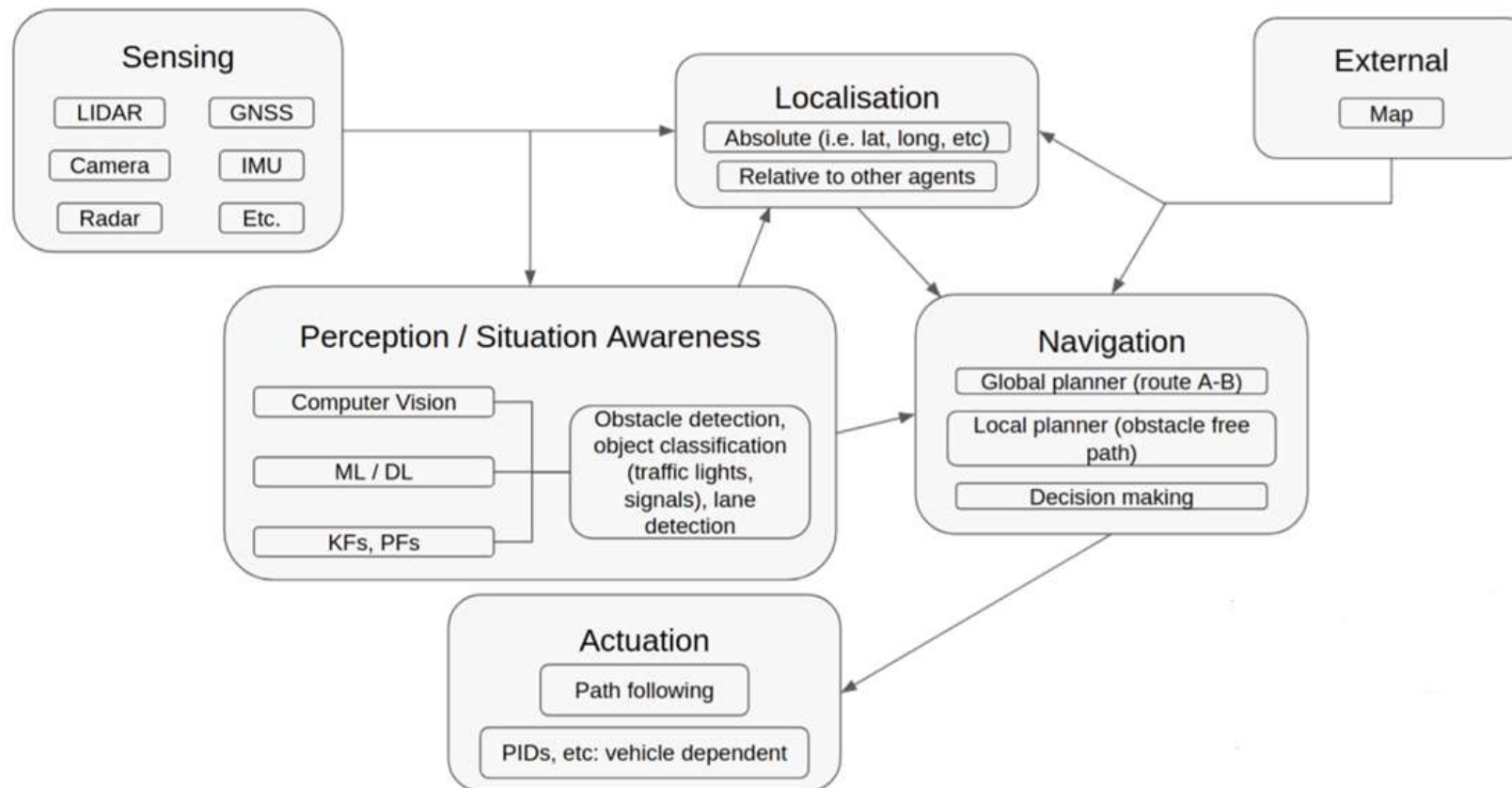
It contains the following modules:

- **Localization** is achieved by 3D maps and SLAM algorithms in combination with GNSS and IMU sensors.
- **Detection** uses cameras and LiDARs with sensor fusion algorithms and deep neural networks.
- **Prediction** and **Planning** are based on probabilistic robotics and rule-based systems, partly using deep neural networks as well.

The output of Autoware to the vehicle is a twist of velocity and angular velocity (yaw rate).

Abstraction layers

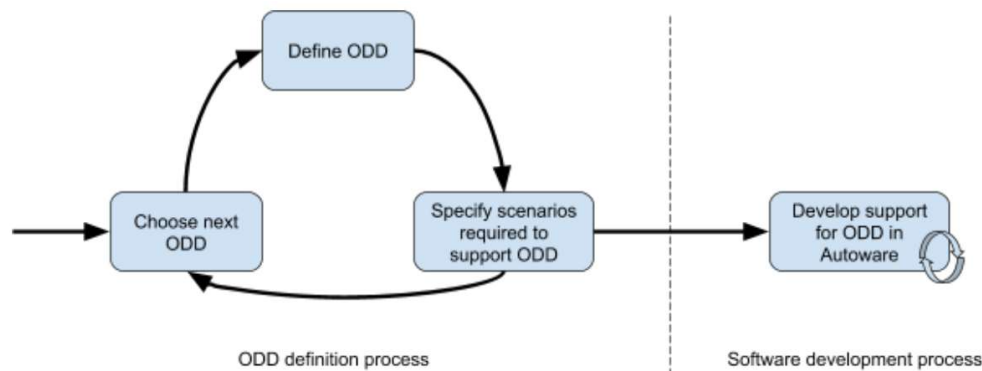






- Re-implementation of Autoware.AI
 - ROS2 based
 - Clearly defined APIs and interfaces for the different modules
 - State-of-the-art development process CI/CD
 - Pull request reviews, pull request builds
 - Comprehensive documentation
 - 100% code coverage
 - Coding style guide
 - Managed by an open source community manager
- <https://autowarefoundation.gitlab.io/autoware.auto/AutowareAuto/contributor-guidelines.html>

- Operational Design Domain (ODD)-based development process



<https://discourse.ros.org/uploads/short-url/yc1H3yPx3yw0QhH25NZYEAG6Xul.pdf>

- The first ODD targeted by the Foundation is Autonomous Valet Parking (AVP)

<https://gitlab.com/autowarefoundation/autoware-foundation/-/wikis/ASWG-AVP-planning-minutes-20191210#autoware-avp-architecture>

- Definition of next ODD in progress

Currently in discussion: (i) Autonomous cargo delivery on closed, private roads, (ii) Highway ACC and driver assistance, (iii) Autonomous Bus Rapid Transit (dedicated, fenced-off lanes), (iv) Active campus navigation

<https://discourse.ros.org/t/technical-steering-committee-tsc-meeting-17-2020-04-15-minutes/13749>



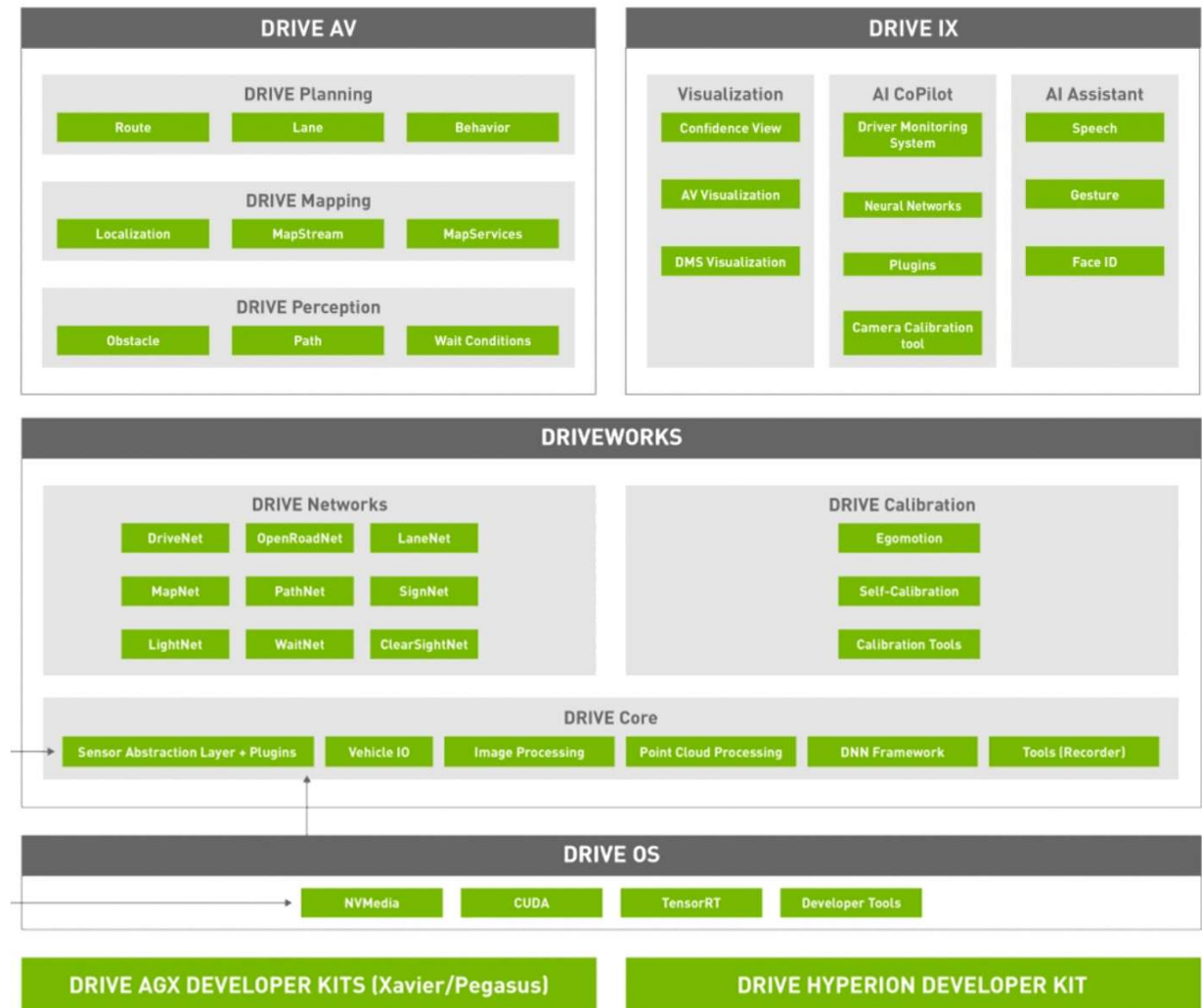
Other AD Stacks

Most relevant software stacks in 2020

- DriveWorks (Nvidia)*
- Apollo*
- EB robinos & EB robinos Predictor (Elektrobit)
- **Autoware**

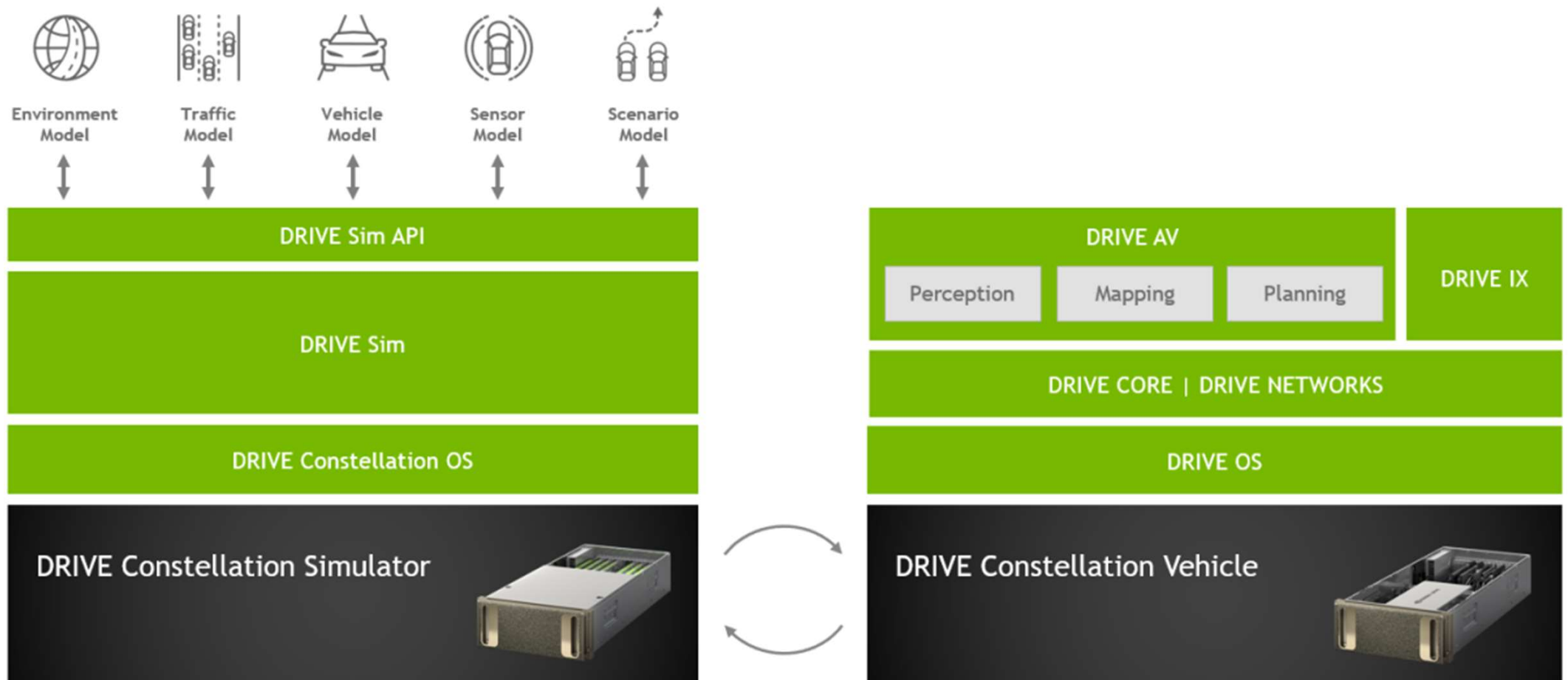
*will be briefly introduced

Nvidia DriveWorks (by courtesy of Nvidia)



<https://developer.nvidia.com/drive/drive-software>

Nvidia Drive Constellation Architecture (by courtesy of Nvidia)



Android of the autonomous driving industry, but more open and powerful.



Apollo / Software modules (by courtesy of Apollo)



- Data Pipeline
- Perception
- Planning
- Control
- Prediction
- Map Engine
- Simulation

