New Architecture for Autonomous Driving

June 4-5, 2018

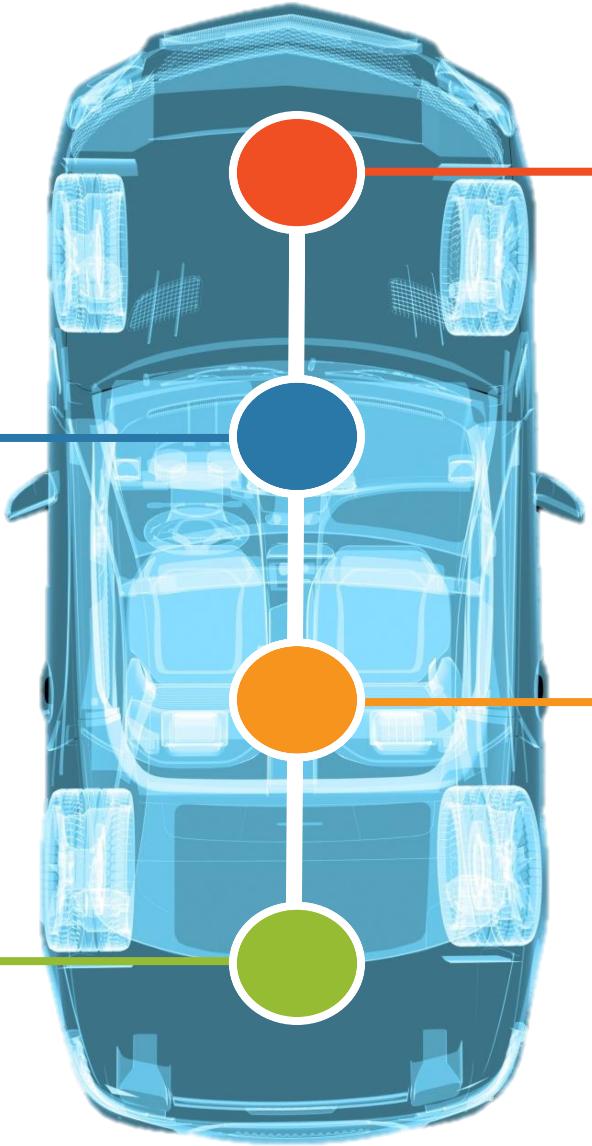
TECHNOLOGY
Defining the Future
of Automotive

COST MANAGEMENT & PRODUCT PLANNING

In the Factory
In the Car
Supplier Management
Technology Roadmaps

ALTERNATIVE PROPULSION

Hybrid & EV
Wireless Charging
Charging/Re-fueling Infrastructure



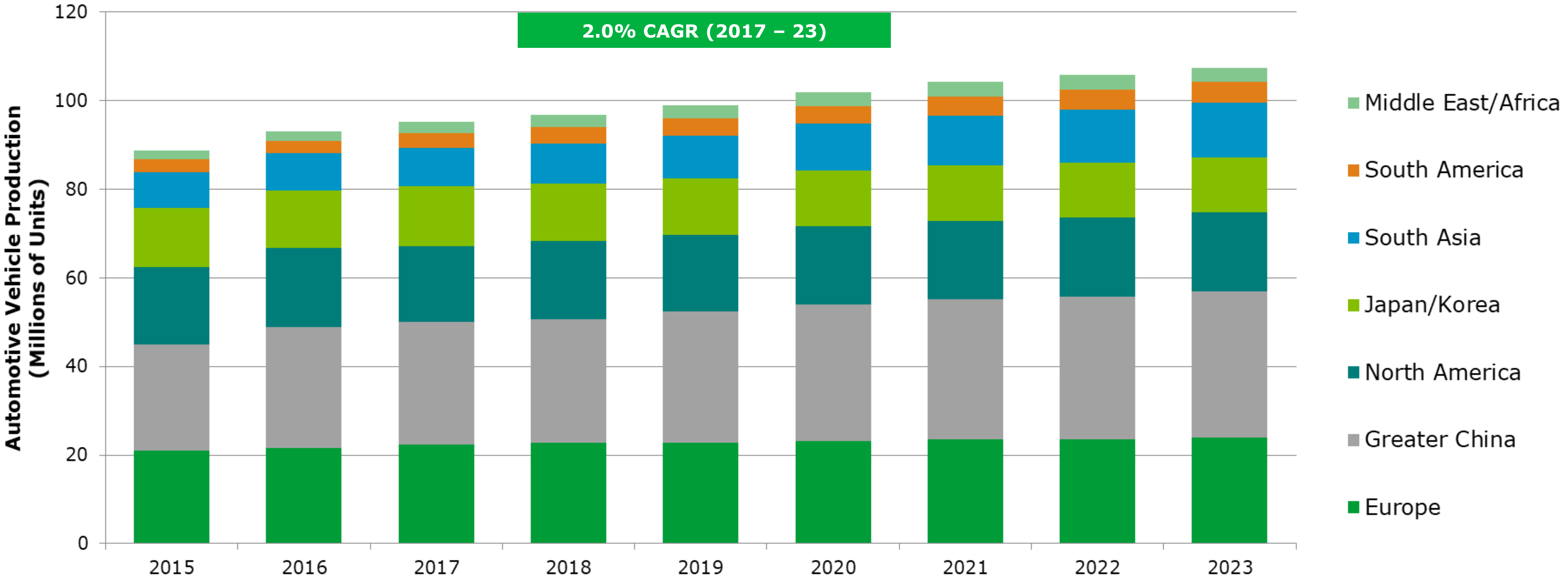
CONNECTED CAR

IoT & Cellular Connectivity
Infotainment
Telematics
Media Integration
Smartphone & Apps
Advertising
Navigation
Wearables
Cyber Security

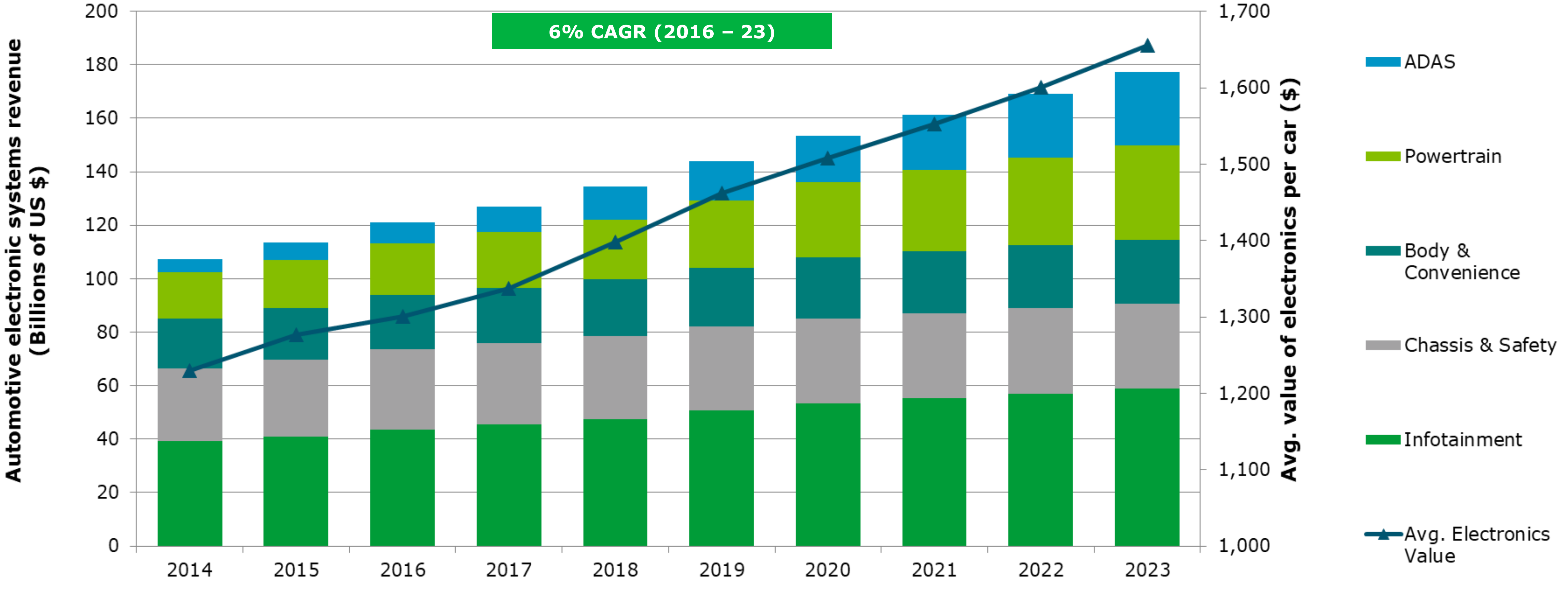
AUTOMONOUS CAR

ADAS
Sensors
V2X Communications
Autonomous Driving

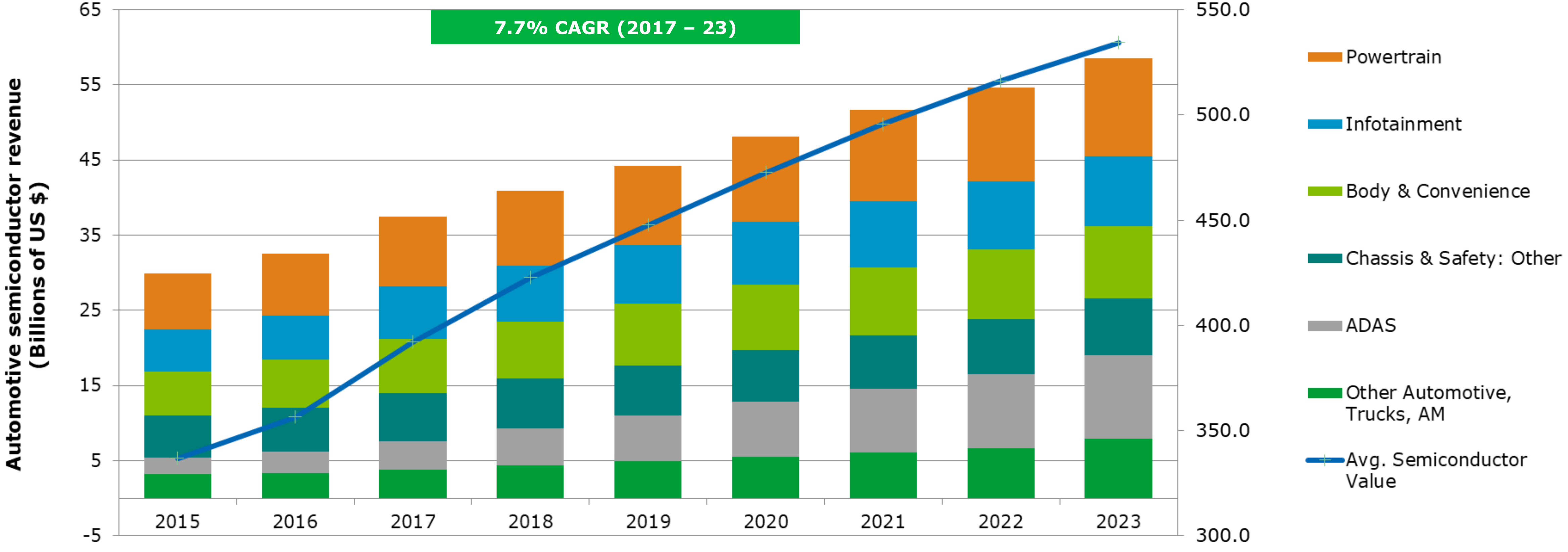
Vehicle production rises steadily but slowly



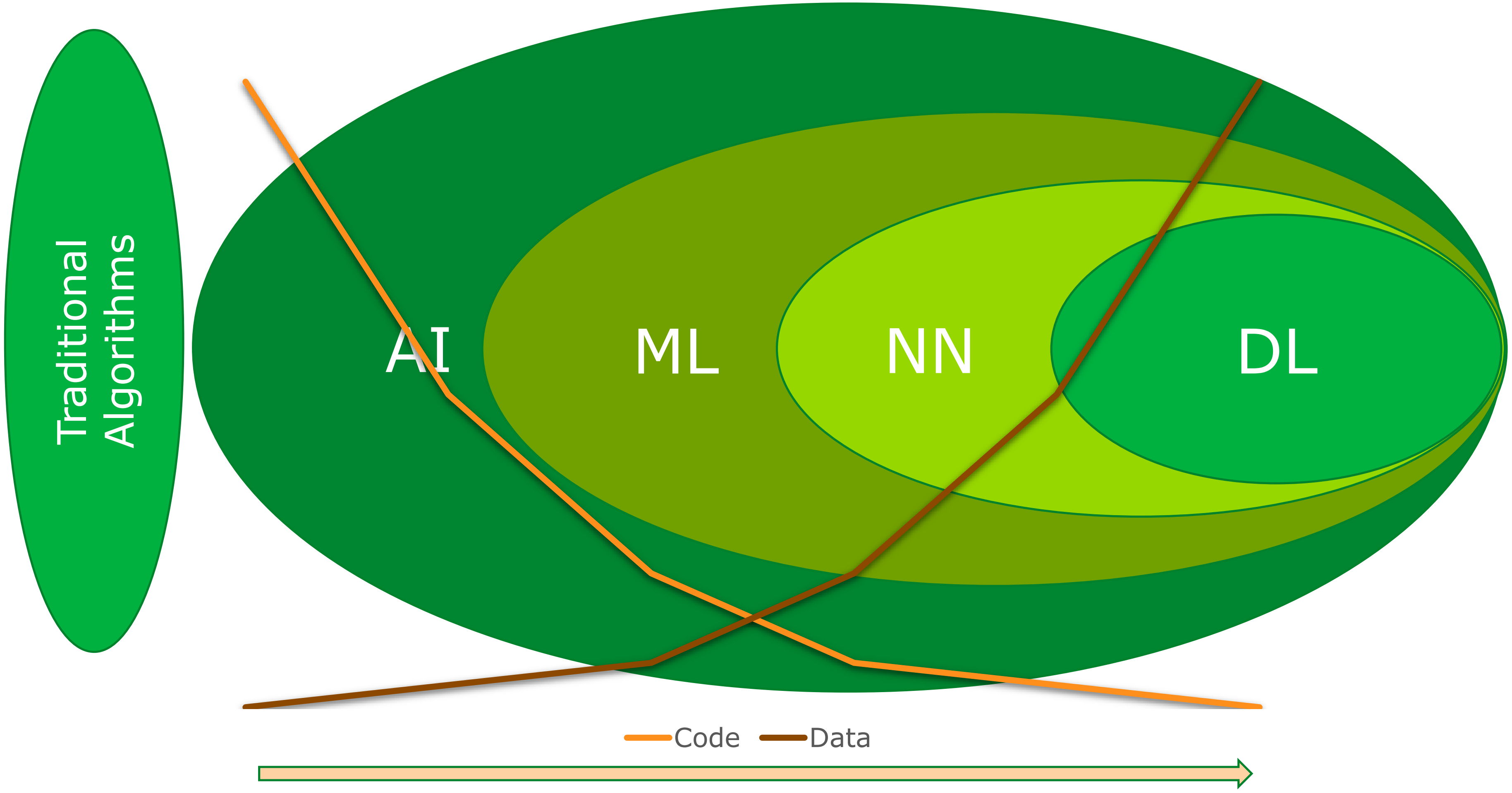
Average value of electronic systems per car to top $1650 by 2023



Electrification, automated driving and connectivity fuel for the automotive semiconductor growth



AI, Machine Learning, Neural Net, Deep Learning
Major differences in the same “intelligent” family



AI in Automotive

HMI
Voice/Gesture

Driver Monitoring

Powertrain

Security

Diagnostic

**From ADAS
To Autonomous**

IHS Markit

Implication of AI and Deep Learning

Major advantages in comparison with traditional machine vision

- **Assumptions:**
  > New silicon solutions will be developed with focus on AI algorithm
  > The functional safety aspect will be addressed by the entire supply chain
- **Deep learning can:**
  > Allow detection and recognition of multiple object ➔ improve perception
  > Perform semantic analysis of the area surrounding the vehicle
  > Reduce development time of ADAS and IVI systems (once DL is in steady-state)
  > Reduce the power required compared to the same operation w/ traditional algo
- **Deep Learning needs help**
  - > Recognition/Prediction of actions and Fusion - Bayesian Net and other stochastic algorithms may complement DL in the run to autonomous cars (L4-L5)
- **Required precondition:**
  - > Telematics will be broadly deployed to: 1) enable gathering of “real” patterns and data for training 2) allow over the air system update and security

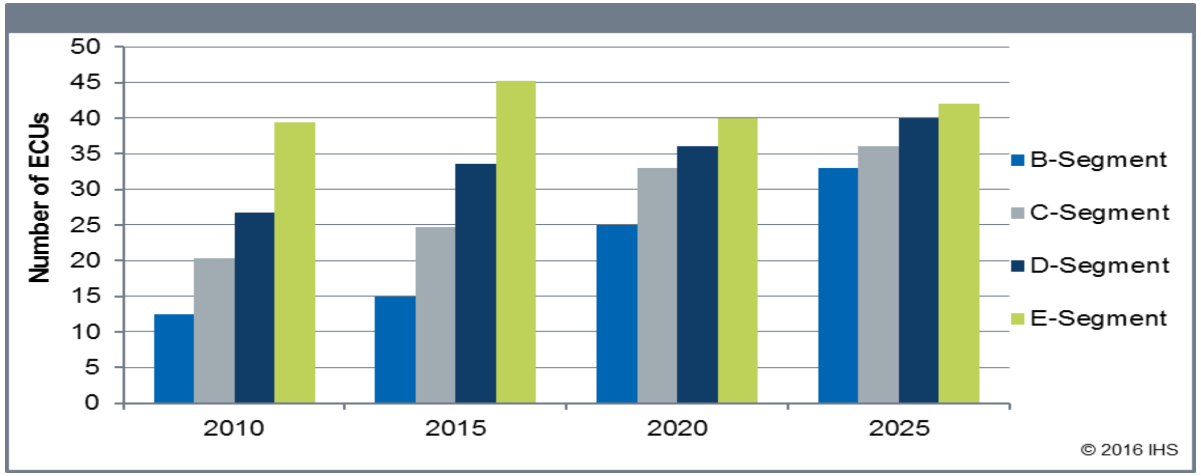
Extra Requirements for Deep Learning in **ADAS & AV**

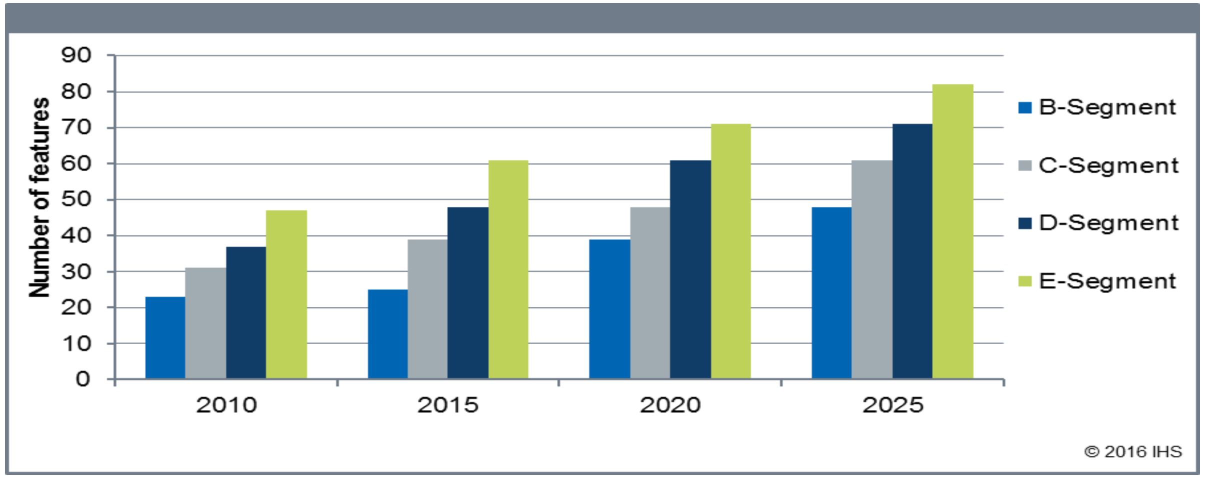
- **DL in ADAS for Autonomous functions requires in-vehicle HW:**
  - Latency: for active function system needs to react in less than 70-80ms
  - Deep Learning offer deterministic latency also for “noisy” input from sensors
  - Performance: TFlop/TOP/TMAC is barely the minimum
- **Power:**
  - Individual sensor subsystems need to stay in the power budget of 4W;
  - Sensor Fusion ECUs might allow targets up to 15-20W or more. Some OEMs expect already they need to find a trade off if no silicon is available and performance needed.
- **Backhaul and data storage infrastructure:**
  - Connectivity (IoT) is a need to:
    - Store training data and vehicle parameters.
    - Update/Upgrade the system
- **Data acquisition** is a challenge for validation and test: mix **Real** & **Synthetic** data
- **Safety** is the biggest uncertainty to have autonomous car based on AI.

Standardisation is a must have

Dynamic of ECU and Features balance

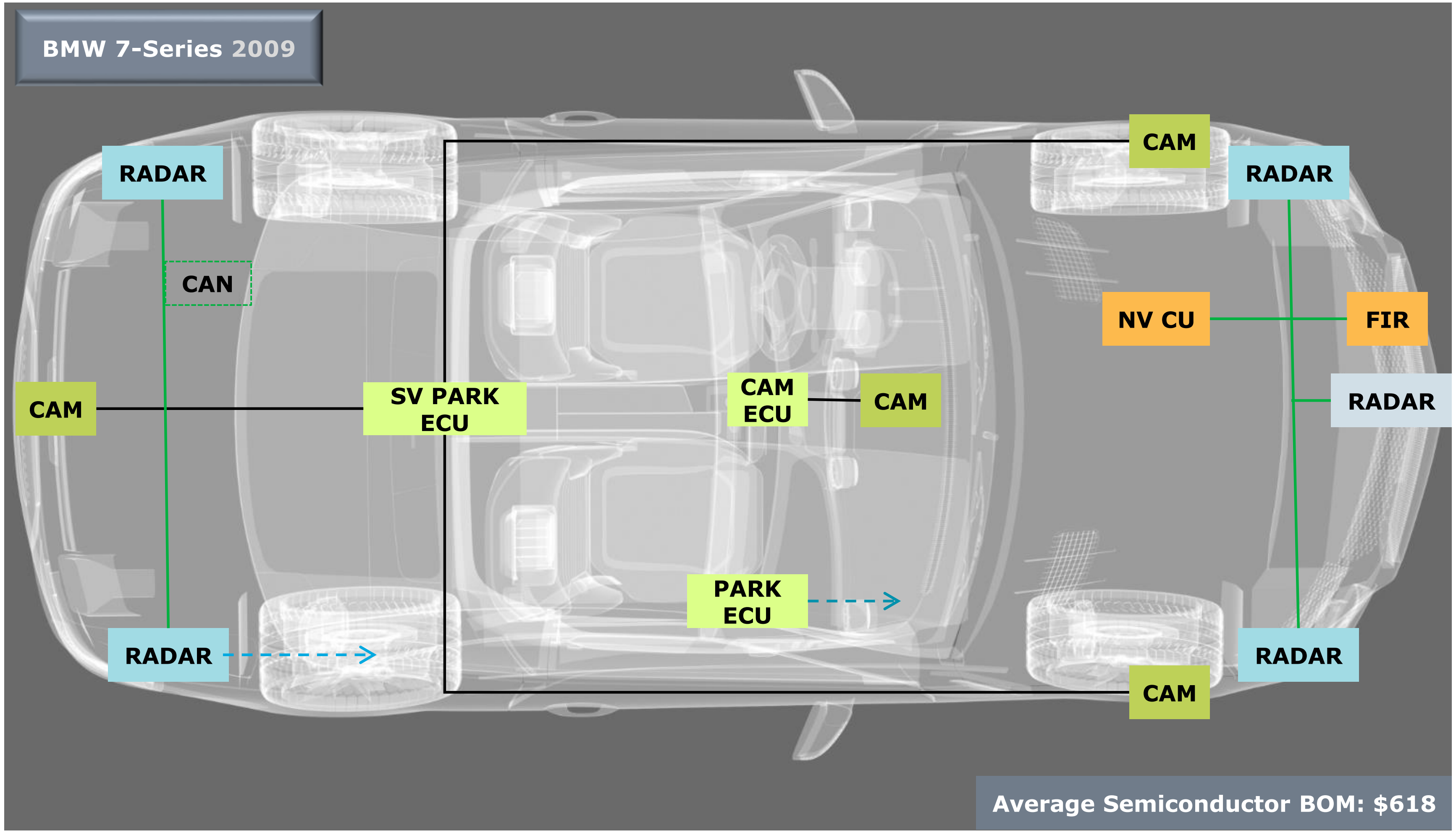
Cost will define the strategy and implementation timeframe



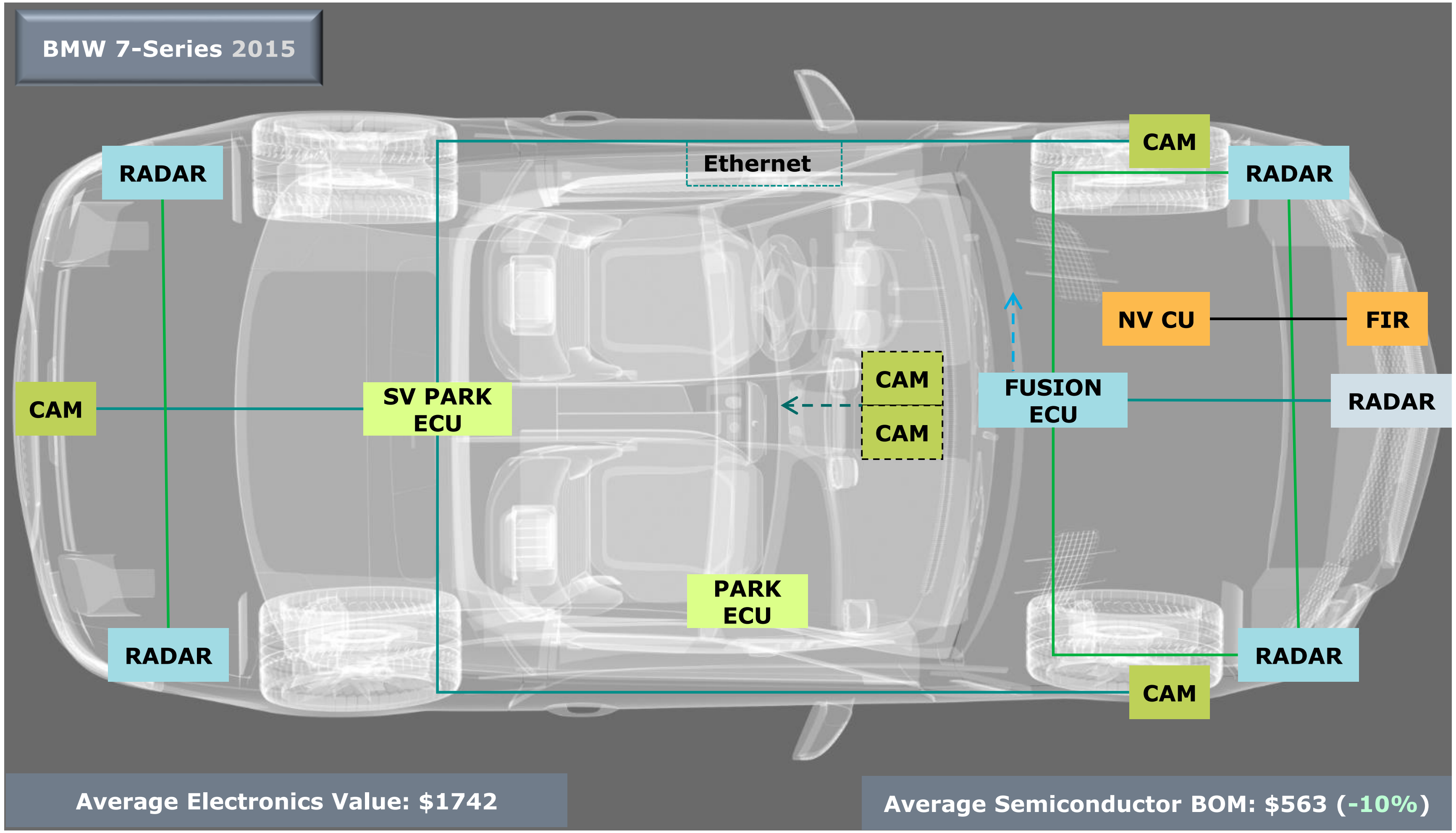


- **Number of ECUs (Average):**
  - in Low and Mid vehicle segment continue increasing.
  - Premium shows already consolidation because close to the “limit”.
- **Feature:**
  - growth in number expected in all segments, driven by ADAS and IVI
- **Costs**
  - OEMs tend to maintain the ECU cost at a constant level adding value and taking advantage of integration.

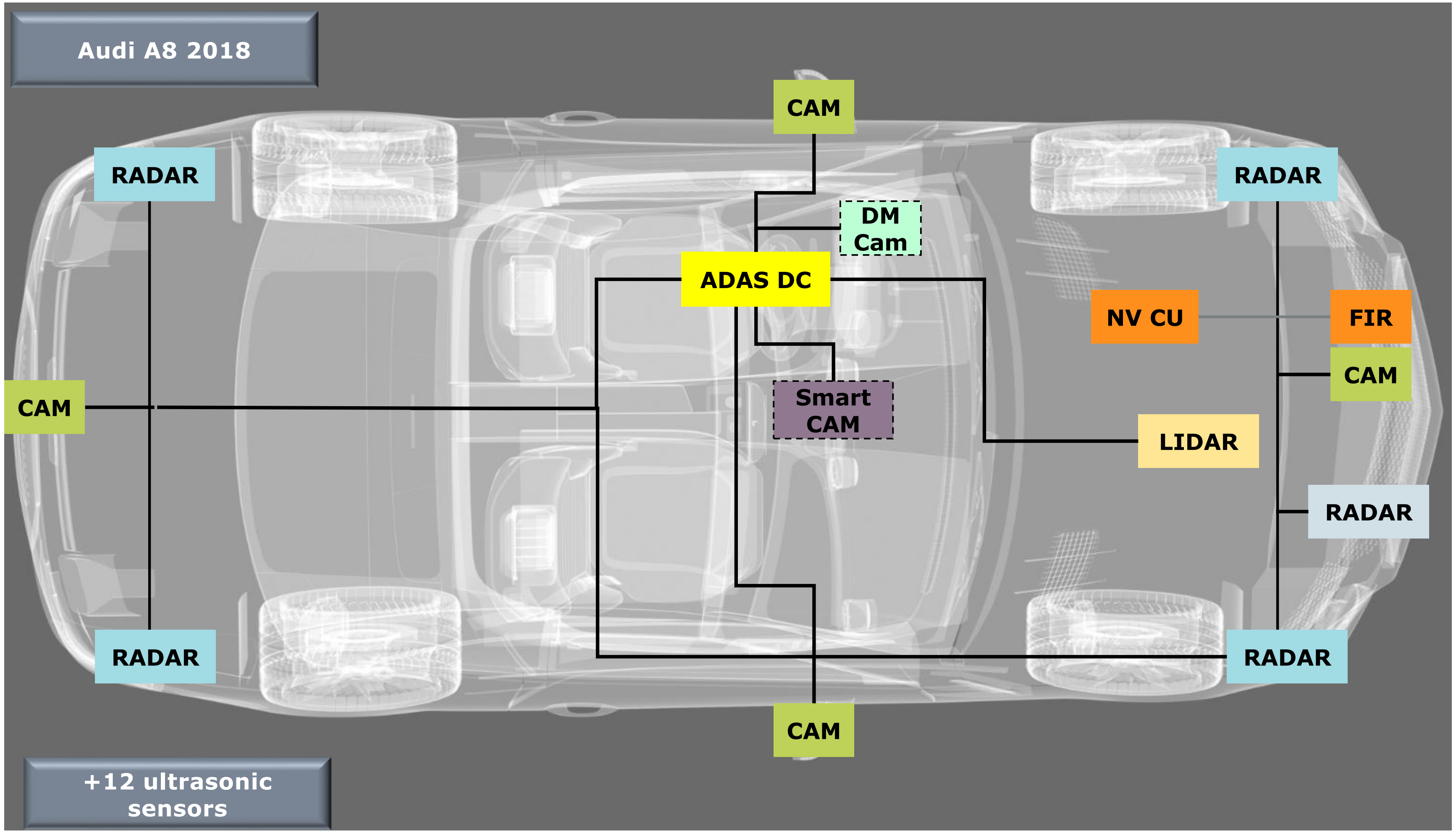
Old generation: E-segment with 14 ADAS ECUs



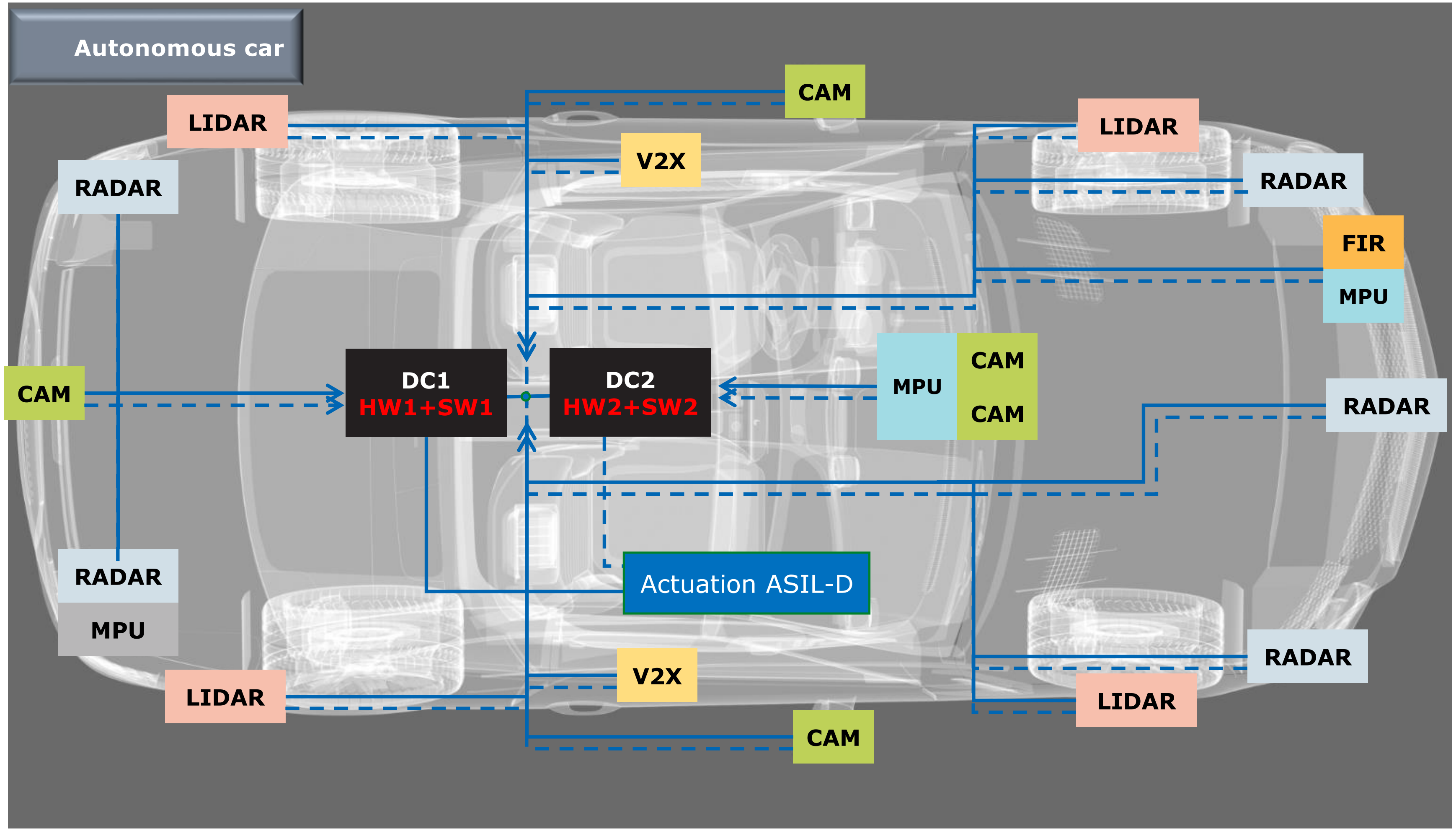
Advancement of features on new platform



System Architecture on Audi A8



Possible System Architecture in 202X



Typical ADAS architecture requirements

ADAS Module	Avg. per L3	Avg. per L4	Avg. per L5
Sensor Fusion	1	2	2
Exterior Camera	5	8	8
Interior Camera	1	1	1
Short/Mid-range Radar	4	6	6
Long-range Radar	1	2	2
Long-range LIDAR	1	1	1-2*
Short-range LIDAR	2*	2-4*	4
	13	**22**	**24**
	$ 2200	$ 6300	$ 9400

***Architectures based on existing pilot car platforms from BMW, Volvo, Audi, Nissan..**

Impact of Autonomous Driving Roadmap

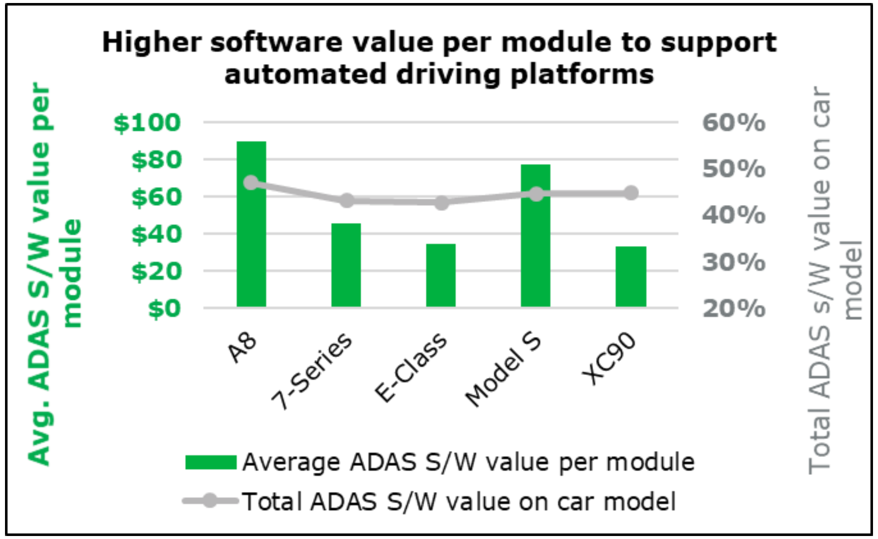
ADAS architecture for automated driving is on the roadmap of many OEMs by 2020

About 45% the total ADAS cost on premium models is accounted for the software
Particularly on A8 and Model S the average software value per ADAS module (excluding ultrasonic sensors) is $90 and $77, above today´s average.

Functional safety standards:
The control units (HW & SW) supporting AD functions should also comply ASIL-B to ASIL-D. Redundancy is a must.

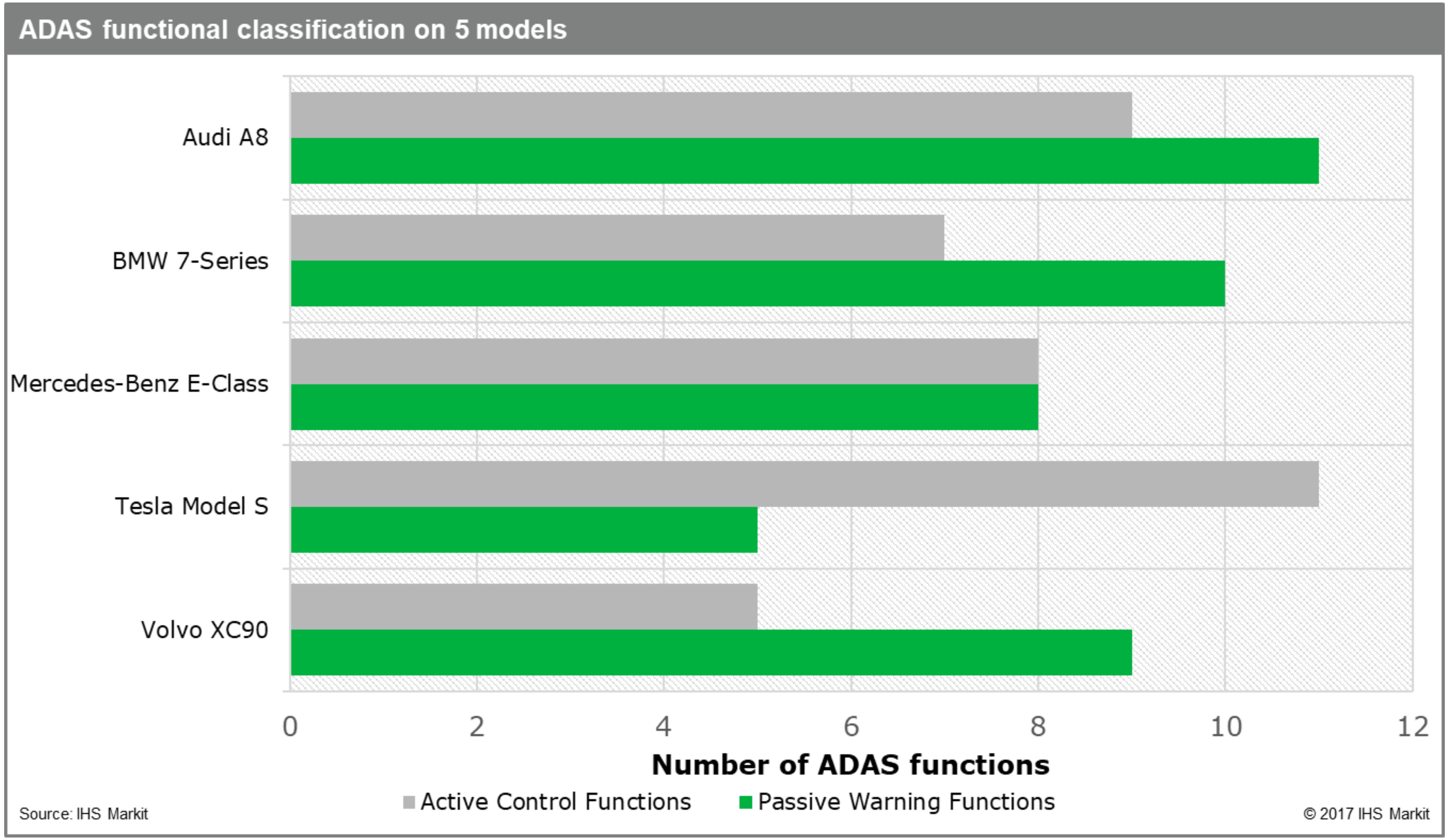
High-performance software blocks:
Front smart cameras, Domain Controllers & LIDARs

***LIDARs and Domain controllers** for instance come with a cost that ranges from 500 for a LIDAR to 850-1000$ for the domain controller.*



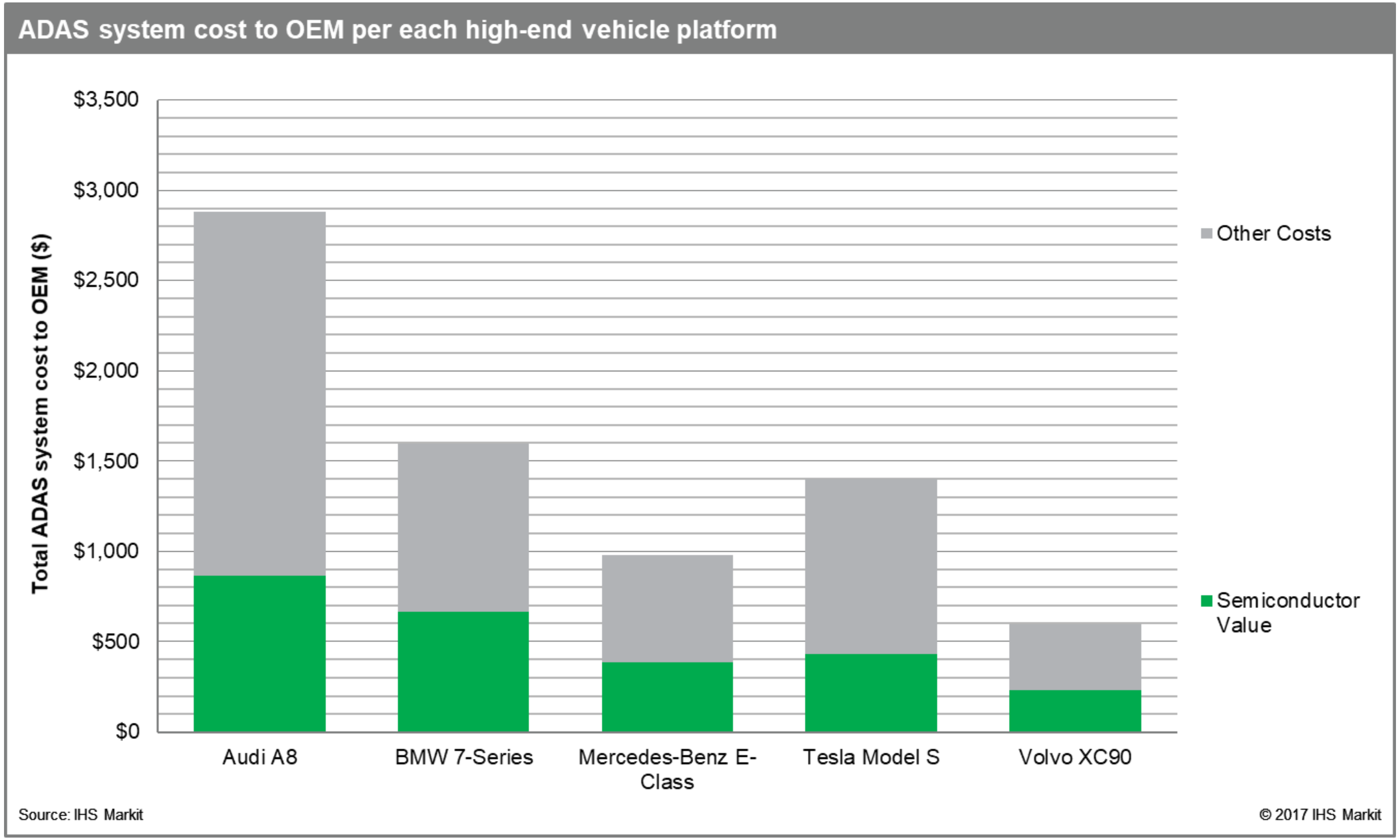
* AD=Autonomous Driving

ADAS classification by passive warning and active control



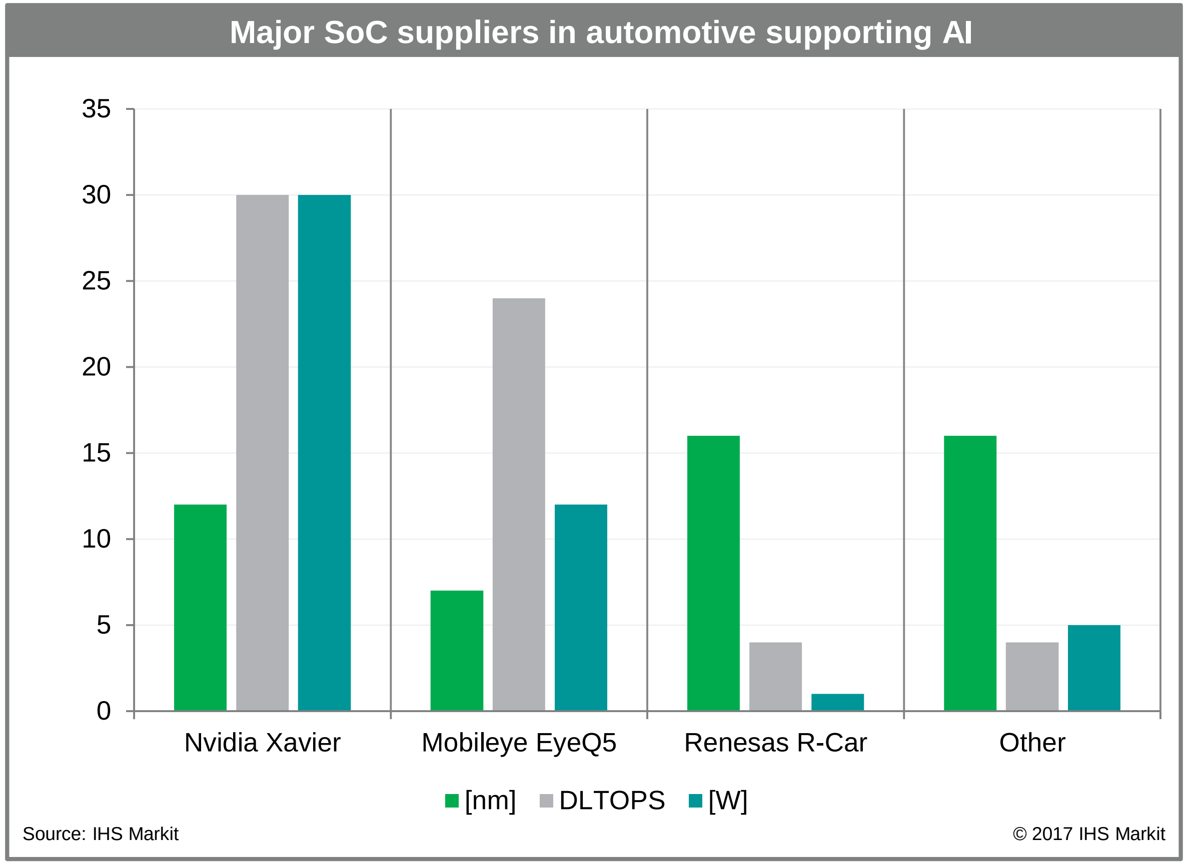
*The results of Tesla Model functions will be updated in the final deliverable

Software value driven by performance and safety



Battle in the SoC space: heterogeneous architecture

- GPU, TPU, CPU, IPU….
  - ❑ **Heterogeneous architecture!**
  - ❑ **DLTOPS and DMIPS/MHz**
- Cost of SoC over time
  - ❑ **Impact on scaling and tech-node**
  - ❑ **Ensure <16nm and high-volumes**
- SW vs HW
  - ❑ **Platform scalability**
- Go to market strategy
  - ❑ **L2-L3 "now" or w/ L4-L5 "later"**



Performance and power: energy efficiency; …and safety

- In datacenter the energy efficiency is directly correlates to the cost
  ➔ Power consumption is critical for auto too but compromise are acceptable

- Let´s consider the overall system power consumption
  ➔ memory is about one order of magnitude more than SoC
  ➔ embedded volatile memory is preferable for performance and power

- If >100 TOPS is the target in L4-L5 type of vehicle,….by when?
  ➔ OEMs´ and suppliers´ strategy might differentiate

- <u>Challenge for AI&DL: Deterministic behavior and ISO26262</u>

Something probably needs to change….

TÜV SÜD and DFKI to develop "TÜV for Artificial Intelligence"

The German Research Center for Artificial Intelligence (DFKI) and TÜV SÜD are launching a joint project to certify systems based on artificial intelligence (AI) used in autonomous driving and develop a 'roadworthiness test' for algorithms

Intel MobilEye - Overview of the Plan

We believe that it is important for the automotive industry to collaboratively establish a methodology and standard for safety validation in partnership with global standards–bodies and regulators. The United States is among the countries leading the way with pending self-driving vehicle legislation and new USDOT Automated Vehicle Guidelines, making this a perfect time to engage in these collaborative next-step discussions.

Our proposed model provides a detailed, practical, and efficient solution for designing and validating an AV system that results in drastically improved safety. Here is an outline of the next-step areas we believe merit attention and the solutions we propose: …..

Thanks for your attention

luca.deambroggi@ihsmarkit.com

Executive Director Transformative Technology
AI and Automotive architecture

URL:https://technology.ihs.com/Research-by-Market