Environmental Data Exchange in Cooperating Driving Systems

DatZZ001 Datorzinātņu doktorantūras zinātniskais seminārs

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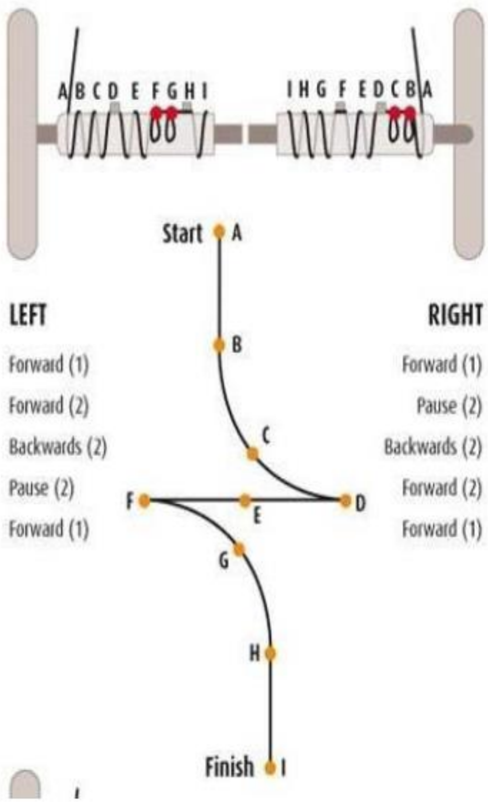
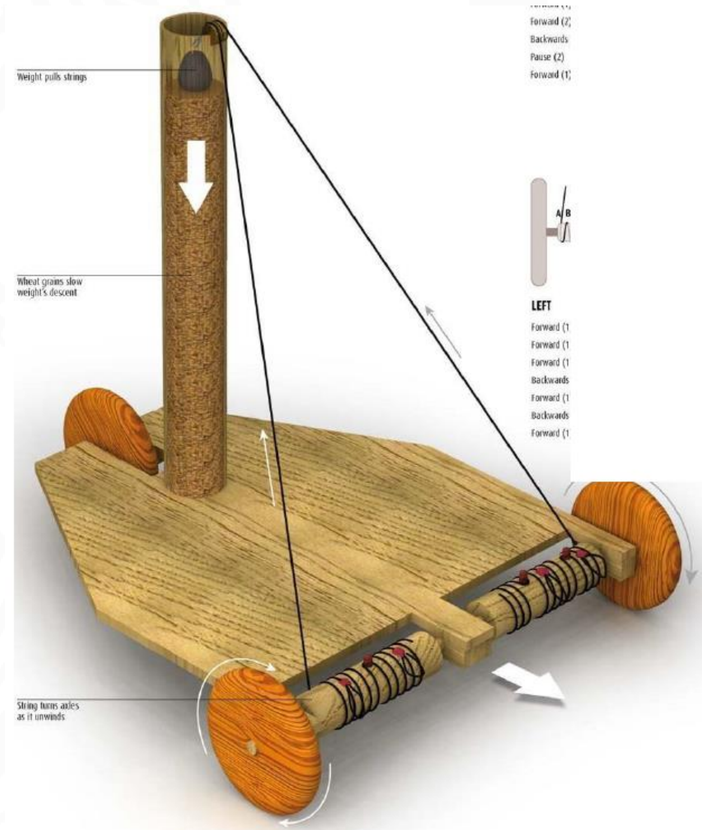
First Ever Self Diving Vehicle





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Greek inventor Hero's "Programmable Cart" AD60

PROMETHEUS project
(lead by Daimlerchrysler Ag)

- PAN European project with 45 partners
- Project started in 1986 and finished in 1994
- 749 mil EUR funding

Working towards traffic without accidents: adaptive cruise control in testing as part of the PROMETHEUS research project

Motivation

1. Lower human fatalities in accidents
2. Improve driving experience
3. Achieve autonomous driving
4. Make traffic more consistent
5. Improve intersection performance
6. Reduce emissions (green technology)

First Ever Latvian Self Driving Car

- 2011 GCDC (Grand Cooperative Driving Challenge) participation in Helmond, Netherlands (Leo Selavo, Andris Gordjusins, Georgijs Kanonirs, Vadims Kurmis, Artis Mednis, Girts Strazdins and Reinholds Zviedris)
- 2016 GCDC participation

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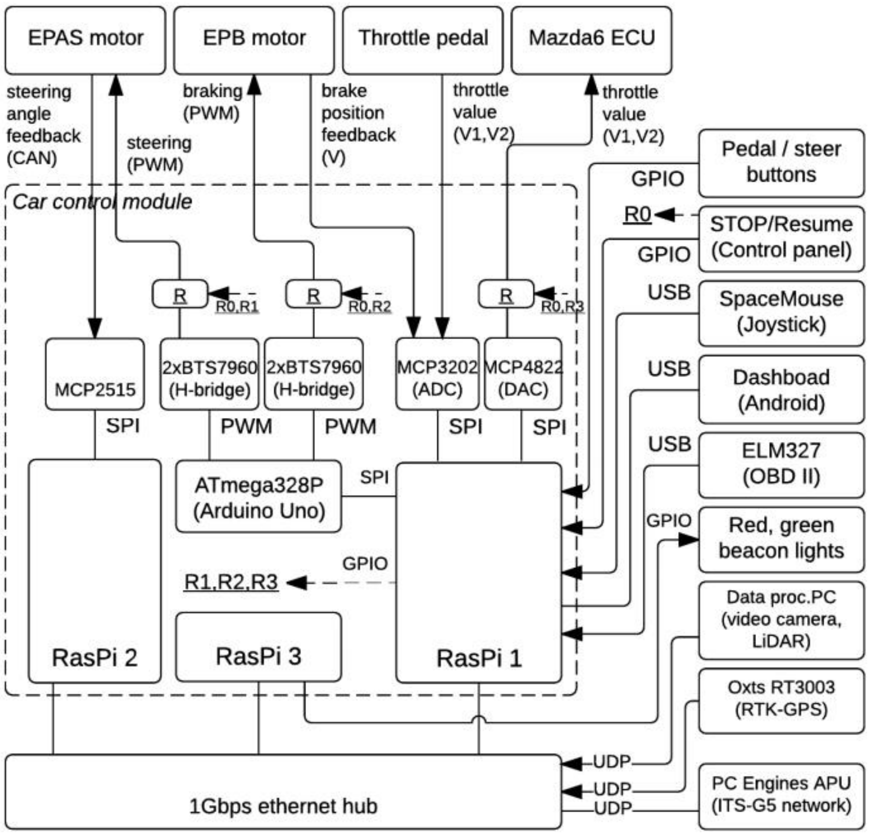
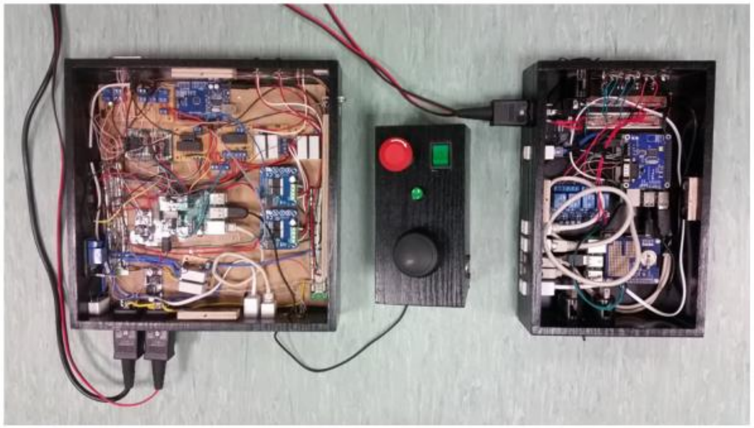
Mazda6 arhitecture





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Current status

- Based on 2018 Kia Soul EV
- Expected 5 radars, 12 cameras, LIDAR
- Nvidia PX2 DRIVE embedded intelegence

EDI developed V2X unit on board
Fully DbW supported

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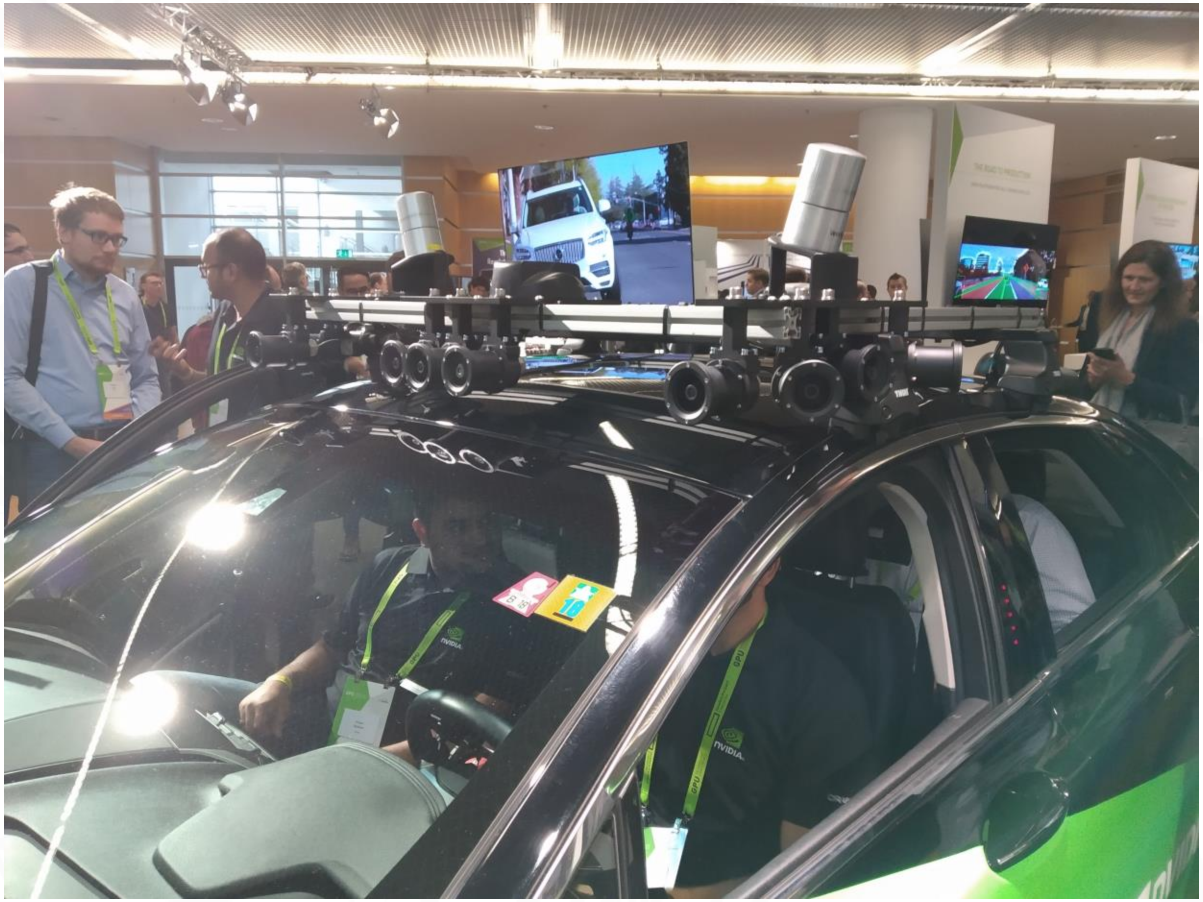
NVIDIA SDC



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NVIDIA SDC

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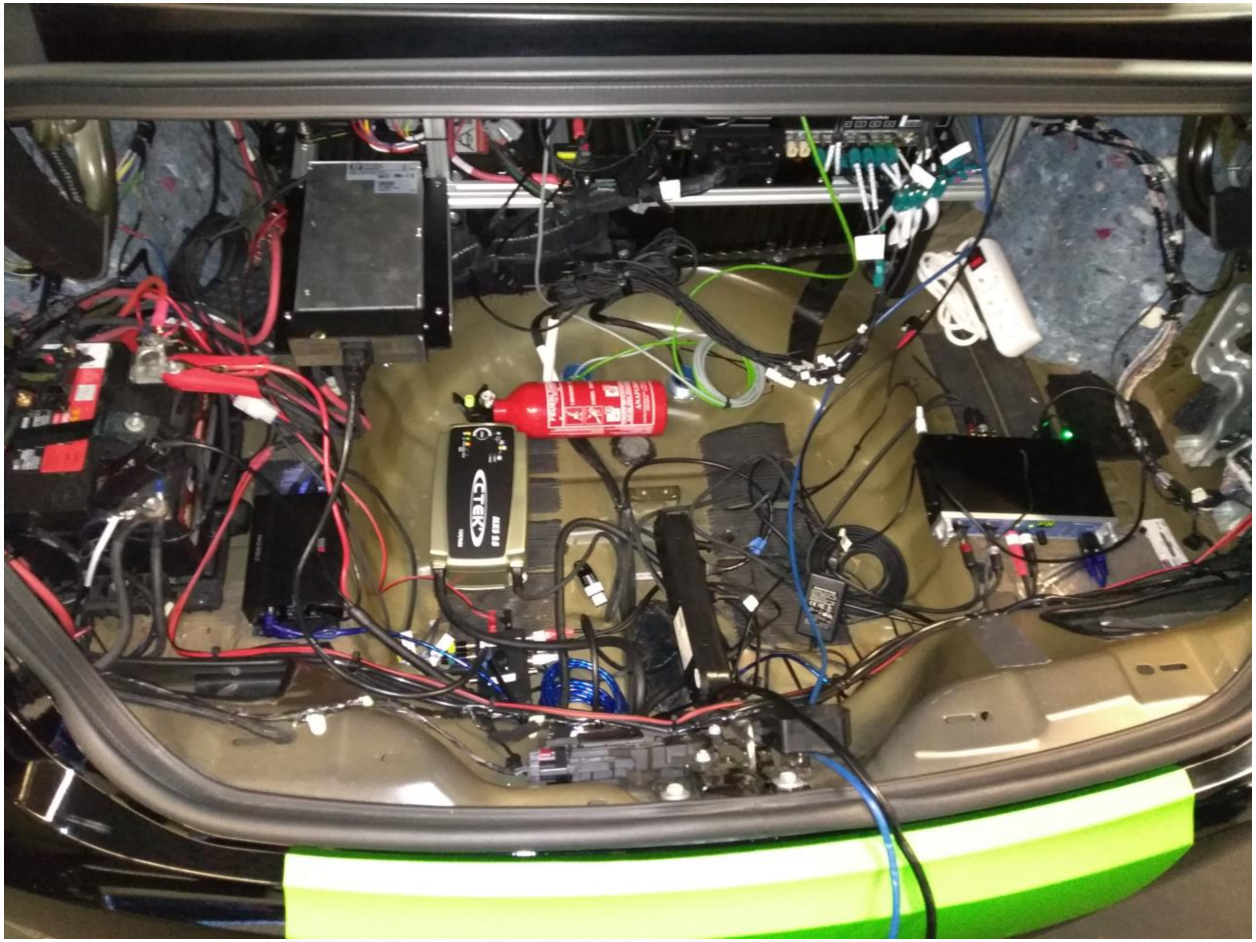
NVIDIA SDC



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SAE Levels of Driving Automation
(in human language)

- Level 0 – No Driving Automation
  - *You drive it*
- Level 1 – Driver Assistance
  - *Hands on the wheel*
- Level 2 – Partial Driving Automation
  - *Hands off the wheel, eyes on the road*
- Level 3 – Conditional Driving Automation
  - *Hands off the wheel, eyes off the road – sometimes*
- Level 4 – High Driving Automation
  - *Hands, off, eyes off, mind off – sometimes*
- Level 5 - Full Driving Automation
  - *Steering wheel is optional*

SAE Levels of Driving Automation

(in SAE J 3016-2018* words)

ODD Operational Design Domain

ADS Automated Driving System
SAE Society of Automotive Engineers

DDT Dynamic Driving Task
OEDR Object and Event detection and Response

LDW Lane Departure Warning
BSW Blind Spot Warning
ABS Anti-lock Braking System
ESC Electronic Stability Control
ACC Adaptive Cruise Control

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*Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles.

SAE Levels of Driving Automation

(in SAE J 3016-2018* words)

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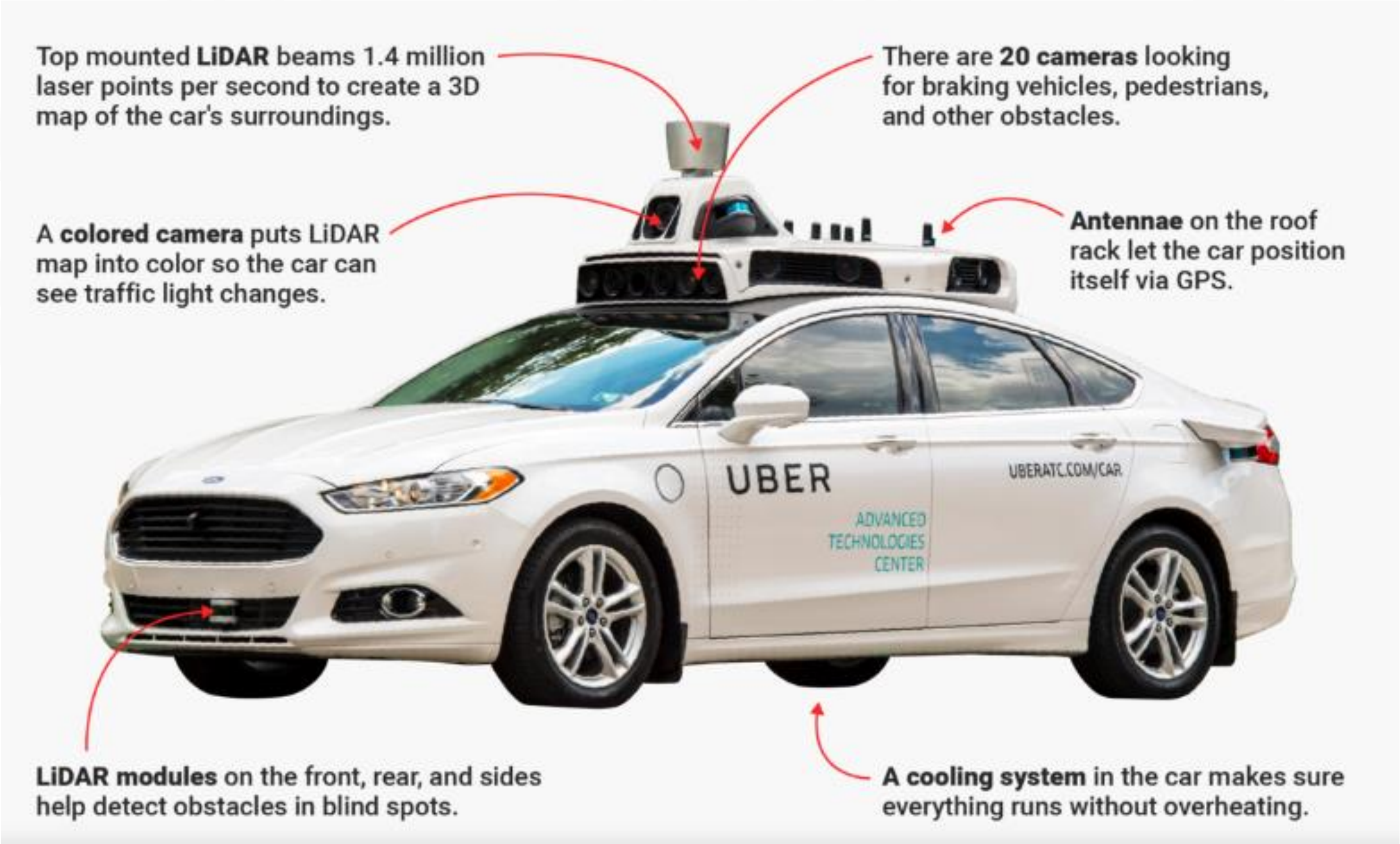
SAE Levels of Driving Automation
(in SAE J 3016-2018* words)

Self-Driving Cars Nowadays



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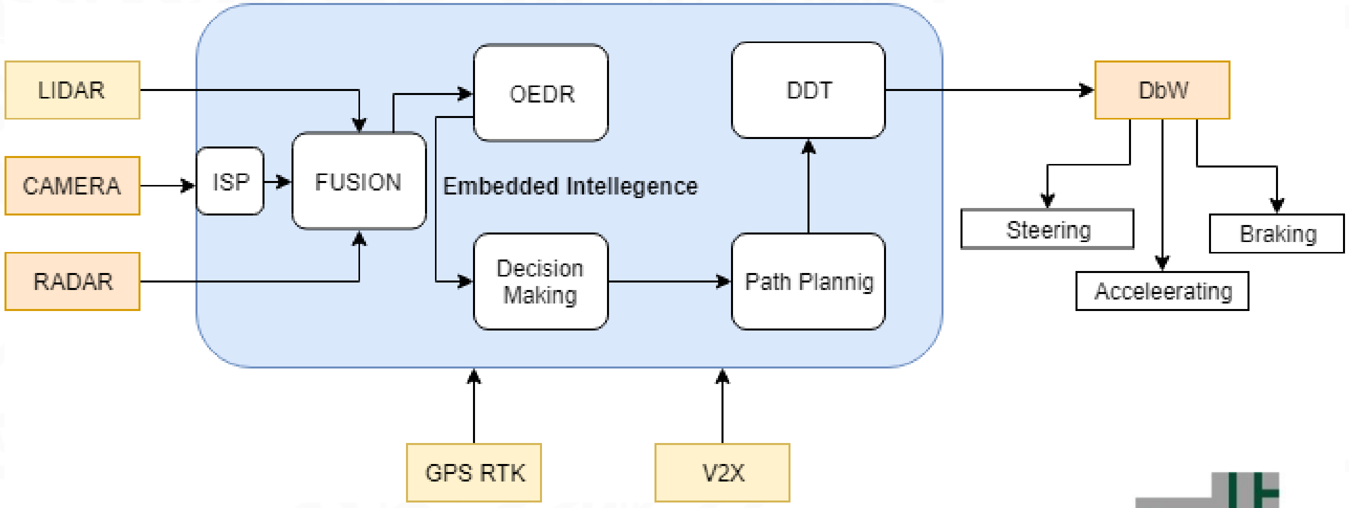
Self-Driving Cars Nowadays

- Environment perception (LIDAR, RADAR, CAMERA, e.t.c)
- Embedded Intelligence (PC ROS, NVIDIA DRIVE PLATFORM)
- Communication (V2X , C-V2X, DSRC)
- Navigation (GNSS, RTK)
- Localization and Maping (SLAM)
- Actuation (DbW Steering, Brakig, Shifting, Acceleration)



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Environment perception

CAMERA

- **RCCB** camera – better SNR, Dynamic range
- RAW data over GMSL (GIGABIT MULTIMEDIA SERIAL LINK) interface 1.6Gbps or 3.12Gps

Pattern	Bayer RG/GB	25%C	50%C: RG/BC Pattern A	50%C: RG/BC Pattern B	50%C: RC/CB Clarity+
Unit cell	2 x 2	2 x 2	4 x 4	4 x 4	2 x 2
SNR improvement	0 dB (ref.)	1 dB	3-4 dB	3-4 dB	3-4 dB
Sharpness	reference	lower	slightly lower	slightly lower	equivalent
Spatial color artifacts	reference	slightly worse	serious	serious	equivalent

Table 1. Summary of commonly used and proposed Color Filter Array (CFA) patterns including Clarity+ RC/CB

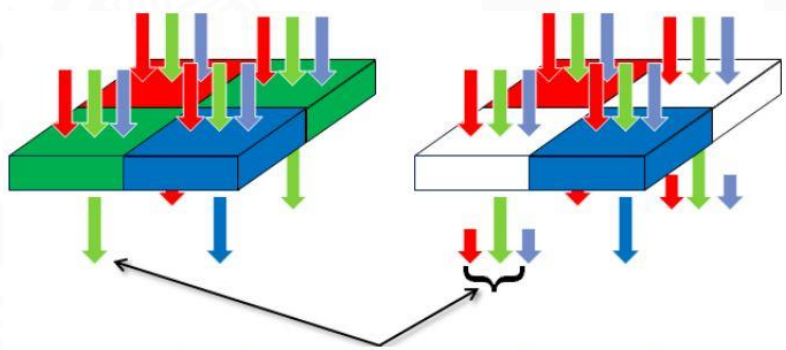

Figure 1. Motivation for Clear: because they span the visible spectrum, Clear pixels collect 2X more signal than Green pixels.

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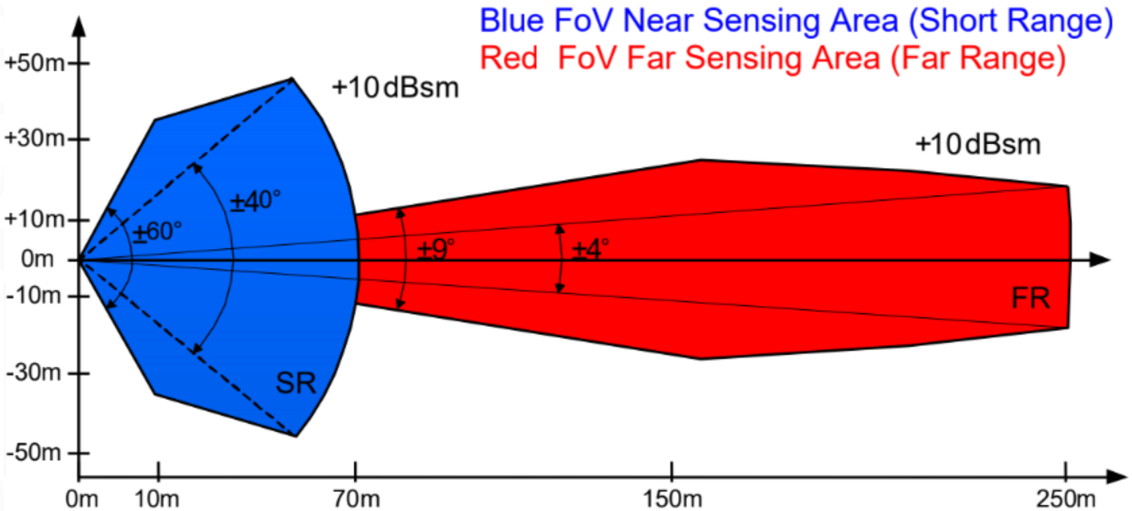
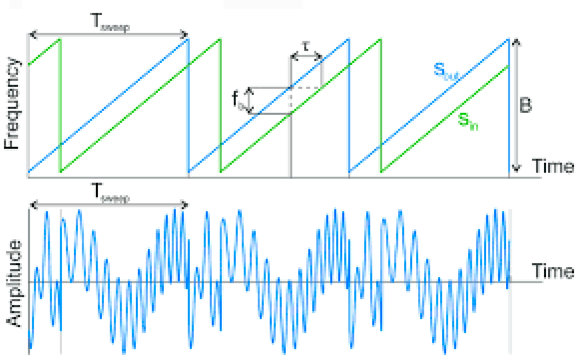
Environment perception

RADAR

- **RA**dio **D**etection **A**nd **R**anging
- CAN2.0 500kbps
- Filtered Cluster Data
- Frequency Modulated Continuous Wave





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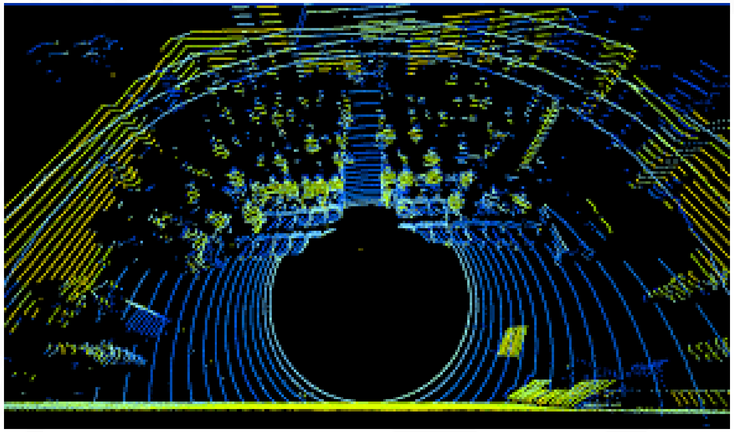
Environment perception

LIDAR

- **L**ight **I**maging, **D**etection **A**nd **R**anging
- HDL-32E 32 laser LIDAR
- 100BASE T ETHERNET
- Broadcasting UDP packets with particular Laser and Sector distance
- +10° to -30° Vertical FOV
- 80m-100m Range
- ± 2 cm Accuracy
- Up to ~1.39 Million Points per Second



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Embedded Intelligence

Embedded Intelligence

Embedded Intelligence

Nvidia provided reference board	Drive CX	Drive PX	Drive PX 2 (AutoCruise)	Drive PX 2 (Tesla)	Drive PX 2 (AutoChauffeur)	Drive PX2 (Tesla 2.5)	Drive PX Xavier[15]	Drive PX Pegasus[20]
GPU Microarchitecture	Maxwell (28 nm)		Pascal (16 nm)				Volta (12 nm)	
Introduced	January 2015		September 2016[21]	October 2016[22]	January 2016	August 2017[23]	January 2017	October 2017
Computing	1x Tegra X1	2x Tegra X1	1x Tegra X2 (Parker) + 1x Pascal GPU		2x Tegra X2 (Parker) + 2x Pascal GPU	2x Tegra X2 (Parker) + 1x Pascal GPU[24]	1x Tegra Xavier[25]	2x Tegra Xavier
CPU	4x Cortex A57 4x Cortex A53	8x Cortex A57 8x Cortex A53	2x Denver 4x Cortex A57		4x Denver 8x Cortex A57	4x Denver 8x Cortex A57	8x NVIDIA Custom Carmel ARM64[25]	16x NVIDIA Custom Carmel ARM64
GPU	2 SMM Maxwell 256 CUDA cores	4 SMM Maxwell 512 CUDA cores	1x Parker GPGPU (1x 2 SM Pascal, 256 CUDA cores)	1x Parker GPGPU (1x 2 SM Pascal, 256 CUDA cores on a MXM slot[11])	2x Parker GPGPU (2x 2 SM Pascal, 512 CUDA cores) + 2x dedicated MXM modules[26]	1x Parker GPGPU 1x 2 SM Pascal, 256 CUDA cores [23][24]	1x Volta iGPU (512 CUDA cores)[25]	2x Volta iGPU (512 CUDA cores) 2x post-Volta dGPUs
Accelerator							1x DLA[25]	2x DLA
Memory			8GB LPDDR4[27]		16GB LPDDR4[27]		LPDDR4[25]	
Storage			64GB eMMC[27]		128GB eMMC[27]			
Performance			4 FP32 TFLOPS 10-12 DL TOPS[28][29]	4 FP32 TFLOPS 10-12 DL TOPS [28][29]	16 FP16 TFLOPS 8 FP32 TFLOPS 20-24 DL TOPS [28][29]	4 FP32 TFLOPS 10-12 DLTOPS [28][29]	20 INT8 TOPS, 1.3 FP32 TFLOPS (GPU) 10 INT8 TOPS, 5 FP16 TFLOPS (DLA)[25]	320 INT8 TOPS (total)[30]
TDP		20W[29]	40W SoC portion: 10 W[21]	40W SoC portion: 10 W[21]	80W[31][32][29][33] SoC portion: 20 W[21]	60W [31][32][29] SoC portion: 20 W[21]	30W[25]	500W[30]

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GNSS, RTK

- GPS/QZSS L1, GLONASS G1, BeiDou B1, Galileo E1, SBAS
- Static: H: 5mm + 1ppm, V: 10mm + 2ppm
- Kinematic: H: 7mm + 1ppm, V: 14mm + 2ppm
- IMU: 9DOF
- Update rate:14 Hz / 5 Hz

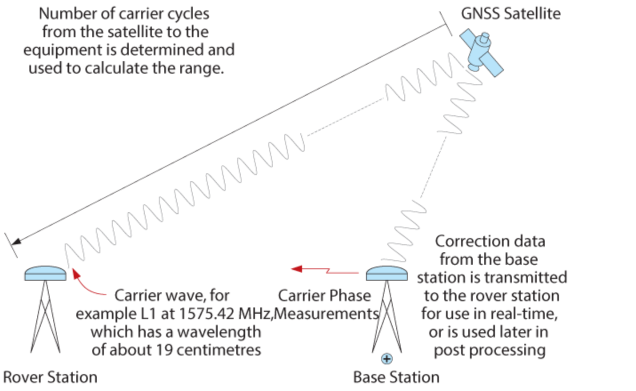

Figure 42 Real-Time Kinematic

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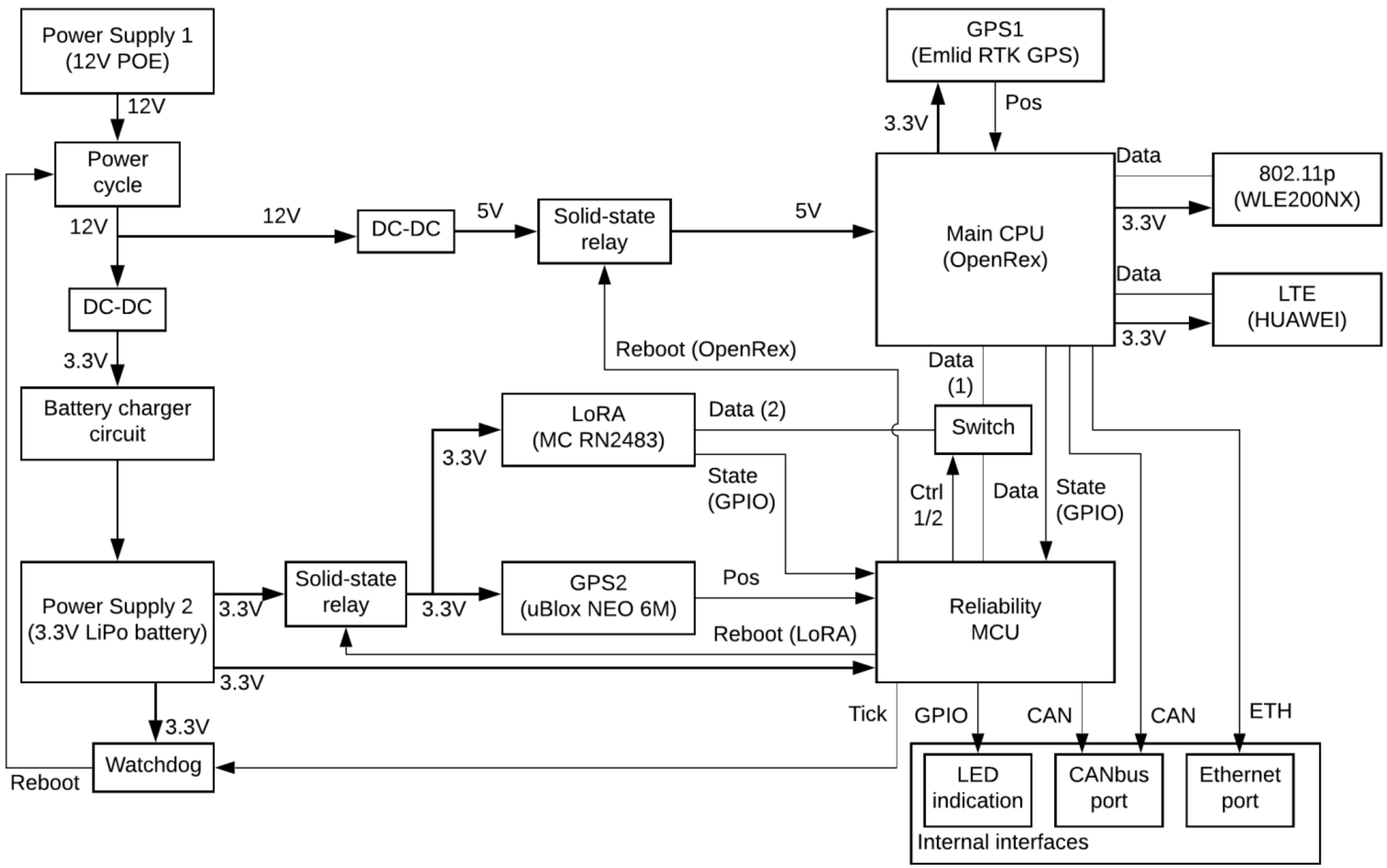
V2X, DSRC

V2X, DSRC



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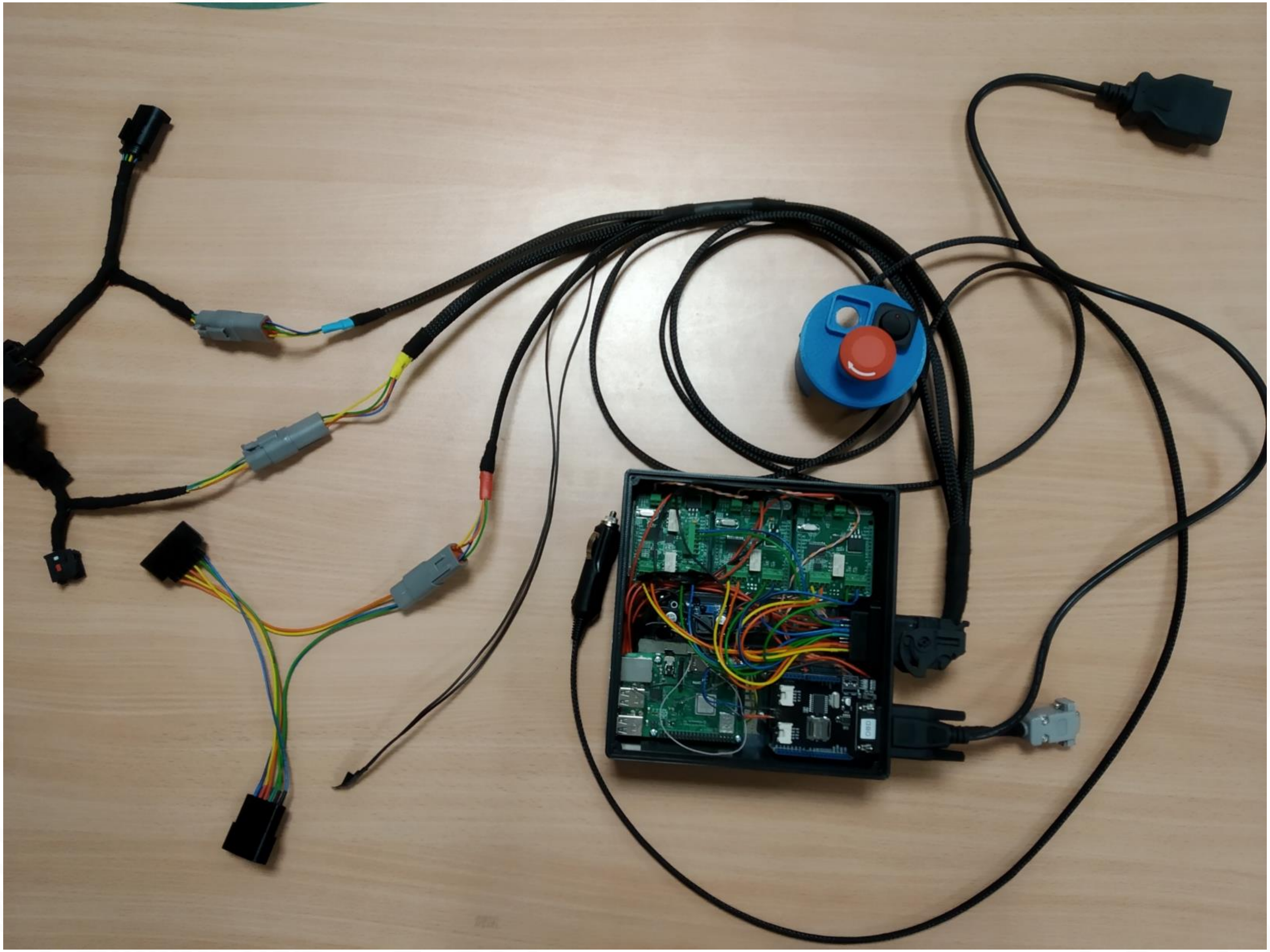
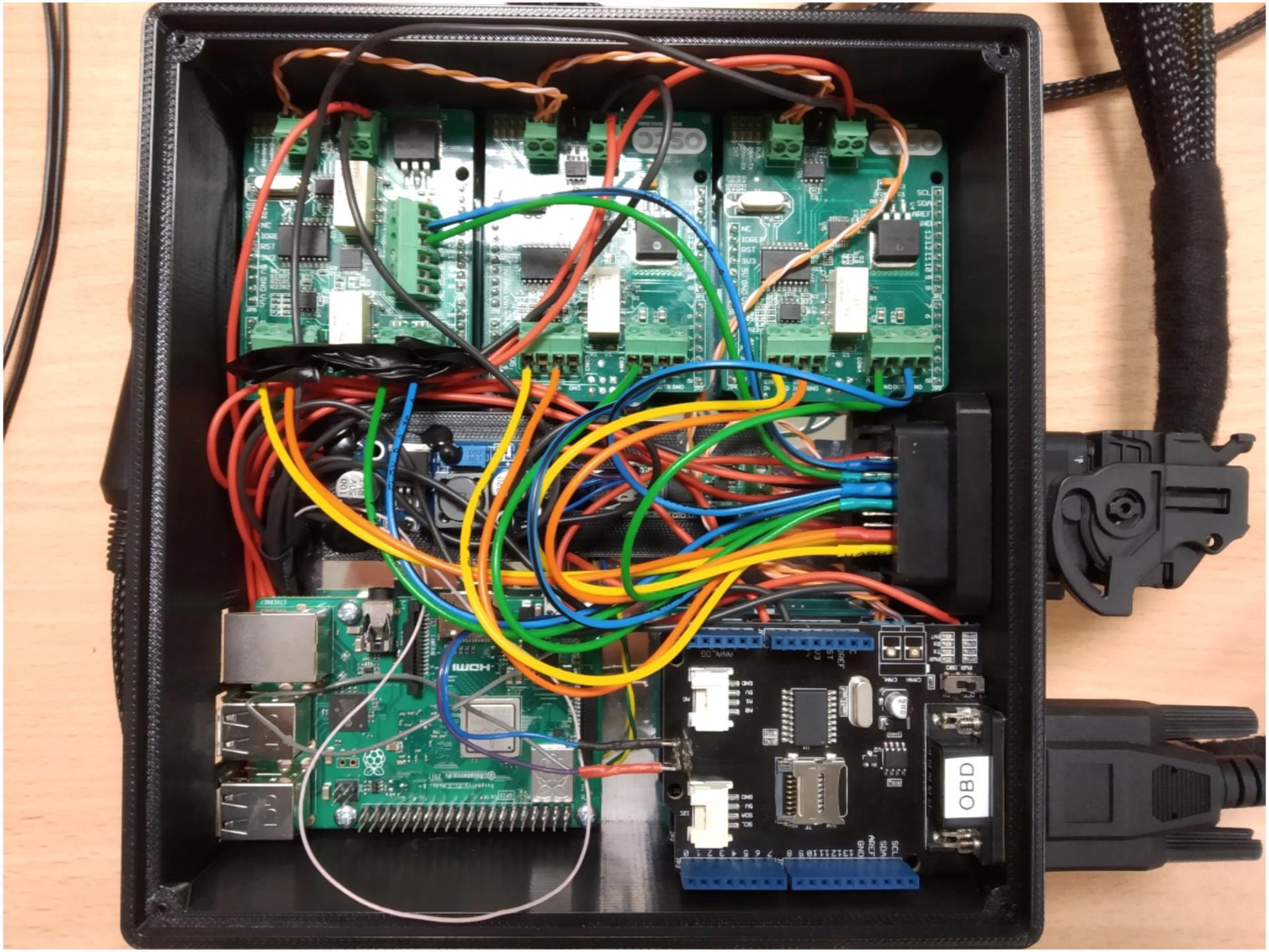
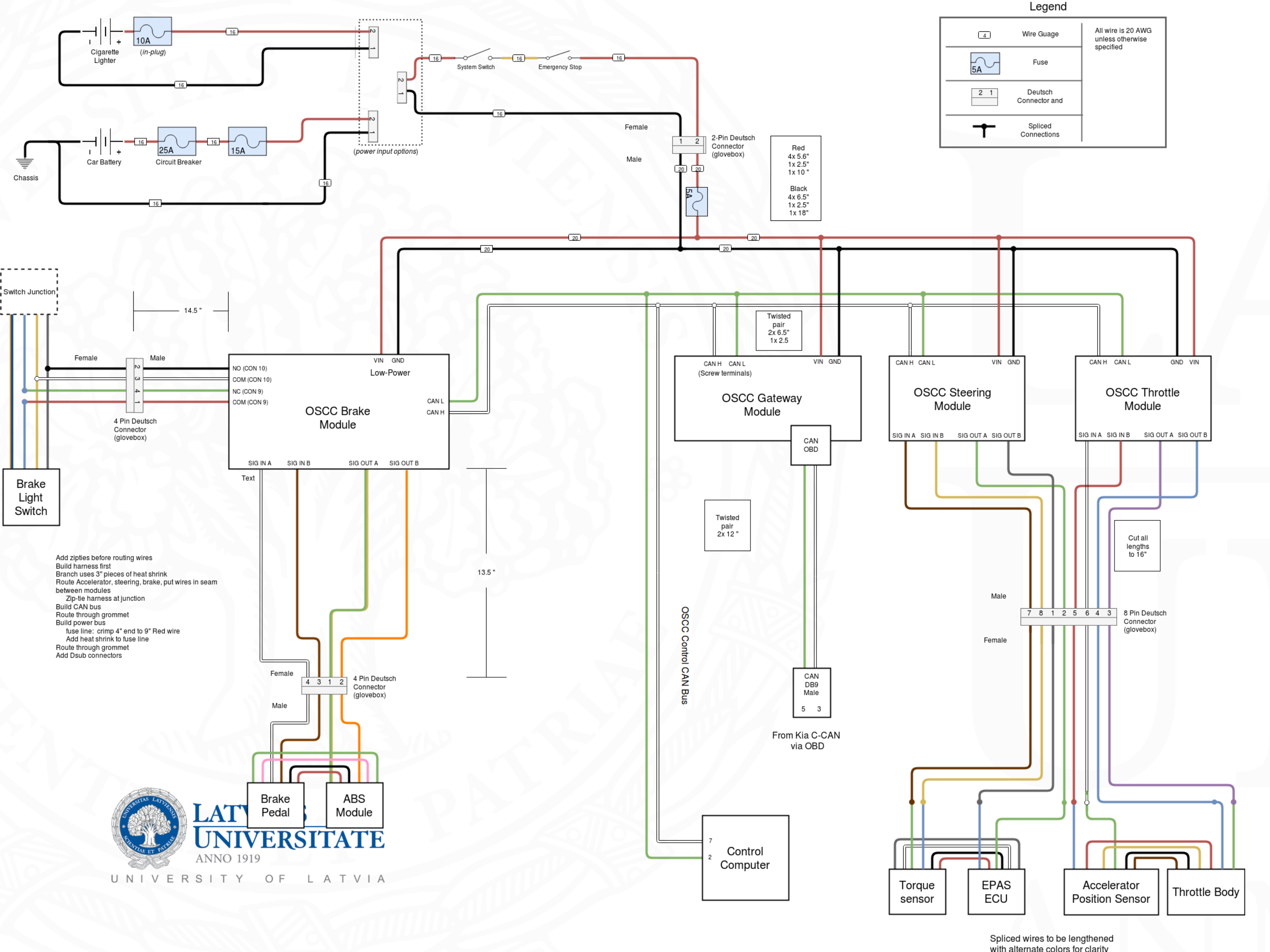
DbW unit




OBD



Legend
Wire Guage
Fuse
Deutsch Connector and
Spliced Connections
All wire is 20 AWG unless otherwise specified
Cigarette Lighter
10A
(in-plug)
Car Battery
25A
15A
Circuit Breaker
Chassis
(power input options)
System Switch
Emergency Stop
Female
Male
2-Pin Deutsch Connector (glovebox)
5A
Red
4x 5.6"
1x 2.5"
1x 10 "
Black
4x 6.5"
1x 2.5"
1x 18"
Switch Junction
14.5 "
4 Pin Deutsch Connector (glovebox)
NO (CON 10)
COM (CON 10)
NC (CON 9)
COM (CON 9)
VIN
GND
Low-Power
OSCC Brake Module
CAN L
CAN H
SIG IN A
SIG IN B
SIG OUT A
SIG OUT B
Text
Brake Light Switch
Twisted pair
2x 6.5"
1x 2.5
CAN H
CAN L
(Screw terminals)
OSCC Gateway Module
CAN OBD
OSCC Steering Module
OSCC Throttle Module
SIG IN A
SIG IN B
SIG OUT A
SIG OUT B
Twisted pair
2x 12 "
Cut all lengths to 16"
13.5 "
Add zipties before routing wires
Build harness first
Branch uses 3" pieces of heat shrink
Route Accelerator, steering, brake, put wires in seam between modules
Zip-tie harness at junction
Build CAN bus
Route through grommet
Build power bus
fuse line: crimp 4" end to 9" Red wire
Add heat shrink to fuse line
Route through grommet
Add Dsub connectors
OSCC Control CAN Bus
CAN DB9 Male
From Kia C-CAN via OBD
8 Pin Deutsch Connector (glovebox)
4 Pin Deutsch Connector (glovebox)
Brake Pedal
ABS Module
Control Computer
Torque sensor
EPAS ECU
Accelerator Position Sensor
Throttle Body
Spliced wires to be lengthened with alternate colors for clarity

Main Thesis Motivation

There are self driving cars already exists and participating in traffic . However they are individual units. There is certain risk for mismatch data exploit for active sensor, like LIDAR or RADAR if many self-driving cars will appear in the same area.

- Using V2V it will be possible to efficiently control channels for such active sensors.

Still the vast of the majority of vehicles doesn't has connecting capability, by enabling fully-equipped vehicles (with V2V unit and Environmental Perception Capabilities) exchange environmental data (what it observes) it is possible to eliminate such problem.

Main Thesis Motivation (cont.)

Detection and data propagation about VRUs (Vulnerable Road Users) such as cyclist, pedestrian …

Better representation of road scene , which can be used for optimized path planning and emergency scenarios execution.

Work in progress…

- Realiable communication, with current prototype.
- PX2 platform deployment (DriveNet, OEDR)
- NS-3 simulations with different conditions.
- Article review

Upcoming publications

LoRa modulation TDMA based Physical Layer Management Entity (PLME) in cooperative vehicular applications.

ACKNOWLEDGMENT

AutoDrive

H2020 ECSEL project "Advancing fail-aware, fail-safe, and fail-operational electronic components, systems, and architectures for highly and fully automated driving to make future mobility safer, more efficient, affordable, and end-user acceptable" (AUTODRIVE)

(**AUTODRIVE** Granta līguma Nr. 737469), skatīt www.autodrive-project.eu/

Ilgums: 36 mēneši (2017 - 2020)
Partneri: 58 partneri no 13 valstīm.

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ACKNOWLEDGMENT

Programmable Systems for Intelligence in Automobiles (PRYSTINE)

(**PRYSTINE** Granta līguma Nr. 783190)
Ilgums: 36 mēneši (2018 - 2021)
Partneri: 60 partneri no 14 valstīm.

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- Gatis Gaigals (Ms. Sc. Ing)
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Thank you for attention!

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