c21-virtual "The IoT Connection" .
October 20th

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Index

Volvo Group

1.000.000 Million

Connected Assets!!! 2020

VOLVO TRUCKS

RENAULT TRUCKS

MACK TRUCKS

UD TRUCKS

GROUP TRUCKS ASIA & JVs

CONSTRUCTION EQUIPMENT

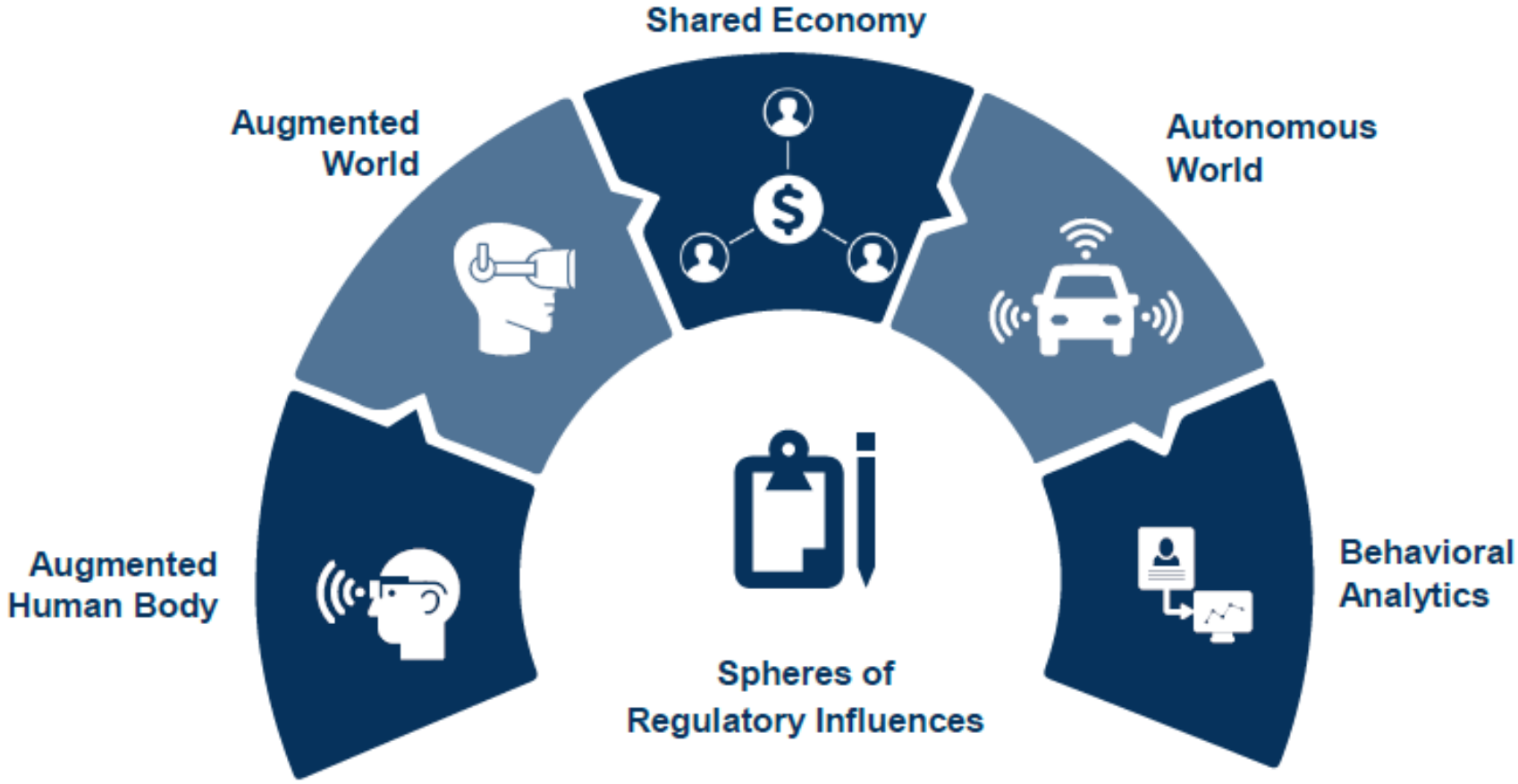
BUSES

VOLVO PENTA

ARQUUS

VOLVO FINANCIAL SERVICES

1.0 Introduction



Source: Frost & Sullivan

Utilizing state of the art software architecture, cloud capabilities and agile way of working

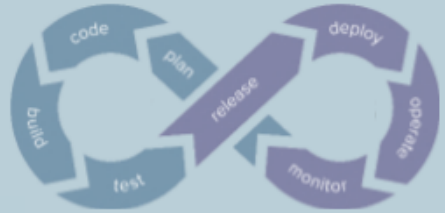
Micro service architecture

- Loosely coupled micro service architecture that enables separate lifecycles of our services.
- Easier to understand, develop and test each service.
- Enabling small autonomous teams to develop, maintain and scale their respective services independently.

Cloud capabilities

- On-demand cloud computing platform that provides infrastructure- and computing building blocks and tools.
- Improved scalability and time to market.
- Big enabler for innovation and utilization of new technologies.

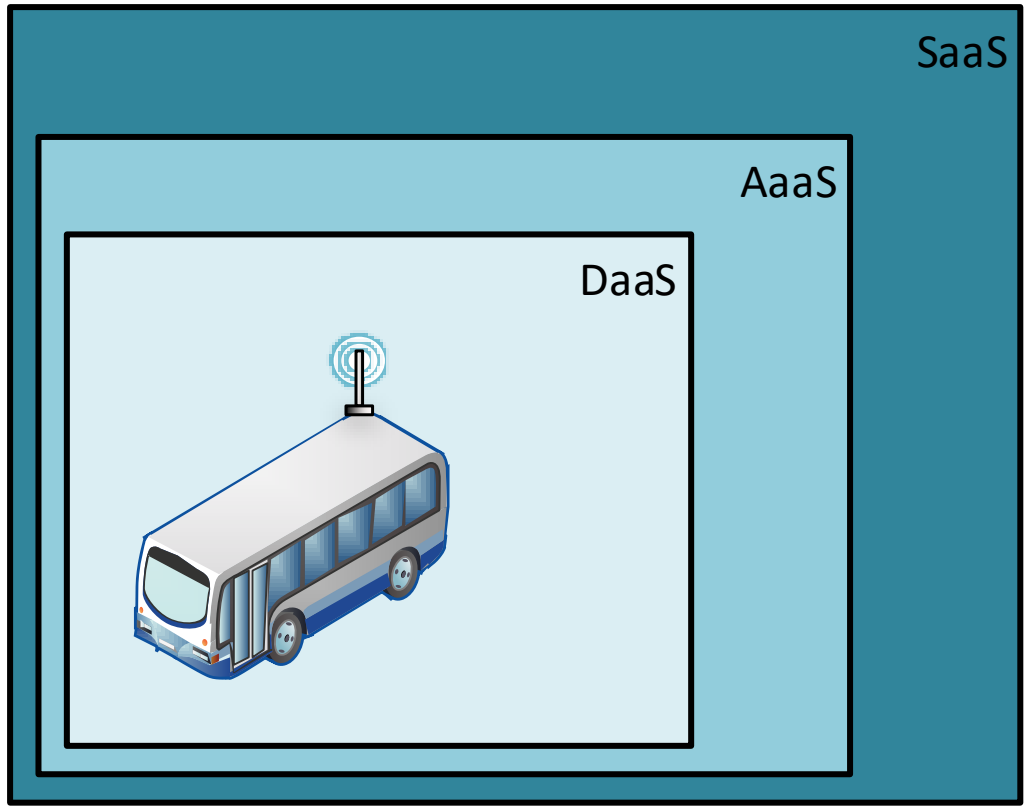
DevOps



- Software development practices with focus on throughput and stability.
- Combines software development and operations to shorten development life cycle while delivering features, fixes, and updates frequently in close alignment with business objectives.
- One product team responsible for the complete life cycle.
- Addresses product and process, continuous delivery, architecture, culture, lean management and monitoring.

2.0 Goals of connected solutions

As part of the overall IoT revolution, the future of public transport implies connectivity and data related services.
As such, the vehicle itself is to be seen as a "**Connected Object**" having three new decisive layers: *DaaS, AaaS* and *SaaS*.



- **DaaS** (*Data as a Service*)
  For fleet operators already equipped with the software necessary to bring value to bus related data.
  The goal here is to offer a cloud API that the operators can connect to conduct data transactions feeding their legacy applications.

- **AaaS** (*Analytics as a Service*)
  Key service layer only Volvo can provide due to our situation as the main OEM and final product integrator. The capacity to make data say something insightful.

- **SaaS** (*Software as a Service*)
  This is the ideal scenario which would allow us to offer a complete end-to-end solution. This service may need to be designed so to "integrate" with already existing SaaS solutions.

2.1 Functionalities .. Examples for connected applications

Preliminary set of high-level functionalities and use cases.

There is enormous value in offering these services with the added benefits of maximizing **customer retention** and **repurchase**.

Most of the functionalities belong to the field of **AaaS** and would often be complementary to legacy solutions like AWS and Microsoft.

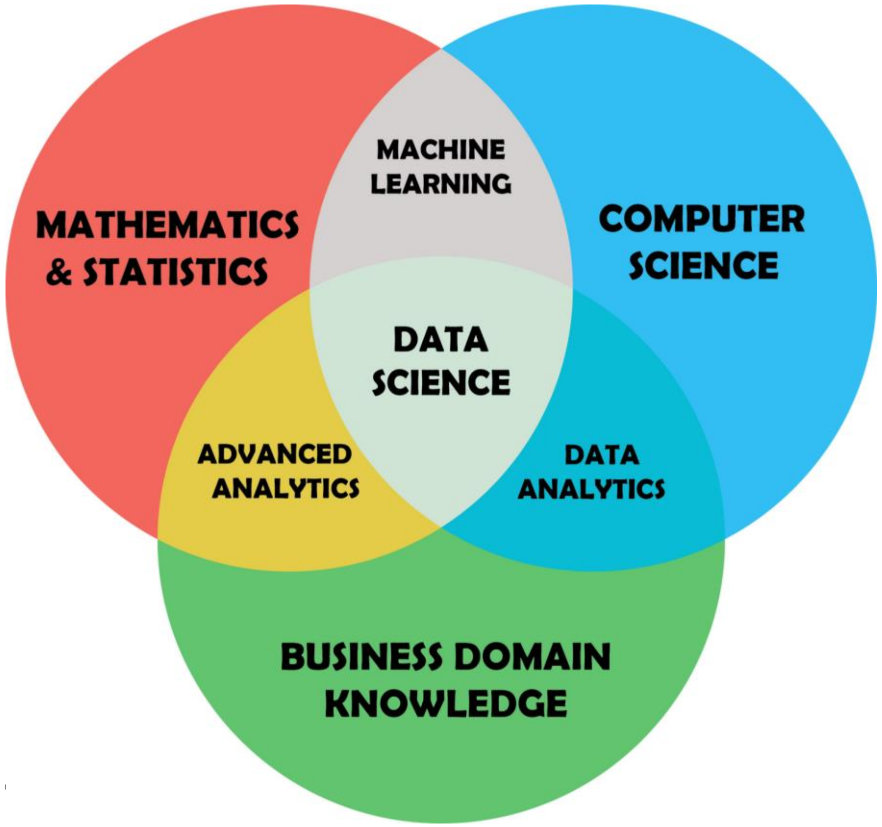
	Management	MRO/Planners	Drivers	Volvo	Public
Dashboard/BI/DSS/KPIs	X	X			
PHM/Predictive Maintenance		X			
Maintenance Alerts		X			
MRO Calendar/Planning		X			
Training		X	X		
GeoFencing		X			
Parts/Inventory Mgmt		X		X	
Electronic Logging Device (ELD)		X	X		
OTA SW Updates		X		X	
AI, Automation, R&D, V2X, V2V, V2i		X		X	X
Comm/Messaging		X	X		
Data Mining	X			X	
Predictive Warranty Services		X		X	
Market Analysis	X			X	
Fleet Mgmt/Call Centers		X		X	
Prefetch Parts		X		X	
Smart City Integration					X
Passage Times					X
Public API/Hackathon					X

2.2 Data has a cost

- Generate data (Sensing, Collecting, Tier-1 access, etc)
- New Hardware (Network, tooling , etc)
- Data transmission (Telecom/LTE, necessary bandwidth, etc)
- Data storage (Cloud/Datastore, Servers, DBMS licenses, etc)
- Human expertise involved (Software eng., DBA, security experts, telecom experts, legal, etc)
- Security and privacy
- Software maintenance/upgrades
- Etc.

2.3 Data ownership rational

- Data Science business potential
- Only us can make sense of the collected data
- Necessary to optimize service quality
- PHM (Prognostics and Health Management)
- Remote monitoring & control (M&C)
- Industry 4.0 potential
- IP related data sources and processes
- BigData and ML expertise
- Autonomous driving and other advanced R&D projects
- Optimized parts/inventory management
- Necessary for predictive warranty service
- Necessary for standardized "Connectivity"
- Guaranties asset’s and data security/privacy
- Optimized quality of collected data. (Currently 20% to 30% are invalid.
- To allow V2x technology development
- Internal OEM components connectivity market (Tier-1s like Cummins, ZF, etc)

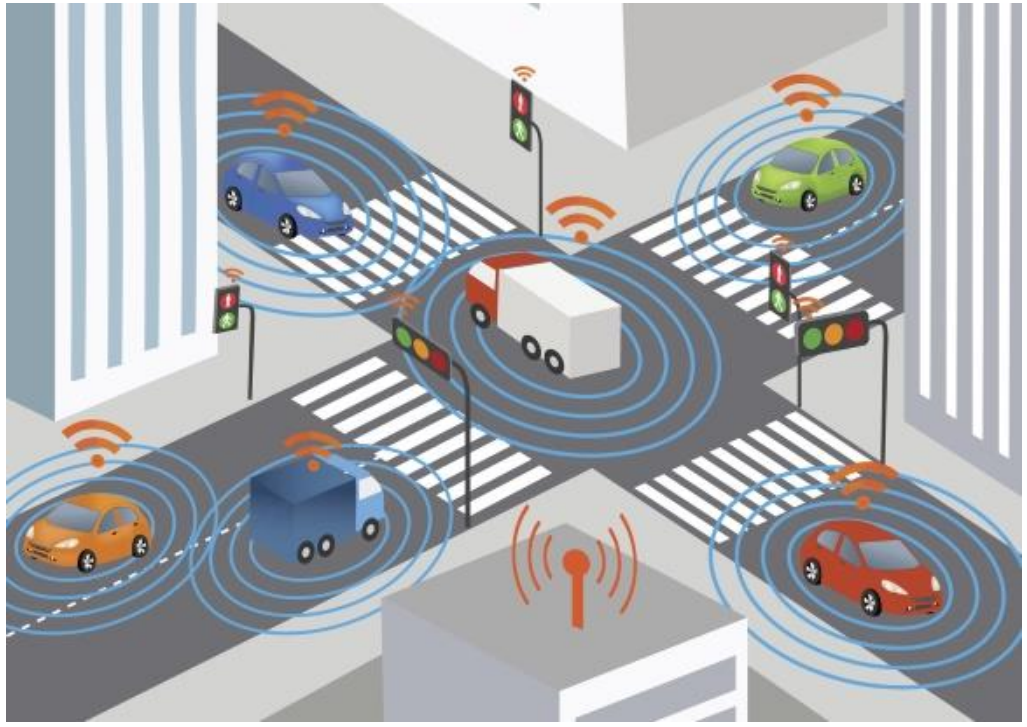


3.0 Smart Cities - V2X, V2I, V2V

Key field of IoT where Volvo could distinguish itself taking a huge leap ahead of our current competition.

All relates to ITS, « Smart City » technologies and autonomous driving.

- V2X : Vehicle-to-Everything
  - IoT technology allowing the vehicle to know the state of the signals as well as the location of every vehicle, pedestrian and potential hazard in its surroundings. (See DSRC, CCW, FCW, EEBL, etc)
- V2I : Vehicle-to-Infrastructure
  - IoT technology that allows transport related infrastructures to adapt so to optimize the most efficient throughput of traffic.
- V2V : Vehicle-to-Vehicle
  - Vehicles equipped with this technology can communicate with each other in real time and relay information. V2V allows vehicles to essentially see further and enhance the level of predictability. (Again, see DSRC, CCW, FCW, EEBL, etc)

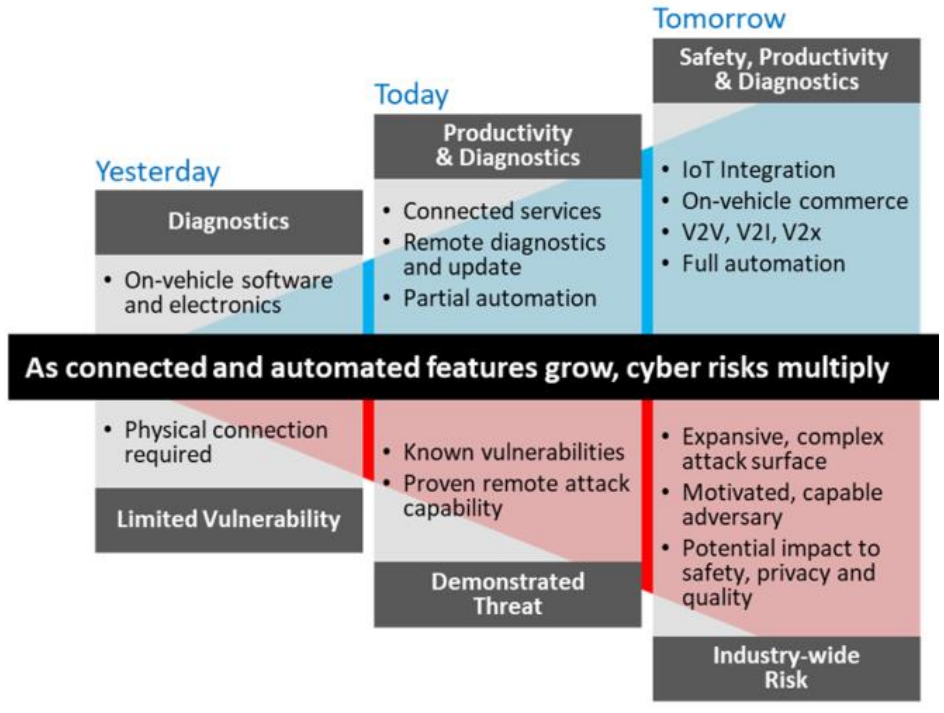


4.0 Risks: Product cybersecurity (PCS)

- Business opportunities to exchange with the vehicle (*Two ways communication*)
- Leap frog our ability to predict and correct situation in real time with customers
- New revenue stream
- New connectivity open doors to unwanted access and changes
- Accelerated learning required from other Volvo entities and focus groups (Expertise)
- Adopt recommended rules like "*Single Antenna*" to manage risks
- Inform / educate Customer as well (RFP)

Opportunity

Responsibility




PREVENTIVE
SAFETY FEATURES

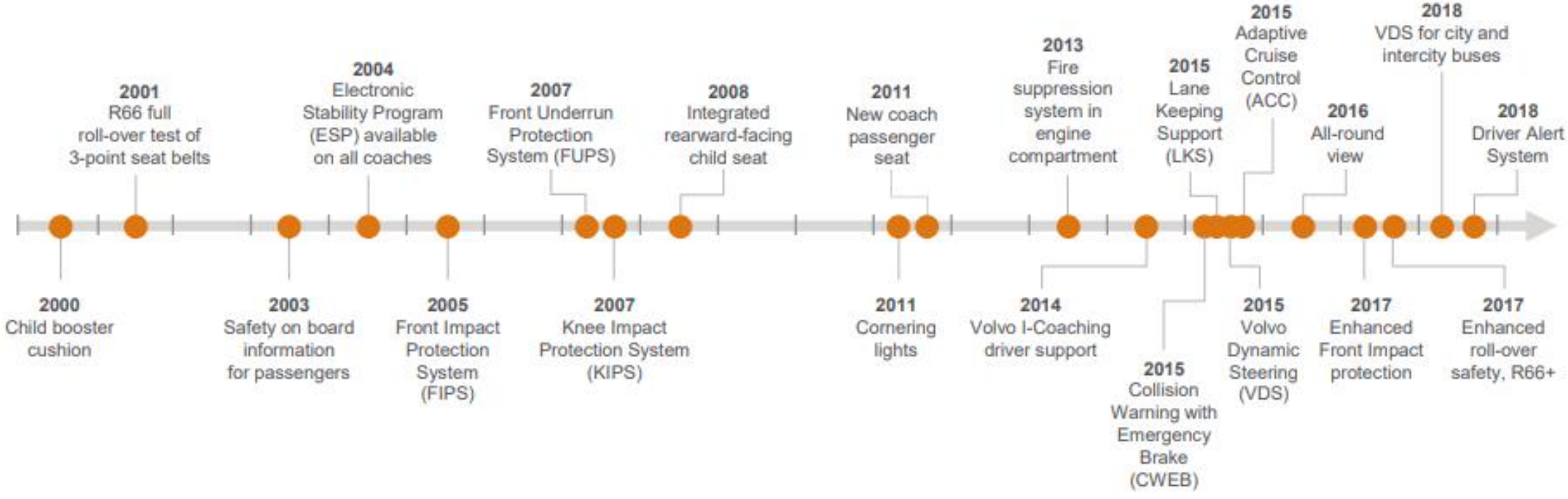
5.0 Safety

"An automobile is made by and for people. The basic principle for all engineering design is and must remain: safety.

On this point we are proud to be conservative. And even in the future this will remain our guiding light."

Volvo's founders Assar Gabrielsson and Gustav Larson in 1927

Volvo Buses has introduced a range of safety features over the years, often a decade ahead of legislation.



5.1 Preventive safety systems

Driver in control

- Advanced driver support systems
- Chassis developed for superior handling and control
- Superior braking system with electronically controlled disc brakes
- World-class driver's environment with excellent visibility, superior HMI and minimised distraction
- Volvo I-Coaching
- Volvo Buses' driver training
- Safety zones

5.1 Safety - Towards a safety future

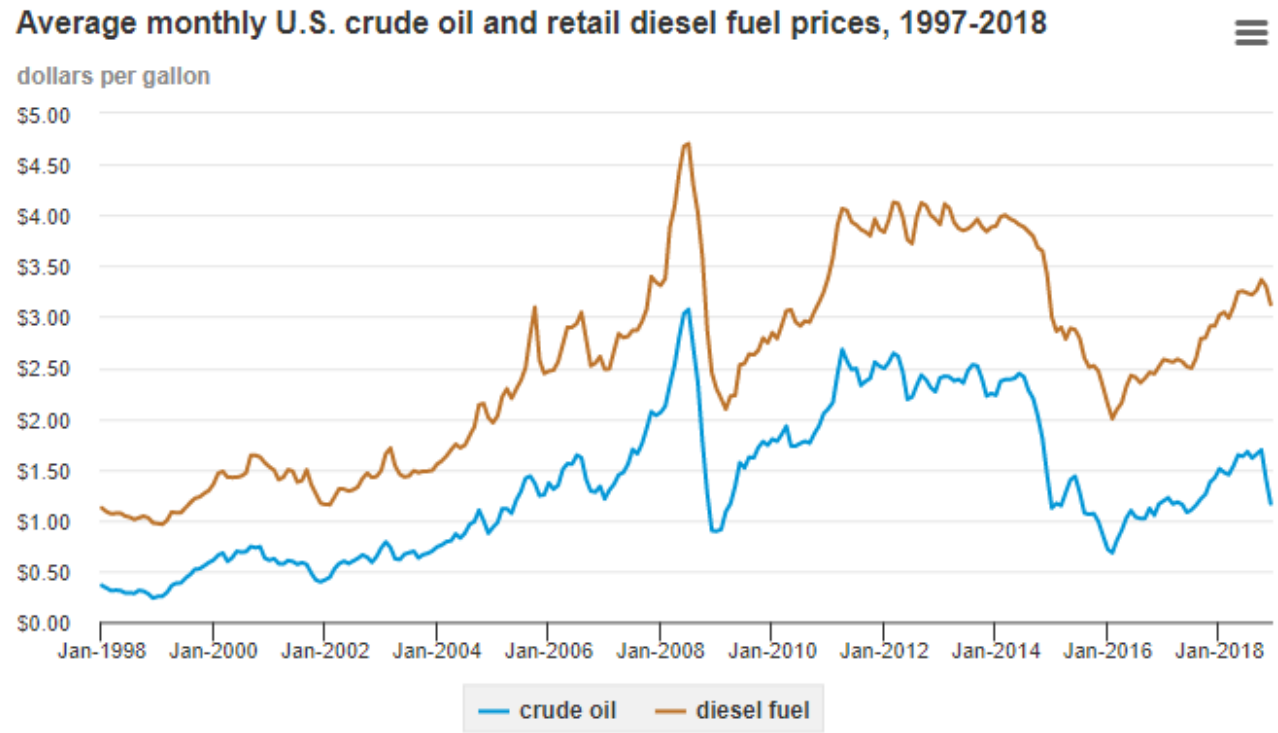
Long-term plan for safety development with emphasis on advanced driver assistance systems:

- Lane Changing Assist with VRU detection
- Active Lane Keeping Support
- Queue Assist
- Camera Monitoring System (CMS) replacing external mirrors
- Side detection

Prioritised research areas

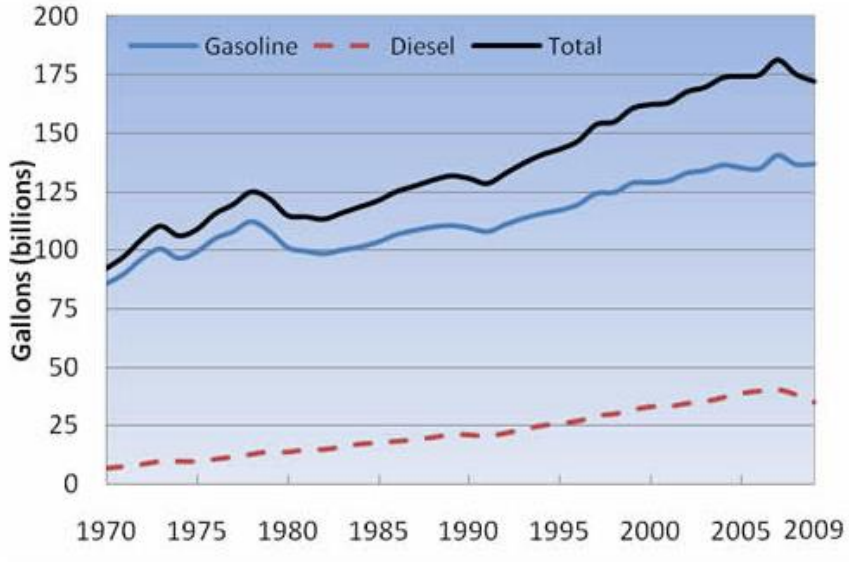
- Pedestrian (Vulnerable Road Users) detection with auto brake
- Vehicle-to-vehicle and vehicle-to-infrastructure communication (V2X)
- Autonomous driving

6.0 Fuel consumption



Note: Diesel fuel price includes taxes. Crude oil price is refiner composite aquisition cost.
Source: U.S. Energy Information Administration, *Petroleum Marketing Monthly*, September 2019, and *Gasoline and Diesel Fuel Update*

Figure 5-1: Highway Fuel Usage Trend: 1970–2009

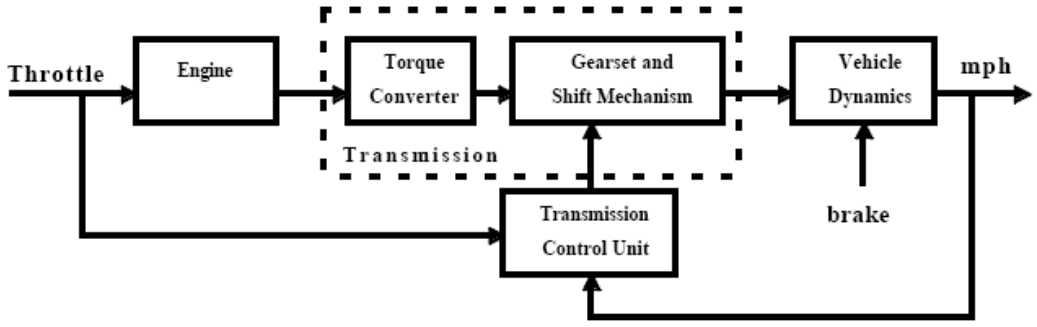


Data Source: FHWA OHPI, Highway Statistics

6.1 Less fuel consumption: Modelling Optimized Gear Intelligent Systems

Buckingham π theorem

Engineering, applied mathematics, and physics, the **dimensional groups theorem** is a key theorem in dimensional analysis, often called **pi theorem** and/or **Buckingham theorem**. It is a formalization of Rayleigh's method of dimensional analysis. Loosely, the theorem states that if there is a physically meaningful equation involving a certain number *n* of physical variables, then the original equation can be rewritten in terms of a set of $p = n - k$ dimensionless parameters $\pi_1, \pi_2, ..., \pi_p$ constructed from the original variables. (Here *k* is the number of physical dimensions involved; it is obtained as the rank of a particular matrix.)
The theorem provides a method for computing sets of dimensionless parameters from the given variables, or nondimensionalization, even if the form of the equation is still unknown



Under Discussion

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https://www.nasdaq.com/press-release/allison-transmission-inc.-launches-next-generation-iscaan-program-to-optimize-vehicle

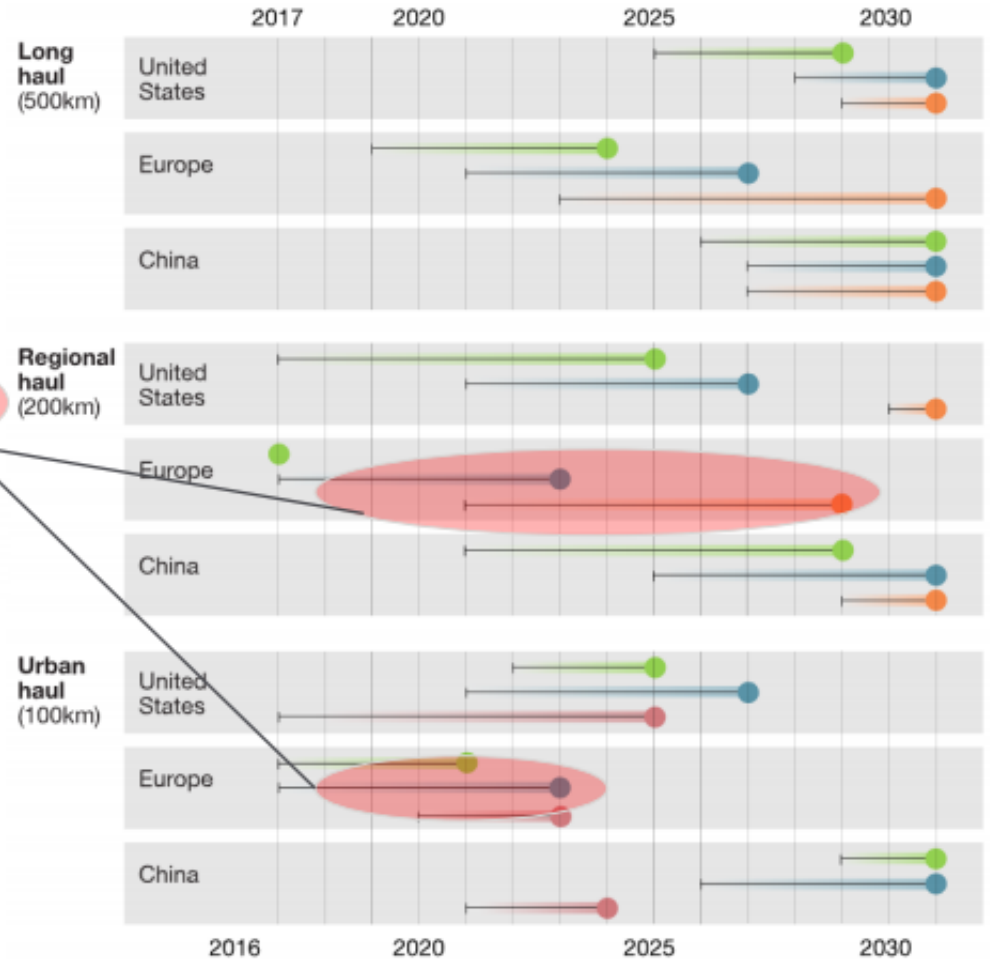
7.0 Electrification

TCO break even points

Different applications and weight classes will see varying breakeven points for electric vehicle total cost of ownership.

FL and FE

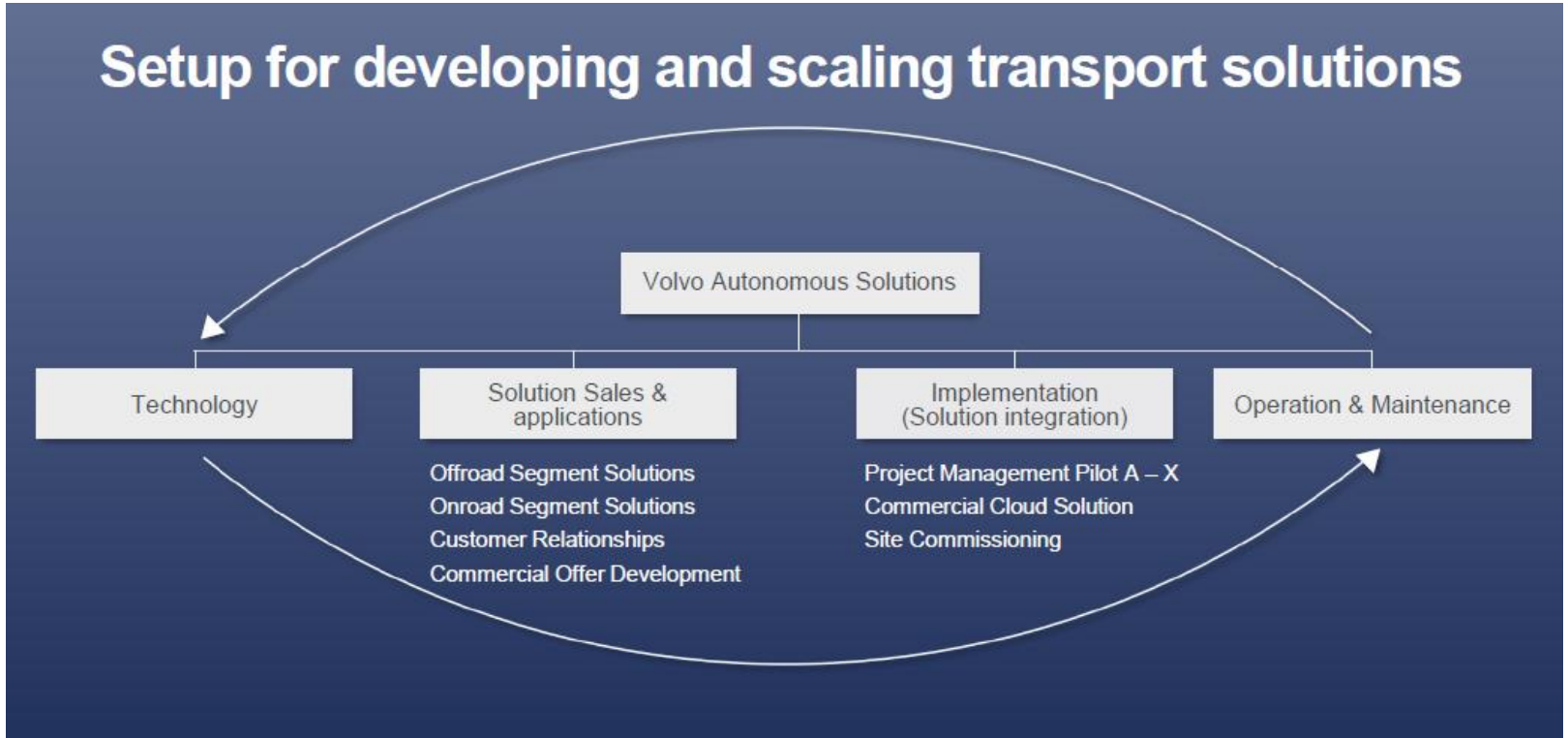
Comments:
Even though logistics companies invest in electromobility before they break even with diesel trucks, the companies has marketing value to gain and the possibility to secure contracts with customers that are demanding a fleet moving towards renewable sources.



Source: McKinsey - What's sparking electric-vehicle adoption in the truck industry?

7.1 Electrification - North American Market

6.0 Volvo Autonomous Solutions

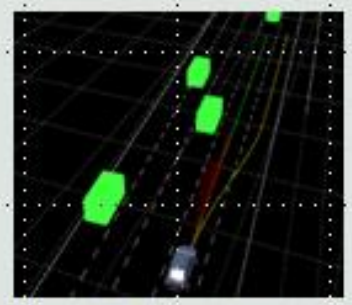


AI/Deep Learning for Autonomous Driving

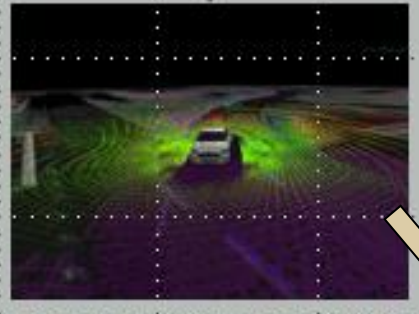
Advanced Sensor Platform

Deep Learning

Intention Recognition



Trajectory Planning



Environment perception

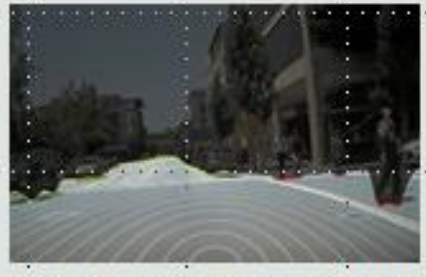
Prediction & Planning

Decision & Control

Autopilot

Object detection

Lane Detection



Free space Detection

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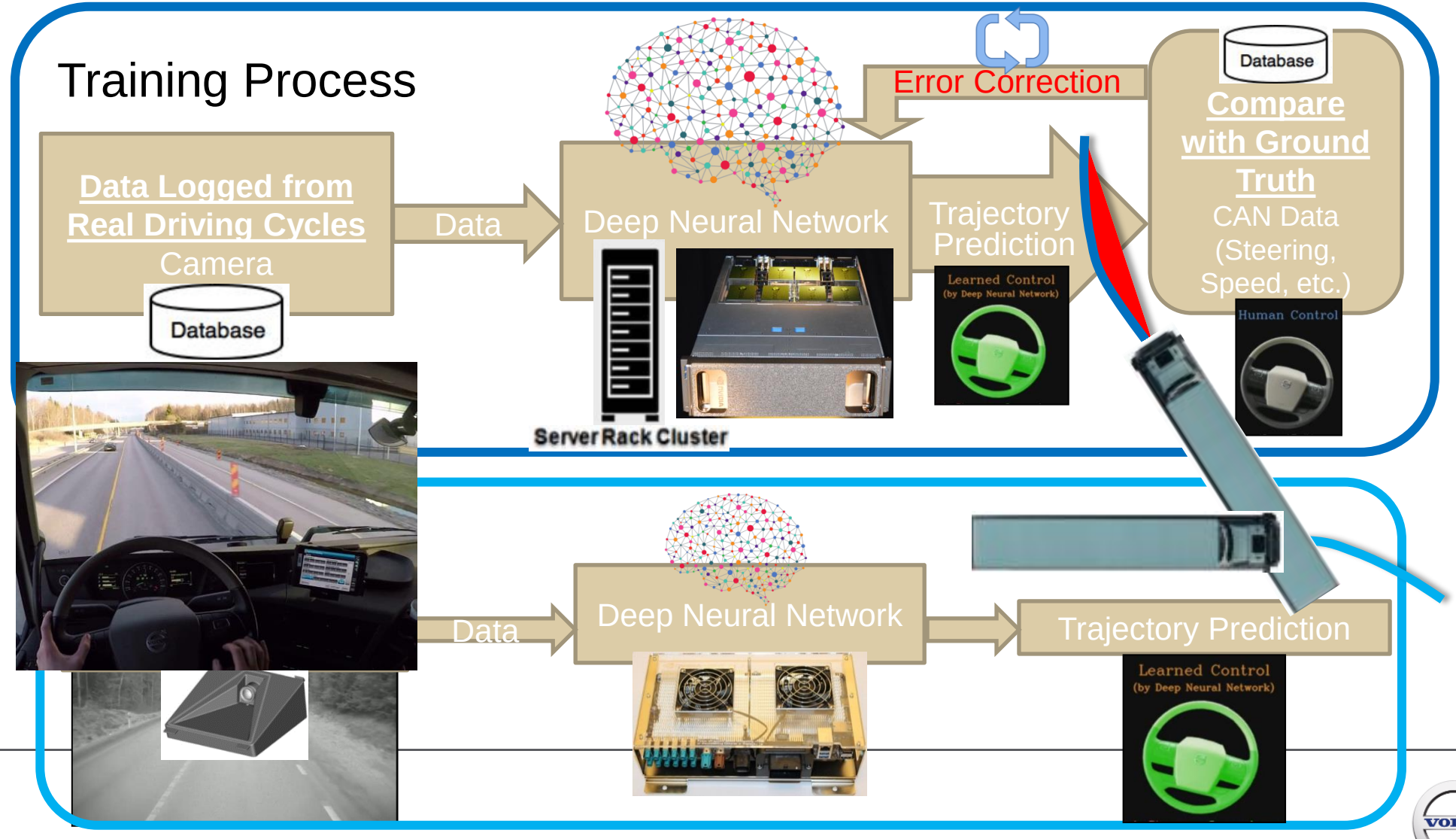
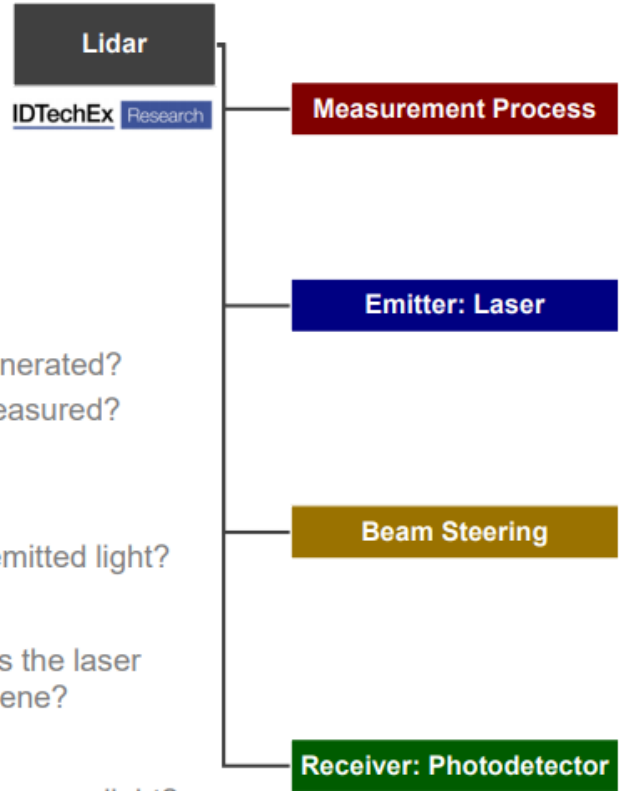
Use Case - E2E Trajectory Planning System

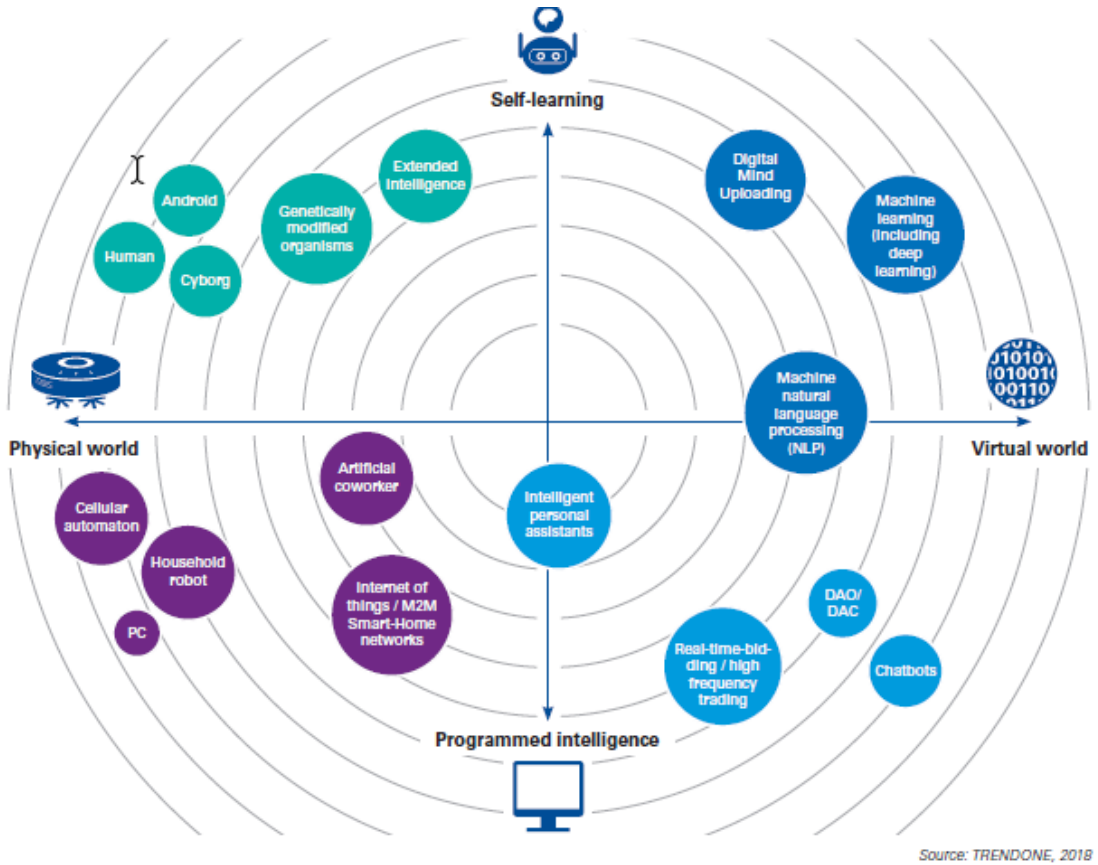


6.1 Autonomous Solutions



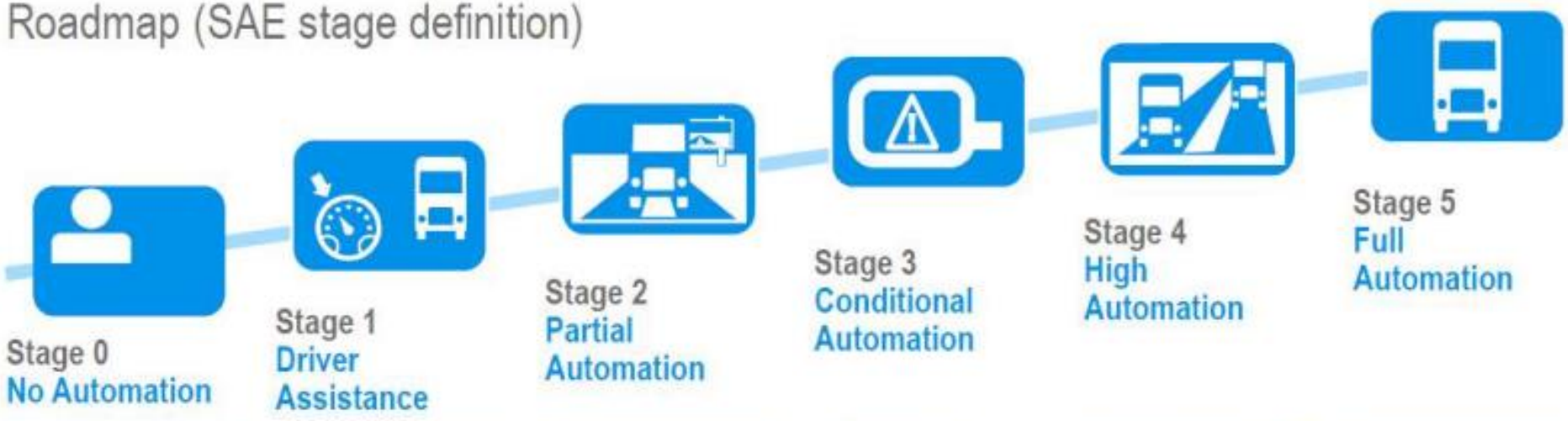
TECHNOLOGY CHOICES

1. **Measurement process:**
   - ❑ How is the light signal generated?
   - ❑ How is the light signal measured?
2. **Laser:**
   - ❑ What is the light source?
   - ❑ What wavelength is the emitted light?
3. **Beam steering:**
   - ❑ What mechanism enables the laser beam to illuminate the scene?
4. **Photodetector:**
   - ❑ How does the detector measure light?
   - ❑ How are the pixels positioned?



Source: TRENDONE, 2018

Roadmap (SAE stage definition)



Stage 0 No Automation	Stage 1 Driver Assistance	Stage 2 Partial Automation	Stage 3 Conditional Automation	Stage 4 High Automation	Stage 5 Full Automation
Driver is fully engaged all the time, warning signals might be displayed	Automation of individual function, driver fully engaged (e.g., emergency braking systems)	Automation of multiple functions, driver fully engaged (e.g., construction site assist)	Automation of multiple functions, driver responds to a request to intervene (e.g., platooning)	Automated in certain conditions, driver not expected to monitor road (e.g., highway pilot)	Situation independent automated driving
✓	✓	Road testing	2020	>2025	>2030

Source: SAE; Roland Berger

Volvo – Vera

Comments

- Same battery technology as our other trucks.
- Autonomous and electric.
- Trucks will be part of a logistic system connected to a central. The system is designed for short distances between fixed hubs, for example within logistics areas.

UD Trucks, Nippon Express and Hokuren Agricultural Cooperative Conduct Japan's First Autonomous Driving Trial by Heavy-Duty Trucks on Public Roads – Showing promise for agriculture and logistics sectors amid shrinking workforce

UD Trucks, Logistics firm Nippon Express and Hokkaido agriculture cooperative Hokuren demonstrated the use of advanced autonomous driving technology in the handling of farm produce at one of Hokkaido's leading agriculture processing facilities on August 29, an important initiative that can help address a shortage of truck drivers as the country's work force contracts.

The demonstration took place at the Hokuren Sugar Refining Mill in Nakashari, Hokkaido. In the trial, a Level 4

Article date 08/29/2019

AUTONOMOUS VEHICLE TECHNOLOGY

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Obrigado!
Gracias!
Tag!

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