Oct 1st-2nd, 2019 @Volvohallen

#AIinAutomotive #TelematicsValley

AI in automotive REALITY CHECK

Session:
Where are we with automation - a reality check

Moderator Jonas Lindén
Telematics Valley

The Great Math Gap of AI

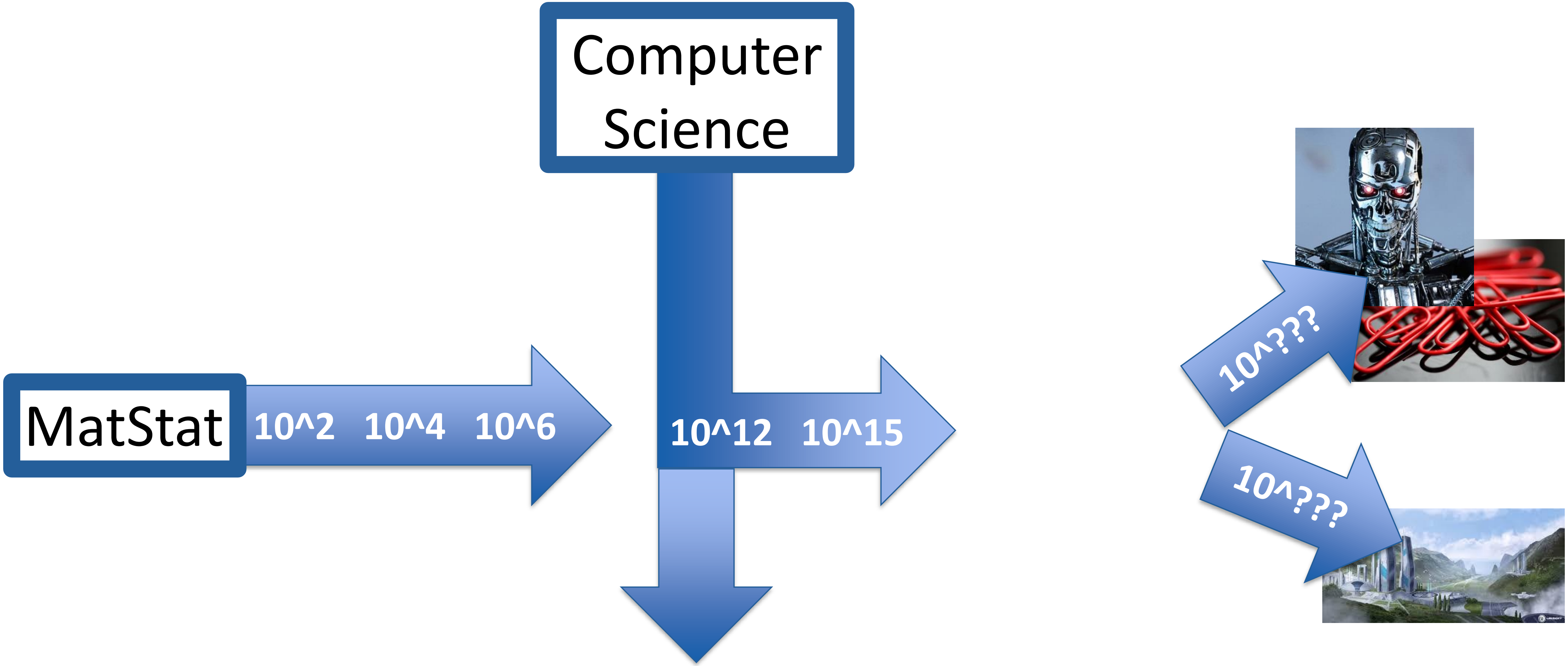
Assoc. Professor Carl Lindberg
Zenuity

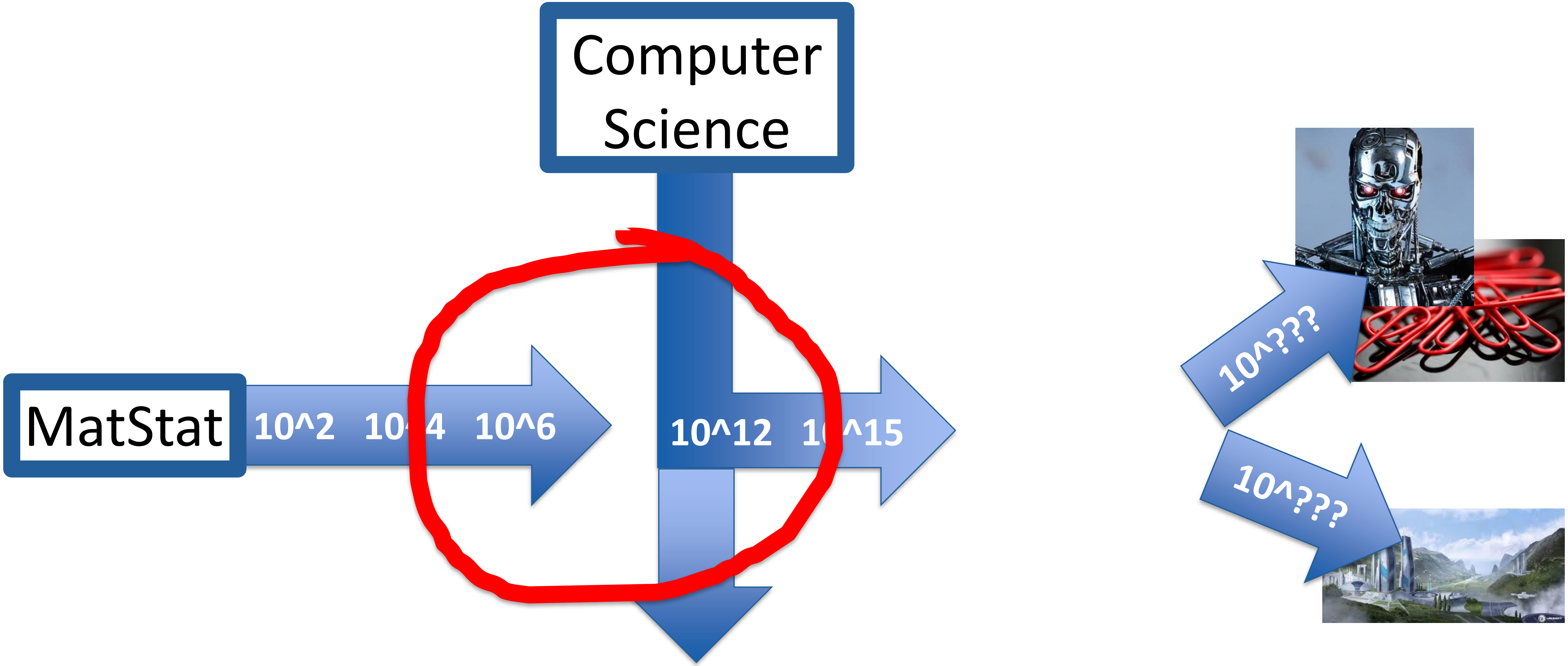
AI

- AI is the love-child between Applied Mathematics and Computer Science
- Sadly, math and programming are anxiety-inducing in different ways

AI

- Math is built up by increasingly complex constructions
  - to apply it successfully you need to understand everything you build your present project on
- Programming always come down to simple operations (”for-while-if-then”), and the complexity is due to the architecture of the system
  - (This is the reason that adoption of other’s code [eg at Github] is so successful)


Computer Science
MatStat
10^2 10^4 10^6
10^12 10^15
10^???
10^???


Computer Science
MatStat
10^2
10^4
10^6
10^12
10^15
10^???
10^???

Amazing Math

- Builds intuition
- Tools for the imagination
- Helps us understand our world
- The language of Science
- …
- ..

”School math” sucks

- ”What do I need this for?”
- School math failure:
  - many hate it
  - most are a little afraid of it
  - almost everyone sucks at it

A Sober Observation

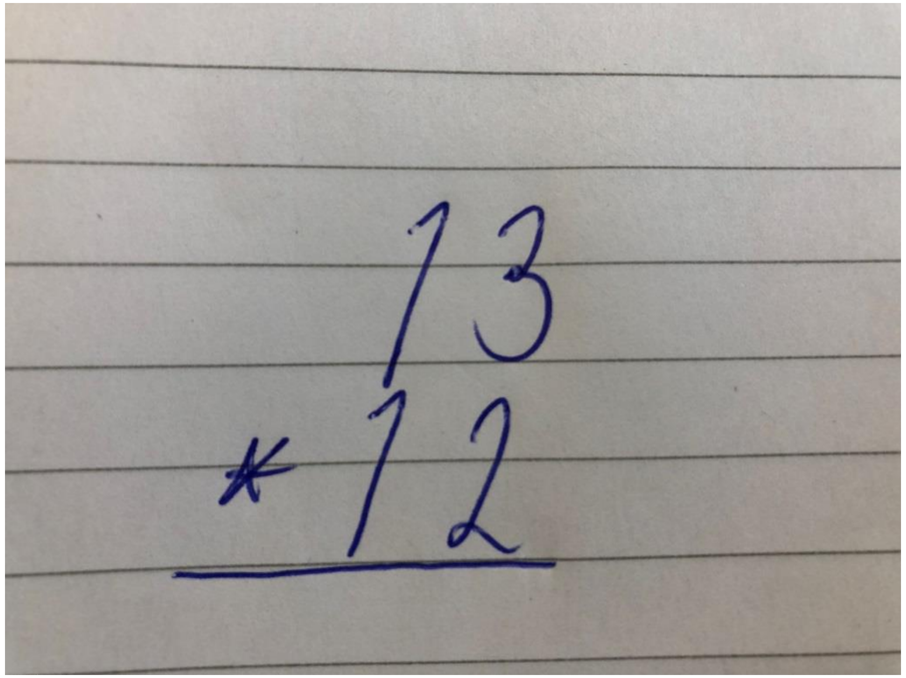
People suck at math. And statistics.

Where do you place?

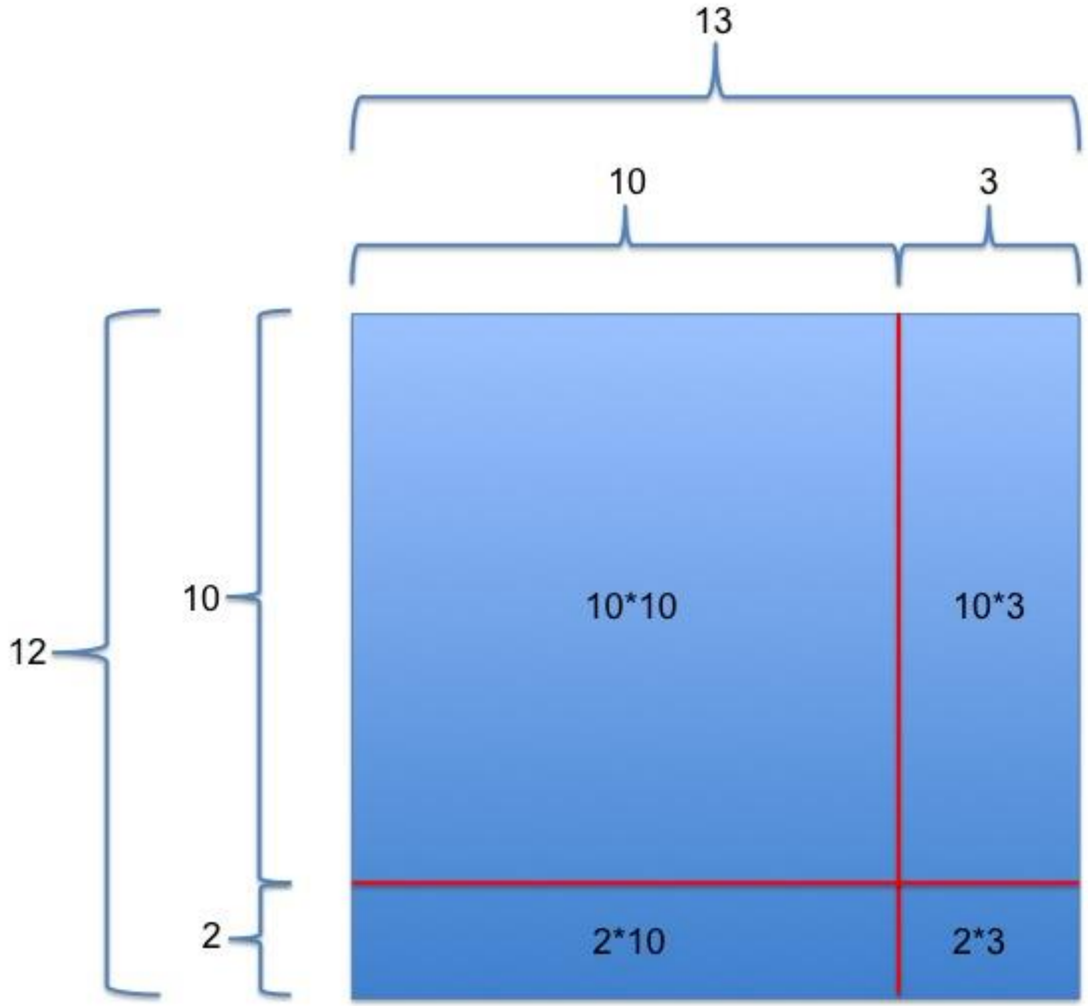
- 17.5*12.6?
  - Middle school
- What are the lengths of the sides of a rectangle with area 19.2 if the longer side is 3.7 longer than the short side? What's the diagonal length of that rectangle?
  - Junior high school
- Derive Newton's laws from experiments, and construct one-dimensional calculus?
  - High school

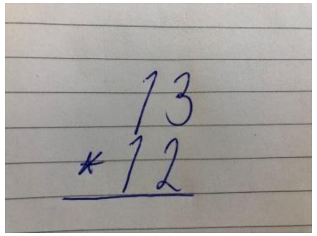
Learning by Heart

- Students are implicitly encouraged to learn by heart



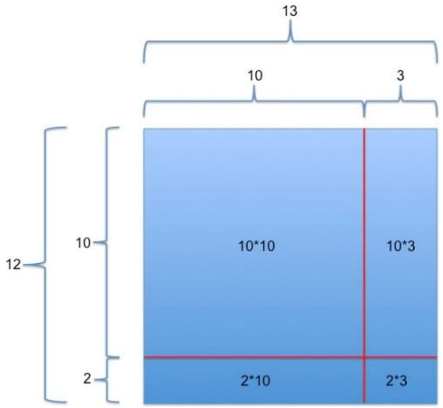
Learning by Heart

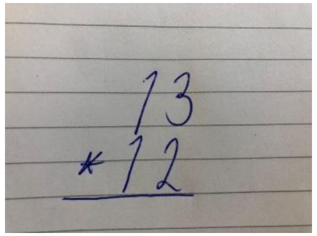




AI & Math

- Again, to apply AI successfully you need to understand engineering math properly, as well as statistics
- Engineers typically only take one course in probability
  – (most people take none)
- Hence, they believe in Science just because ”it seems to work”





Science requires Understanding

AI

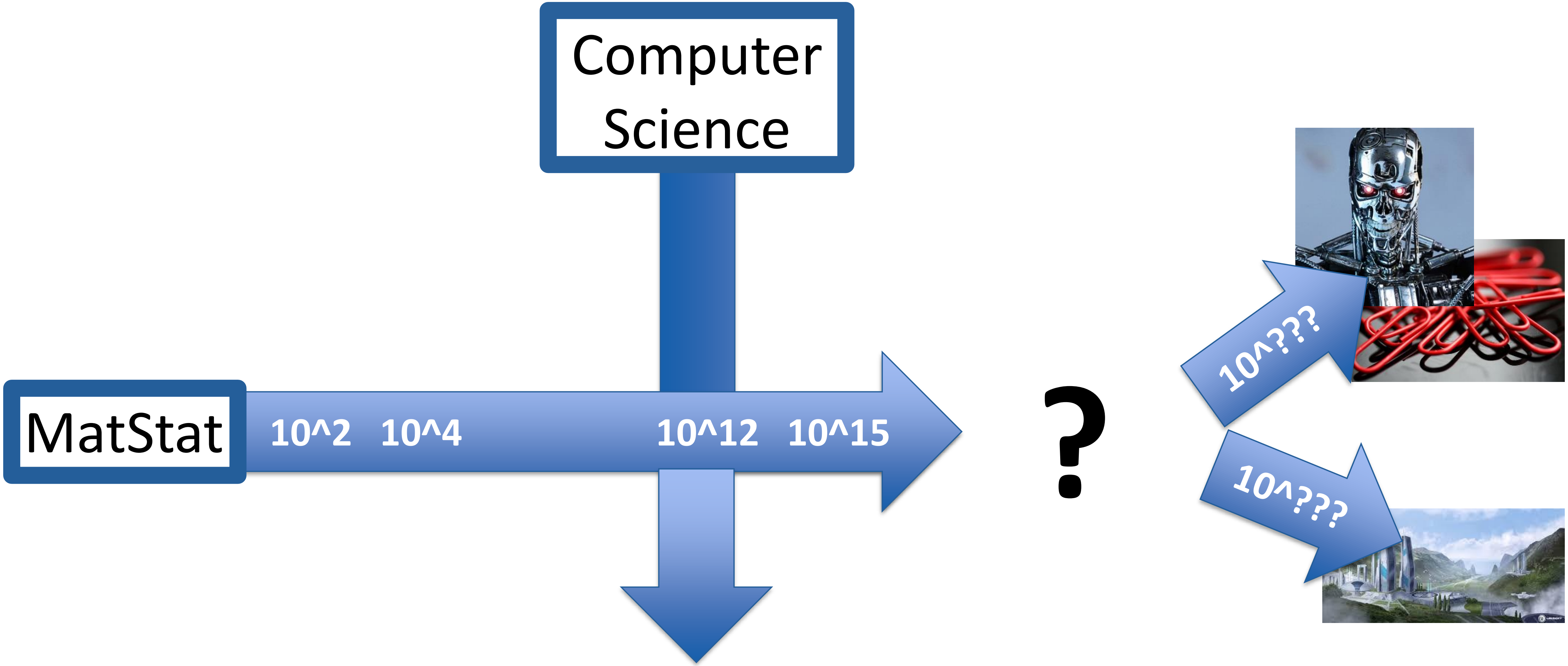
AI development is bound to

1. become more mathematical
2. require more statistical and data handling skills

A Great Opportunity

Enhancing mathematical and statistical skills in your AI-teams will be central to their productivity going forward

(They are probably good enough at programming…)


Computer Science
MatStat
10^2
10^4
10^12
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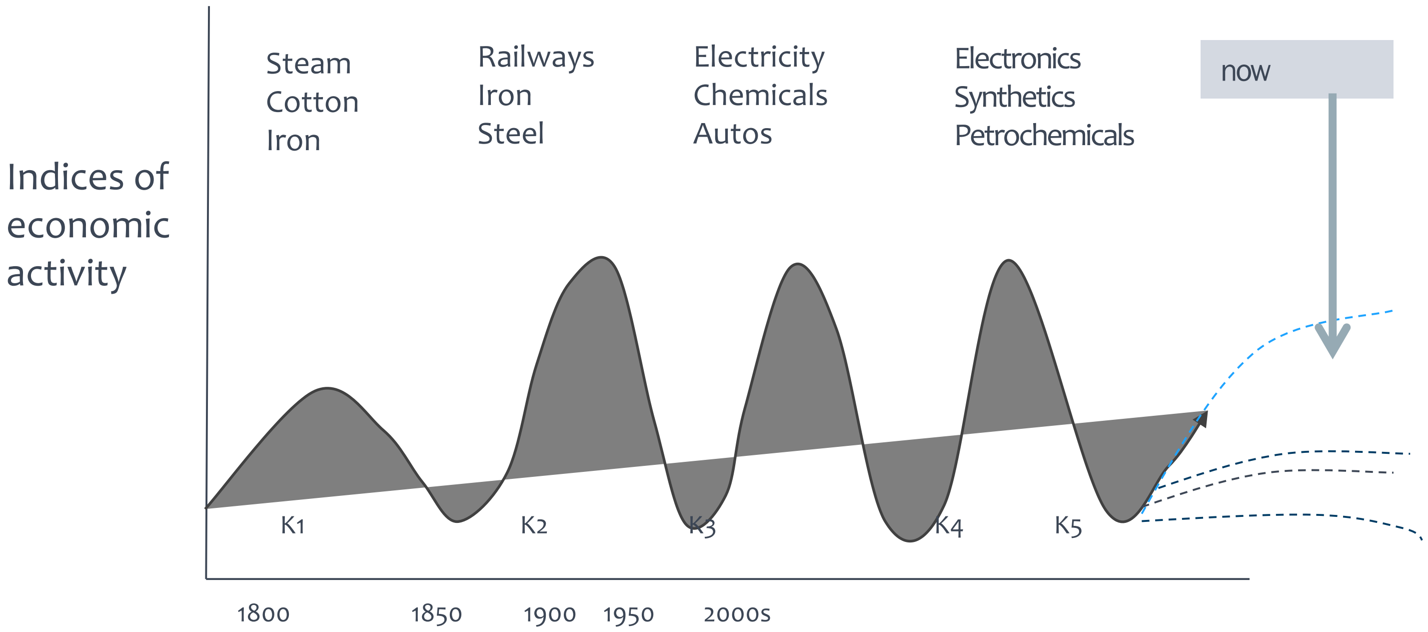
Thank you

AI essential component for Automotive

Shafiq Urréhman, PhD

AI: WHY NOW

Kondratiev's Long Waves



IQ ANALYTICS

AI & MACHINE LEARNING: A FORECAST

"COMPARED TO THE INDUSTRIAL REVOLUTION, AI IS CONTRIBUTING TO TRANSFORMATION OF SOCIETY, 10 TIMES FASTER, AT 300 TIMES

"COMPARED TO THE INDUSTRIAL REVOLUTION, AI IS CONTRIBUTING TO TRANSFORMATION OF SOCIETY, 10 TIMES FASTER, AT 300 TIMES THE SCALE, WITH 3,000 TIMES THE IMPACT"

MCKINSEY GLOBAL INSTITUTE

Healthcare | Retail | Banking and Finance

The overall artificial intelligence market is expected to reach **$16.06bn** by 2022

Natural language processing is expected to hold the **largest market share** by 2022

RPA is forecast to reach **$4.98bn** by 2020

North America leads the artificial intelligence market in terms of market size

USA

THREE FACTORS ENABLING AI GROWTH

Algorithms and hierarchical pattern recognition

Unlimited access to computing power via **Cloud**

Growth in **Big Data** feeding AI improvements

SOURCE: GARTNER, MARKETS & MARKETS, RESEARCH AND MARKETS, ACCENTURE, TRANSPARENCY MARKET RESEARCH

AI: Definition

Artificial intelligence (AI) is intelligence exhibited by machines. In computer science, the field of AI research defines itself as the study of "**intelligent agents**"

Artificial intelligence is technology that appears to emulate human performance typically by learning, coming to its own conclusions, appearing to understand complex content, engaging in natural dialogs with people.

The capability of a functional unit to perform functions that are generally associated with human intelligence such as **reasoning** and **learning**. (ISO/IEC 2382-28:1995)

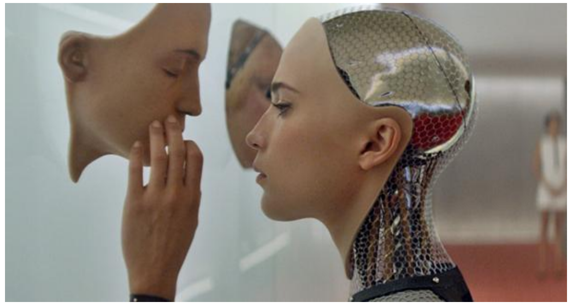
AI : Levels?

Narrow Artificial Intelligence:

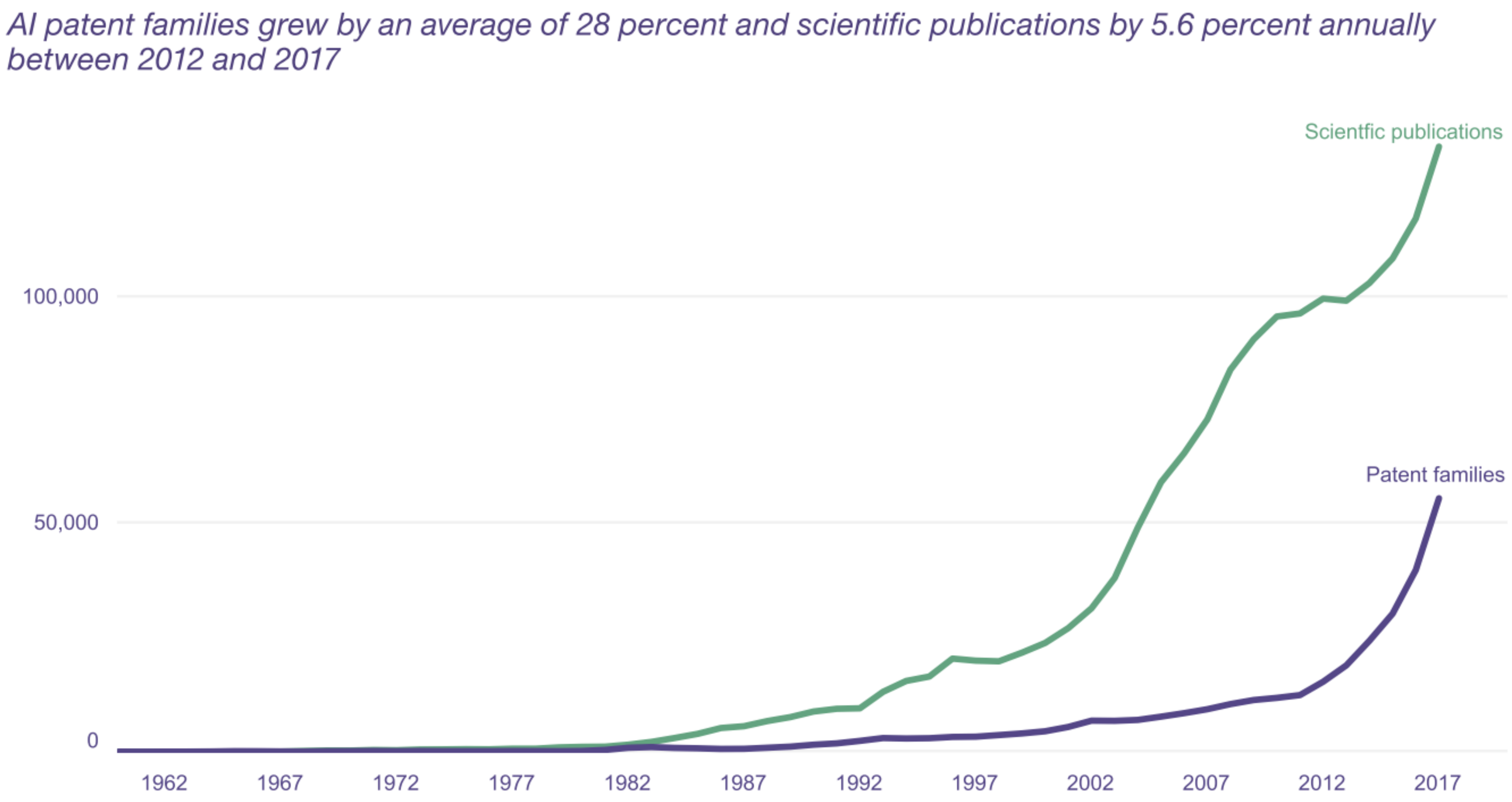
Machine focused on narrow task-specific domain knowledge. E.g. Siri on your phone

Artificial General Intelligence (not yet)

Machine applies intelligence to any task, not only one-social, aware and creative, e.g. movies "Eva in Ex Machina"

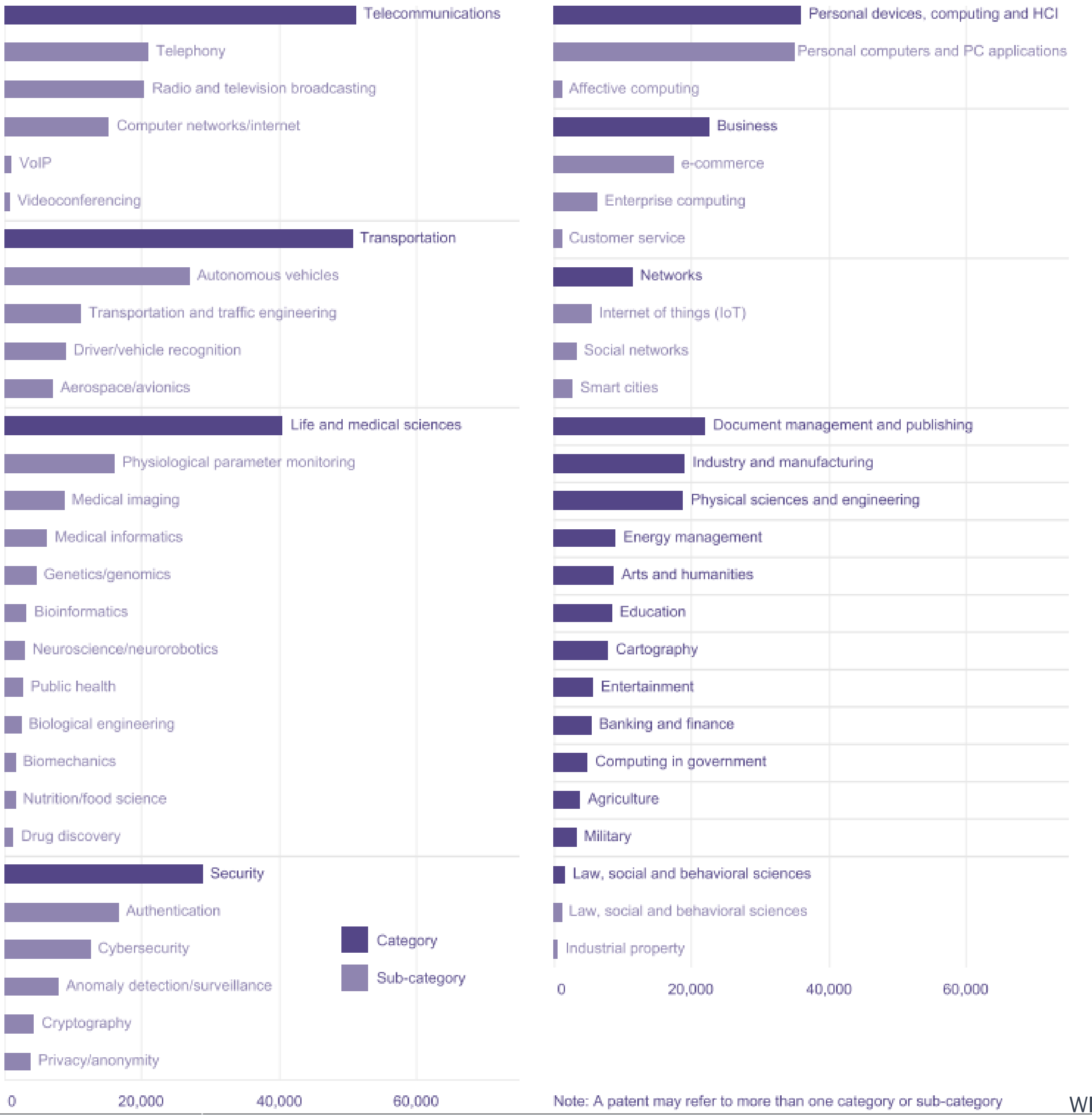


AI patent families and scientific publications by earliest publication year



WIPO (2019)

Telecommunications, transportation, life and medical sciences, and personal devices, computing and HCI are the top four application fields mentioned in patent documents and represent 24, 24, 19 and 17 percent of all patent families related to AI application fields, respectively

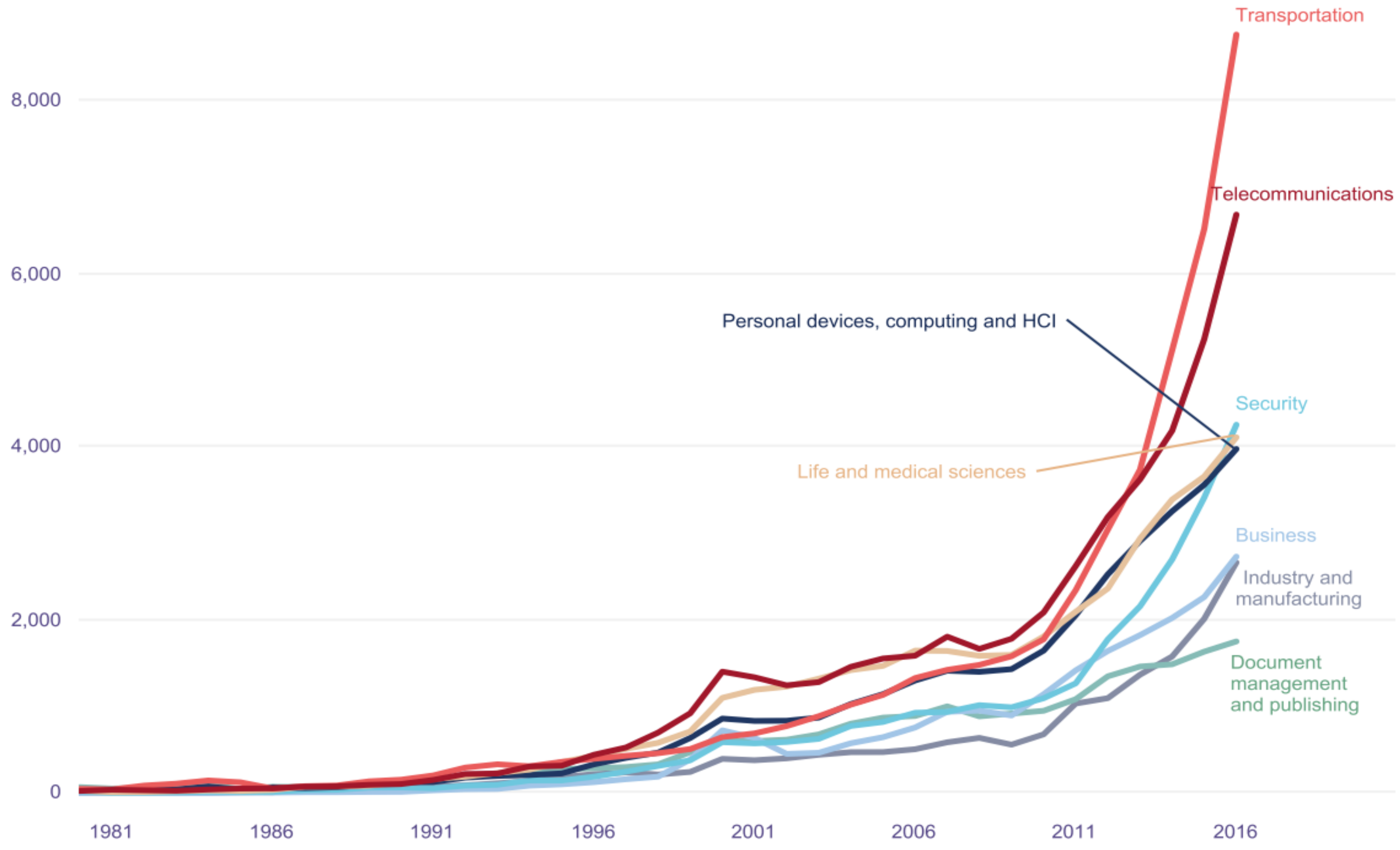


Note: A patent may refer to more than one category or sub-category

WIPO (2019)

AI Patent families for top application field categories by earliest priority year

Patent families related to AI application fields emerged in the 1990s, with transportation and telecommunications overtaking all other fields

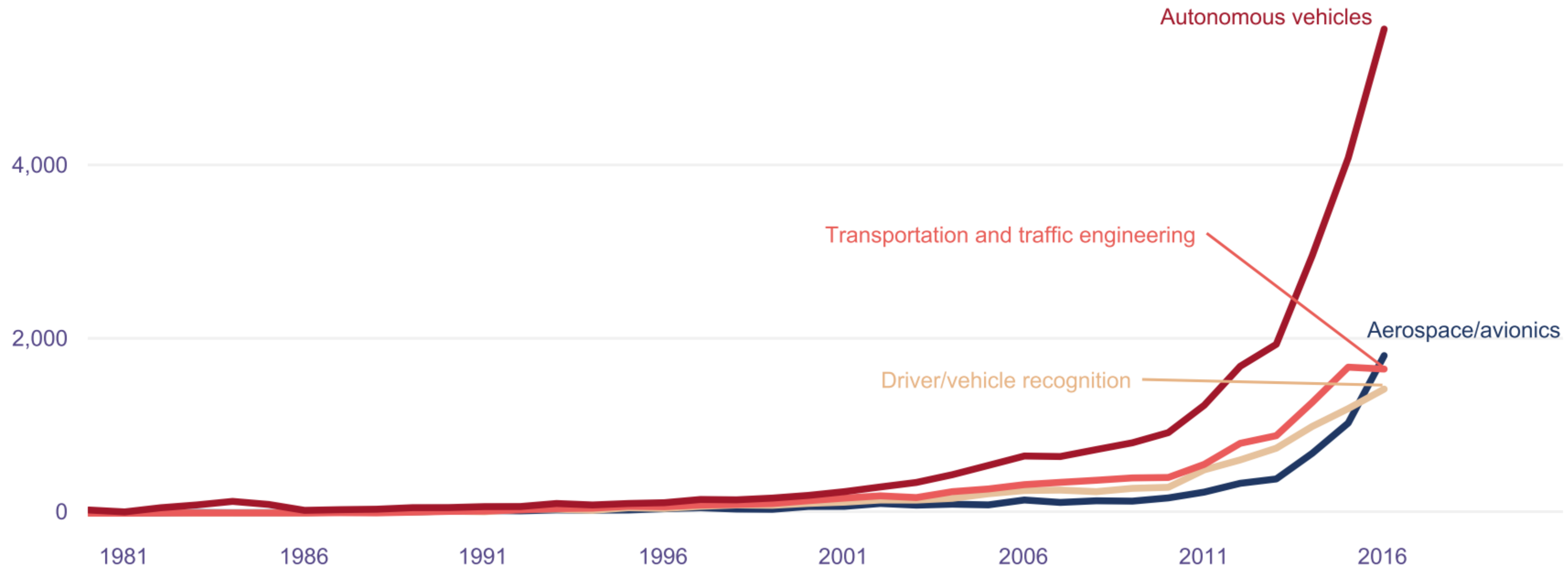


Note: A patent may refer to more than one category

WIPO (2019)

AI Patent families for transportation sub-categories by earliest priority year

Autonomous vehicles grew an average of 35 percent annually from 2011, rising to 42 percent annually from 2013 to 2016. Over the same three years, aerospace/avionics grew even faster, at 67 percent

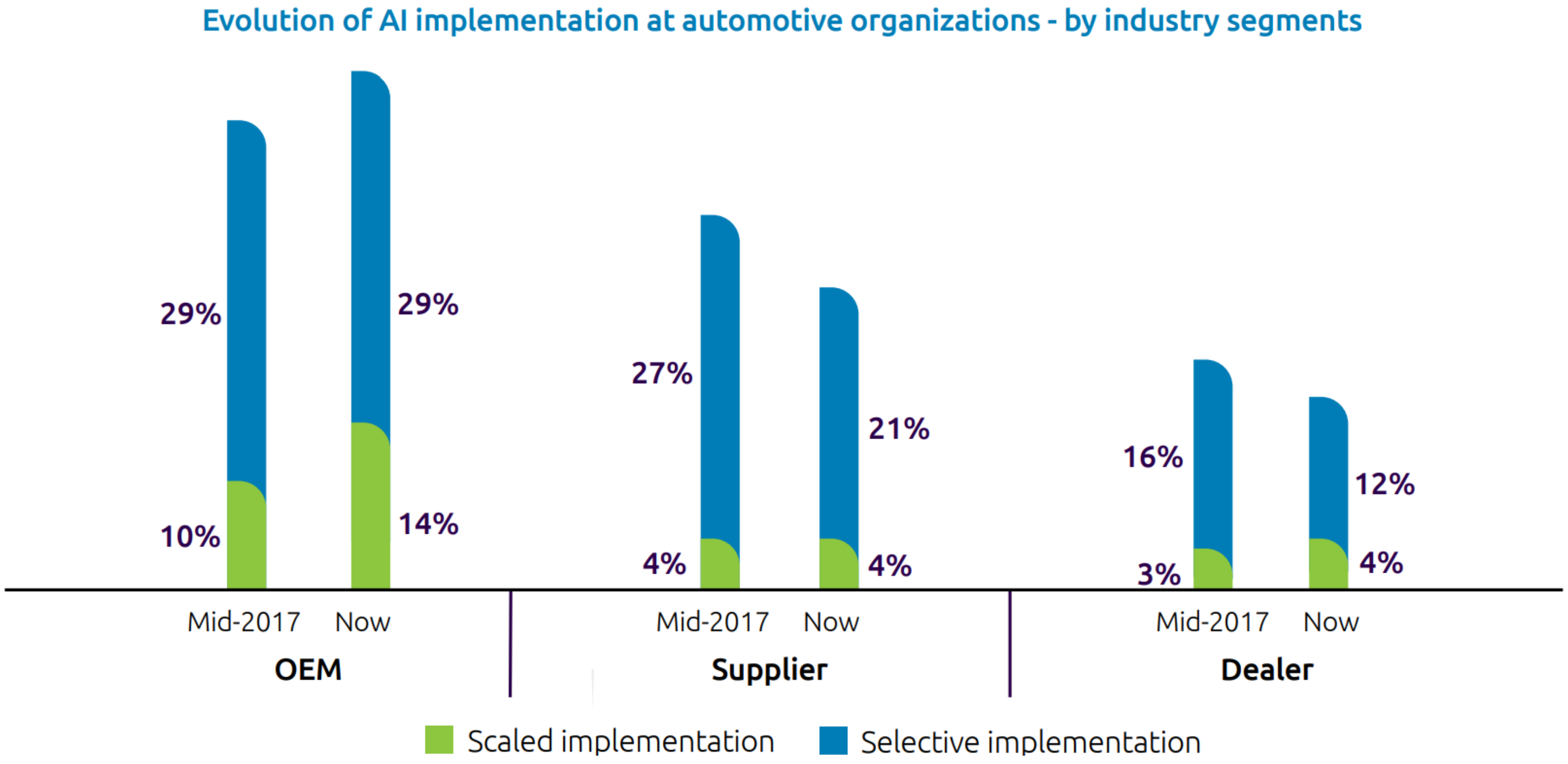


Note: A patent may refer to more than one sub-category

WIPO (2019)

Artificial intelligence for vehicles (AIV)

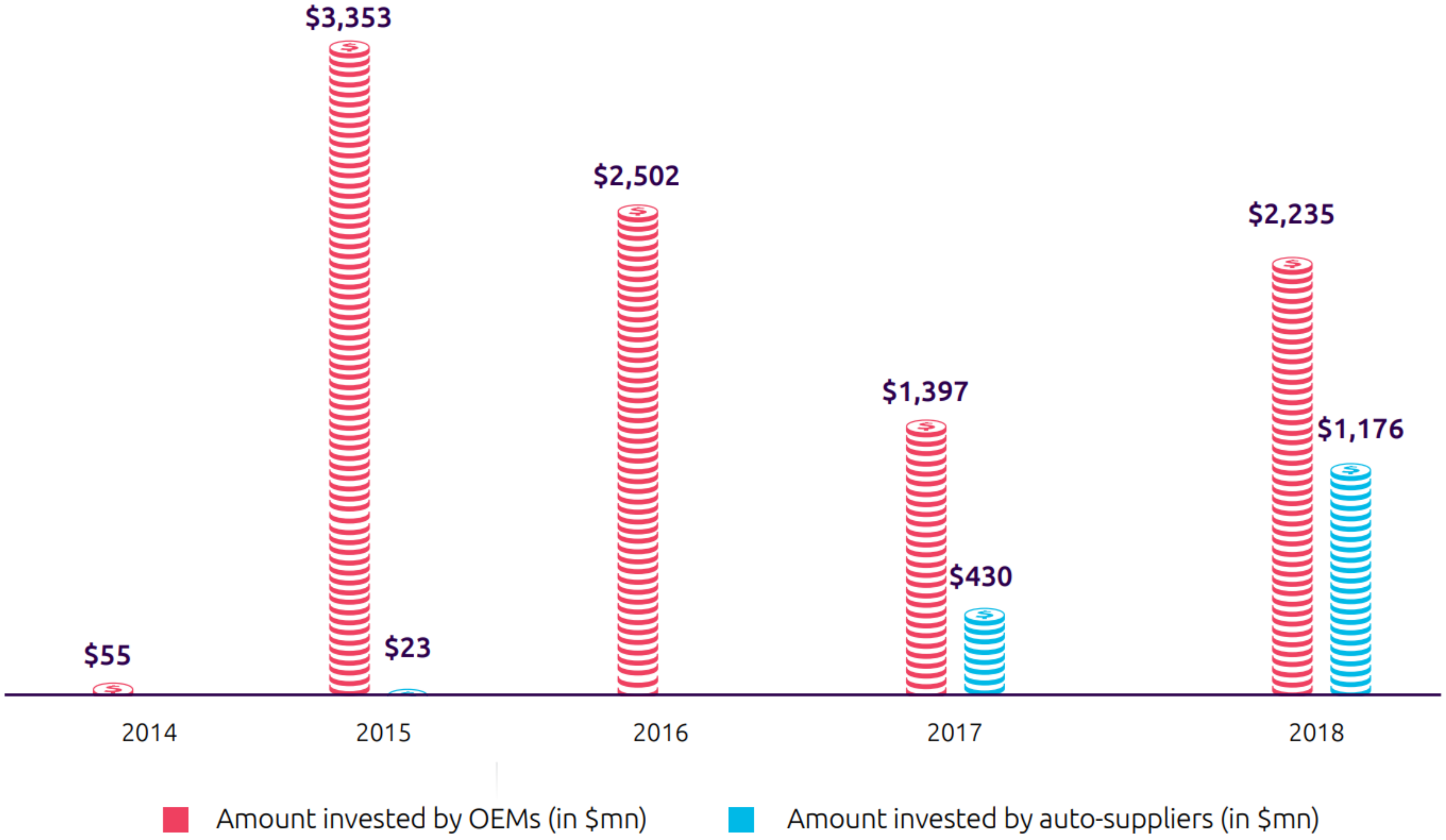
Artificial intelligence for vehicles (AIV) aims at applying both practical and advanced AI techniques to vehicles so that vehicles can perform human-like or even superhuman behaviours



AI implementation in the automotive industry – by industry segment

Capgemini Research Institute

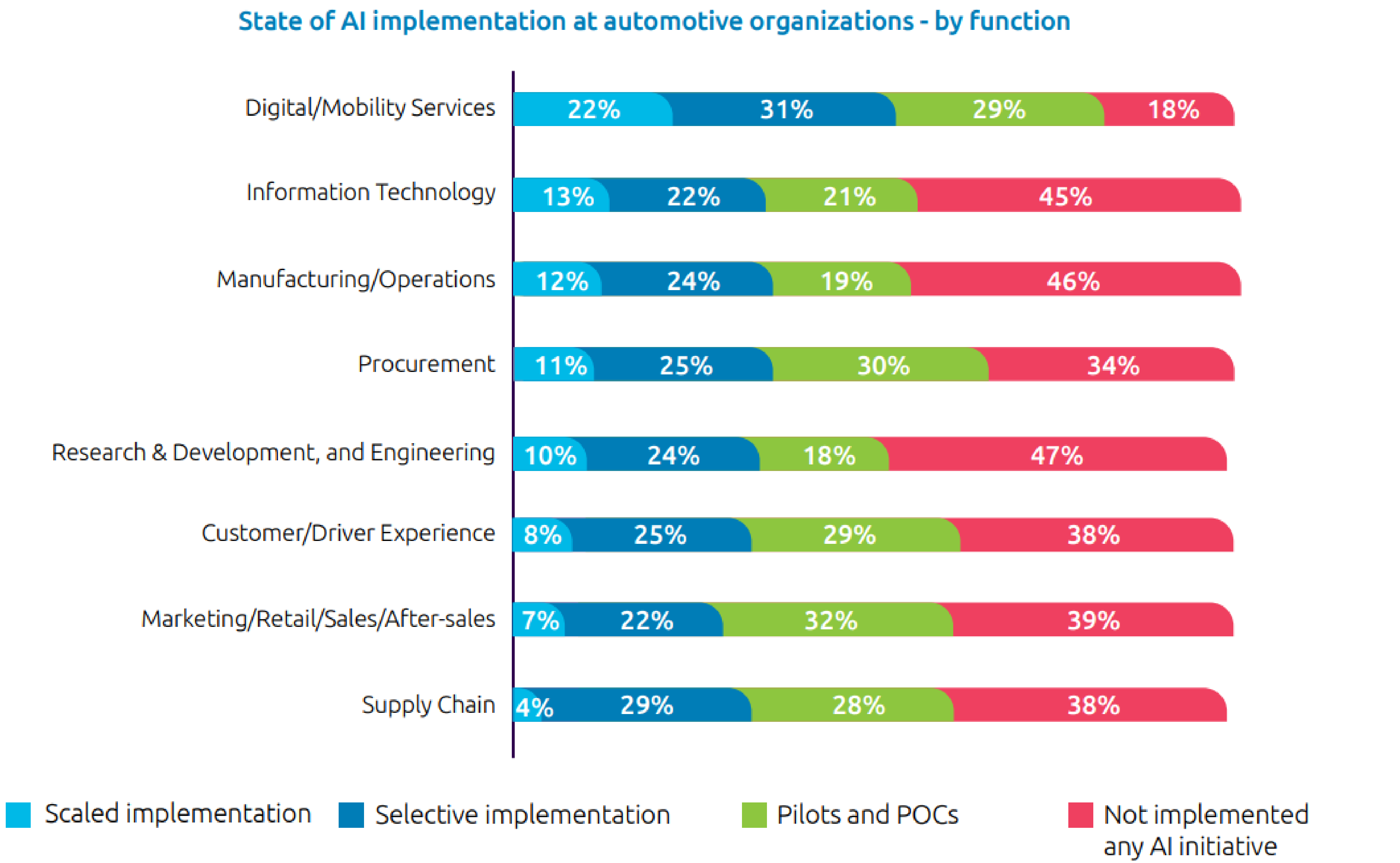
Artificial intelligence in vehicles



Automotive companies have invested $11.2 billion in AI-led start-ups since 2014

CEVT

AIV: AI can assists without providing full AV



Few functions have implemented AI at scale

Capgemini Research Institute

CEVT

AIV: Large OEMs can boost their pre-tax operating profit by 5%–16% from scaling up AI Implementation

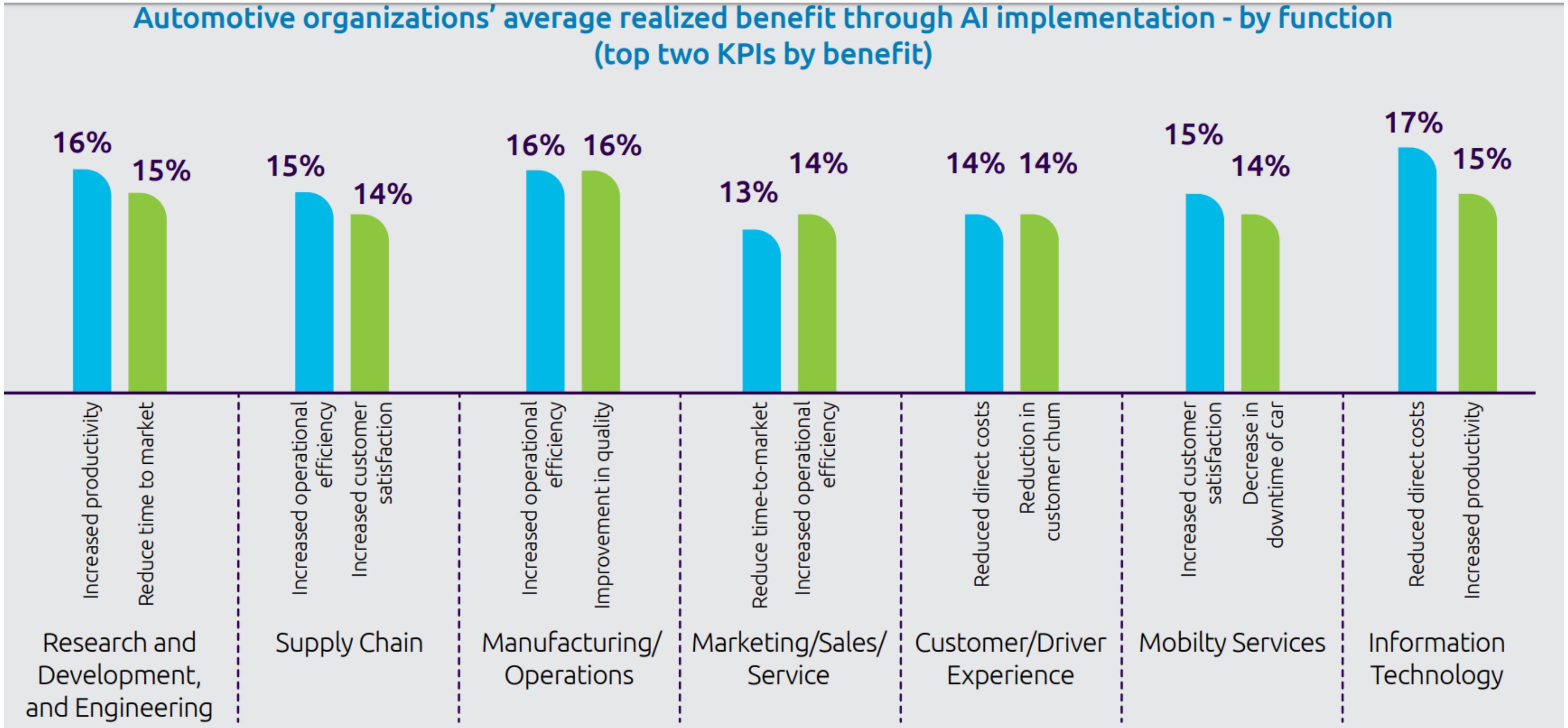
Factors	Scenarios based on industry estimates		
	Present day ($bn, % of revenue)[2]	Conservative improvement from AI ($bn, % of revenue)[1,2]	Optimistic improvement from AI ($bn, % of revenue)[1,2]
A. Revenue	$79.4	$79.4	$79.4
B. Direct costs (material, labor, etc.)	$50.8	$50.6	$48.4
C. Selling & distribution, R&D, administration, etc.	$9.7	$9.7	$9.6
D. Other indirect costs including maintenance and inspection	$7.5	$7.5	$7.4
E. Others (depreciation and amortization)	$6.7	$6.7	$6.7
F. Total costs	$74.7	$74.5	$73.9
G. Operating profit	$4.7	$4.9 **($232mn or 5% increase from current level)**	$5.4 **($764mn or 16% increase from current level)**
H. Operating margin (A-F)	5.9%	6.2%	6.8%

1 A conservative estimate takes into account 10% of estimated improvement from our survey results translate into actual efficiency gains; whereas an optimistic estimate implies that 33% of estimated improvement from our survey results translates into cost and efficiency gains. Note that in both scenarios, we assumed only a fraction of benefits (as estimated by our survey data) translate to cost savings – to the extent of average AI implementation in 24% of processes across functions. Figures are rounded off to the nearest decimal.

2 Assumed typical cost breakup of an automotive OEM: Direct costs (material, labor, etc.) – 64%; selling and distribution, R&D, administration, etc.) – 12%; Other indirect costs (including maintenance and inspection) – 9%; Other costs (including depreciation and amortization) – 8%. We considered investments in AI resources and skills as well, however they were fairly small in comparison to the overall cost base of large OEMs to have a substantial impact on P&L.

Source: Capgemini Research Institute Analysis; Bloomberg.

AIV: Every function has high-benefit use cases

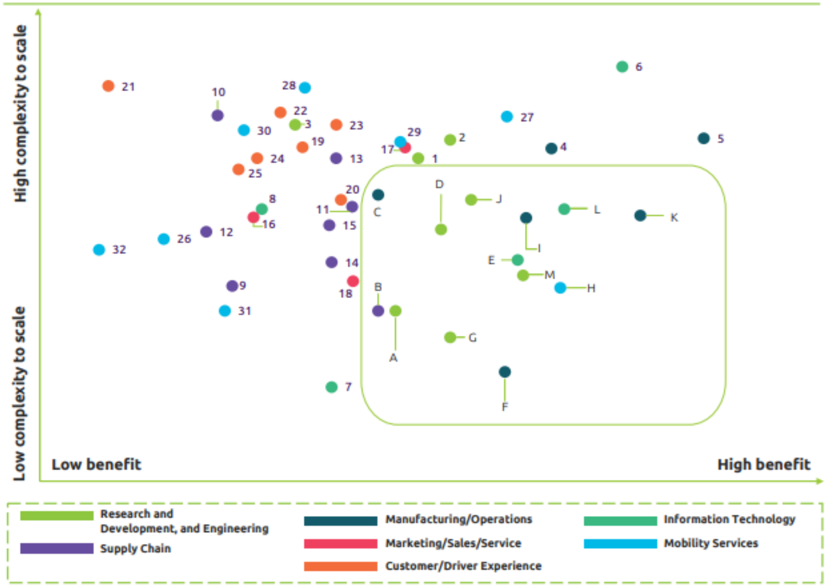


Source: Capgemini Research Institute, AI in Automotive Executive Survey, December 2018–January 2019, N=500 automotive companies.

AI implementation yields big benefits across functions

AIV Use Case : AI can assists without providing full AV

- Driver Interaction and Security
- Personalization
- Non-Verbal Interaction
- Automated Driving & Driver Assist Products
- Cruising Chauffeur
- Smart Cruise Control
- Auto Insurance Adjustment
- Monetization Models
- Manufacturing
- Supply Chain Optimization
- Shared Mobility Services
- Automotive Electrification
- Predictive Maintenance
- Connected vehicles
- ...

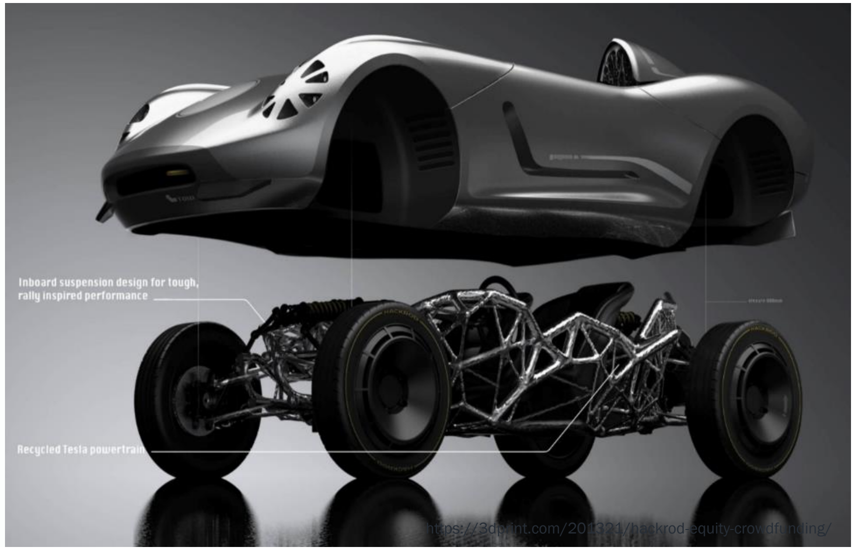


Use cases in high benefit-low complexity area

A	Predict outcome using simulations to reduce experimental R&D costs (e.g., component testing, track testing)	H	Improve fleet management for B2B services
B	Predict and forecast orders thereby reducing excess stock	I	Energy consumption management in plant operations/warehouses
C	Smart asset management using AI	J	Automated, in-line quality control (i.e. robotics checking the paint job, welding quality, AI software working on videos, images, sound, etc.)
D	Virtual prototyping of new product models	K	Predictive maintenance for equipment to reduce manufacturing downtime (e.g., robotic arm failure)
E	Autonomous self-heal systems (decide on network re-optimization based on conditions not yet occurred)	L	Cybersecurity (e.g.,. proactive threat detection and response)
F	New visualization and productivity optimization options to improve Overall Equipment Efficiency (OEE) in production	M	Emissions control /fuel efficiency improvement /power efficiency (for electric cars)
G	Analyze real-time diagnostics from the vehicle for continuous improvement of future models		

S.No.	Use cases not in high benefit-low complexity area	Function
1	Modeling the end-to-end engineering process i.e., digital twin	Research and Development, and Engineering
2	Development and testing of an autonomous driving system	
3	Leveraging customer information for optimizing product design	
4	Advanced process control using AI	Manufacturing/ Operations
5	Support augmented/mixed reality applications for plant and machinery maintenance	
6	Real-time application performance management e.g., predictive/preventive load balancing	Information Technology
7	Event correlation to detect errors and patters to forecast issues	
8	Energy management in data centers and server cloud	
9	Adjusting routes and volumes to meet predicted demand spikes, or re-routing in case of unforeseen events	Supply Chain
10	Supplier selection based on the ability to meet specific requirements and track their performance	
11	Quality control of supplies and finished goods e.g., automated visual inspection	
12	Robots for warehouse management and inspection using AI	
13	AI in reverse supply-chain and returns management	
14	Use AI for inventory optimization	
15	Assortment and storage level optimization for spare parts	
16	Analyze the online behavior of shoppers on different channels (websites, social media, etc.) to personalize offerings/promotions	Marketing/Sales/Service
17	Use AI to predict best possible additional products/services offer for an existing customer	
18	Provide recommendations of new and innovative products and services	
19	Use AI-powered virtual sales assistants/chat bots for sales support, schedule service appointments, cut wait times, and better communicate with customers	
20	Machine/vehicular object detection/identification/avoidance	Customer/Driver Experience
21	Voice assistants to access any customer/digital service and support	
22	Assessing traffic and road conditions in real time by crowdsourcing sensor information from connected vehicles	
23	Smart sensors to detect any technical/medical emergency situations inside the car	
24	Assisted driving features such as – self parking, lane departure, drowsiness and emotion detection, driver face analytics	
25	Predicting vehicle/component breakdown and alerting user/driver in advance	
26	Predicting demand for car/ride sharing or hailing	Mobility Services
27	Autonomous robots delivering parcels using mobile lockers	
28	Detecting and averting frauds in aftermarket and resale	
29	Predictive maintenance of fleet of vehicles using advanced analytics	
30	Supporting multi-modal travelling e.g., delay management, recommending alternative modes of transport	
31	Dynamic pricing to best determine price for each ride	
32	Dynamic routing based on traffic flow	

AIV Use Case: Generative Design

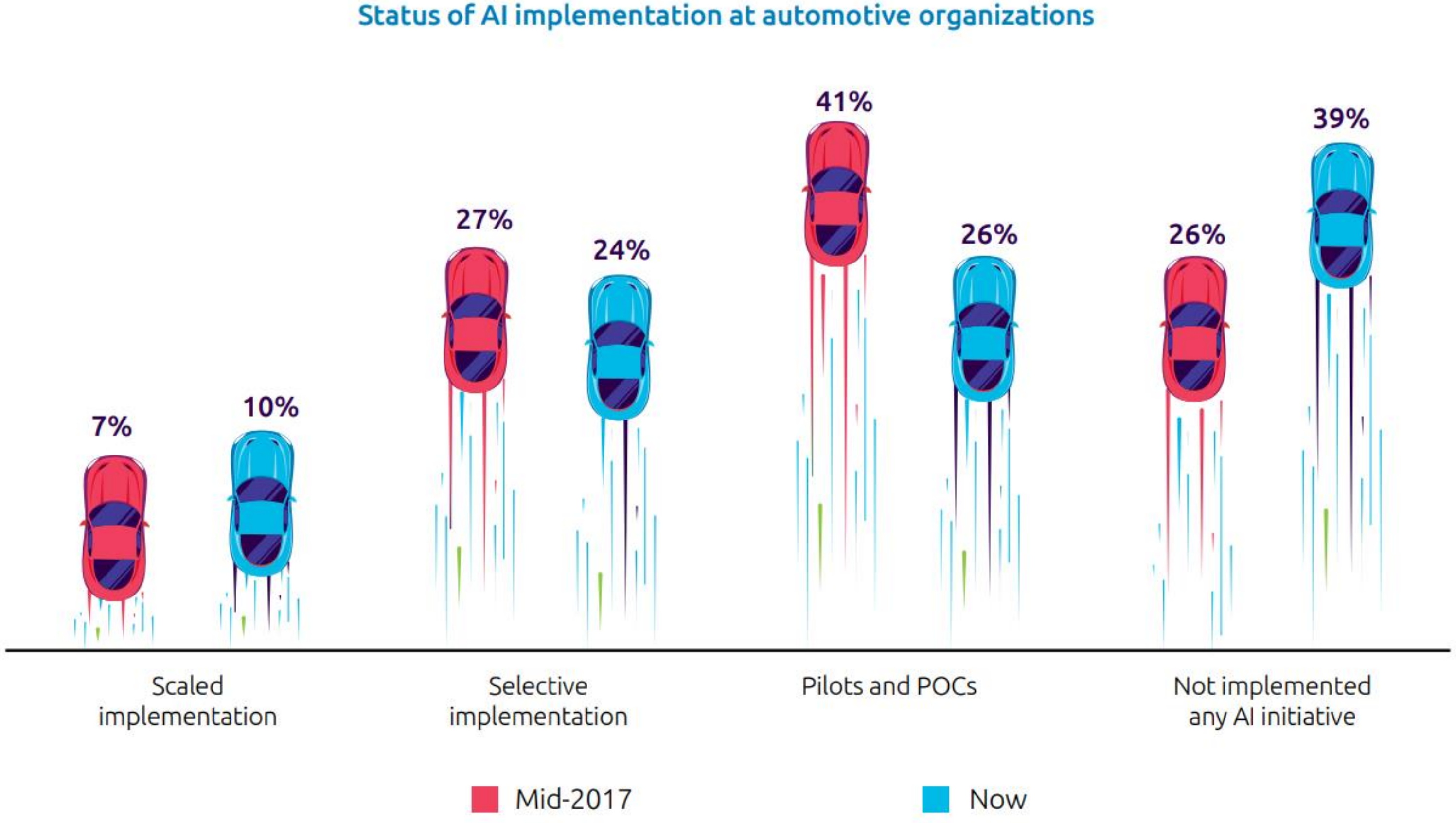


https://3dprint.com/201321/hackrod-equity-crowdfunding/

Generative Design

https://www.youtube.com/watch?v=vtfNIWEJxw4

AIV Challenge: Modest progress in scaling AI



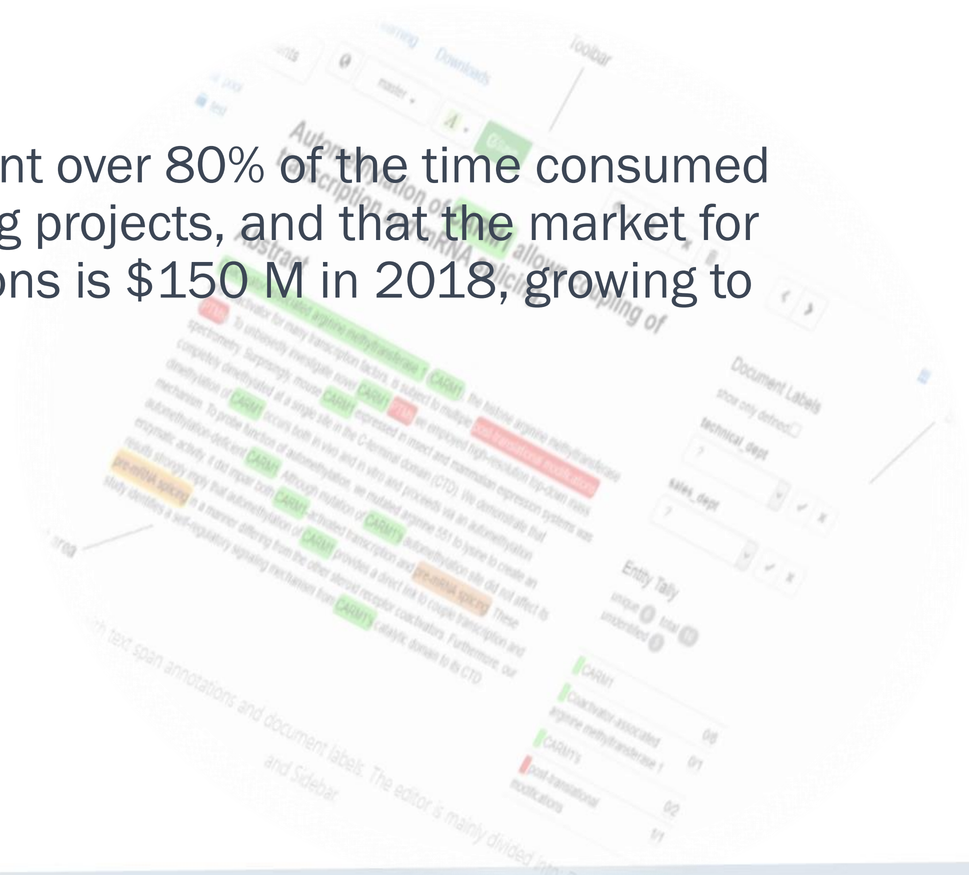
Source: Capgemini Research Institute, AI in Automotive Executive Survey, December 2018-January 2019, N=500 automotive executives. Scaled implementation = ongoing implementation across all sites/enterprise wide with full scope and scale; Selective implementation = ongoing implementation at multiple sites in various parts of an organization, but not at an enterprise level; Pilots = initial roll out with limited scope at one site. "Now" refers to December 2018 – January 2019, the period during which the survey was conducted.

Number of automotive organizations implementing AI at scale has increased only marginally

AIV Challenge: Micro-work is crucial to AI production

> AI-based innovations in the automotive industry are not all meant to be labour-saving

> Data preparation tasks represent over 80% of the time consumed in most AI and machine learning projects, and that the market for third-party data labelling solutions is $150 M in 2018, growing to over $1B by 2023.



Shafiq Urréhman, PhD.
Tech lead AI/ML (Innovation).
Email: Shafiq.Urrehman@CEVT.se

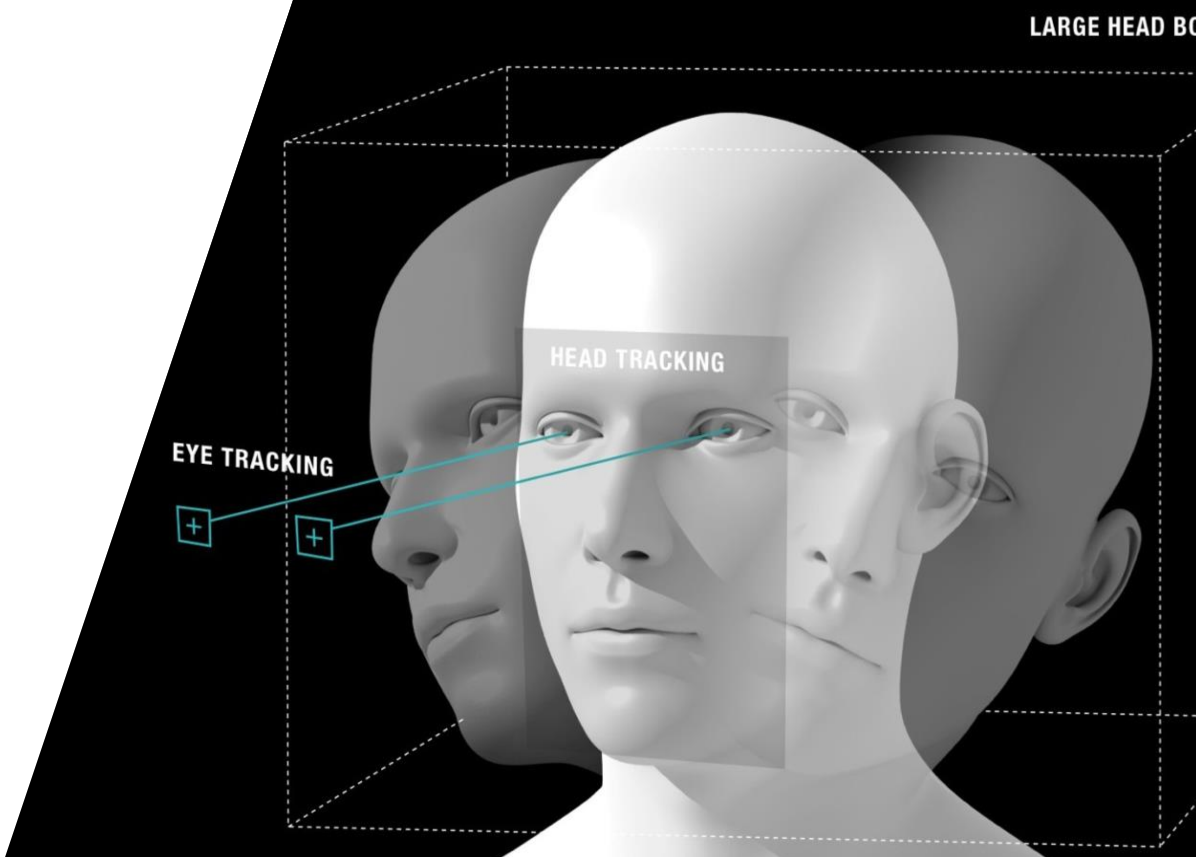
CEVT

A Geely Auto Company

thank you!

AI based occupant sensing is the key to unleash a new level of functions

Henrik Lind, CRO



Market structure for Automotive solutions

smart eye

OEM

Car Manufacturer (Original Equipment Manufacturer)

Tier 1

Tier1 as global suppliers providing OEM with system solutions

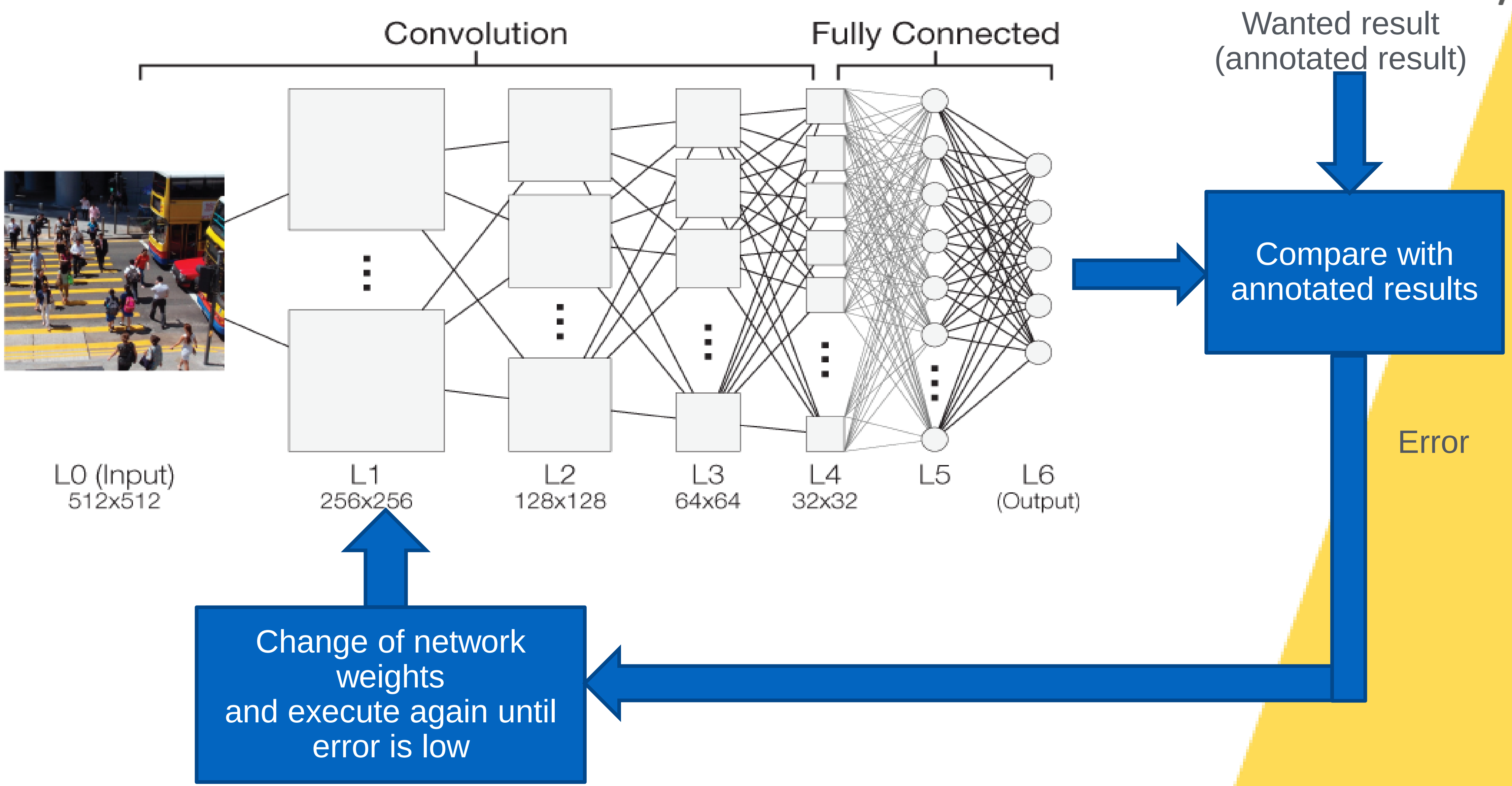
Tier 2

Tier2, like Smart Eye, is direct supplier of systems to Tier1 as well as supplier to OEM for research and ground truth purposes

What is AI?

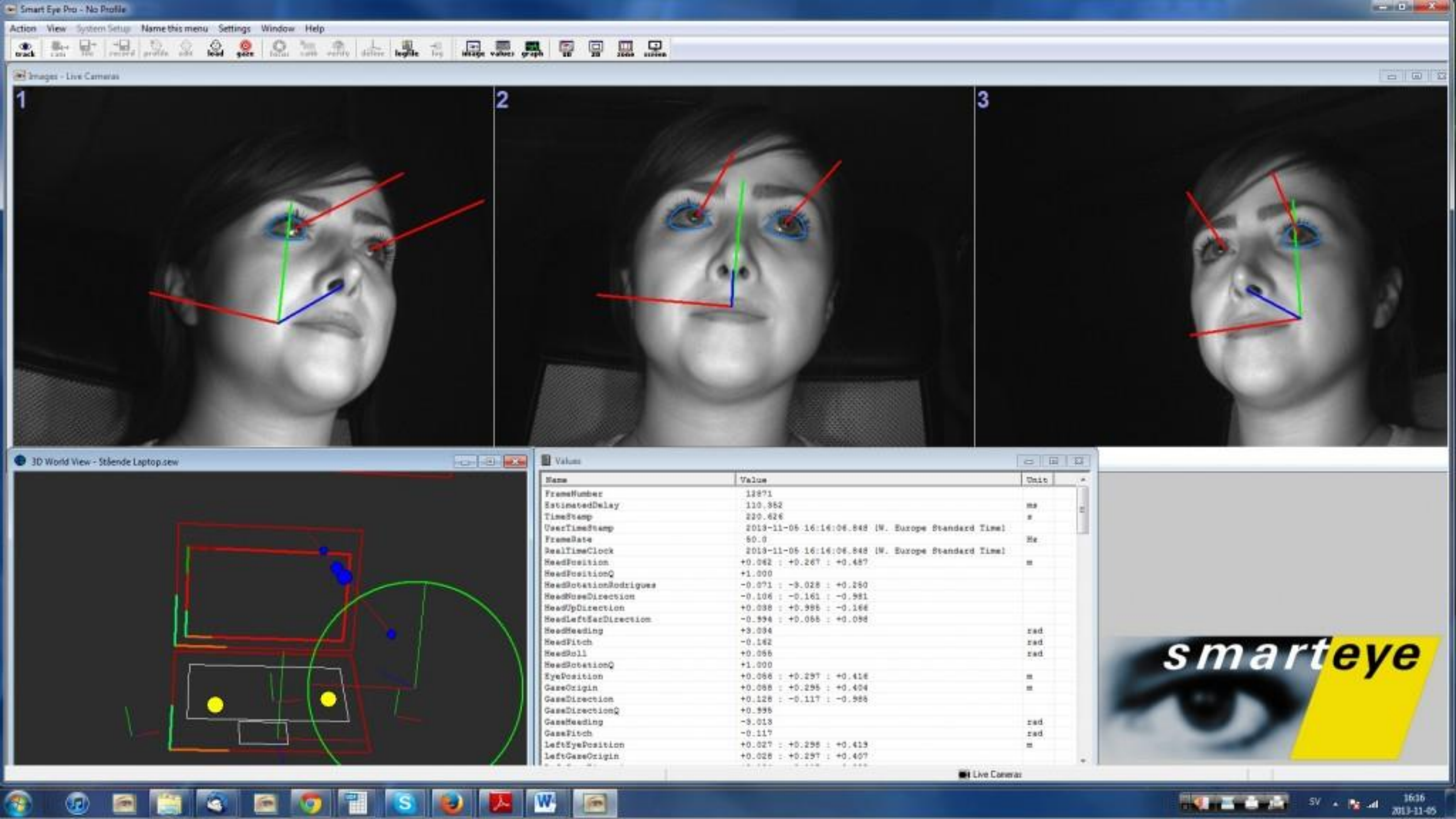
- New programming paradigm inspired by neurons
- Revolutionized new development within vision and speech (Google home)
- Faster development by allowing a computer select weights in the neural network until the best fit for thousands of example images is achieved
- Examples need to be collected and annotated with the wanted answer
- Need higher performance to execute compared to standard vision algorithms

Neural networks and training



Driver monitoring systems

- Human factor is the cause of most on road accidents (like distraction or just looked in the wrong angle)
- Approximatelly 20% of the fatalities on road are due to drowsiness
- In highly automated vehicles where driver will take over a fittness to drive is important
- EU laws will soon require DMS on new vehicles
- EuroNCAP is now pushing for DMS


Smart Eye Pro - No Profile
Action
View
System Setup
Name this menu
Settings
Window
Help
track
load
gaze
logfile
image
values
graph
2D
3D
zoom
screen
Images - Live Cameras
1
2
3
3D World View - Stående Laptop.sew
Values
Name
Value
Unit
FrameNumber 12871
EstimatedDelay 110.352 ms
TimeStamp 220.626 s
UserTimeStamp 2013-11-05 16:16:06.848 (W. Europe Standard Time)
FrameRate 60.0 Hz
RealTimeClock 2013-11-05 16:16:06.848 (W. Europe Standard Time)
HeadPosition +0.062 : +0.267 : +0.487 m
HeadPositionQ +1.000
HeadRotationRodrigues -0.071 : -3.028 : +0.250
HeadNoseDirection -0.106 : -0.161 : -0.981
HeadUpDirection +0.038 : +0.985 : -0.166
HeadLeftEarDirection -0.994 : +0.055 : +0.098
HeadHeading +3.034 rad
HeadPitch -0.162 rad
HeadRoll +0.056 rad
HeadRotationQ +1.000
EyePosition +0.066 : +0.297 : +0.416 m
GazeOrigin +0.068 : +0.295 : +0.404 m
GazeDirection +0.128 : -0.117 : -0.985
GazeDirectionQ +0.995
GazeHeading -3.013 rad
GazePitch -0.117 rad
LeftEyePosition +0.027 : +0.298 : +0.419 m
LeftGazeOrigin +0.028 : +0.297 : +0.407
smarteye
Live Cameras
SV
16:16
2013-11-05

Driver monitoring HW technology

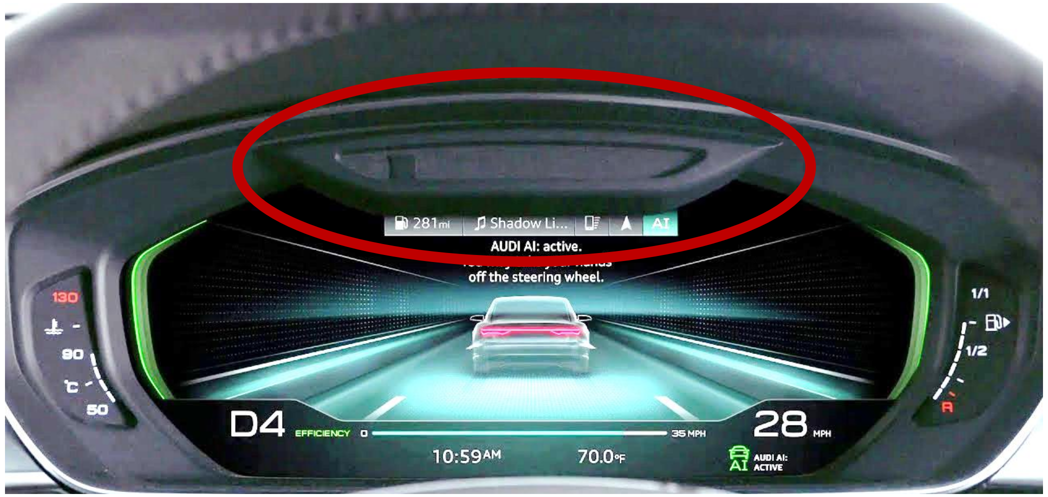
- **Support gaze tracking in all angles and headposes.**
  One up to 4 cameras (vehicles)

- **Environmental light invariance**
  Active flash illumination
  Imager with global shutter

- **Configurable head/eye tracking headbox**
  Supports from VGA to 2.3 Megapixel resolution cameras

- **Invisible light source**
  940 nm IR light using LED or VCSEL

Examples of DMS packaging



S8 - Courtesy of Audi

X5 - Courtesy of BMW

Smart Eye core software algorithms pre AI

Computer vision based and some machine learning

- **Head Tracking** – in 6DOF using individual self-learning 3D head-model. Feature points, like eye corners is positioned in 3D space even during occlusions.
- **Eye Tracking** – gaze and eye lid
- **Mouth tracking – speaking/not speaking**
- **Driver Identification with spoofing rejection** – for automotive use-cases

---

- <u>**New features**</u>
- **Facial Expression**
- **Region of interest filters** Eyes on road, mirrors, instrument cluster
- **Drowsiness** Sleepiness prediction and Microsleep detection
- **Inattention warning** Not paying attention to the forward road

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Smart Eye core software algorithms as of today

smart eye

Yellow marked is to significant extent based on AI algorithms – Deep Neural Networks

- Head Tracking – in 6DOF using individual self-learning 3D head-model. Feature points, like eye corners is positioned in 3D space even during occlusions.
- Eye Tracking – gaze and eye lid
- Mouth tracking – speaking/not speaking
- Driver Identification with spoofing rejection – for automotive use-cases

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- New features
- Facial Expression
- Region of interest filters Eyes on road, mirrors, instrument cluster
- Drowsiness Sleepiness prediction and Microsleep detection
- Inattention warning Not paying attention to the forward road

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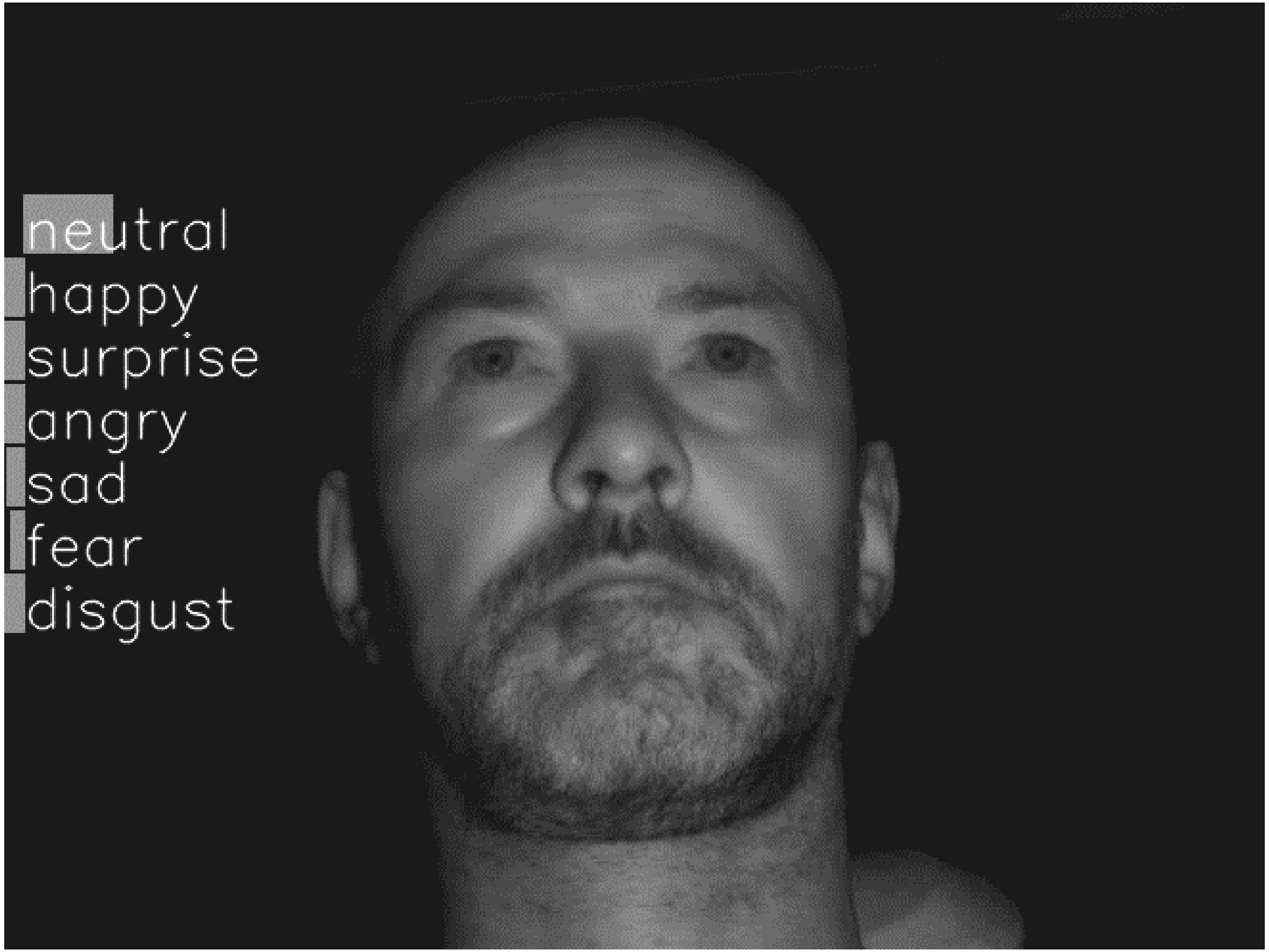
DMS Facial Expressions

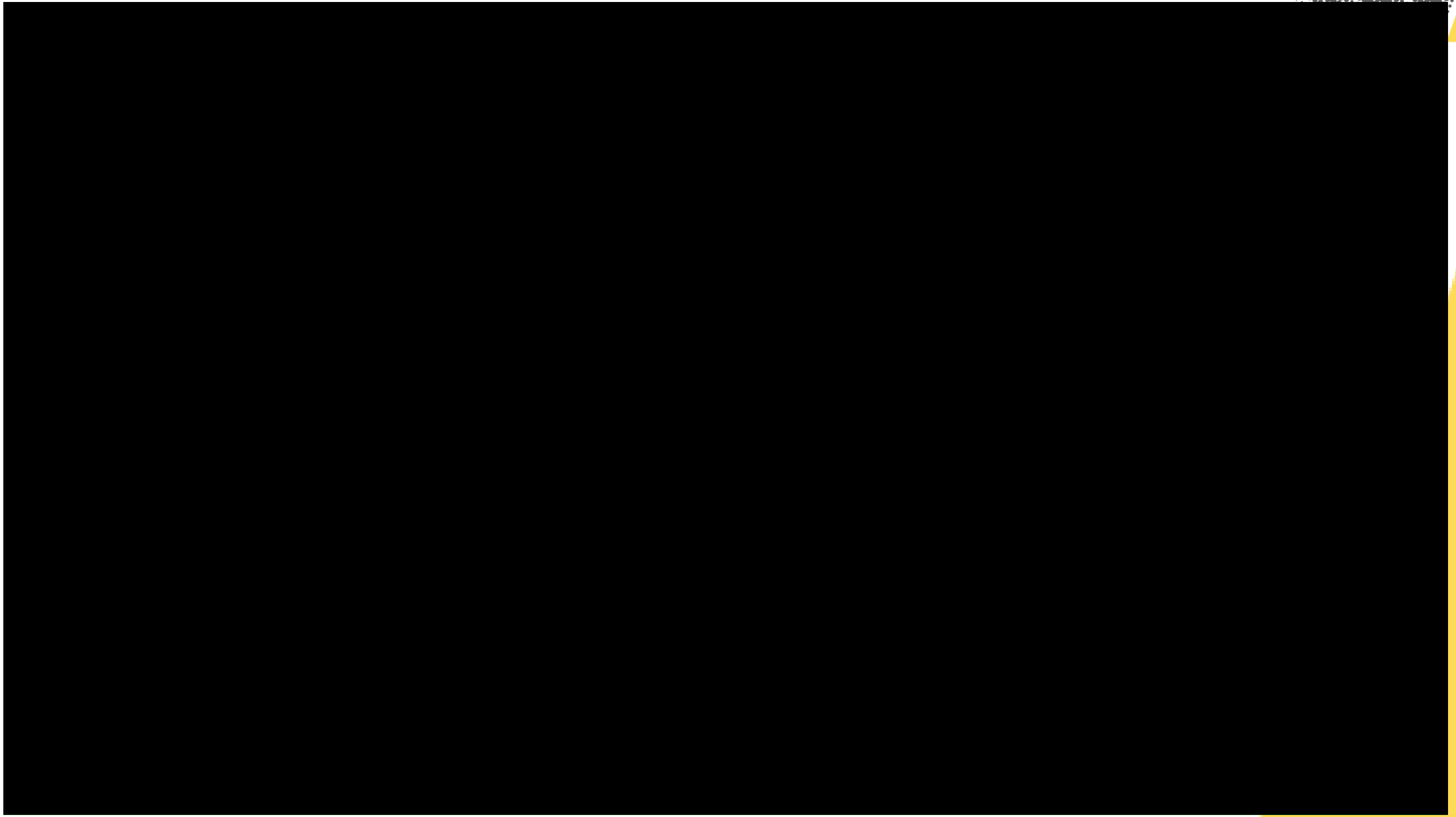



smart eye
Interior
sensing

Interior sesning using Smart AI

smart eye

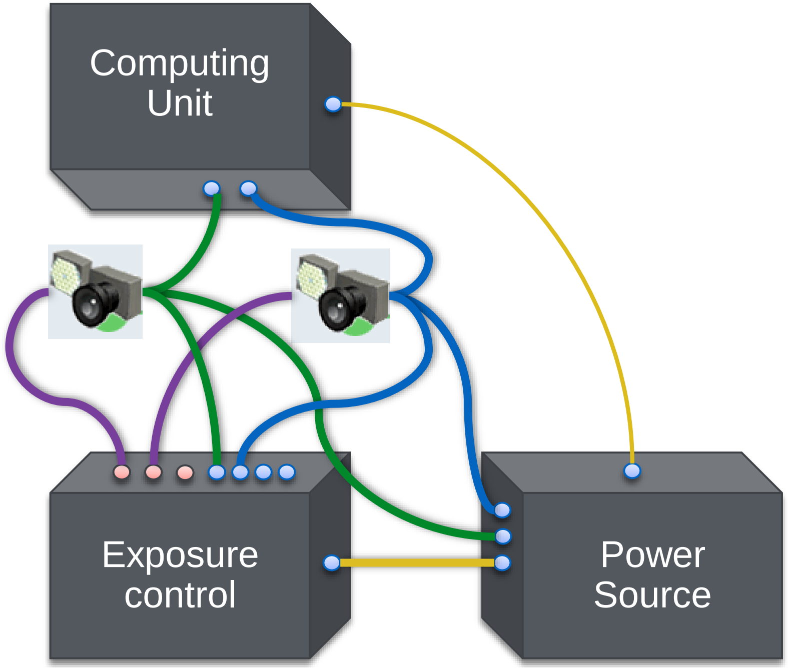
- Develop a model for integration of AI type of technologies on scalable platforms
- Using AI- technology and computer vision in combination to achieve high update rate on accelerated architectures and good performance and update rate on non accelerated architectures.
- Adopting enhanced colour sensors to provide full detection in darkness

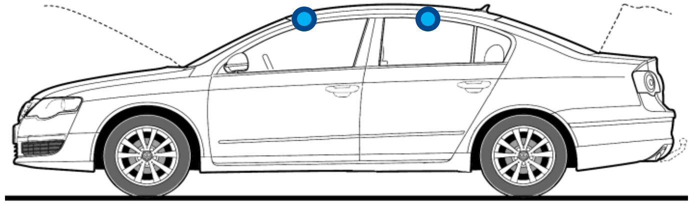


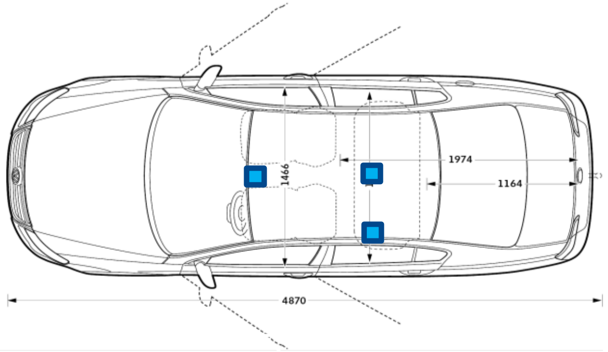
Courtesy of Daimler

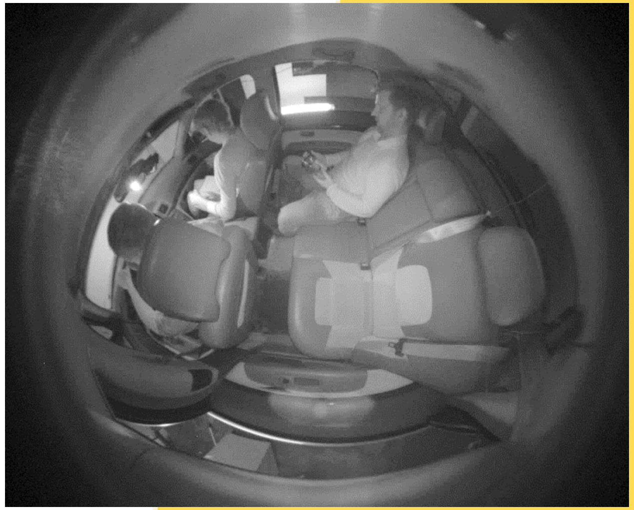
Hardware example for the interior sensing: RGB-IR camera system with fisheye lens

- Camera(s) (2Mpix, 30-60Hz, GMS/USB3)
  + lens(es) (DSL-180B, fisheye 160-200 deg lens)
  + filter(s) (Dual bandpass visible+940nm)
- IR illuminators
- Computing unit (ECU)
- Exposure control
  (for synchronization of cameras
  and IR-flash illuminators)
- Power source









Automated vehicle use-cases

Courtesy of Volvo Cars

Interior sensing: Object recognition

smart eye

Why do we need to identify objects?

- Seat occupancy
- Comfort
  - Not to forget your lunch or umbrella in the vehicle
  - Not to forget your purse or laptop or phone in the taxi
  - Body gestures
- Safety
  - To see if the seat belt is fastened
  - To make sure that the child is not forgotten in the vehicle
- Actions
  - What are the actions of passengers

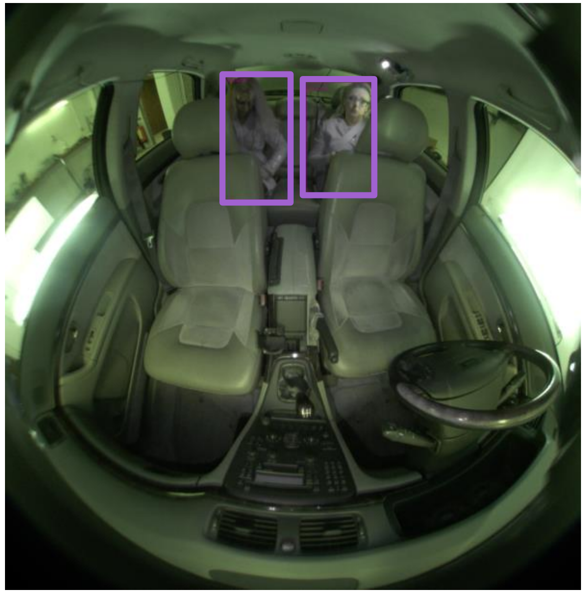
List of object classes:

1. Person
2. Baby
3. Human face
4. Glasses
5. Hat
6. Child seat
7. Book
8. Mobile phone
9. Tablet computer
10. Watch
11. Umbrella
12. Keys
13. Cigarette
14. Cigarette pack
15. Lighter
16. Carry bag
17. Backpack
18. Bottle
19. Mug
20. Tin can
21. Banana
22. Apple
23. Rice ball
24. Sandwich
25. Lipstick
26. Mascara
27. Clothing

Seat occupancy detection

Front-seat camera
(Occluded face case)

Front-seat camera
(Blurry image case)



Front-seat camera
(Back-seat passengers case)

Rear-seat camera
Baby detection

Interior sensing:
Body pose recognition

smart eye

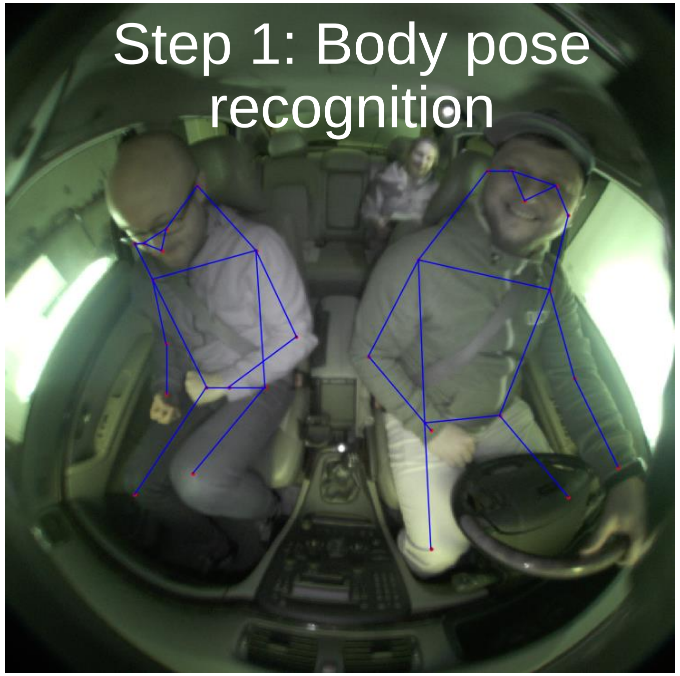
Why do we need to identify body pose?

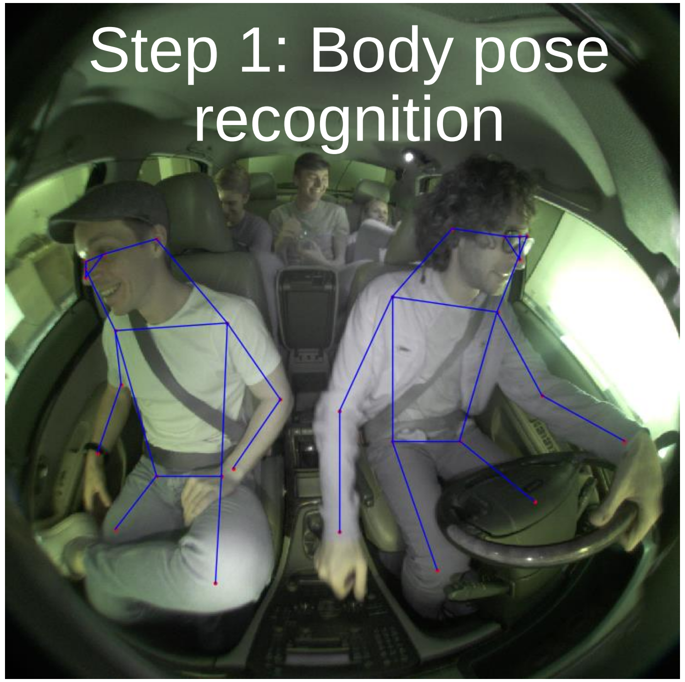
- Comfort
  - L3+: Adjust the way to drive
  - Gestures
- Safety

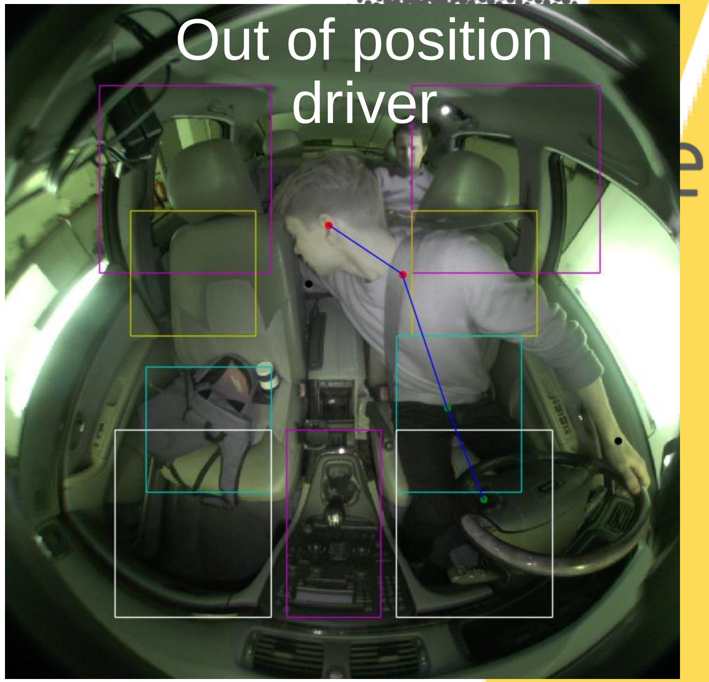
  To detect if person is out of position
- Support action recognition

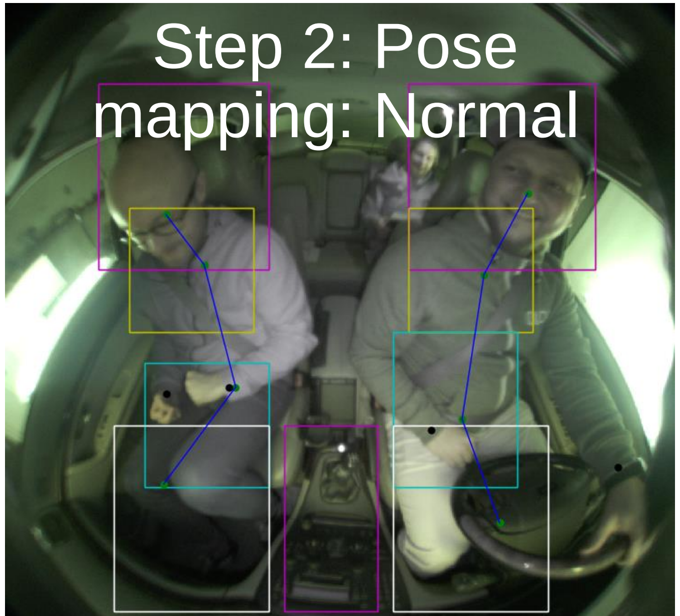
Keypoints that are currently being predicted are:

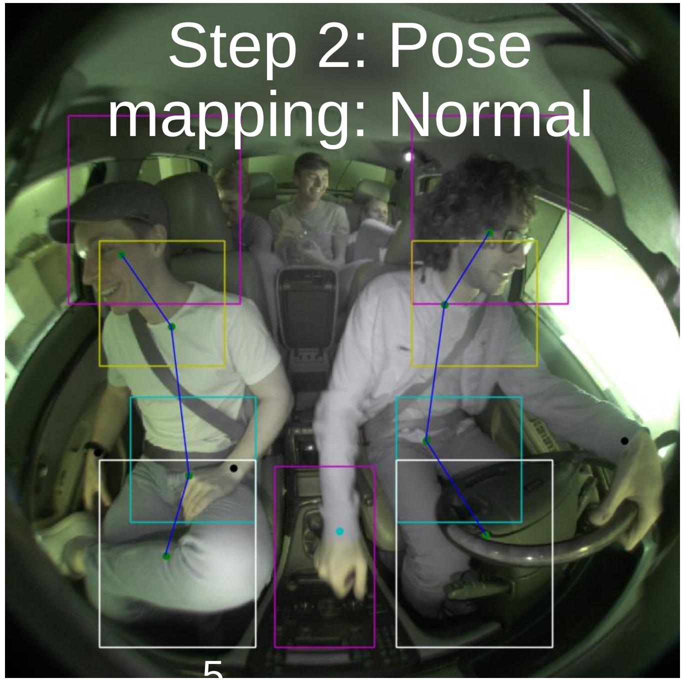
1. Nose
2. L/R Eyes
3. L/R Ears
4. L/R Shoulders
5. L/R Elbows
6. L/R Wrists
7. L/R Hips
8. L/R Knees

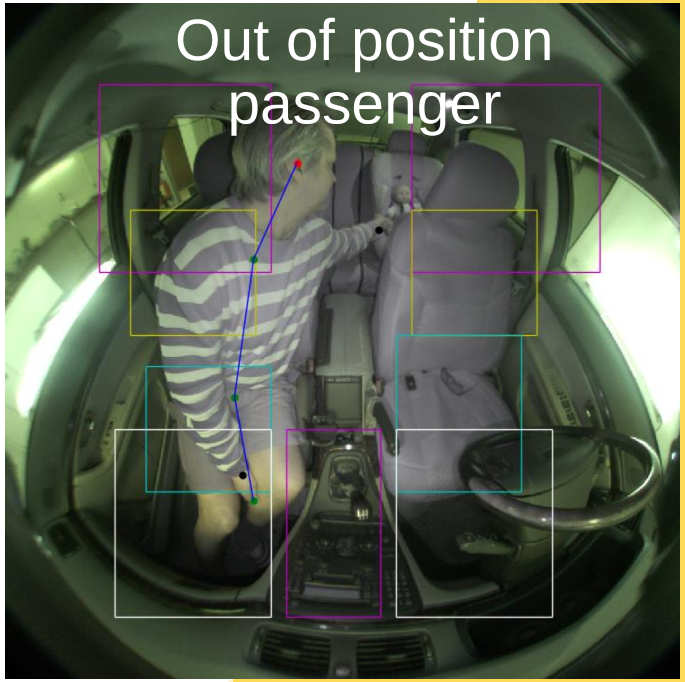

Step 1: Body pose recognition


Step 1: Body pose recognition


Out of position driver

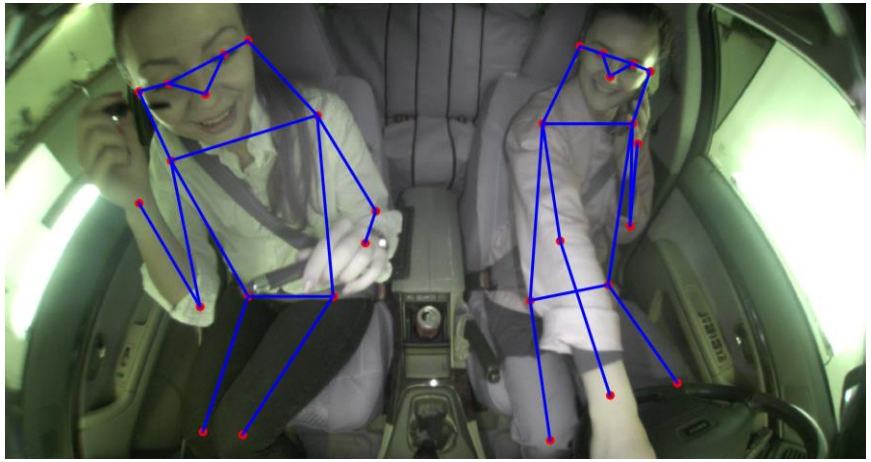

Step 2: Pose mapping: Normal


Step 2: Pose mapping: Normal


Out of position passenger

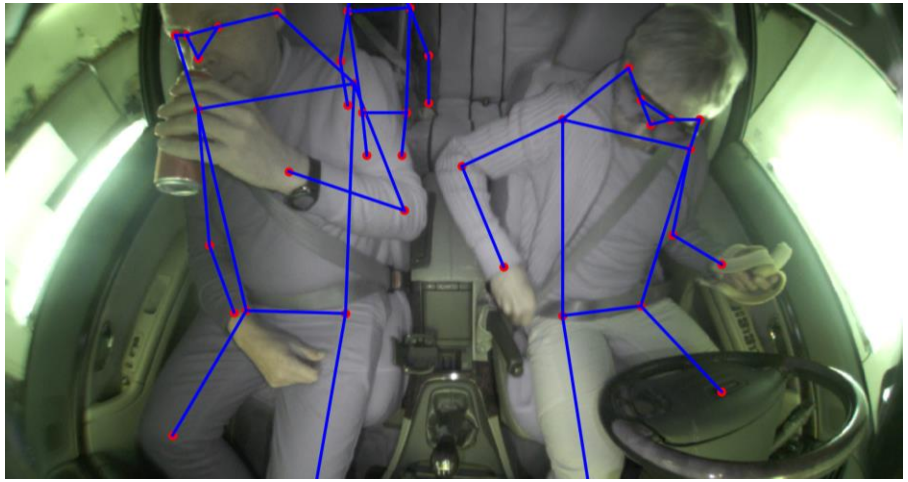
2019-09-26

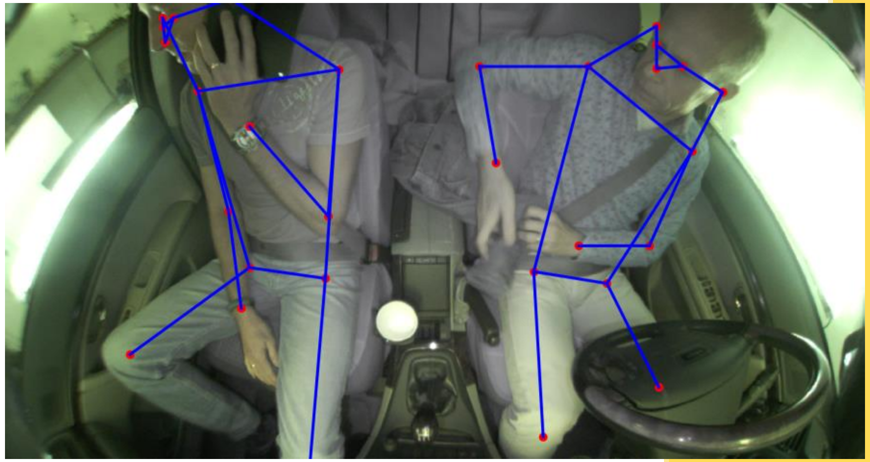
Body pose recognition w. action recognition



Driver is talking on a phone
and
Passenger is putting on make-up

Driver is eating banana
and
Passenger is drinking from a can

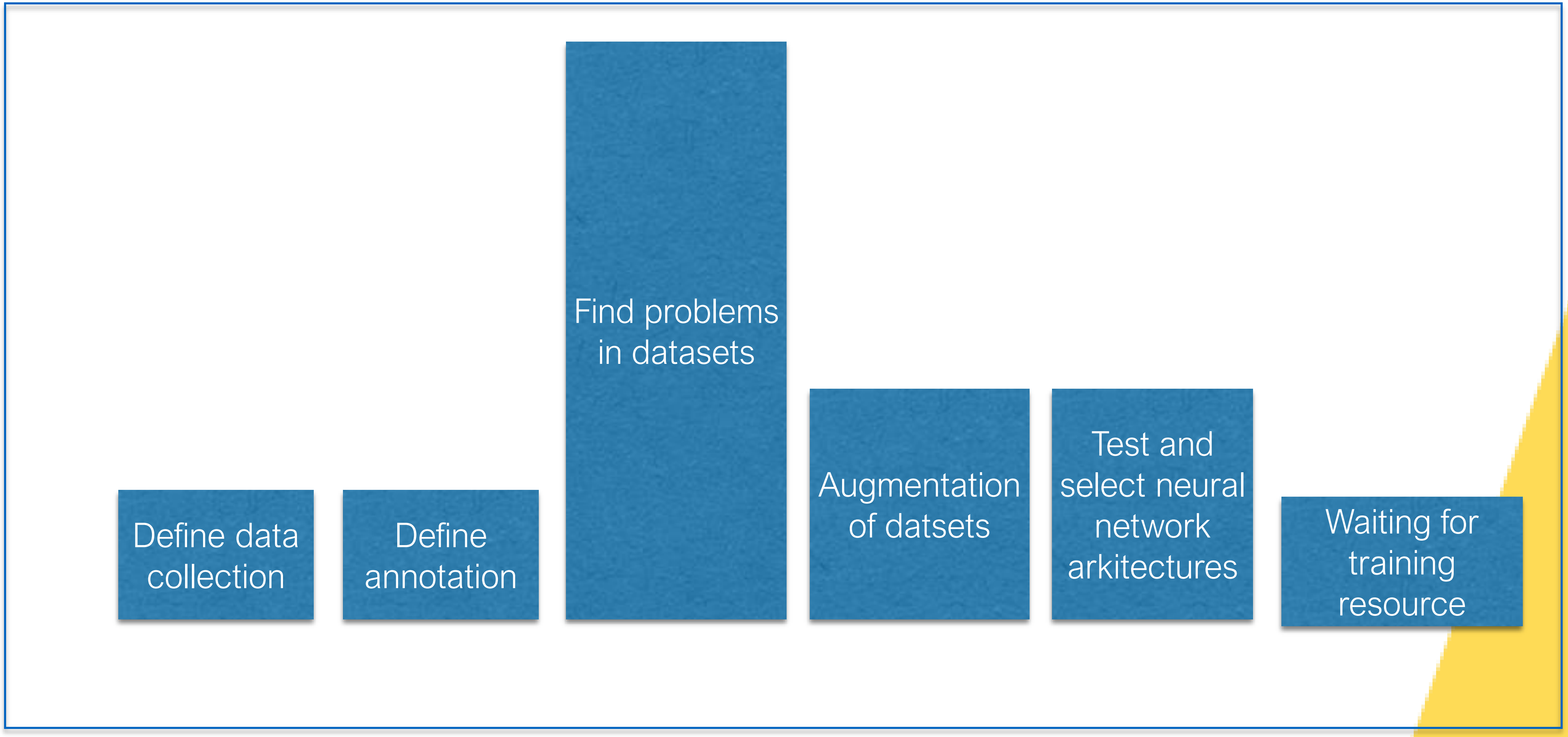




Driver is puting away jacket
and
Passenger is talking on a phone

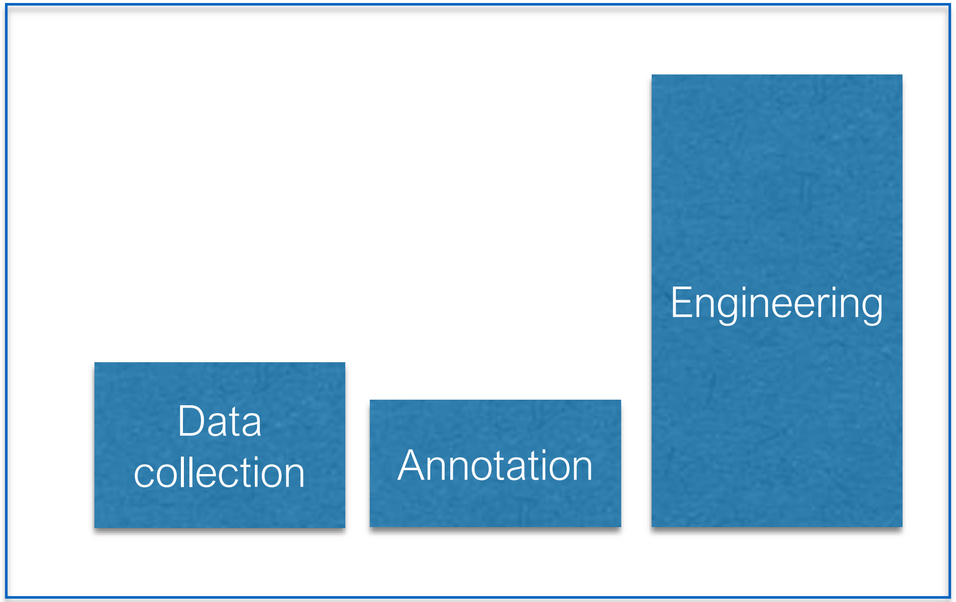
Organisation when adopting AI

An AI engineers work week

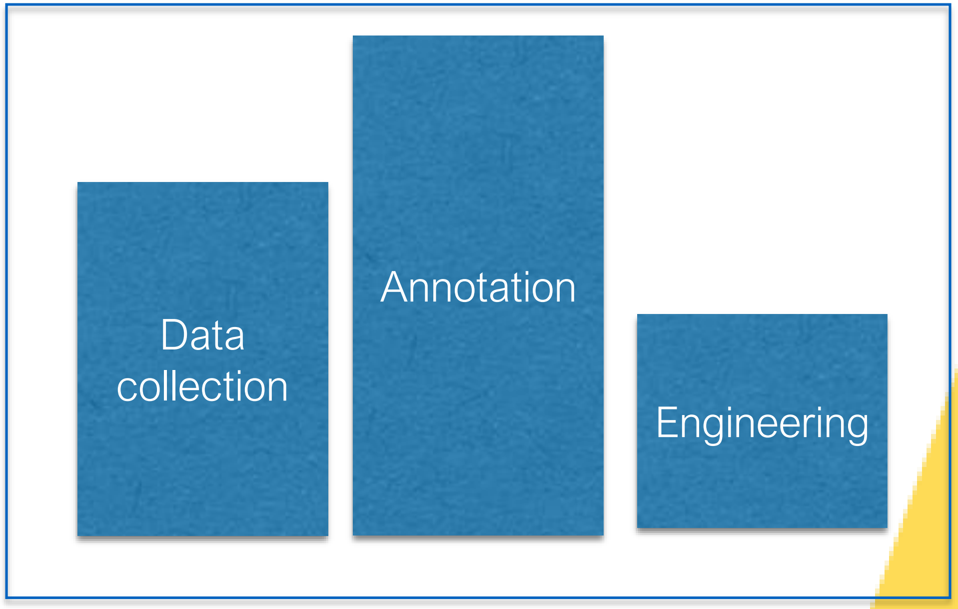


Work investment pre AI and AI

Pre AI effort



AI effort



Organisation

Data management

Data collection
Annotation
Storage

Development

AI engineers

IT

Training computers
Storage

Sum up

Use cases in highly automated vehicle brings new opportunities for in-cabin sensing supported by AI driven applications.

Driver monitoring will increase in adoption during the next 10 year period

- **Safety (NCAP and EU type approval)**
- **Gradual increase of automation level with driver responsible and in the loop**

Not every one is fit to become an AI engineer

AI requires a supporting organisation

Thank you!

We support projects incorporating DMS and interior sensing

Contact:
Henrik Lind
henrik.lind@smarteye.se
+46 708 444898

Panel

Presenting the exhibitors

Networking break
see you back at 15.20!

ZENUITY

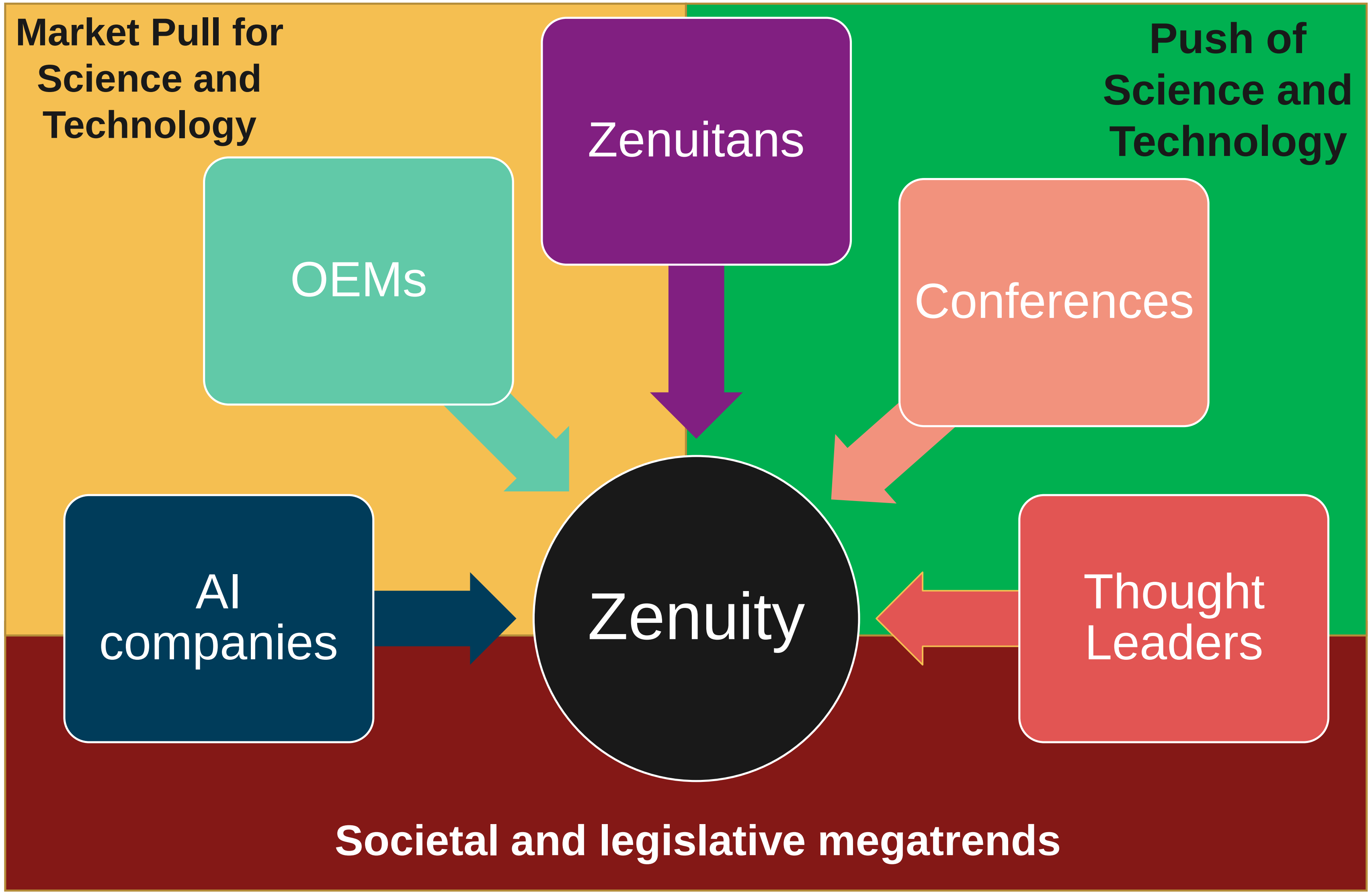
What we know that we don't know

Mats Nordlund
Director Research

Key Questions

- What are the key challenges that need to be solved
- How are we thinking about addressing these challenges?
- Who are the key players that we can work with?

Key Sources of Information



Key Challenges

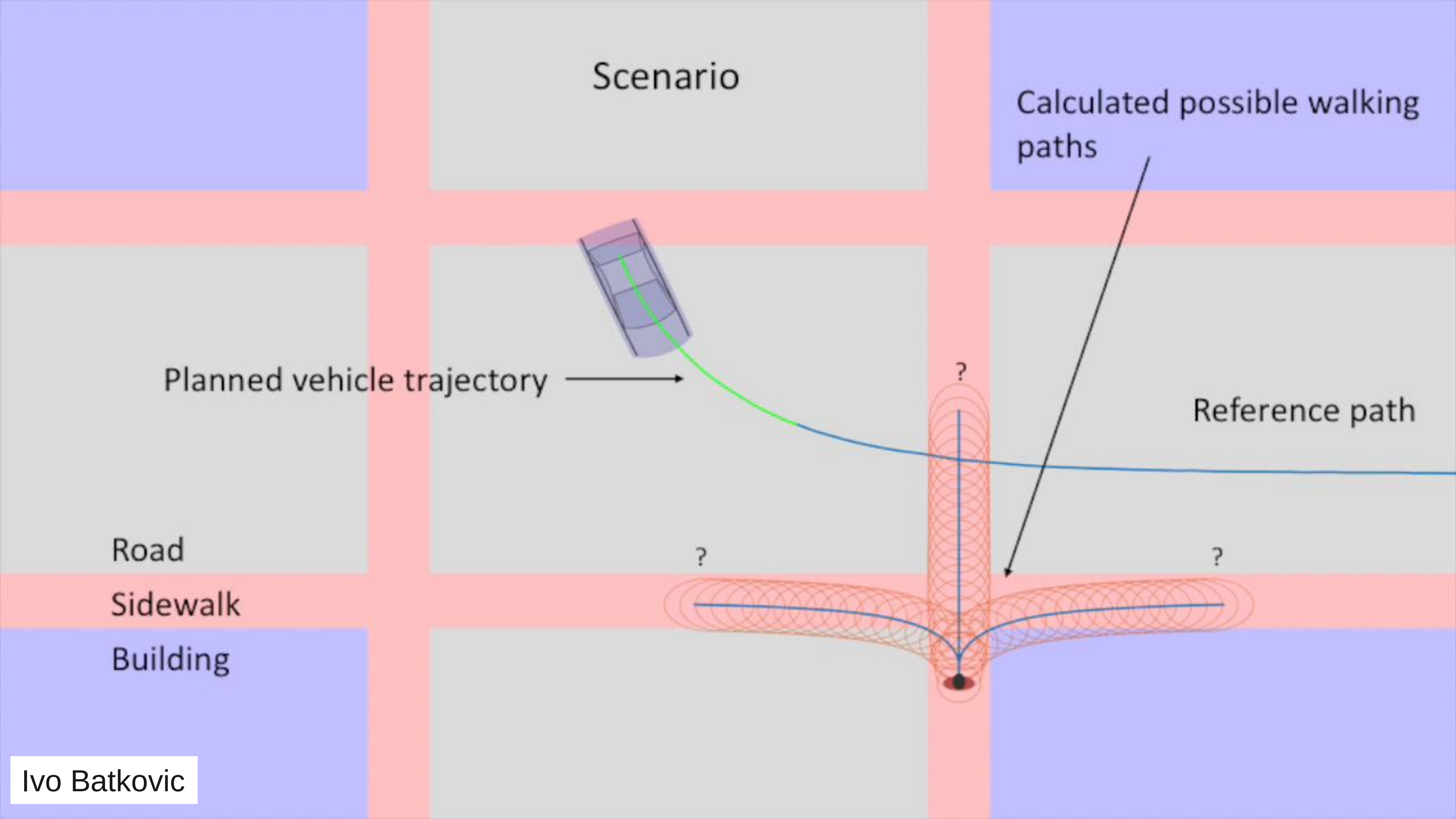
- What will other road users do next (**intent**)?
- How do we **train networks** efficiently (data management, hardware, etc)?
- How can we **easily replace one or more sensors** without re-training the entire neural networks?
- How do we **prove completeness in safety** argumentation?
- What will be the **future legislative and regulatory environment**?


Despite High Hopes, Self-Driving Cars Are 'Way in the Future'

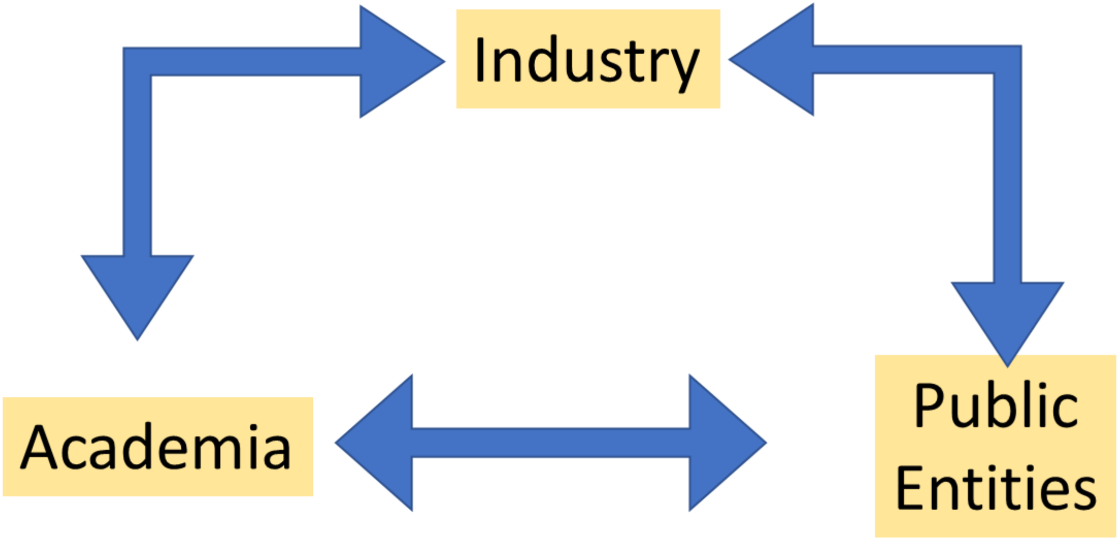
Ford and other companies say the industry overestimated the arrival of autonomous vehicles, which still struggle to anticipate what other drivers and pedestrians will do.

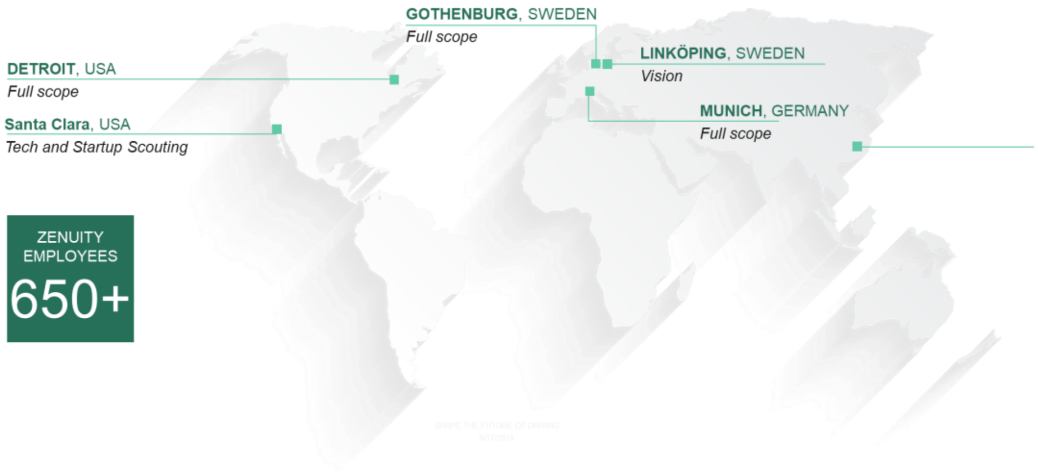
NYT 17 Jul 2019

Why interaction is hard?


Scenario
Calculated possible walking paths
Planned vehicle trajectory
?
Reference path
Road
?
?
Sidewalk
Building
Ivo Batkovic

How - Leverage the Ecosystem at our Global Locations





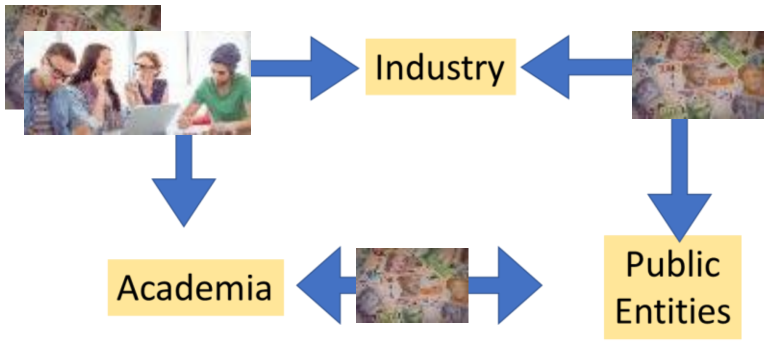
Knowledge Transfer in People – Industry PhD Students

In Sweden since 1990s

Industry PhD Program

- Students – A Key Interface Mechanism

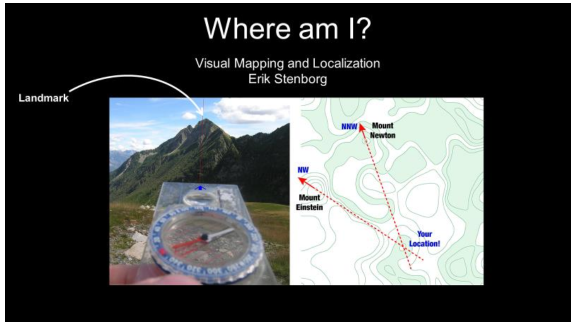
Employ high potential students, send them to university, co-fund with government and foundations



Zenuity Advanced Graduate Program

- 11 Industry PhD Students
- Research areas
  - Pedestrian prediction
  - Verification processes
  - Safety in Autonomous Cars
  - Applications of ML/DL to Perception and Decisions
  - Positioning and Route Prediction

Example Advanced Graduate Projects



WHERE ARE EVERYONE ELSE?

LEARNING 3D PERCEPTION FROM ONE CAMERA

ESKIL JÖRGENSEN

Automated Driving in Complex Environments

Ivo Batkovic

ZENUITY

How to interact with road users?

Dapeng Liu

2019-02-18 How to interact with road users

WHERE CAN WE DRIVE?

SAMUEL SCHEIDEGGER

ZENUITY

WHICH SHOULD A SELF DRIVING CAR CHOOSE?

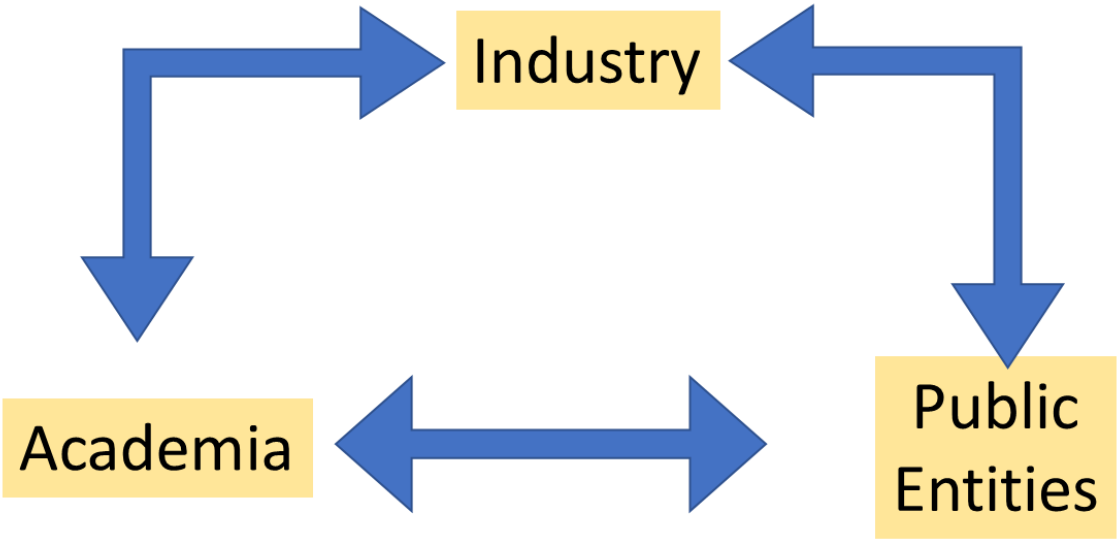
ZENUITY

WHAT CAN GO WRONG?

YUVARAJ SELVARAJ

ZENUITY

The Key Players – Constantly Changing



Thank you!

Mats.Nordlund@zenuity.com

AUTOMATION

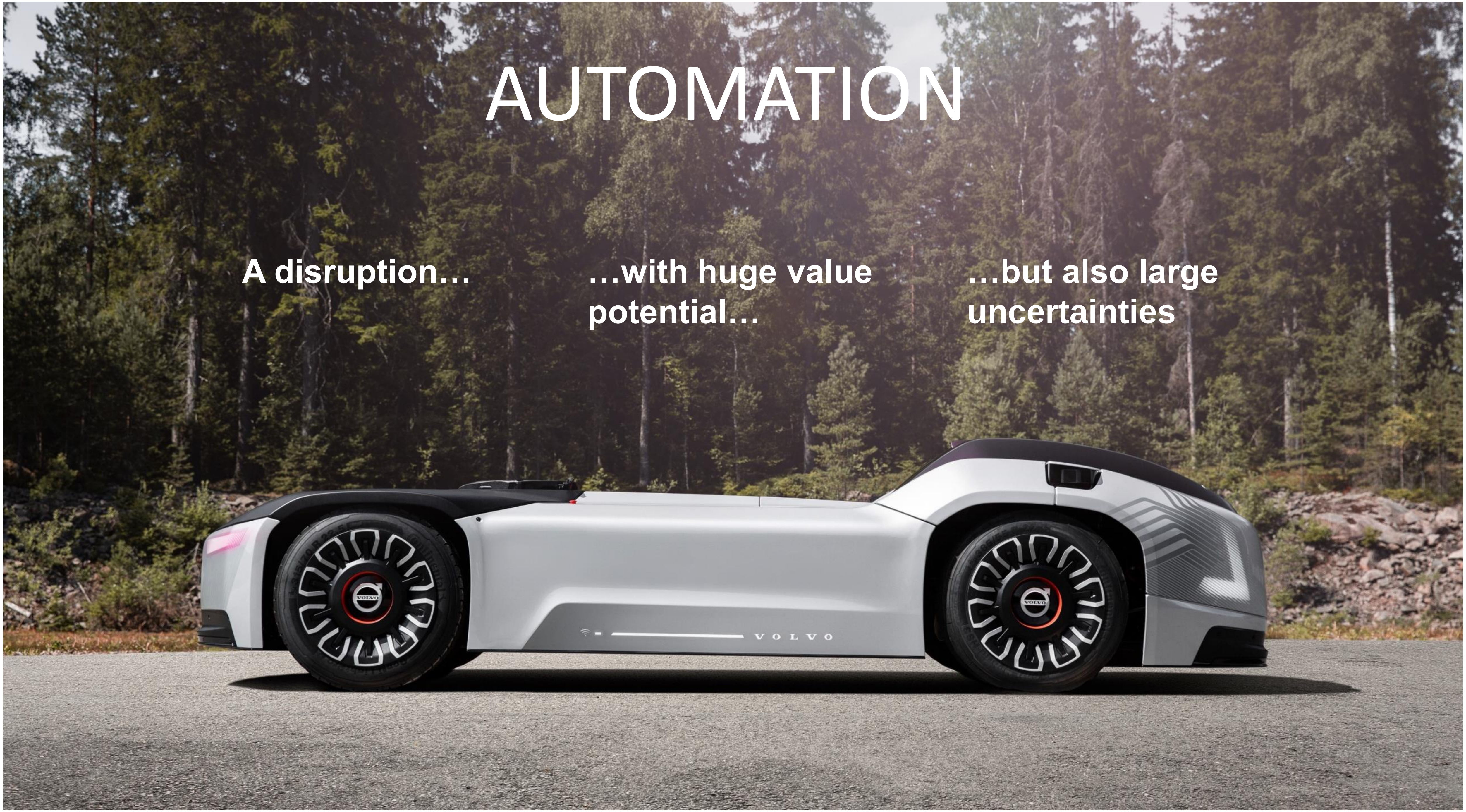
Sasko Cuklev
Director Autonomous Solutions
Volvo Trucks

AUTOMATION

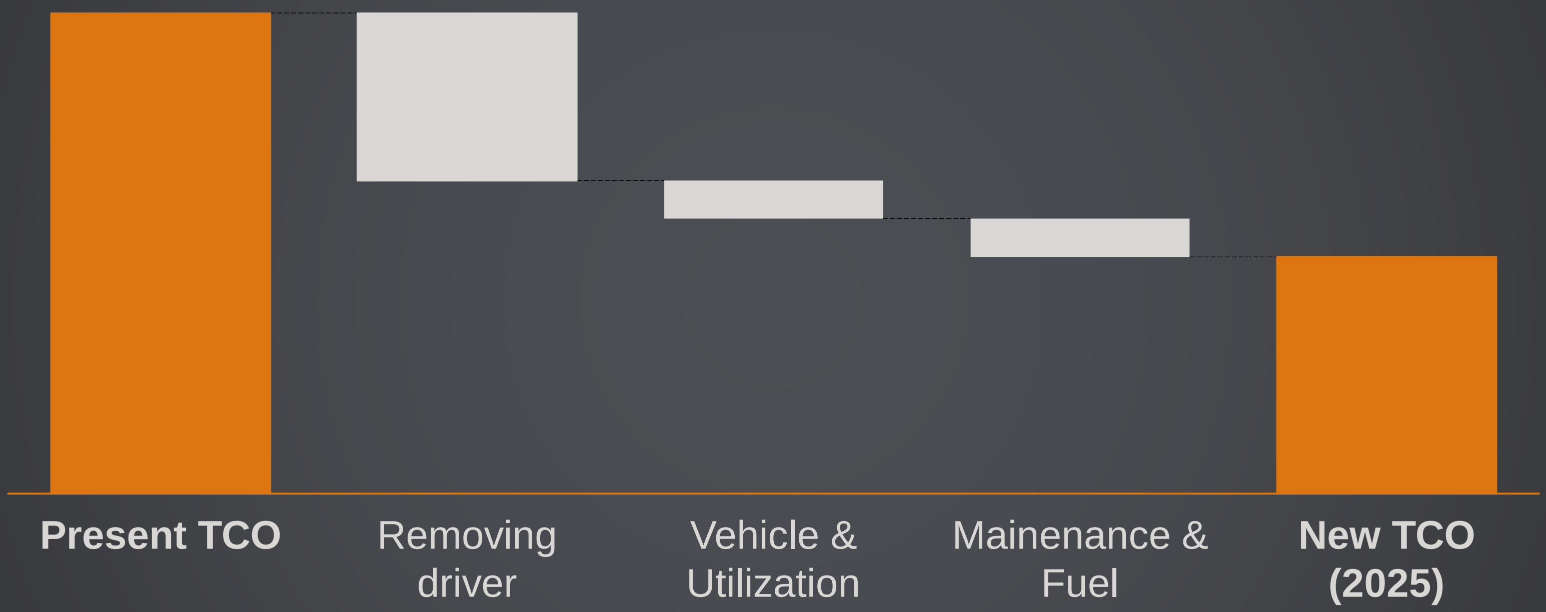
A disruption…

…with huge value potential…

…but also large uncertainties

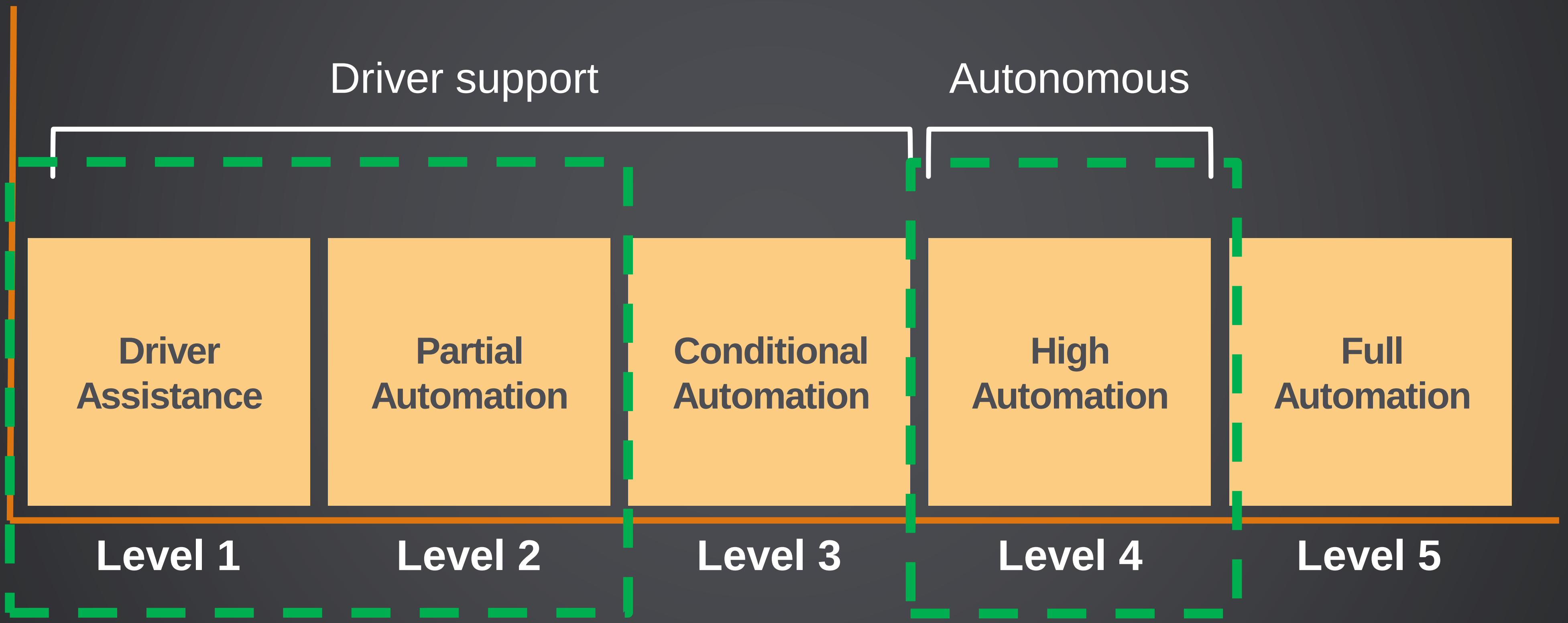


Huge Value potential



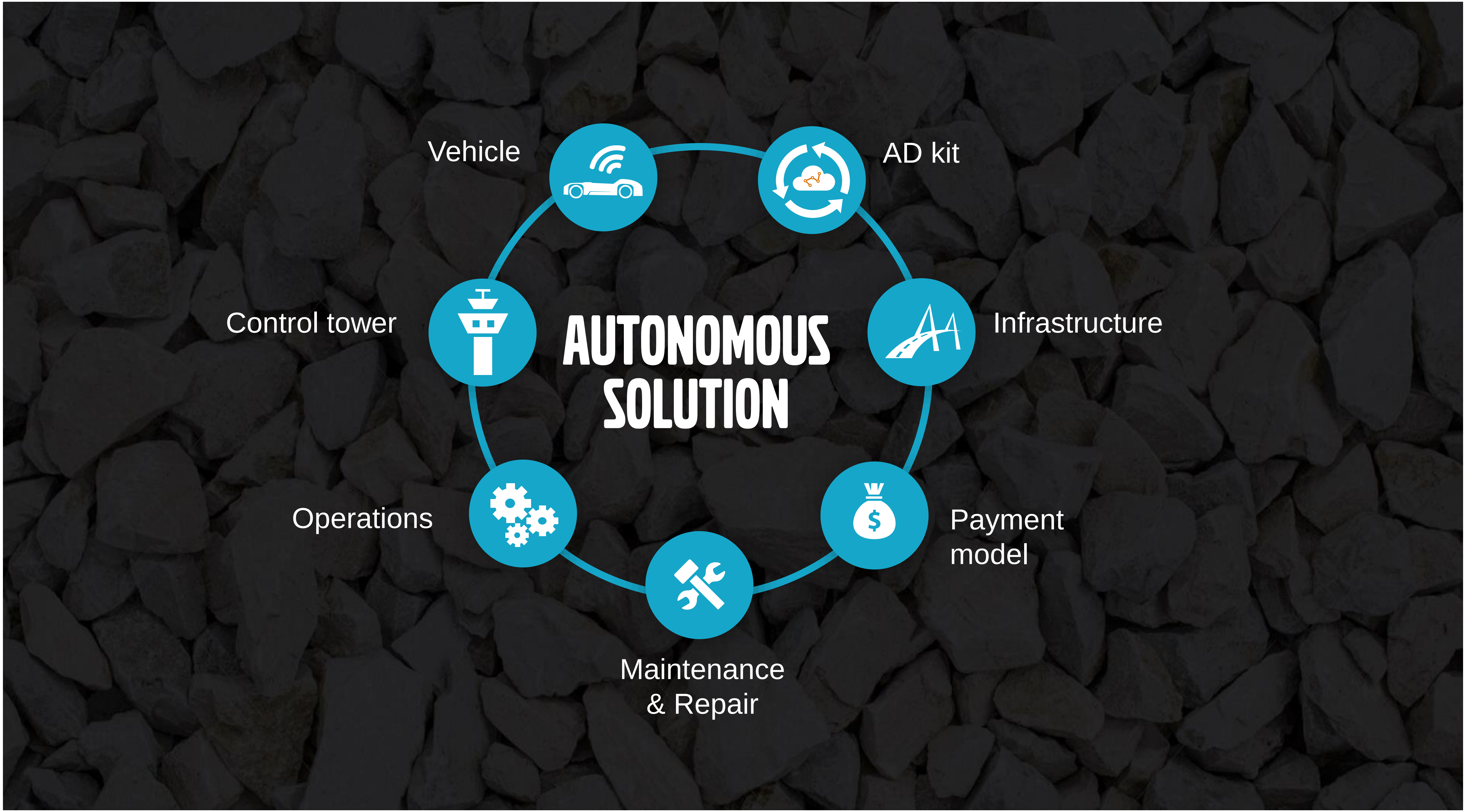
Safety | UPTIME | PREDICTABILITY | RELIABILITY

Different offers for different solutions

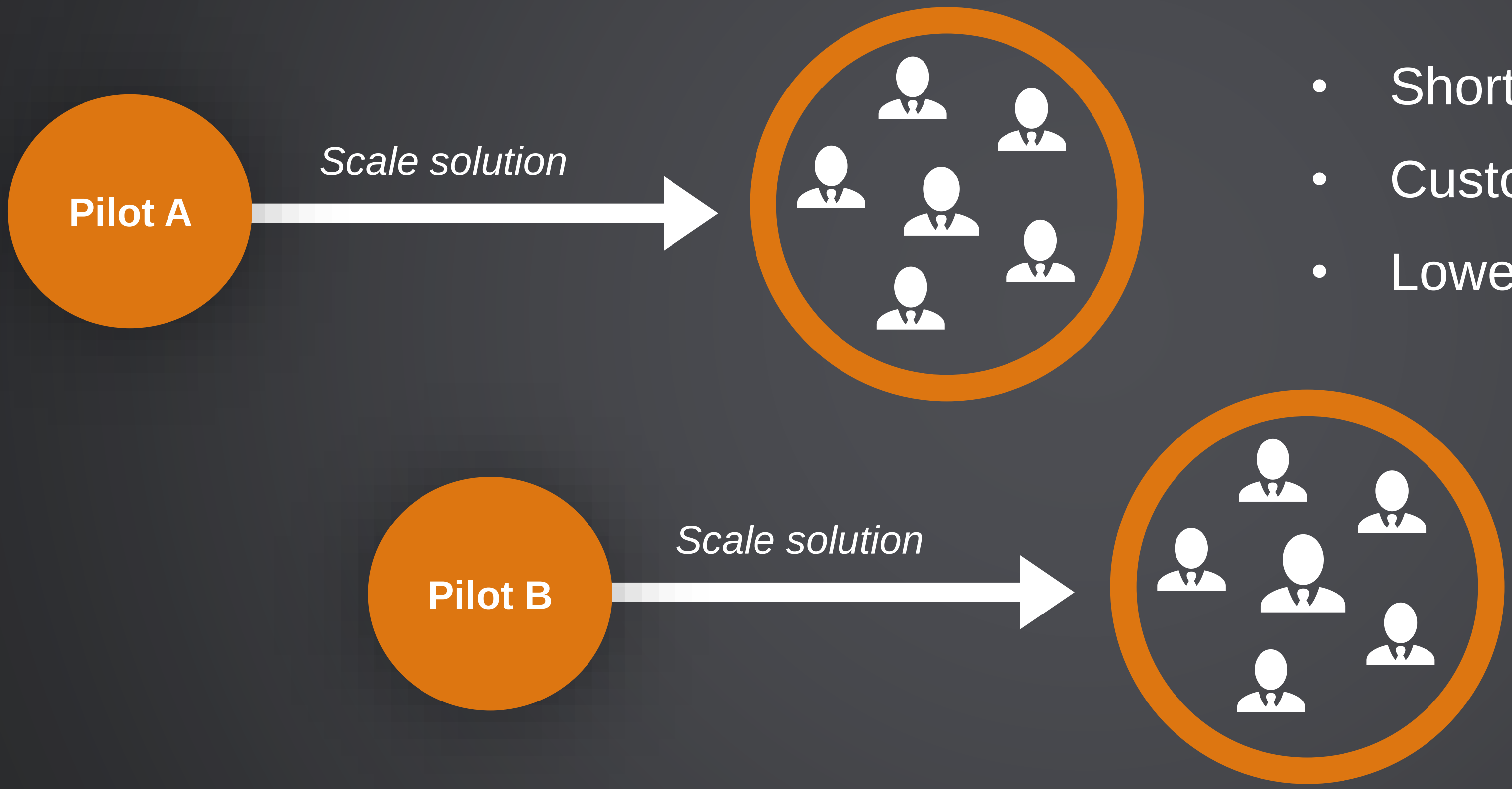


*SAE Stage Definition (SAE J3016)

SELLING AN AUTONOMOUS SOLUTION


AUTONOMOUS SOLUTION
Vehicle
AD kit
Control tower
Infrastructure
Operations
Payment model
Maintenance & Repair

APPLYING PILOT APPROACH



- Shorter time to market
- Customer involved development
- Lower development cost

ongoing pilots

CONFINED AREAS

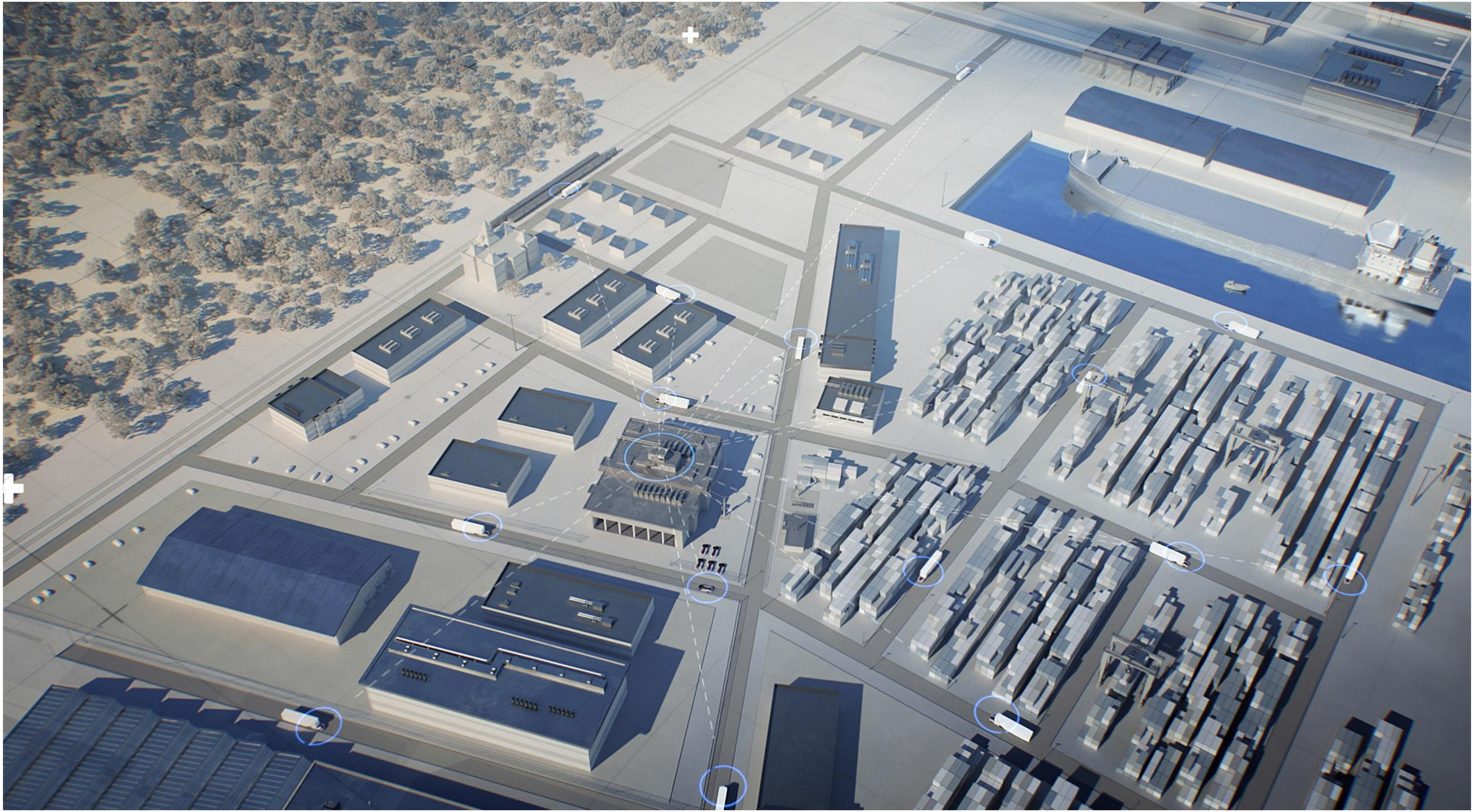
1. Mining

PUBLIC ROADS

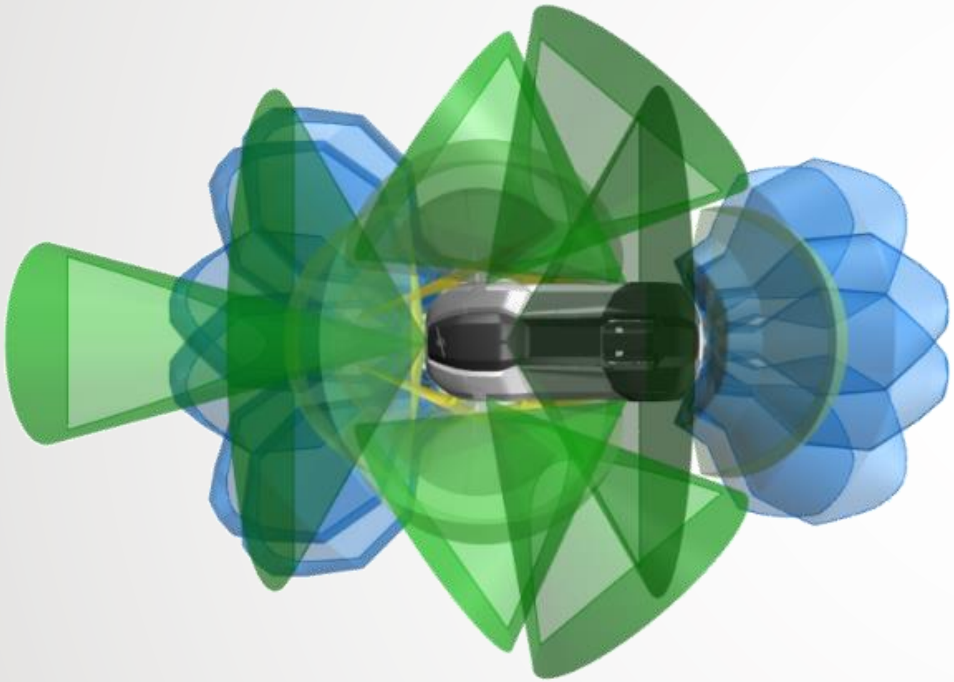
2. Hub-to-hub regional electric
3. Hub-to-hub Highway


VOLVO
FILM


VERA



Perception System



Some technical facts about this vehicle

- Energy capacity: 200 kWh
- Inductive charging: 30 minutes
- Range: 100 km
- Speed: < 40 km/h


EMBRACE THE POTENTIAL

sensible 4

AUTOMATED DRIVING IN THE ARCTIC

GEOFENCED OR SAE L5?

By Harri Santamala — CEO

GEOFENCED


SAE LEVEL 5

WHAT ABOUT
ODD CONDITIONS


ALL CONDITIONS

1985 — 1993 — 1998 — 2007 — **2018**

AV & WEATHER

For 365 days/year performance of Autonomous Vehicle, the automated platform should be validated in such environments.

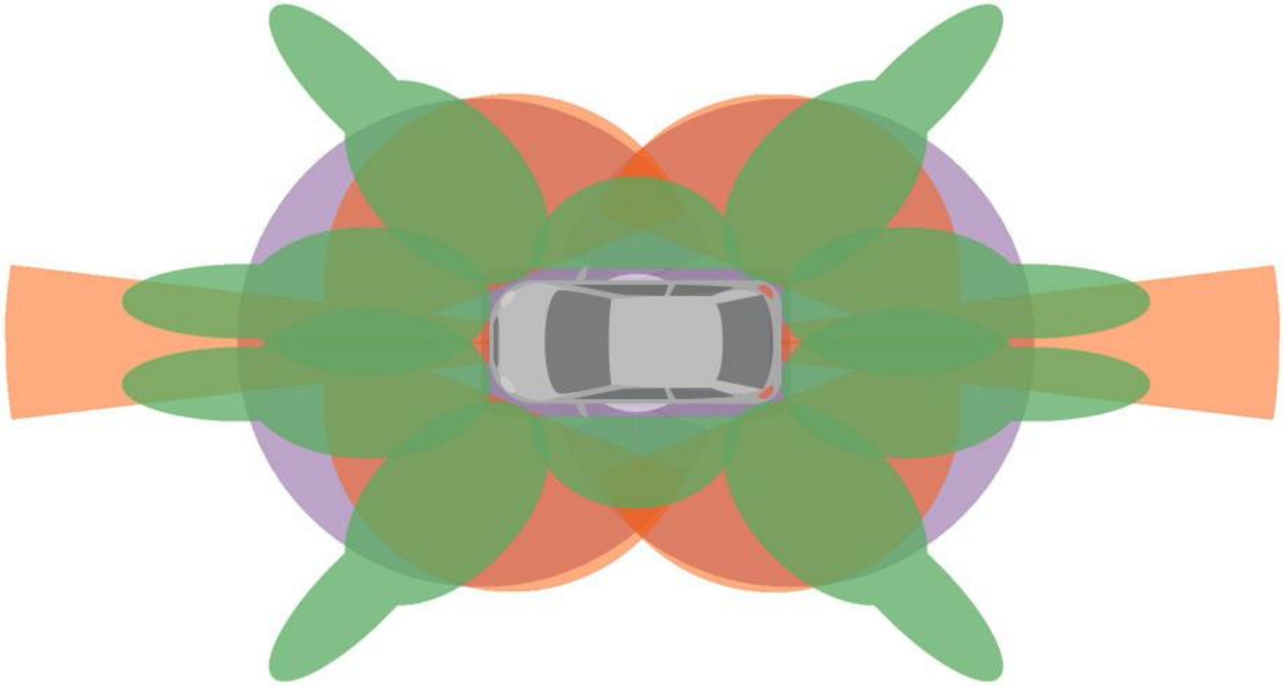
Snowstorm, Fog and Tropical Rain remain the **challenge** which hinders the rapid development of Autonomous Vehicle globally, particularly with respect in the positioning issue.

→

Subsequently, this yields unreliable AV performance in **bad weather.**

THE CHALLENGE OF BAD WEATHER

REDUNDANCY IN HARDWARE



1+1+1 = 3

2 VS 1 = 2

1 VS 1 = 0

WHAT ABOUT POSITIONING WITH CAMERA

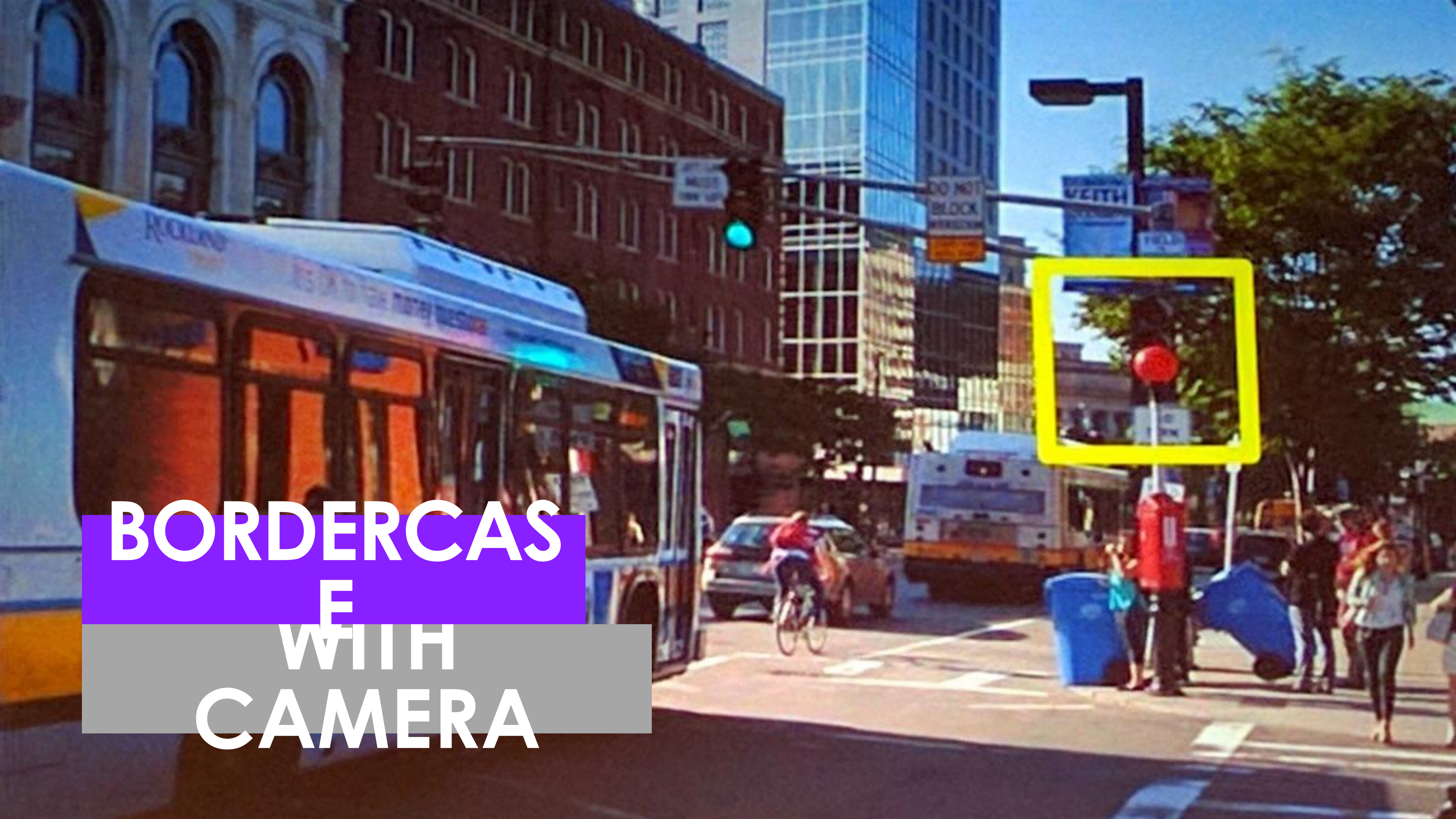
Positioning

- No lane markings
- Side of the road moves
- Plenty of white color
- Darkness
- Or low sun

As a result video-algorithms are bound to have severe problems if they work at all


BORDERCASE
WITH CAMERA

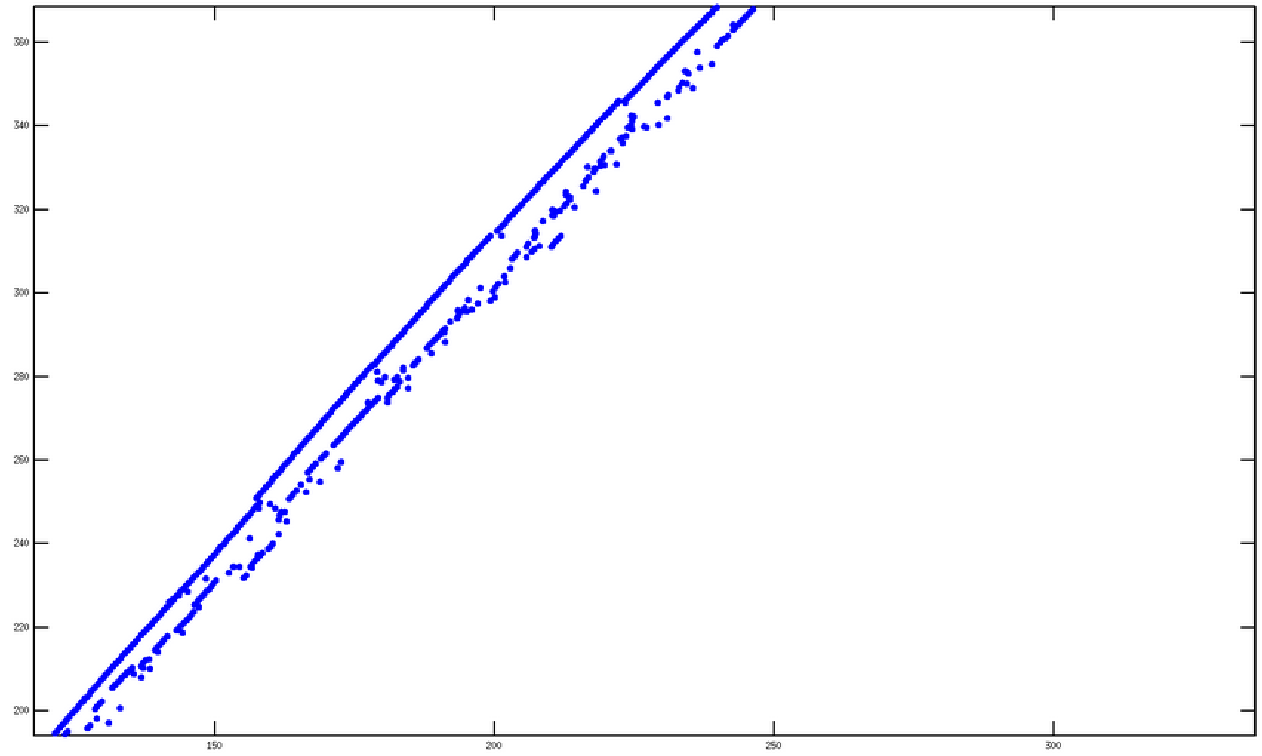
BORDERCASE WITH CAMERA



GNSS

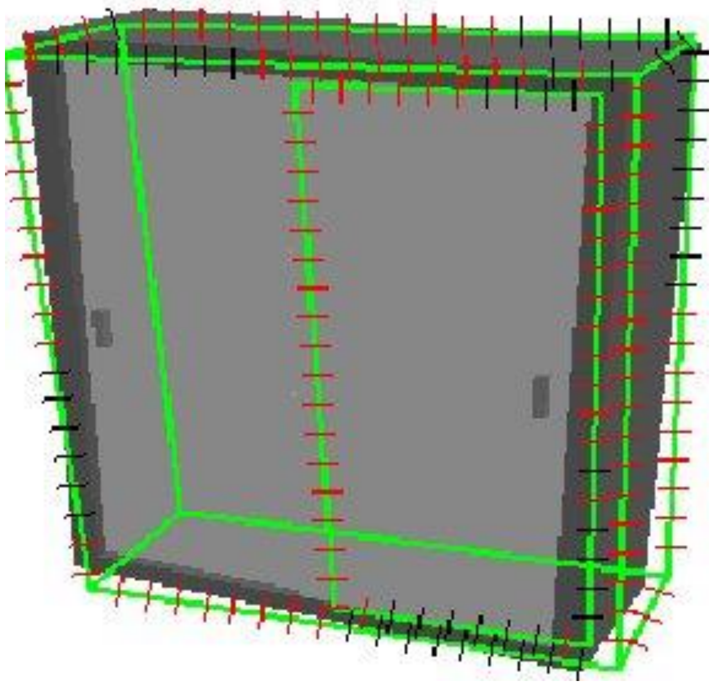
POSITIONING

- Satellites are not here
- Side of the road still moves
- Can GNSS be trusted by itself ?



LIDAR

- No built environment
- Feature based methods aka HD-maps are useless

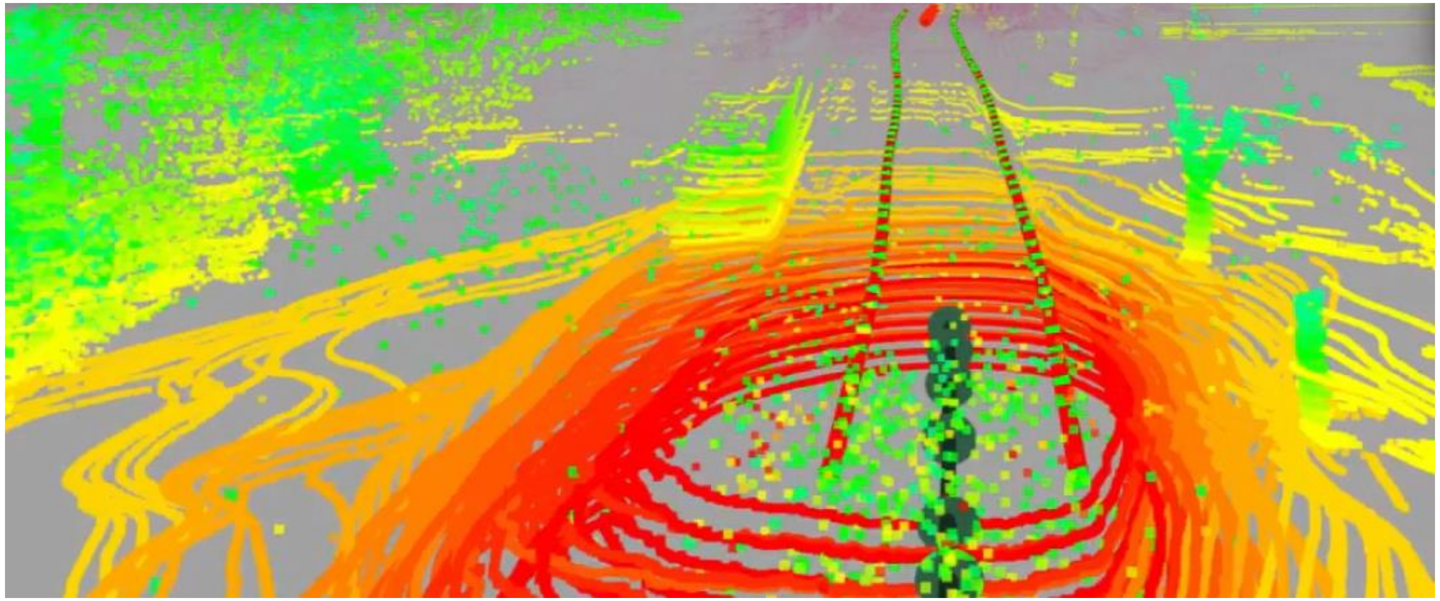


LIDAR

- Heavy seasonal vegetation
- Map needs to be tolerant to changes and updated on regular basis

LIDAR

Side of the road moves



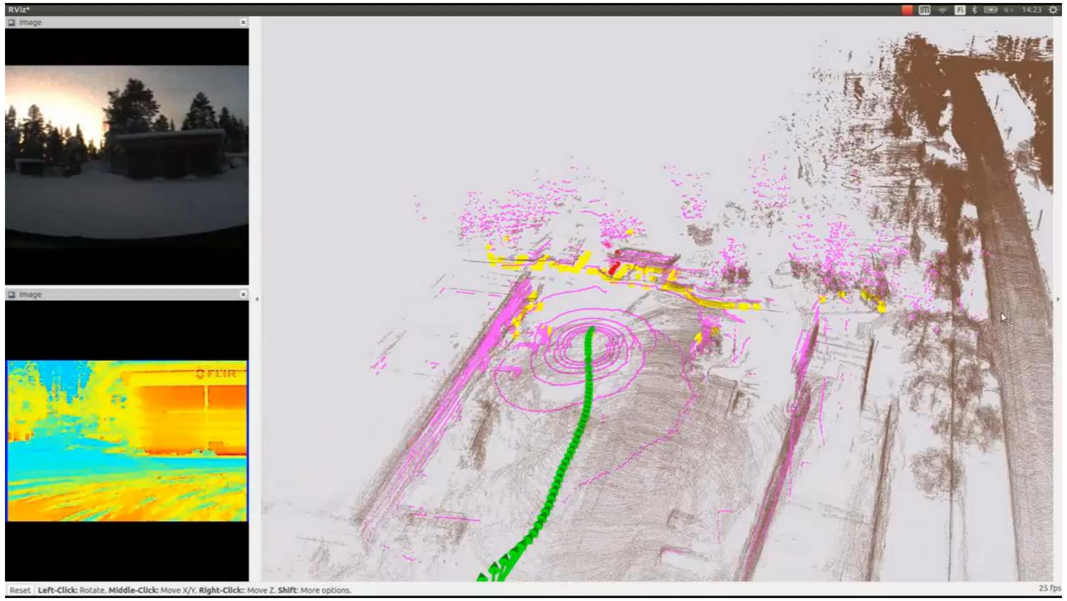
LIDAR

Lidar suffers from snow and rain

PERCEPTION
– OBSTACLE DETECTION

- Image based methods are easily disturbed by light, white, change of contrast, rain, snow, fog
- Radar works well but still suffers low resolution compared to lidar
- Lidar also suffers from different forms of rain thus giving only partial information No single solution by itself is enough

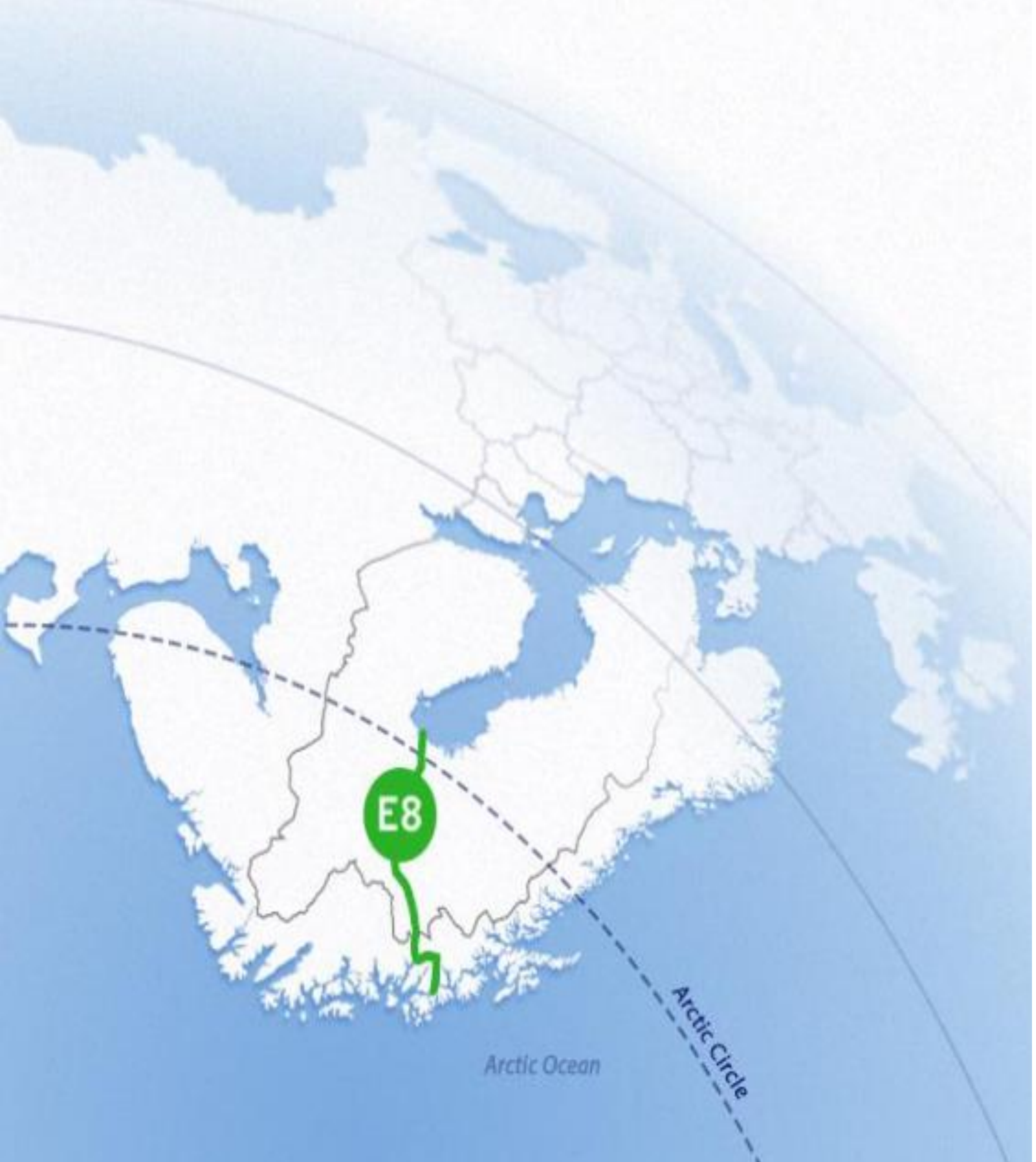
- **Hardware solves half of the problem,** system redundancy based on mixed sensor information and confidence levels



DYNAMIC CONTROL

- When tires detect low friction it is often too late already
- We need to predict road conditions using what we have

sensible 4



CASE STUDY AURORA

TRAFICOM
Liikenne- ja viestintävirasto

sensible 4

Co-financed by the Connecting Europe Facility of the European Union

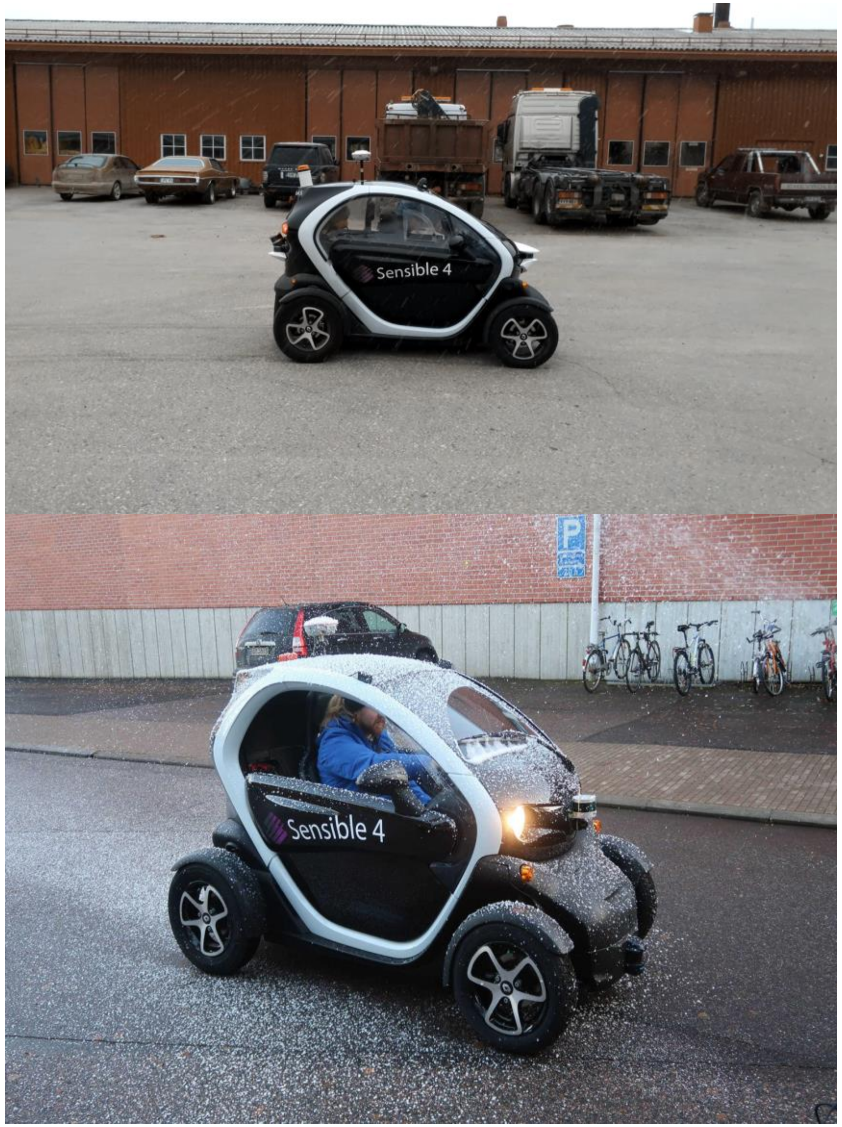
VÄYLÄ
Finnish Transport Infrastructure Agency

LAPLAND POSITIONING TESTS

- The test is done using single same map in varied weather condition (normal & snowstorm) to validate the positioning strategy ability.
- **Snowstorm which happened on 5th October 2018** allows for a test in extreme weather condition.

TEST VEHICLE

- Sensible 4 Autonomous Vehicle Prototype Test Rig.
- Equipped with drive by wire. Installed with required sensors such as 3D-lidars, radars for positioning and obstacle detection.
- More details can be found at http://sensible4.fi/technology



TEST VEHICLE

SENSOR PACKAGE

- 2 Lidars
- 3 radars
- Front camera vision
- RTK-GNSS
- Inertia unit (mems)
- Control over 4GLTE

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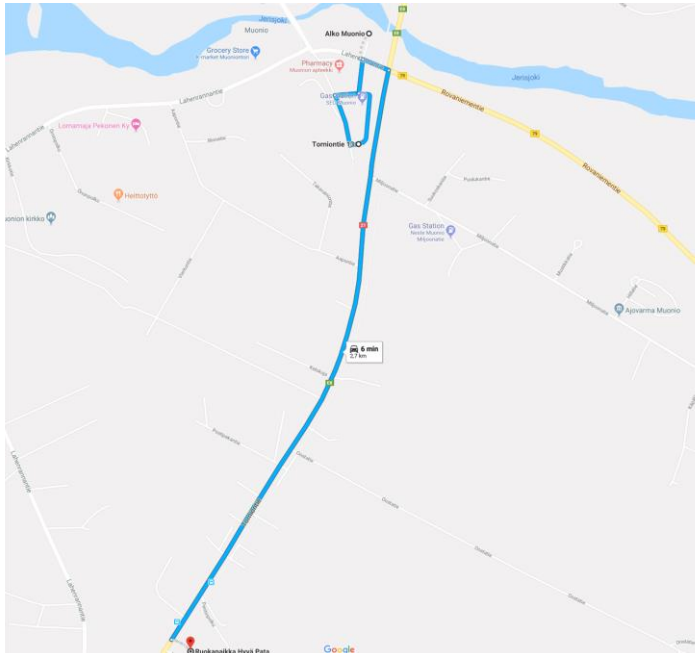
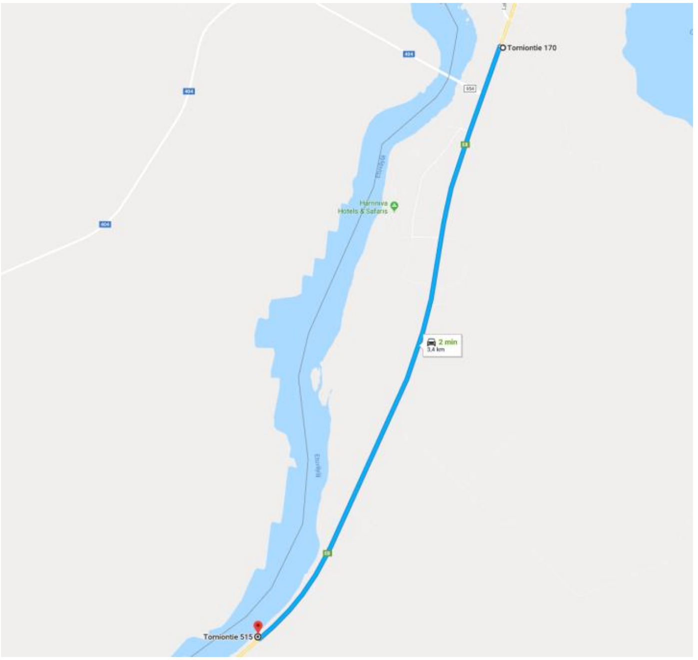
TRAFICOM
Liikenne- ja viestintävirasto

EXPERIMENTAL SETUP





1) Multi-Weather Driving using Non-Snow Map, 0 Celcius, Slippery Road, Mapping Speed 20 KM/H.

2) Multi-Weather Driving using Snow Map, -2 Celcius, Slippery, Icy and Snowy Surface, Mapping Speed 20 KM/H.

FOUR SCENARIOS

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sensible4

FOUR SCENARIOS

SELF-DRIVING EVERYWHERE

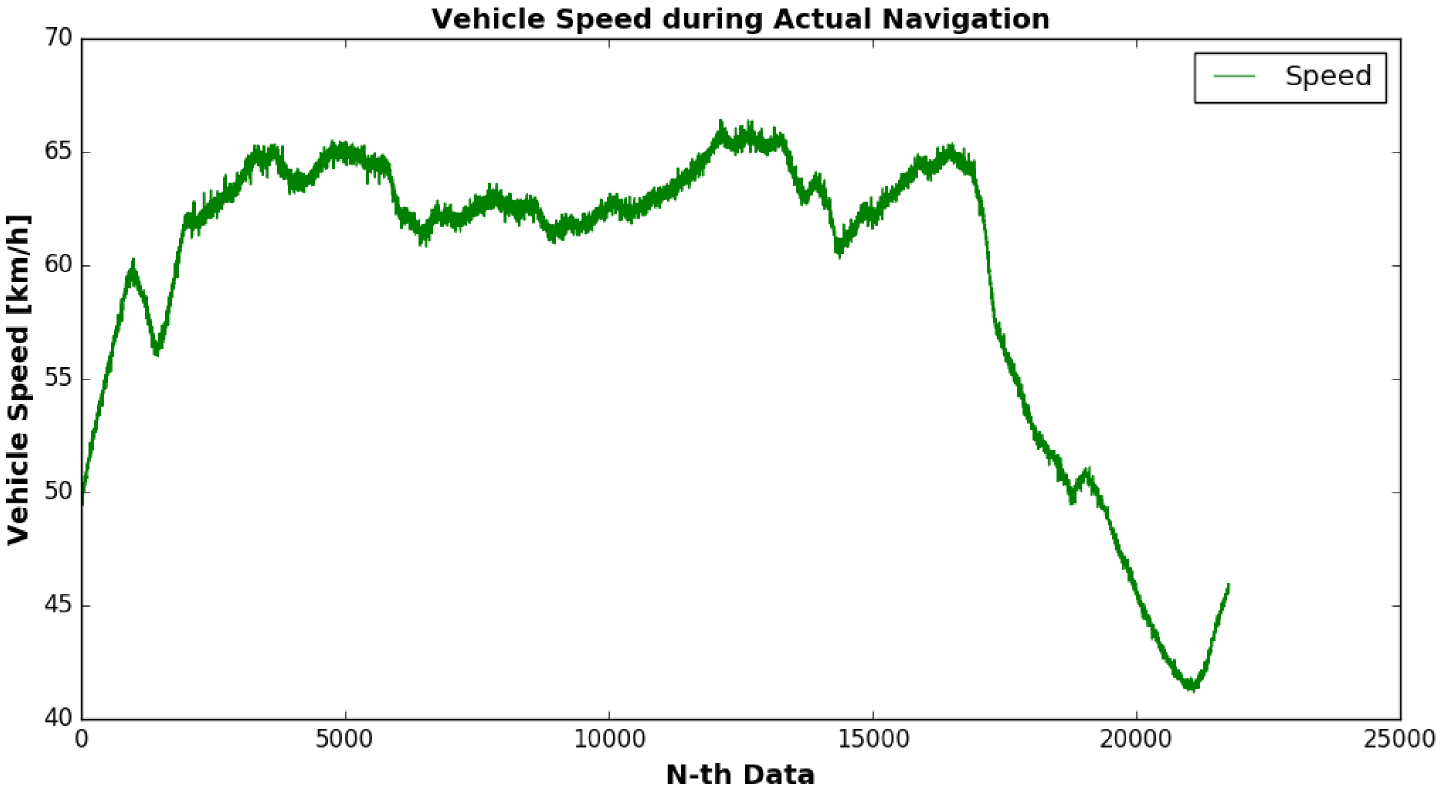
TWO MAPS GENERATED:

- Normal condition and after snow-storm

POSITIONING TEST USING COMBINATION:

- Using snow map, test positioning in non-snow environment and in snow environment
- Using “clear map”, test positioning in clear weather and in snowy weather.

SPEED PROFILE OF "NO-SNOW" POSITIONING



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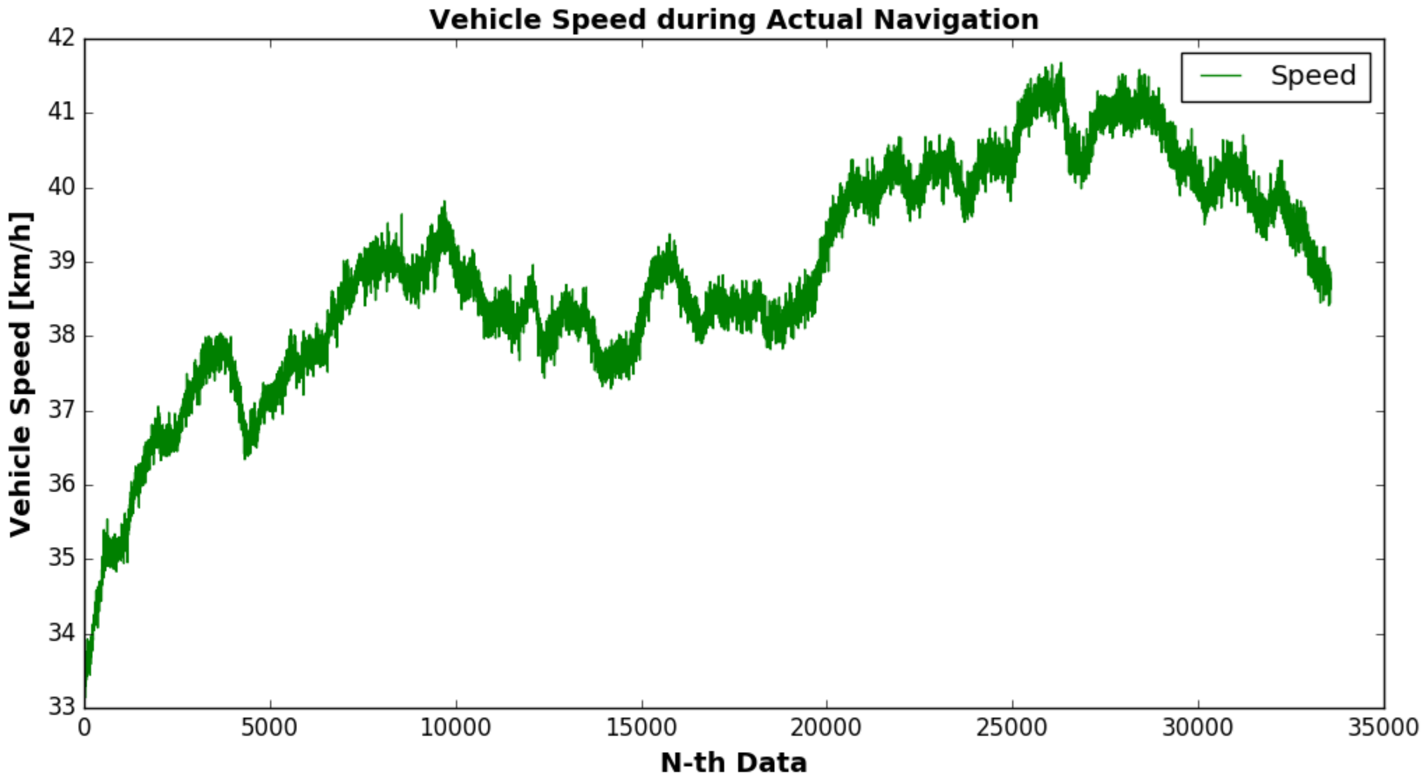
SPEED PROFILE OF "SNOW" POSITIONING



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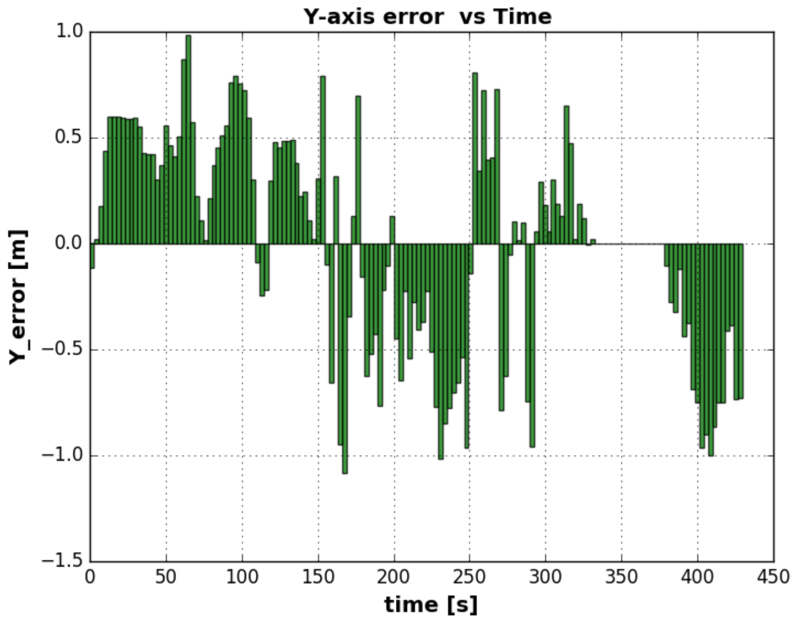
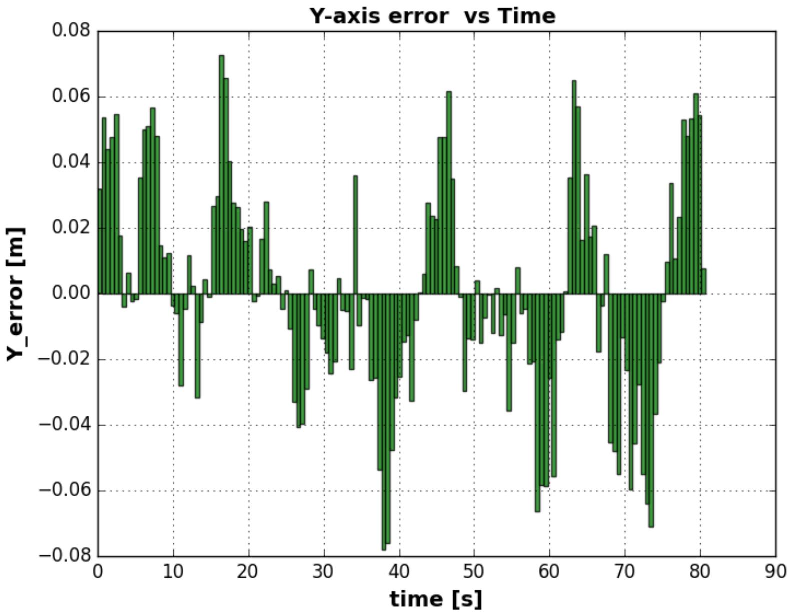
LATERAL POSITIONS ERRORS (NON-SNOW MAP)



No-Snow Map, No-Snow Positioning



No-Snow Map, Snow Positioning

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Liikenne- ja viestintävirasto

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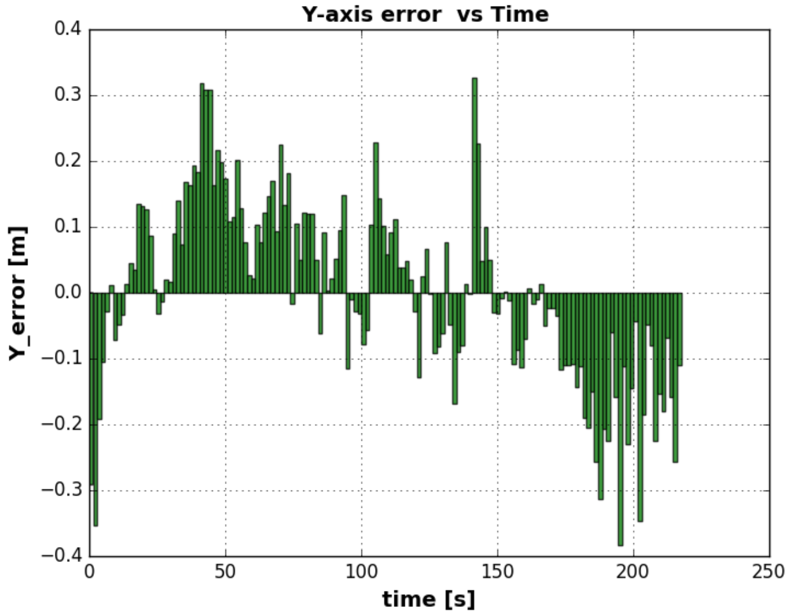
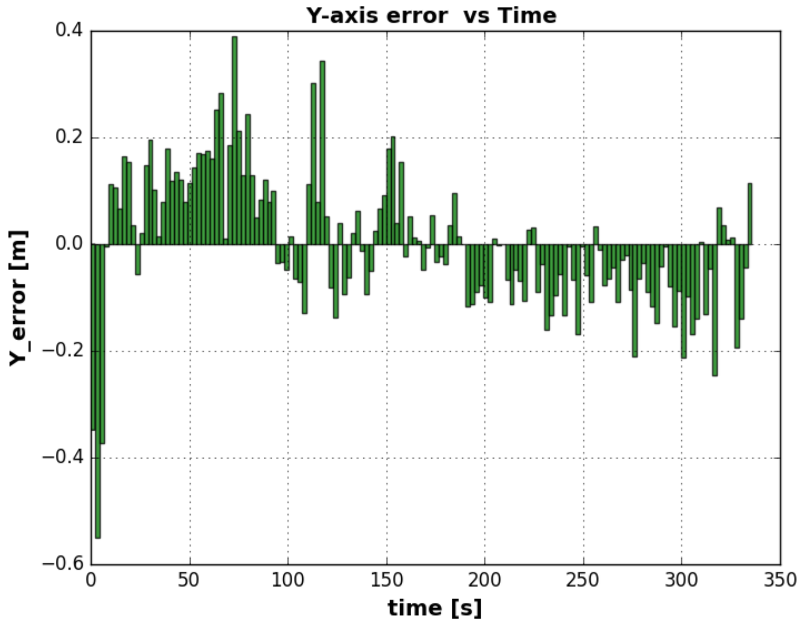
LATERAL POSITIONS ERRORS (SNOW MAP)



No-Snow Map, No-Snow Positioning



No-Snow Map, Snow Positioning

sensible4

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Liikenne- ja viestintävirasto

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PERFORMANCE SUMMARY Y-AXIS

NON-SNOW DRIVING USING NON-SNOW MAPS

Average Error (Relative Position of Vehicle) 0.187 m	0.187 m

SNOW DRIVING USING NON-SNOW MAPS

Average Error (Relative Position of Vehicle)	0.105 m

NON-SNOW DRIVING USING SNOW MAPS

Average Error (Relative Position of Vehicle)	0.166m

SNOW DRIVING USING SNOW MAPS

Average Error (Relative Position of Vehicle)	0.117 m

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Q&A

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Recap Day 1

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What is the first word on your mind when thinking of AI

See you back at tomorrow at 8.45!