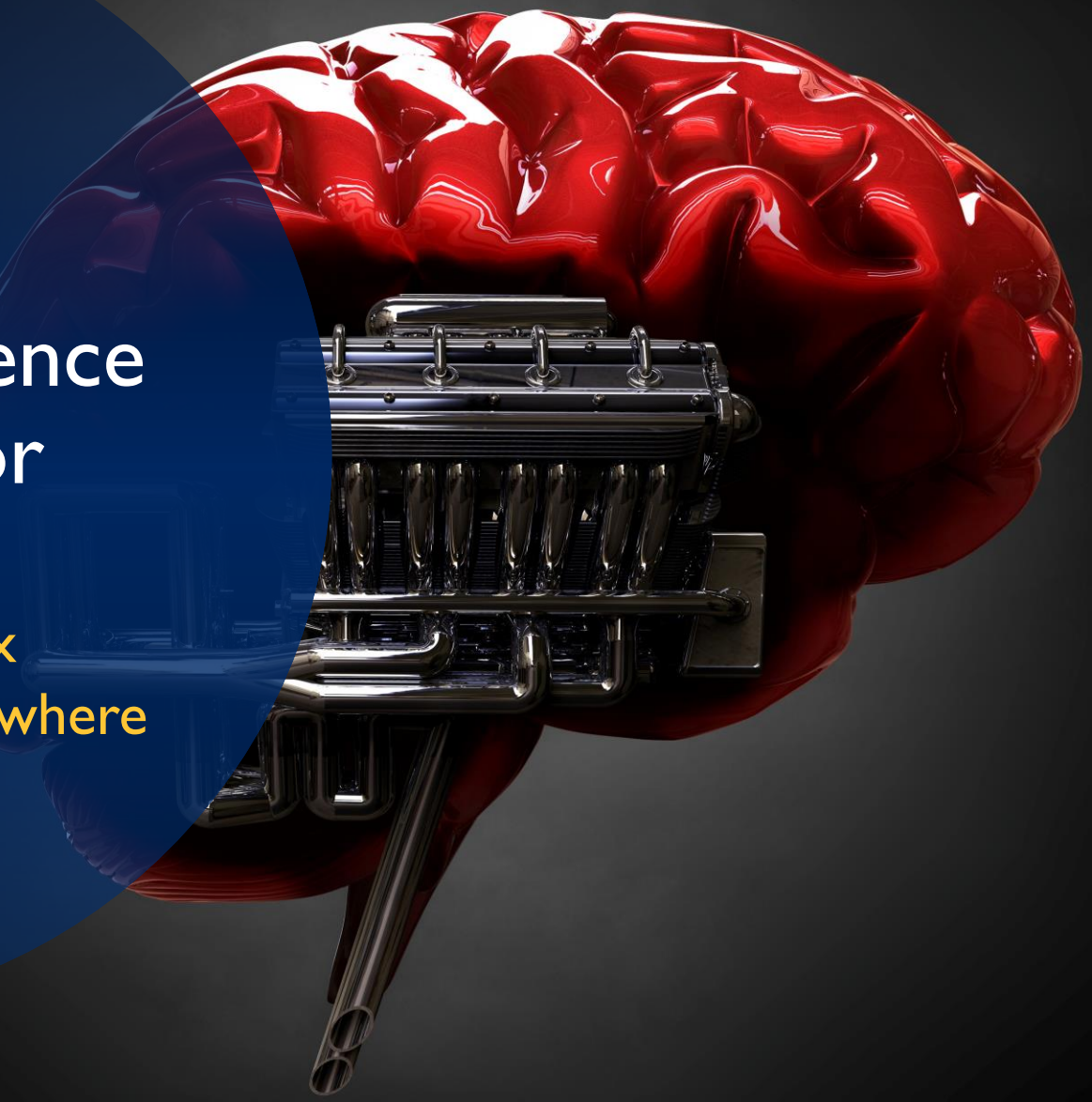
From Technologies to Markets

Artificial Intelligence Computing for Automotive

Webcast for Xilinx

Adapt: Automotive: Anywhere

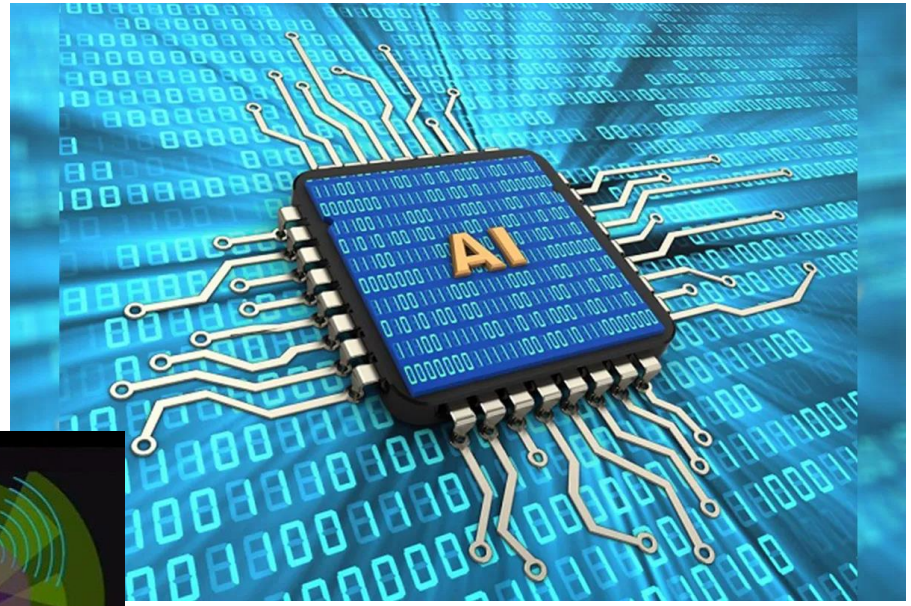
January 12th, 2021

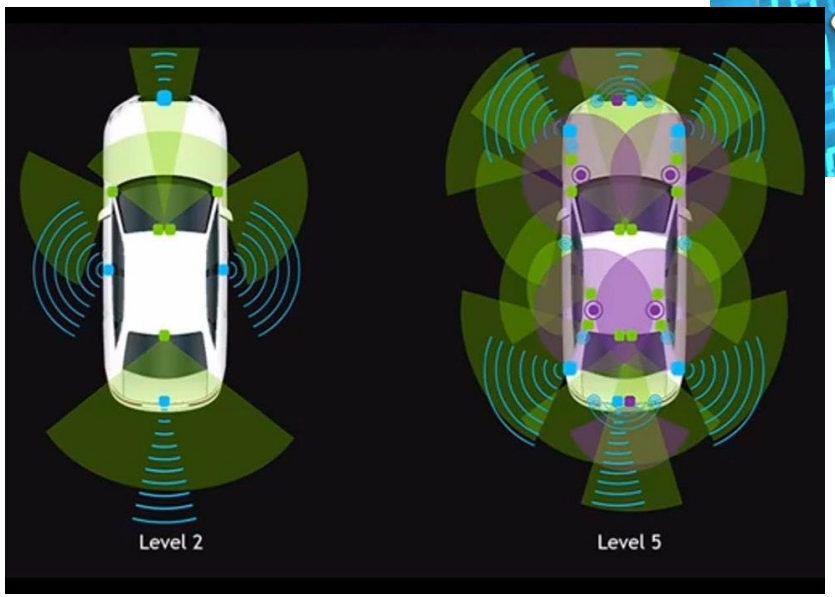


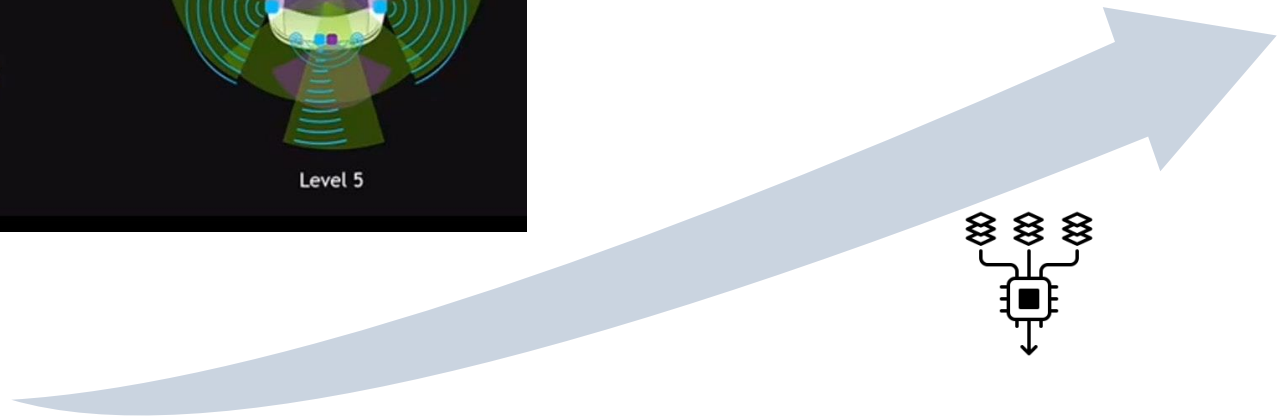
YOLE Développement

AGENDA

- Scope
- From CPU to accelerators to platforms
- Levels of autonomy
- Forecasts
- Trends
- Ecosystem
- Conclusions







SCOPE

Robotic cars
Autonomous driving

Level 5
Level 4

Advanced Driver-Assistance Systems (ADAS)

Level 3
Level 2

Understand the impact of Artificial Intelligence on the computing hardware for automotive

Edge computing
Computing close to sensor

Not included in the report

Data center computing

Cloud computing

Performance

Centralized computing

Multimedia computing

Driver environment
Infotainment

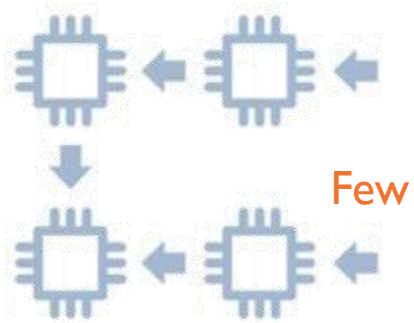
Gesture recognition

Speech recognition

FROM GENERAL APPLICATIONS TO NEURAL NETWORKS

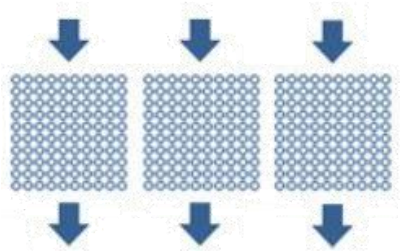
The focus for the semiconductor industry is shifting

Parallelization is key explaining why this is so popular



from	to
General Applications	+ Neural Networks
General workloads	+ Deep learning workloads
• Integer operations	+ Floating operations
• Tend to be sequential in nature	+ Tend to be parallel in nature

Scalar Engines	Platforms and Accelerators
Few powerful cores that tackle computing tasks sequentially	Hundred of specialized cores working in parallel
Only allocate a portion of transistors for floating point operations	Most transistors are devoted to floating point operations



Source: Deep Learning: An Artificial Intelligence Revolution by ARK Investment

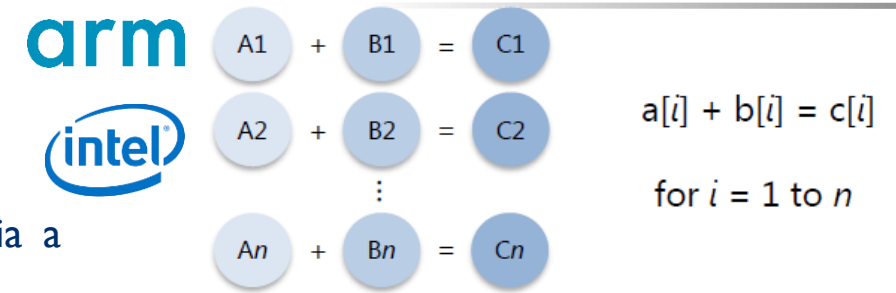
GOING FURTHER WITH DEDICATED PLATFORMS AND ACCELERATORS

From Applications processors to GPUs to accelerators to platforms

Graph processing at the heart of neural networks

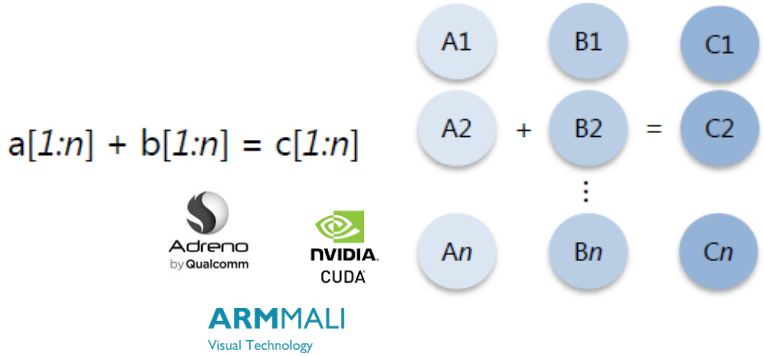
Scalar Processing

- Processes an operation per instruction
- CPUs run at clock speeds in the GHz range
- Might take a long time to execute large matrix operations via a sequence of scalar operations



Vector Processing

- Same operation performed concurrently across a large number of data elements at the same time,
- Single Instruction Multiple Data (SIMD)
- GPUs are effectively vector processors



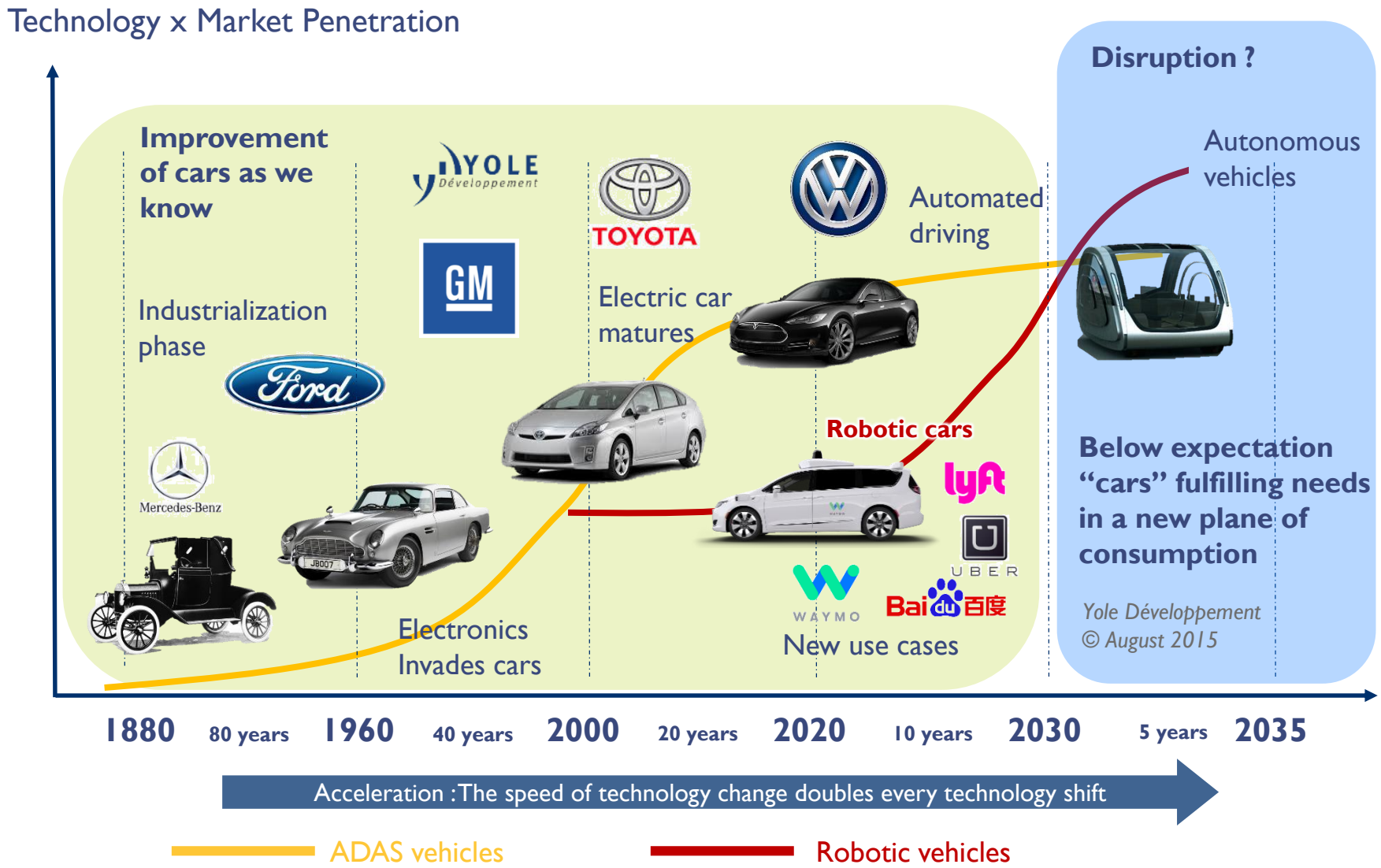
Matrix Processing

- Runs many computational processes (vertices)
- Calculates the effects these vertices on other points with which they interact via lines (i.e. edges)
- Overall processing works on many vertices and points simultaneously
- Low precision needed
- Names: accelerators, neural engine, tensor processing unit (TPU), neural network processor (NNP), intelligence processing unit (IPU), vision processing unit (VPU), AI Processing Unit (AIPU)…

AUTONOMOUS VEHICLES - THE DISRUPTION CASE

Two distinctive paths for autonomous vehicles

2020 should see the first commercial implementation of autonomous vehicles

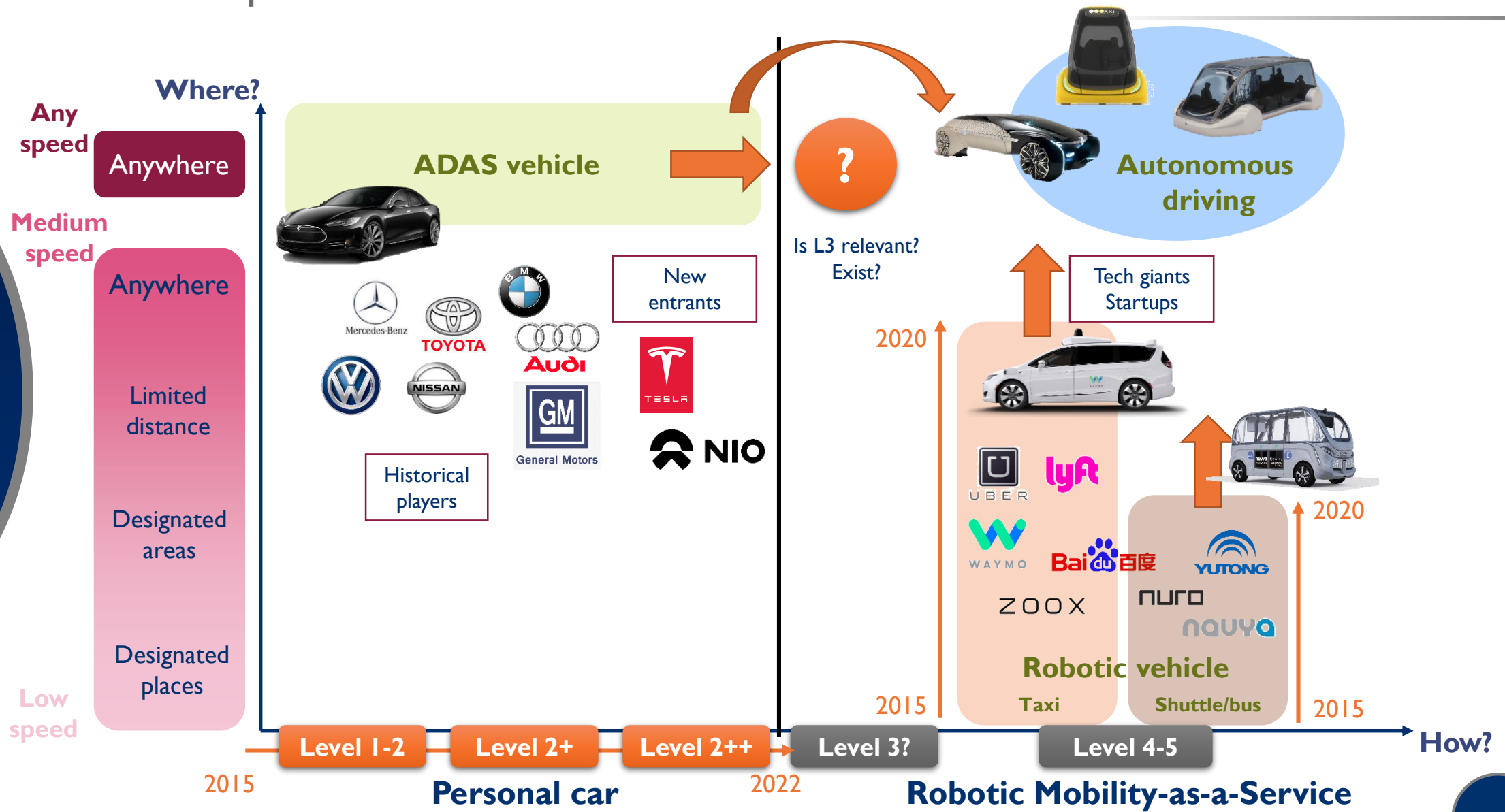


AUTONOMOUS VEHICLES - THE ROBOTIC DISRUPTION CASE

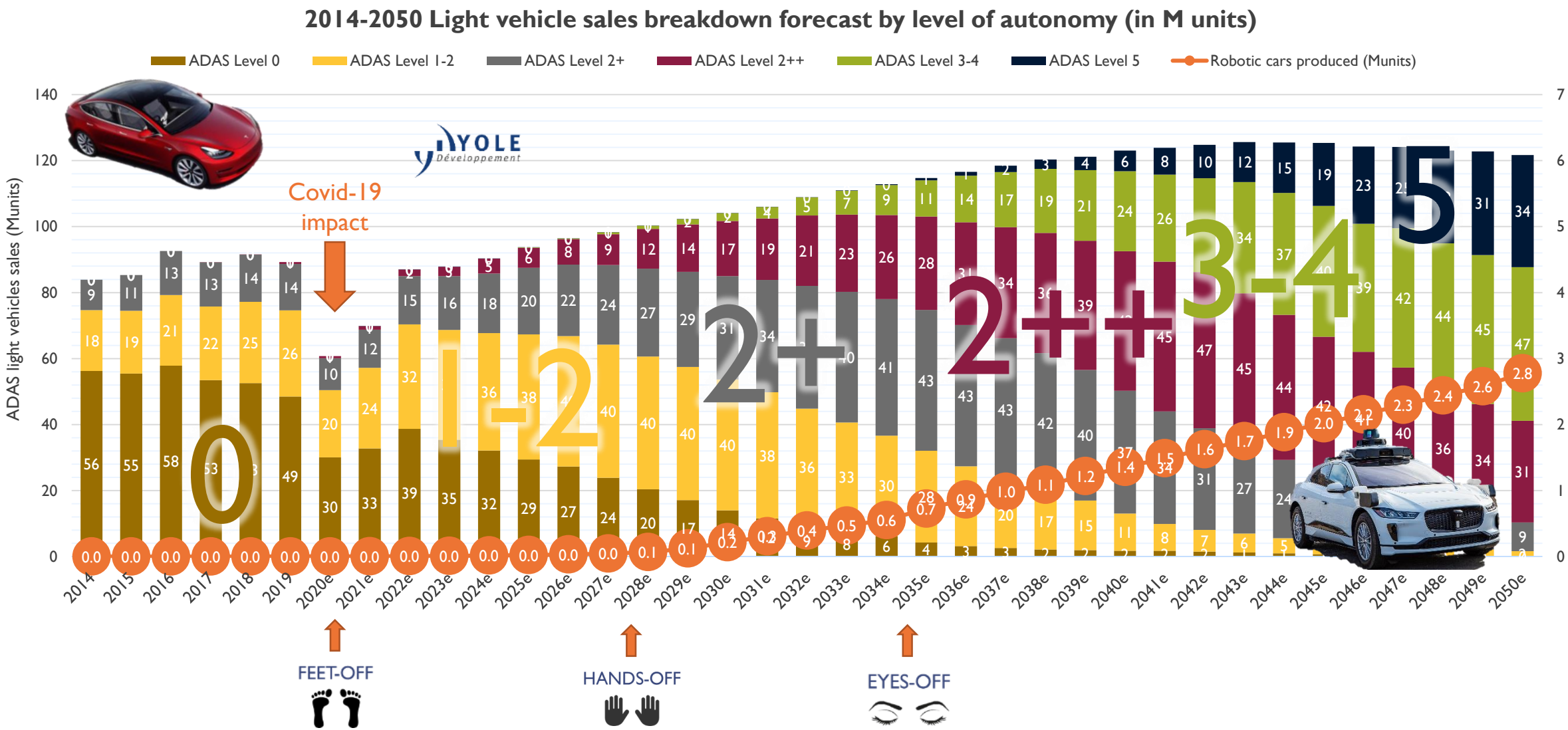
Two distinctive paths for autonomous vehicle

Levels became marketing definitions but we consider that they do not represent the reality.

The reality is whether it is autonomous, whether it is not



AUTOMOTIVE MARKET TREND – YOLE MARCH 2020

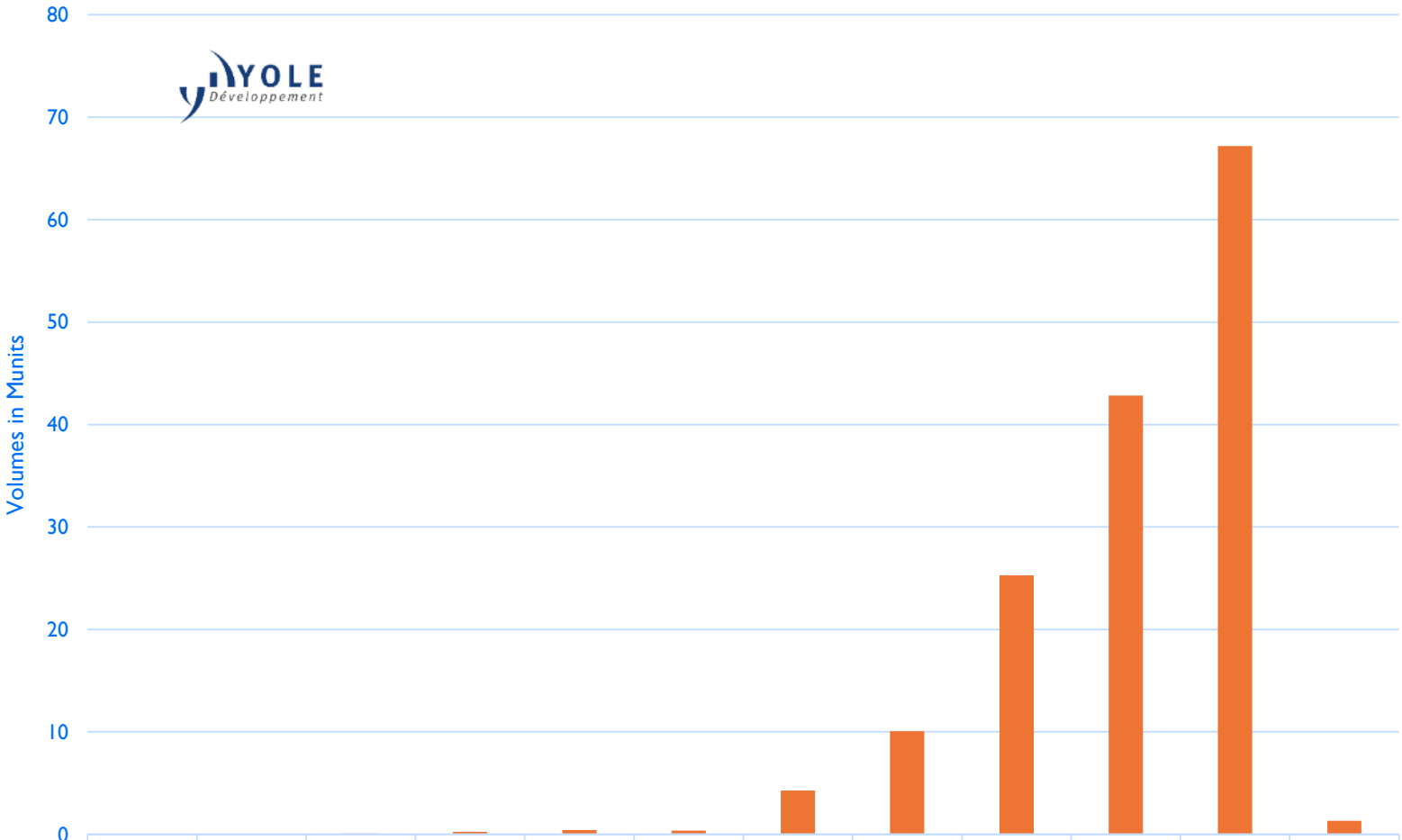


By 2035 cars with autonomy level L3-4-5 will represent 25% of global production the rest will be L1-2-2+

ARTIFICIAL INTELLIGENCE IN AUTOMOTIVE

2015-2025e Total AI computing hardware volume forecast

- Artificial Intelligence based on images from cameras for automotive will generate a total volume of 67M(unit) chips for computing hardware in 2025 for ADAS vehicles only.
- Currently, we consider that for one type of camera, one chip is used. We can find multiple chips in one car. Fusion of inputs from multiple types of cameras is not considered, as fusion is mostly used for inputs of different types of sensors for now.
- **Ultimately, platform solutions** will enable a variety of vision formats and sensor inputs to enable multiple strategies.



	2015	2016	2017	2018	2019	2020e	2021e	2022e	2023e	2024e	2025e	CAGR19-25
Total	-	-	0.09	0.26	0.43	0.38	4.26	10.08	25.27	42.82	67.19	132.4%

FROM LEVEL 0 TO LEVEL 2++ ON ONE SIDE, ROBOTIC ON THE OTHER

Inclusion of accelerators and multiplication of the number of chips

Computing introduces AI and follows what has been seen in consumer

- Level 0 to Level 2+/2++ are differentiating mostly by improved functionalities such as Automatic Emergency Braking (AEB) and some new functionalities such as Traffic Jam Assist (TJA) or Lane Keeping Assist (LKA)
- On the robotic side, full autonomy was first realized in closed area at low speed (<15miles/h) to open designated area and at medium speed (<30 miles/h)

These improvements are realized thanks to the introduction of AI algorithms and its related hardware

Implementation of AI : following what have been done in consumer applications

ADAS

Robotic

Implementation in SoC > as a standalone chip of **accelerators > platfoms**

x2 x4 x8

Multiplication of the number of computing chips

FROM SENSOR SUITE TO COMPUTING SUITE FOR AUTONOMY

Levels and functionalities

AEB L1 | AEB L2 | AEB L2+ | HP | AP

Level 1 → Level 2 → Level 2+/2++ → Level 3/4 → Level 5/Robotic

ACC | LKA | PA | TJA | DM

1 — 5 — >10

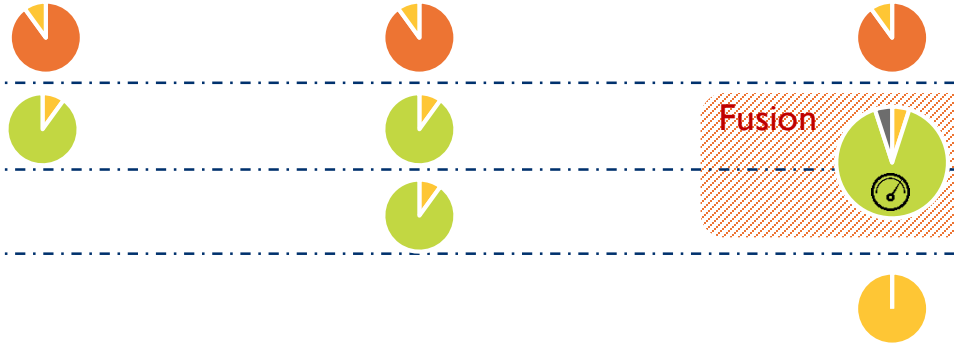
Technology penetration

Radar

Forward/Rear Cam.

Surround Cam.

LiDAR



Computer Vision algorithms 2012

Deep Learning algorithms 2016 by Tesla – 2021 for others

Increasing number of neural networks 2030 — 2040

Performance and ASP

Infineon | NXP | intel FPGA | XILINX

MCU | FPGA | Centralized platform | VP

Low — High

RENESAS | TESLA | NVIDIA | Texas Instruments | TOSHIBA | Ambarella | Mobileye

FOUR BUSINESS MODELS

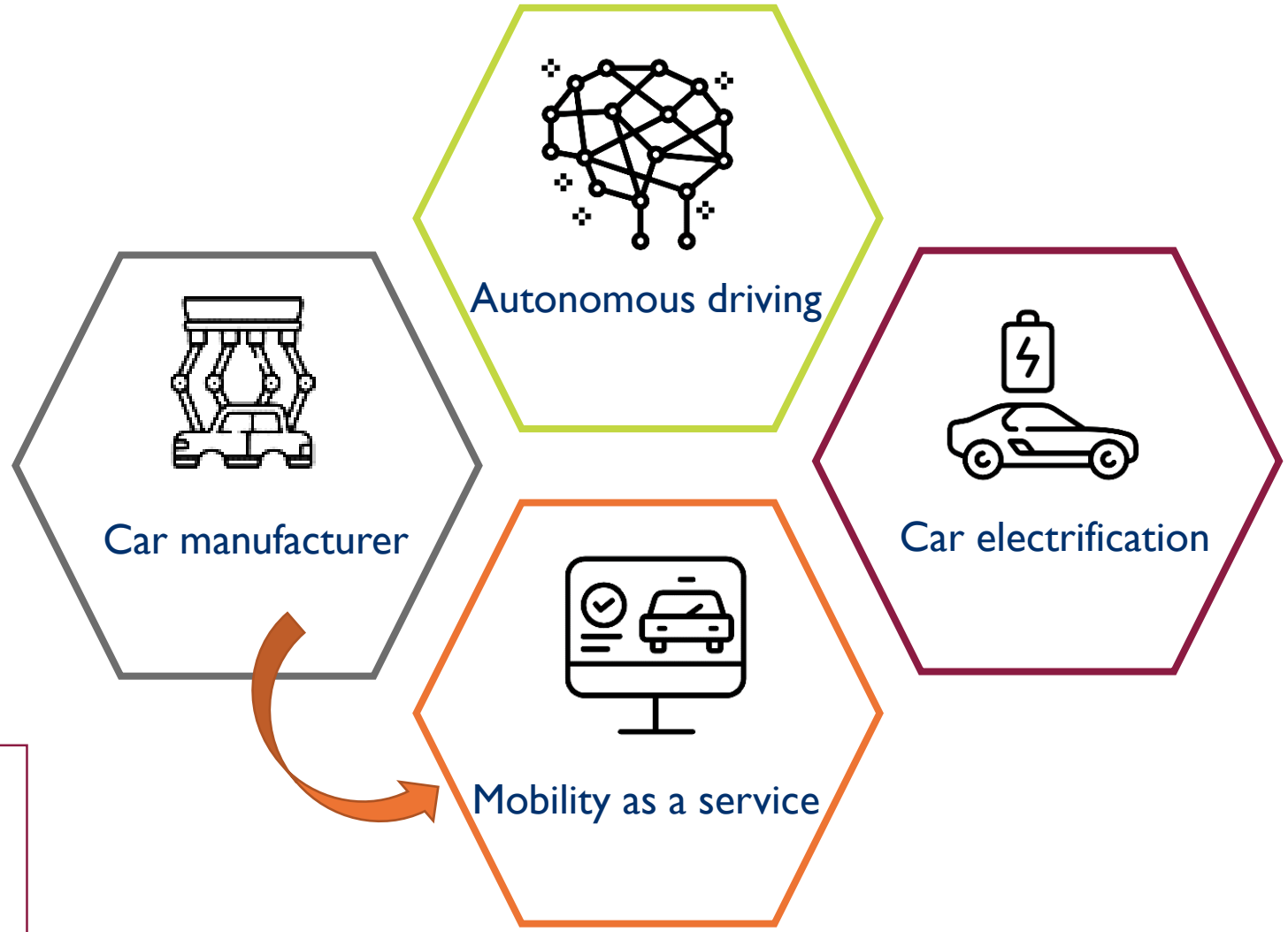
Each business model gains value from different sources

Most of the net value will come from mobility as a service

Four main business models can be identified:

- **Car manufacturer :** OEMs
- **Autonomous driving :** Software and IP hardware:- they are developing the brains of cars and all the driverless application
- **Car electrification :** battery and power train manufacturers:- they are turning cars into electric powered systems
- **Mobility as a service :** service providers (robot taxis or shuttles):- they will offer transportation as a service

But the major **value flow** will go to the **service provider**: by changing consumer use they will overtake the others



SUMMARY

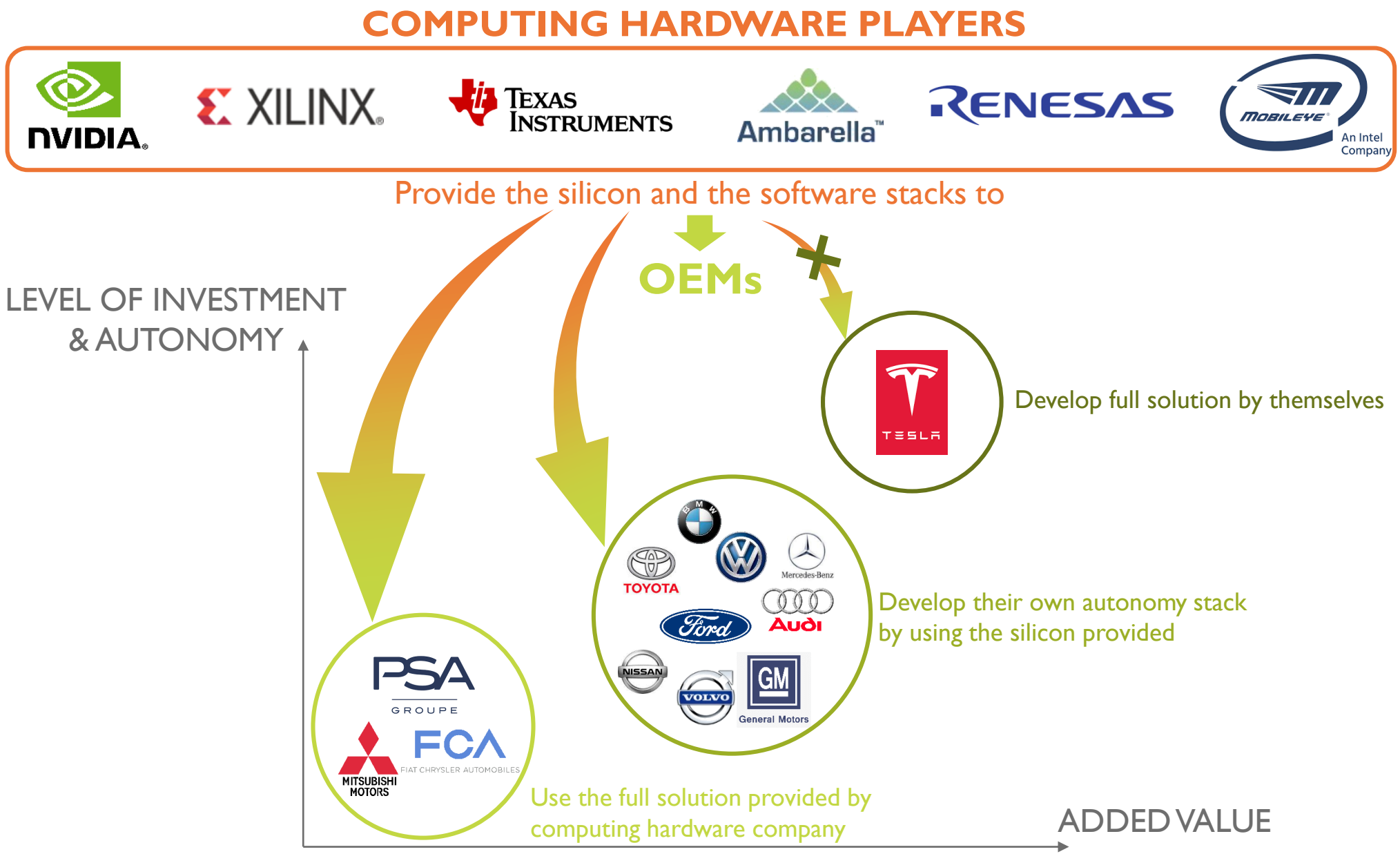
Ecosystem

- Because the technologies are different, ecosystems and supply chains for ADAS and robotic cars are different;
- In both of these ecosystems, the supply chains are organizing;

- ADAS ecosystems are built around historical automotive OEMs, though with classical supply chains going less and less through Tier 1s.

- Robotic vehicles ecosystems are built around full stack solution partnerships – In-vehicle edge platforms to infrastructure to cloud platforms as model to grow transportation as a service

FOUR TYPES OF PLAYER



SUMMARY

Trends

- Levels of autonomy should not be considered as incremental as the underlying technologies are evolving thereby requiring intermediate levels, currently Level 2+ and level 2++.
- Level 3 is questionable as liability and regulations are not included. Many OEMs have, therefore, decided to skip Level 3 and are working directly on Level 4/5 vehicles.
- ADAS vehicles and robotic vehicles are two completely different markets as ecosystems, technologies, ASP, objectives and business models are different.
- The entrance of Artificial Intelligence, bringing with it their dedicated hardware, called accelerators, enables increased understanding of the environment around the car and can therefore allow more and more autonomy as the software and the hardware are improving.
- For ADAS vehicles, AI has been around since 2016 in Tesla vehicles running on their own platform. However, as accelerators will be embedded in next generation SoCs from historical players and partners from OEMs from 2021, AI will spread quickly.
- For robotic vehicles, AI has been in use for a few years and GPUs were used to process these algorithms. As fusion of multiple inputs is already in place, a combination of GPUs and accelerators in the same SoC or as two different chips will be used for vision acceleration.
- To get to the performance needed for Level 4/5, vision accelerators may not be enough, vision and sensor fusion platform solutions as well as data fusion from infrastructure and cloud services will gain traction, especially in mobility as a service. AI platforms in domain control solutions will take share from independent ADAS application systems. Data fusion will become more prevalent to further autonomous evolution.
- The application is key : focus should not initially be on the performance or power, but on the application/technology, so that the software (stack and algorithm) will make this application possible and the hardware can handle this software perfectly.

Tesla was first in introducing AI and is driving the AI hardware trend: moving computer vision from AI on GPUs, to AI on accelerators.

Matrix Accelerators are replacing Vector processing for AI algorithms especially for vision systems.

All along the value chain, NN software should be the focus for success. To be successful, platform providers will also engage in holistic AI solutions.