The Data Deluge: View from the Automotive World

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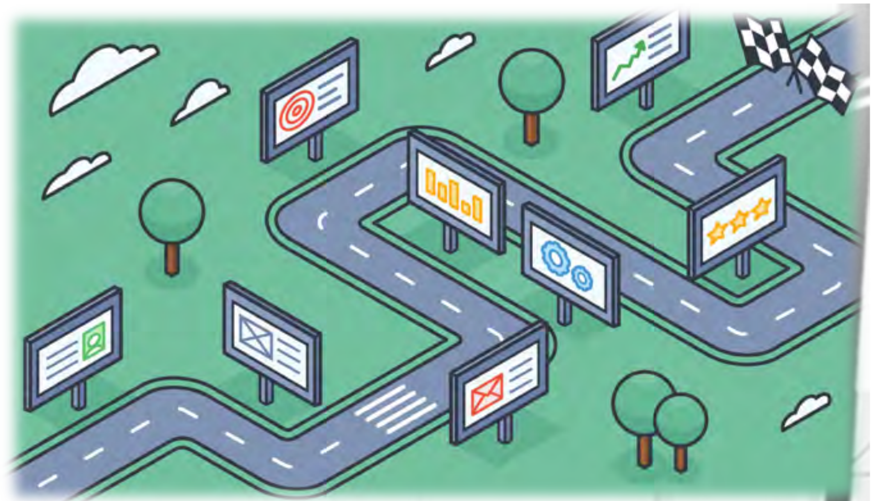
DataSwing
Senior Member IEEE, Computing Society

Roadmap



- History of computing in the automobile
- Five areas of usage & growth
  - ECUs, Safety Systems
  - Infotainment
  - Cars: the new talk show hosts (Connectivity or V2X)
  - Current drive to Autonomy
  - Areas often overlooked – The data deluge
- Summary: Current state of the art, vision and long term direction

Your messenger today

- A little bit about me:
- A seasoned scientific, technical and computing professional, spent over 20+ years implementing many new and pioneering technologies from operating systems (UNIX/Linux) , high performance computing (Cray, SGI, compute clusters), engineering applications (CAE simulations), networking (TCP/IP, Infiniband), operations (ITIL/ ITSM), scientific domain (BioInformatics), Machine Learning, Data Science applications and project management. I enjoy teaching, contributing to STEM activities and publishing.
- Currently a senior member of IEEE, ACM, Emeritus member of Michigan!/usr/group, and lead the SIG-Linux section of SEMCO.org.
- Also currently the Chair of the IEEE SE Michigan Education Society Chapter for 2017-18 and heads the Professional Activities Committee for Engineers (PACE) for IEEE-USA SE Michigan geographic section.
- A published author on the topic: "UNIX and TCP/IP Network Security“
- Authoring a new book on “Julia: a new programming language”

How Did We Get Here?

- Mechanical systems became electrically-driven
- Manual switches transitioned to electronic controls
- Addition of displays, touchscreen technology, advanced HMI
- Sensor technology enabled Advanced Driver Awareness Systems
- ADAS moves from Awareness to Assistance
- Electric actuators (originally for fuel economy) and computer controls for throttle, steering, and braking
- Platforms are now in place for more advanced automation

How Did We Get Here?

- The first use of a computer in a car was for engine control. It was called the ECU computer, or Engine Control Unit. The year was 1968 when the first ECU appeared in a VW to perform one specific function: EFI (electronic fuel injection)

How Did We Get He

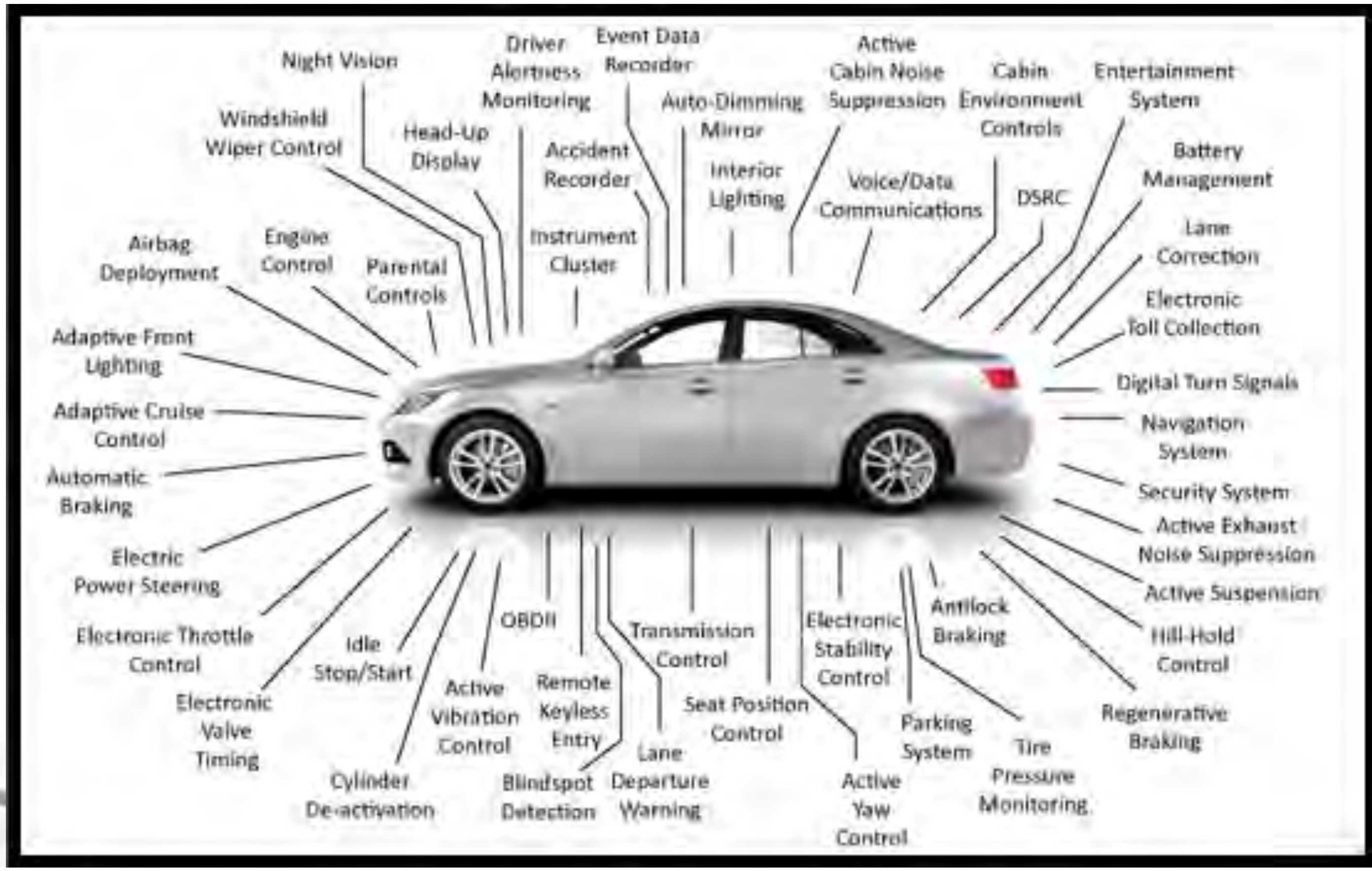
- Soon after Volkswagen computers in cars, other manu to adopt this approach

Other Early Automotive Computer Controlled Systems

- 1969 - Ford introduces their first computer controlled anti-skid system.
- 1971 - General Motors introduces their first computer controlled transmission.
- 1978 - Cadillac introduces a computer controlled trip computer powered by a Motorola Microprocessor.
- 1986 - Carnegie Mellon University's "Navlab 1" becomes first self-driving, autonomous car.
- 1986 - Chrysler introduces multiplexing wire communication modules with chips supplied from Harris Semiconductor.
- 1987 - First automotive microcontroller chips produced to CAN vehicle bus standards by Intel and Philips Semiconductor.
- 2014 - First commercially available self-driving vehicle introduced - The Navia shuttle.
- 2015 - Daimler's "Freightliner Inspiration" becomes First self-driving, semi-autonomous, Semi-Truck.

Situation Today

- Today's Automobiles contain lots of Computer Chips...to do lots of things!

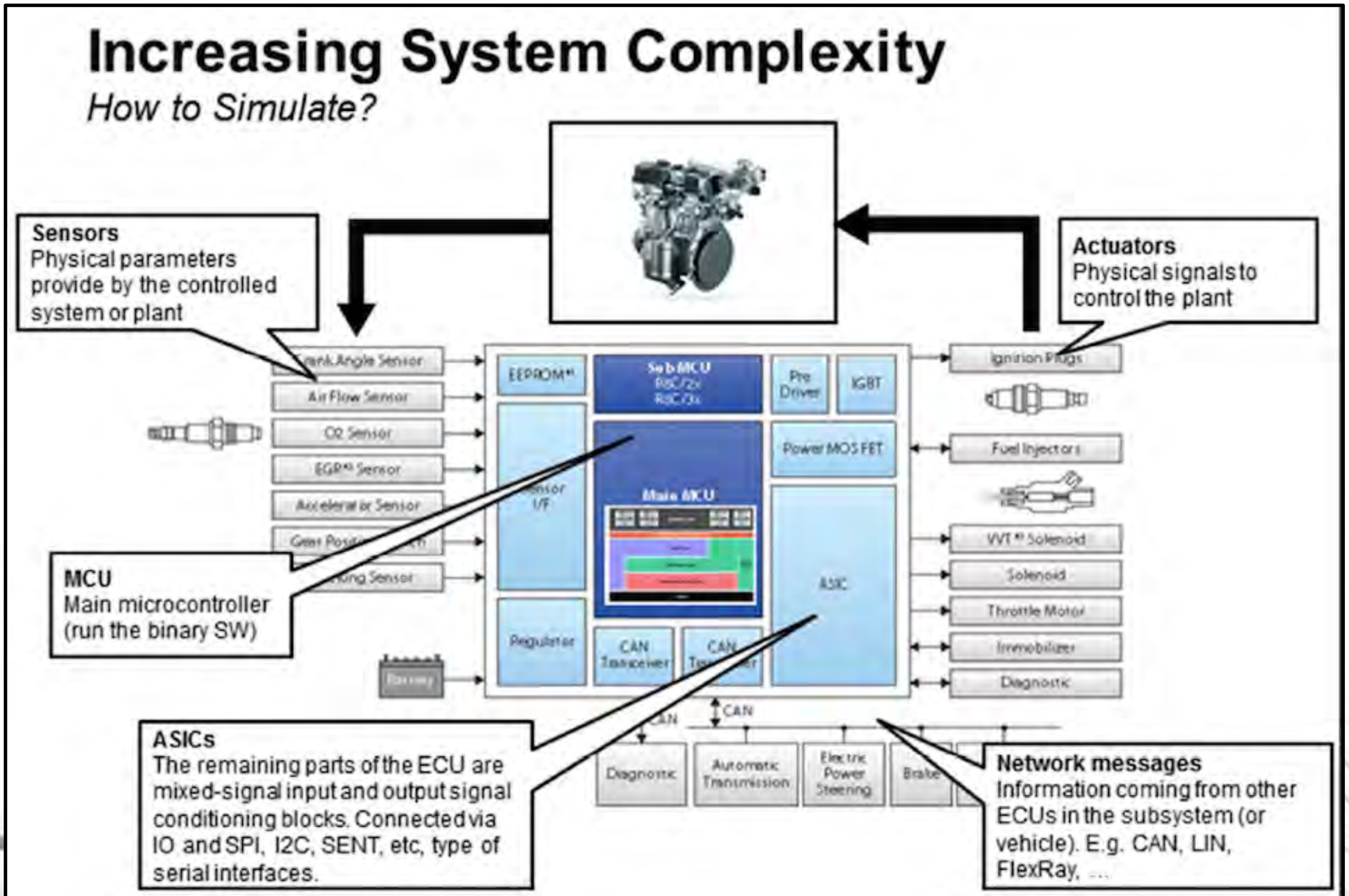


Computing Major Area (1):

- **ECUs and Safety Systems**
- In 2006, there were approximately 13 ECUs (PCM, OCS, ABS, etc)
- In 2010, this grew to a total of 26 ECUs (added TCU, etc)
- For model year 2013, shot up to 65 ECUs, e.g. DCU, HMI , etc…
- Projections are for 2019, this could number well over 100!

a. https://en.wikipedia.org/wiki/Electronic_control_unit

Computing Area (1): ECUs and Safety Systems



Computing Area (2): In-Vehicle Infotainment (IVI)

- When I first moved back in 2012, infotainment was all the rage (hiring)
- The digital lifestyle, plug in your music, WiFi, internet, apps, etc.

Computing Area (2): In-Vehicle Infotainment (IVI)

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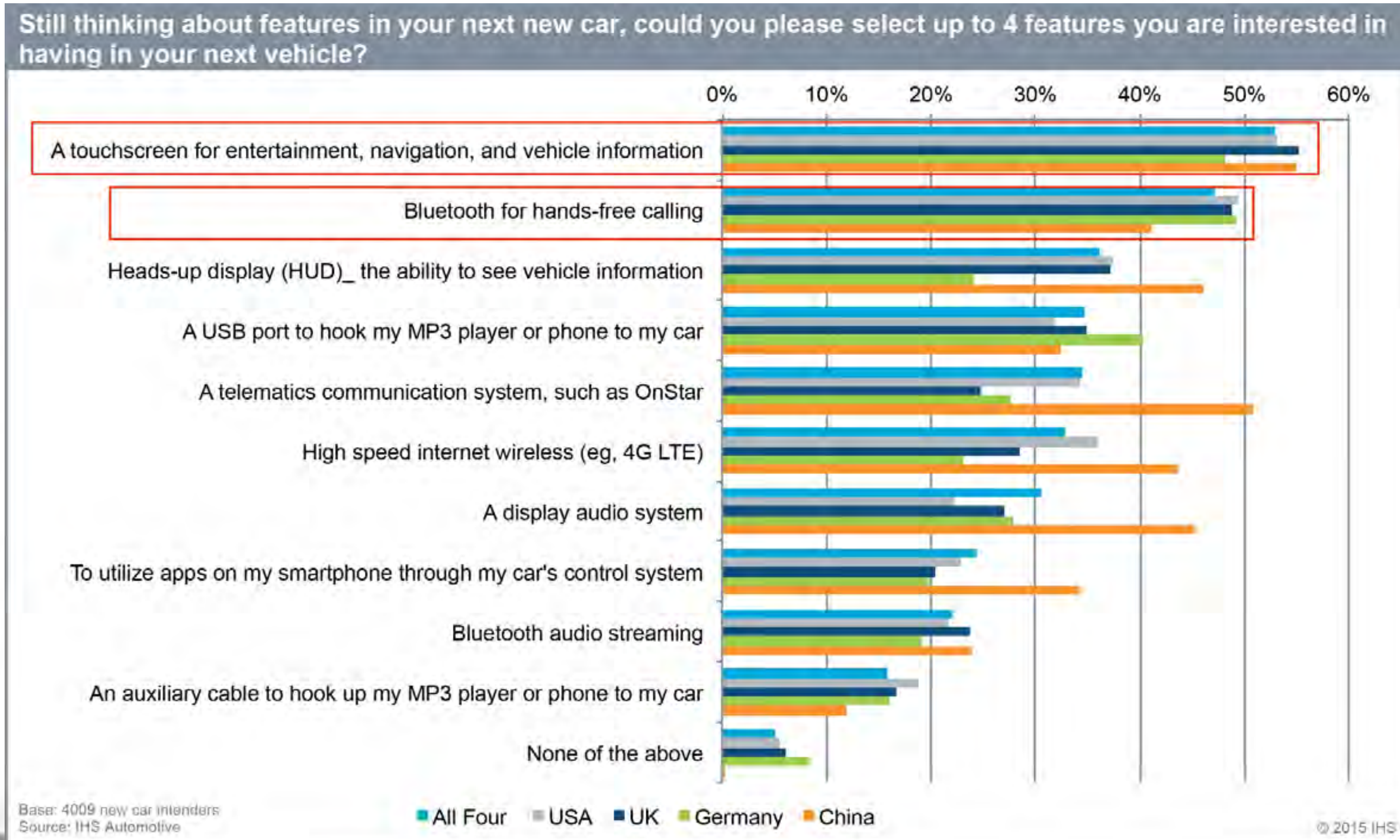


Computing Area (2): In-Vehicle Infotainment (IVI)

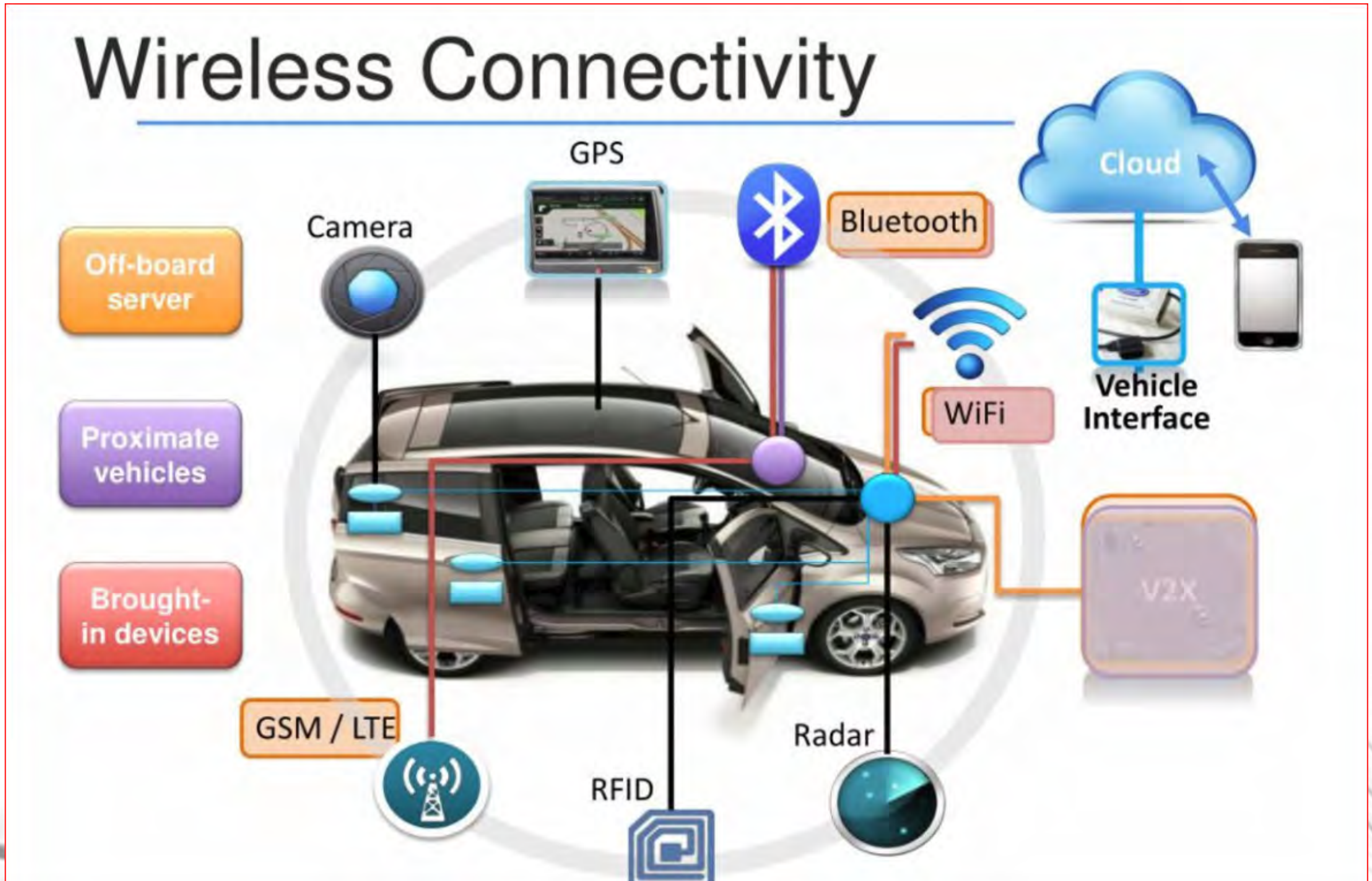
- Value of software in the premium car a staggering percent!
- What is inside?
  - Audio
  - Navigation
  - Telecommunications
  - Climate control
  - Entertainment
  - Touchscreen Displays
  - Multifunction Choice
  - Voice processing, *etc…..*

a. IEEE Spectrum

Computing Area (2): In-Vehicle Infotainment (IVI)

- What is involved?
- Embedded sensors
- GPS
- Haptics
- NLP systems
- WiFi, 3G/4G/5G/LTE
- HMI
- Connected Car

Computing Area (3): Connectivity + V2X



Computing Area (3): Connectivity + V2X

- E-payment
- V2V safety messages
- V2X infrastructure communications (m-City)
- Signal Phase and Timing - Traffic
- Smart City
- Vehicle Data (more on this later….)
- Geo-locating (follow me, gaming inter-vehicle occupants/loosely coupled)
- Fuel economy, driver assistance (tightly coupled)
- Innovative stuff we have to yet to dream up!

Computing Area (3): Connectivity + V2X

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a. *US Department of Transportation*

Computing Area (3): Connectivity + V2X

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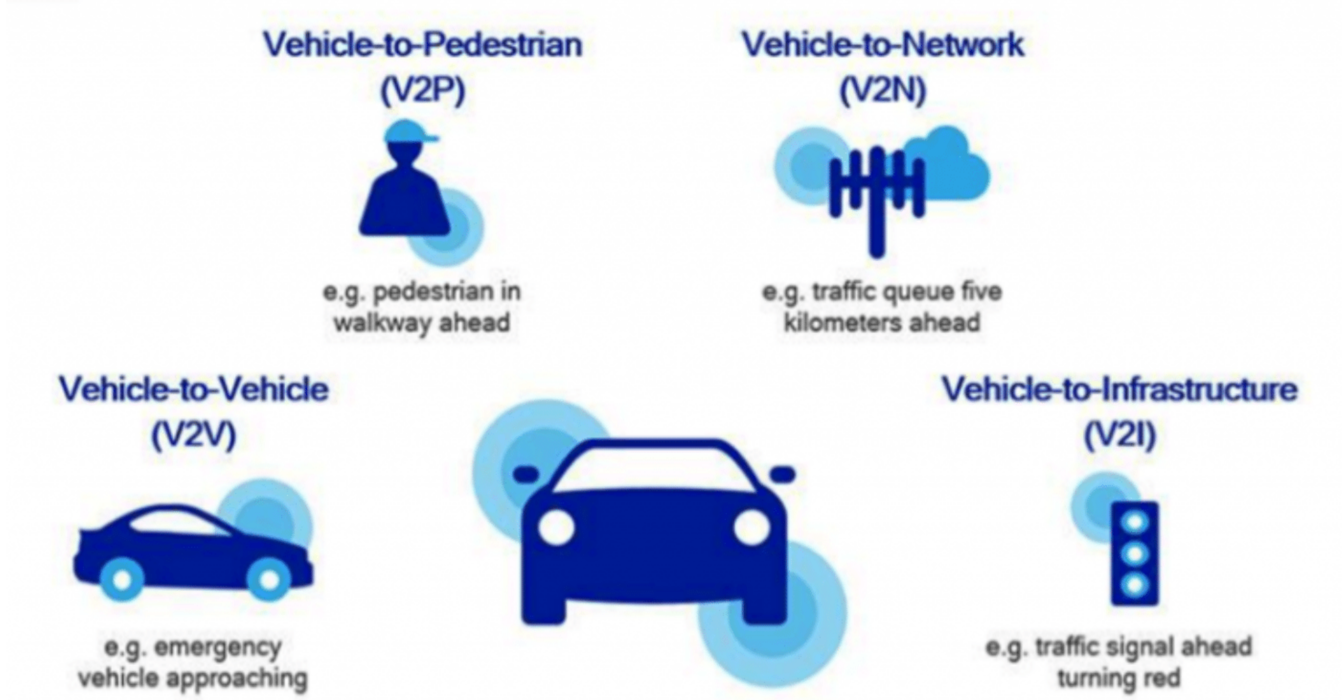

C-V2X (Cellular Vehicle-to-Everything) gives vehicles the ability to communicate with each other (V2V), to pedestrians (V2P), to roadway infrastructure (V2I) and to the network (V2N)

a. *US Department of Transportation*

Computing Area (3): Connectivity + V2X

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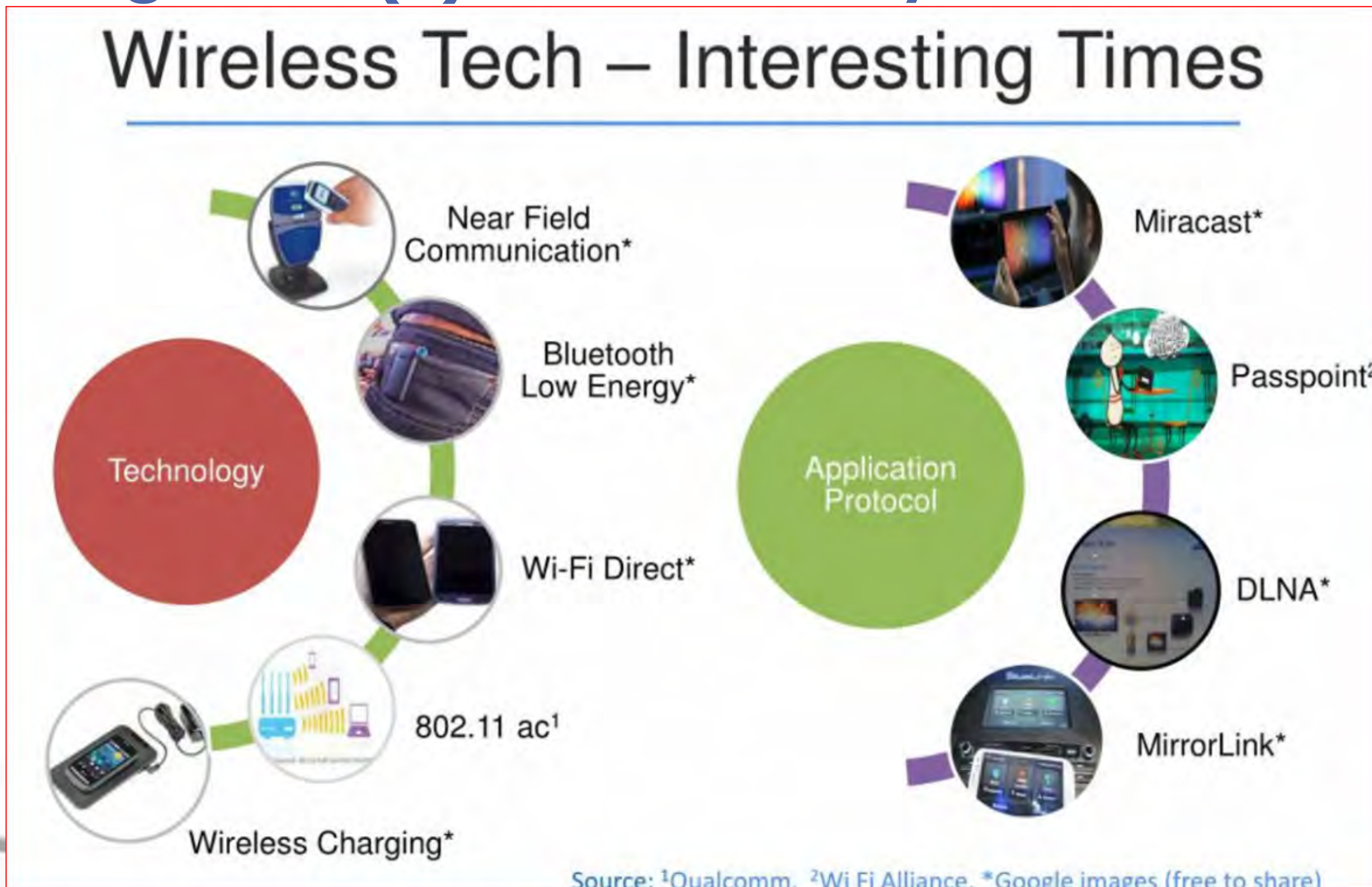

Computing Area (4): ADAS/Autonomy

Computing Area (4): ADAS/Autonomy

- SAE Level 0 - the human driver does everything
- SAE Level 1 - an automated system on the vehicle can sometimes assist the human driver conduct some parts of the driving task
- SAE Level 2 - an automated system on the vehicle can actually conduct some parts of the driving task, while the human continues to monitor the driving environment and performs the rest of the driving task
- SAE Level 3 - an automated system can both actually conduct some parts of the driving task and monitor the driving environment in some instances, but the human driver must be ready to take back control when requested
- SAE Level 4 - an automated system can conduct the driving task and monitor the driving environment, and the human need not take back control, but the automated system can operate only in certain environments and under certain conditions
- SAE Level 5 - the automated system can perform all driving tasks, under all conditions that a human driver could perform them
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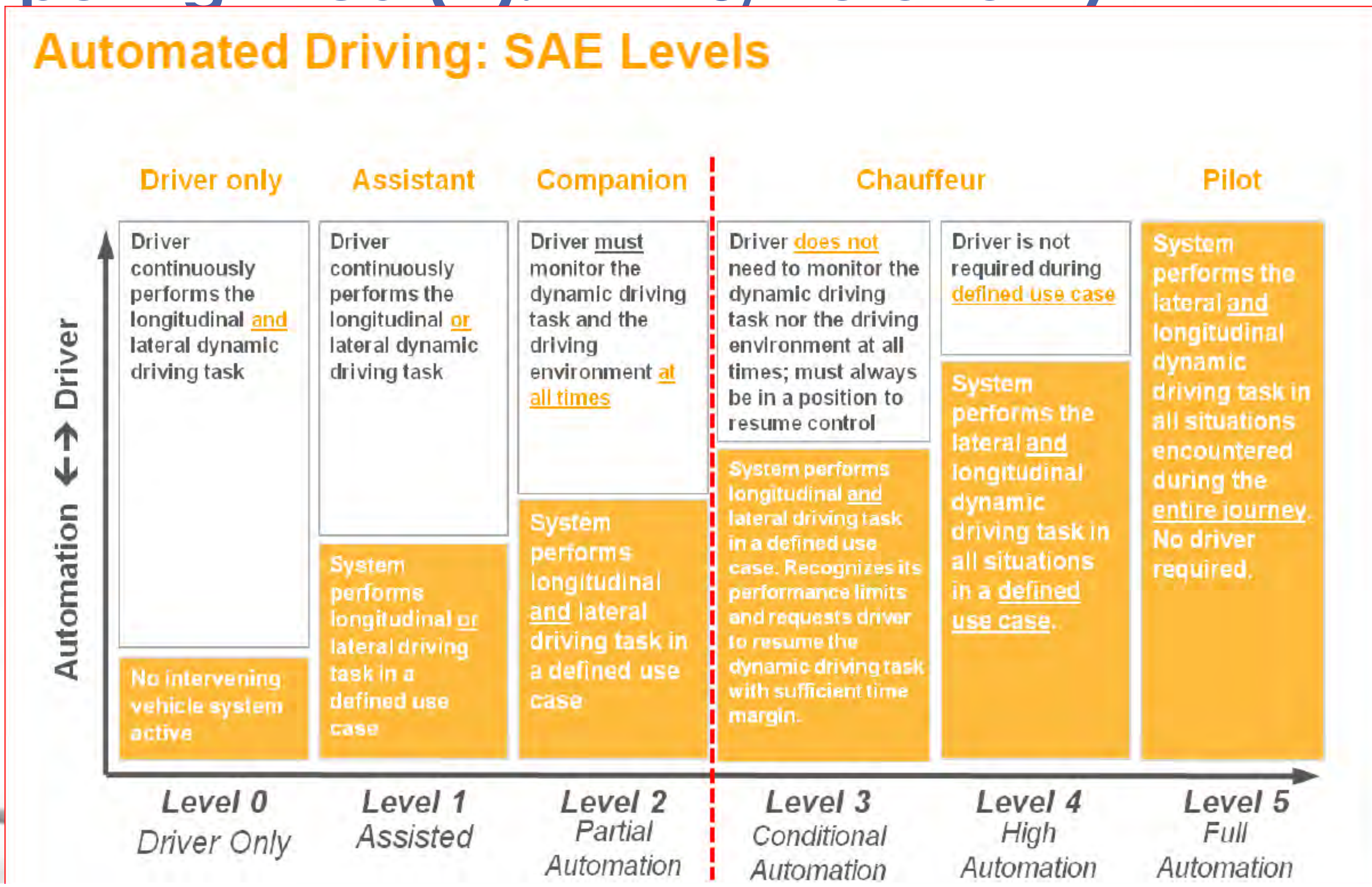
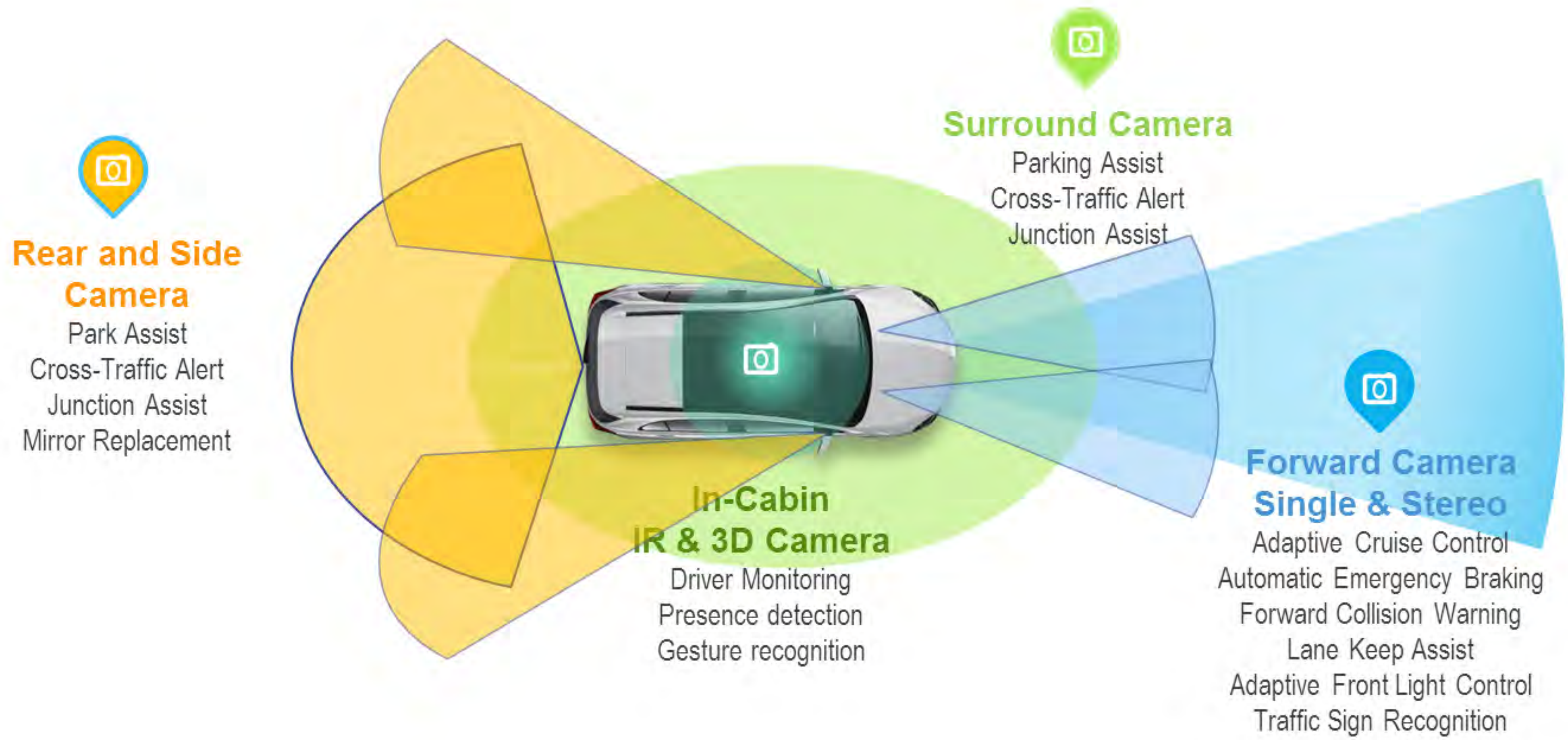
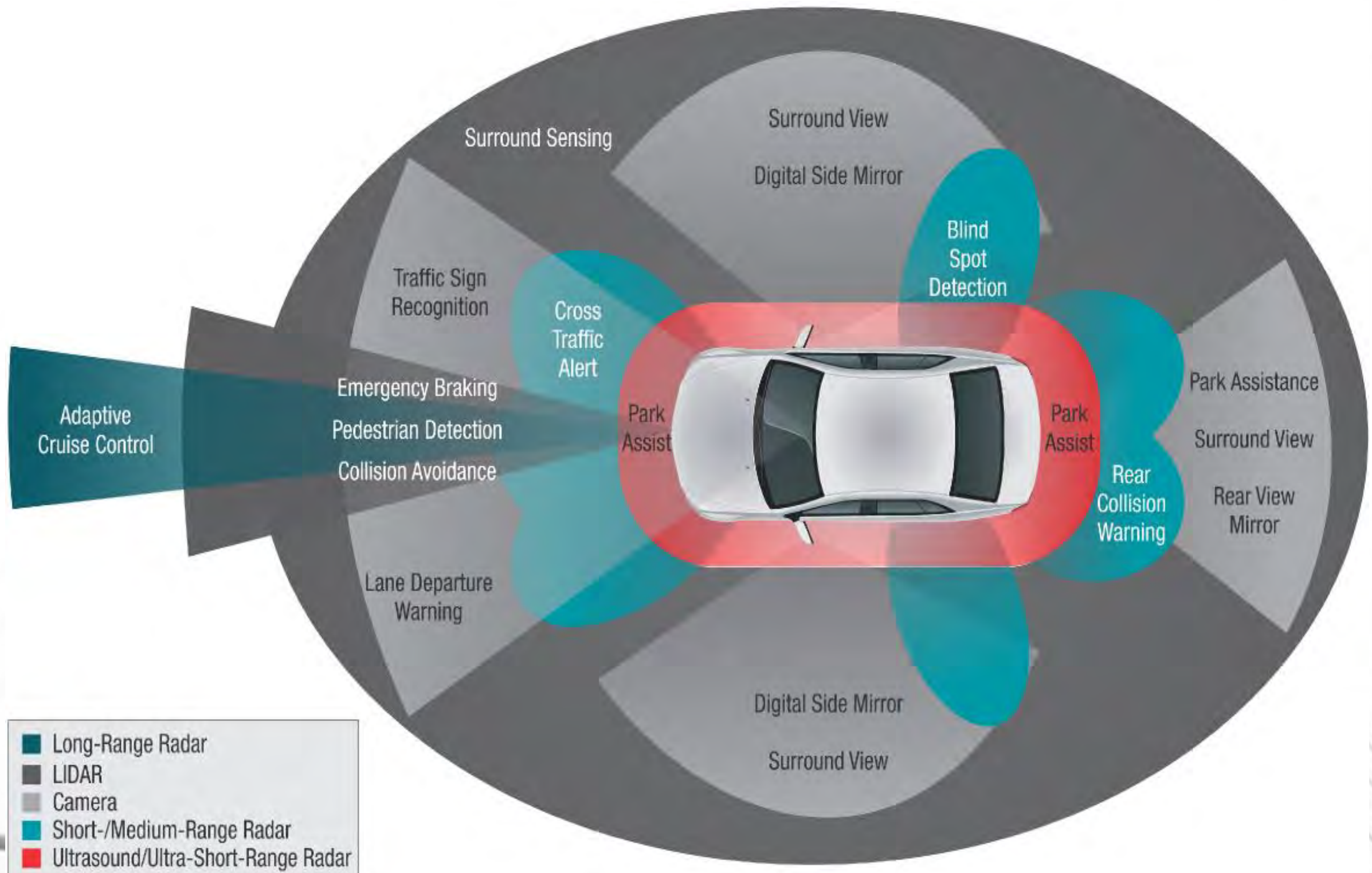
Computing Area (4): ADAS/Autonomy



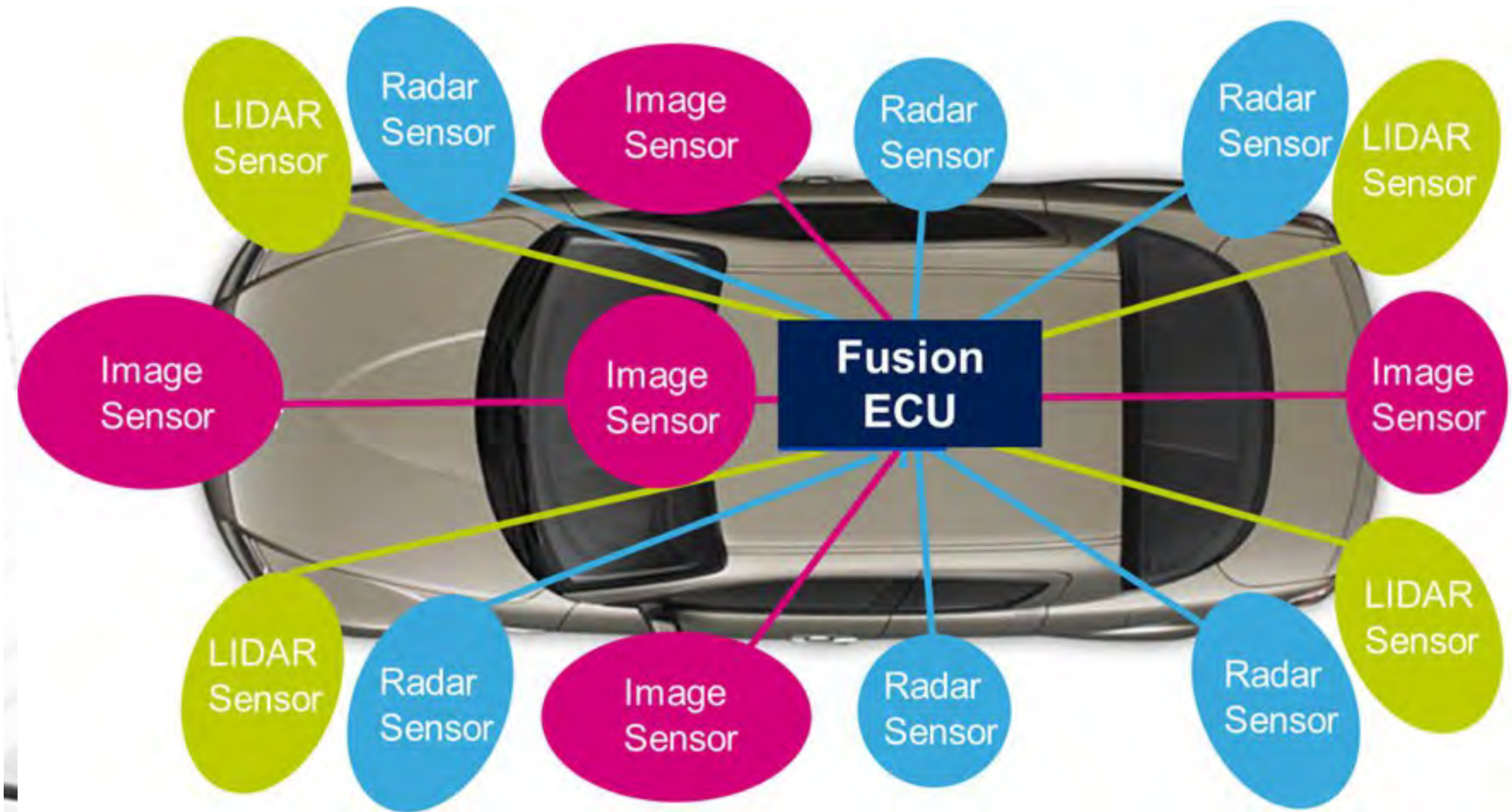
Computing Area (4): ADAS/Autonomy



Computing Area (4): ADAS/Autonomy



Computing Area (4): ADAS/Autonomy

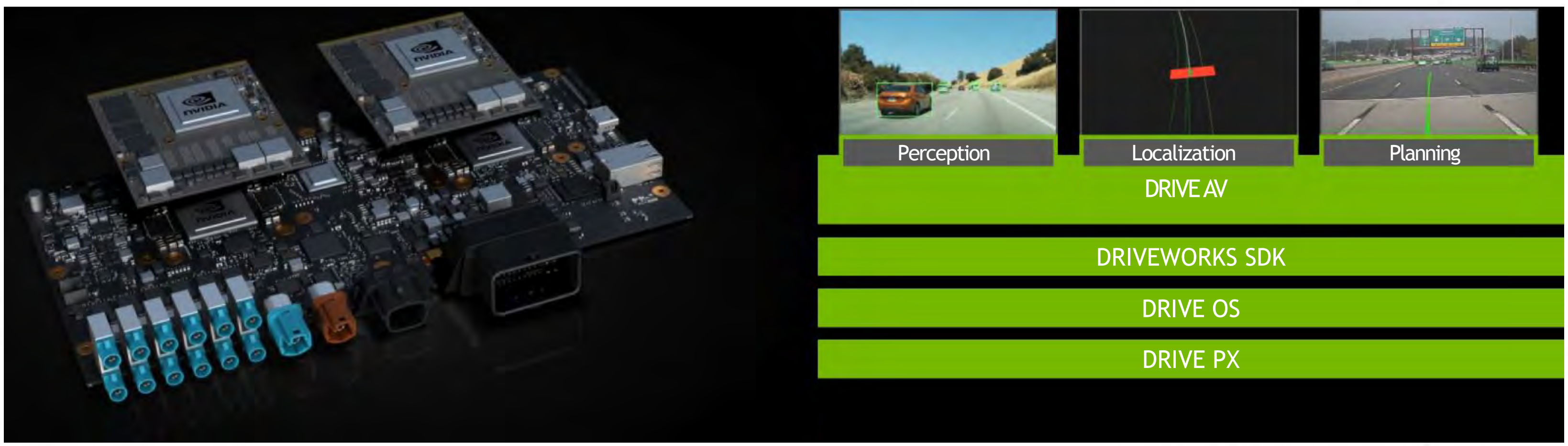



A REVOLUTION IN AUTOMOTIVE
NVIDIA
It began its driving lessons in a parking lot

A REVOLUTION IN AUTOMOTIVE

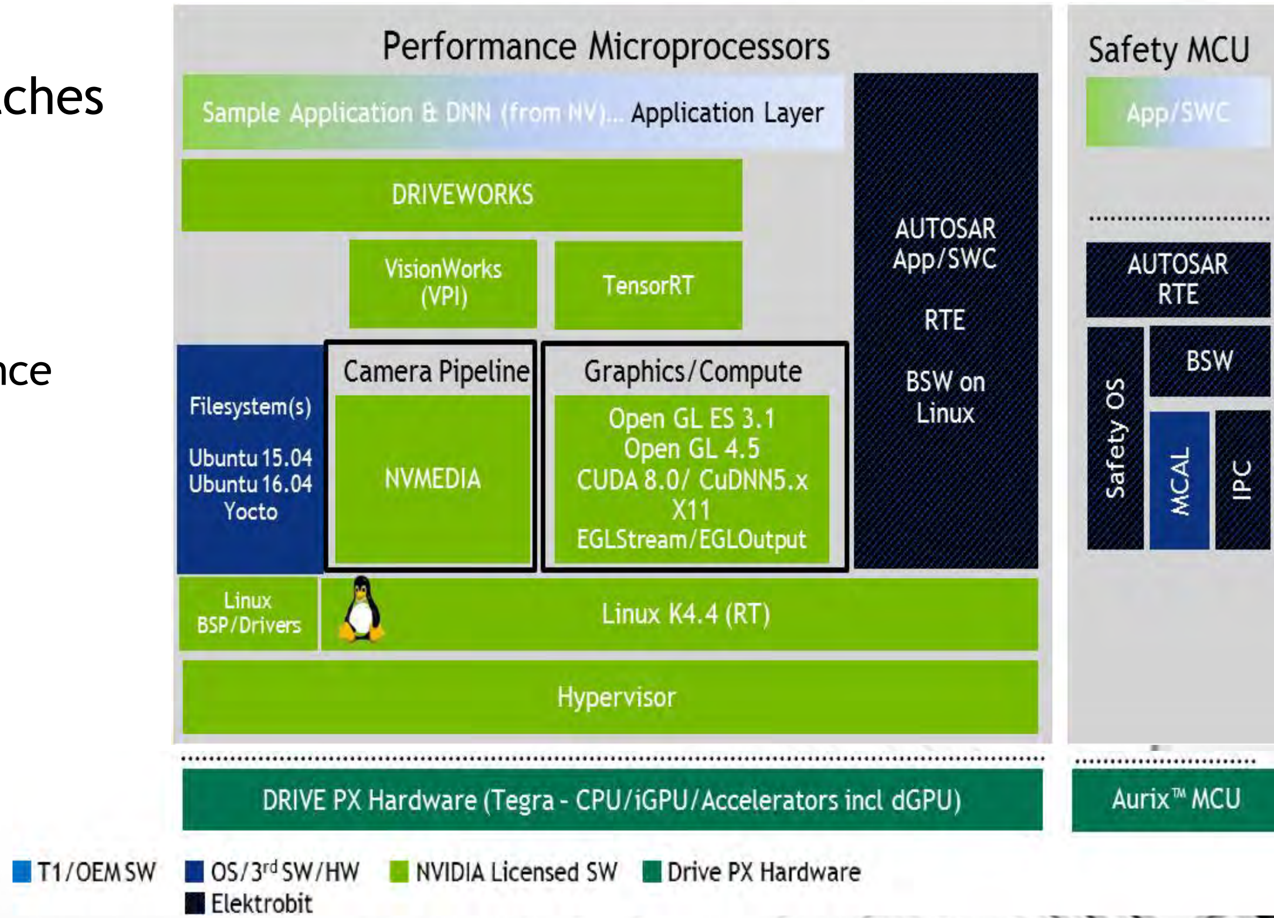
Computing Area (4): ADAS/Autonomy

- How does it do this?
- Example: nVIDIA Drive PX



Computing Area (4): ADAS/Autonomy

- Linux Kernel with RT patches
- QNX for production / safety certified kernel
- Rich Middleware
- Camera (NVMEDIA), Compute (CUDA), Vision APIs (VPI), Inference optimization (TensorRT)
- DriveWorks comprising
- SDK, Samples and more

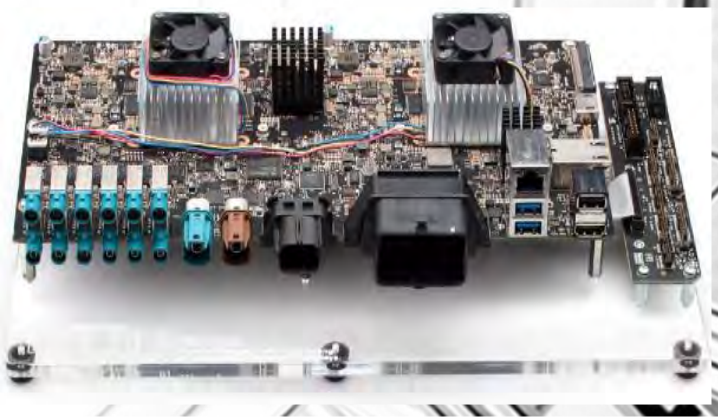


Computing Area (4): ADAS/Autonomy

DRIVE™ PX 2: AI Supercomputer for Self Driving Cars

Built for application development, rapid embedded prototyping and to help migrate to series production.

Delivers powerful I/O and processing capabilities, rapidly expanding product ecosystem and several means to shorten the path to production.



Computing Area (5): Overlooked Aspects

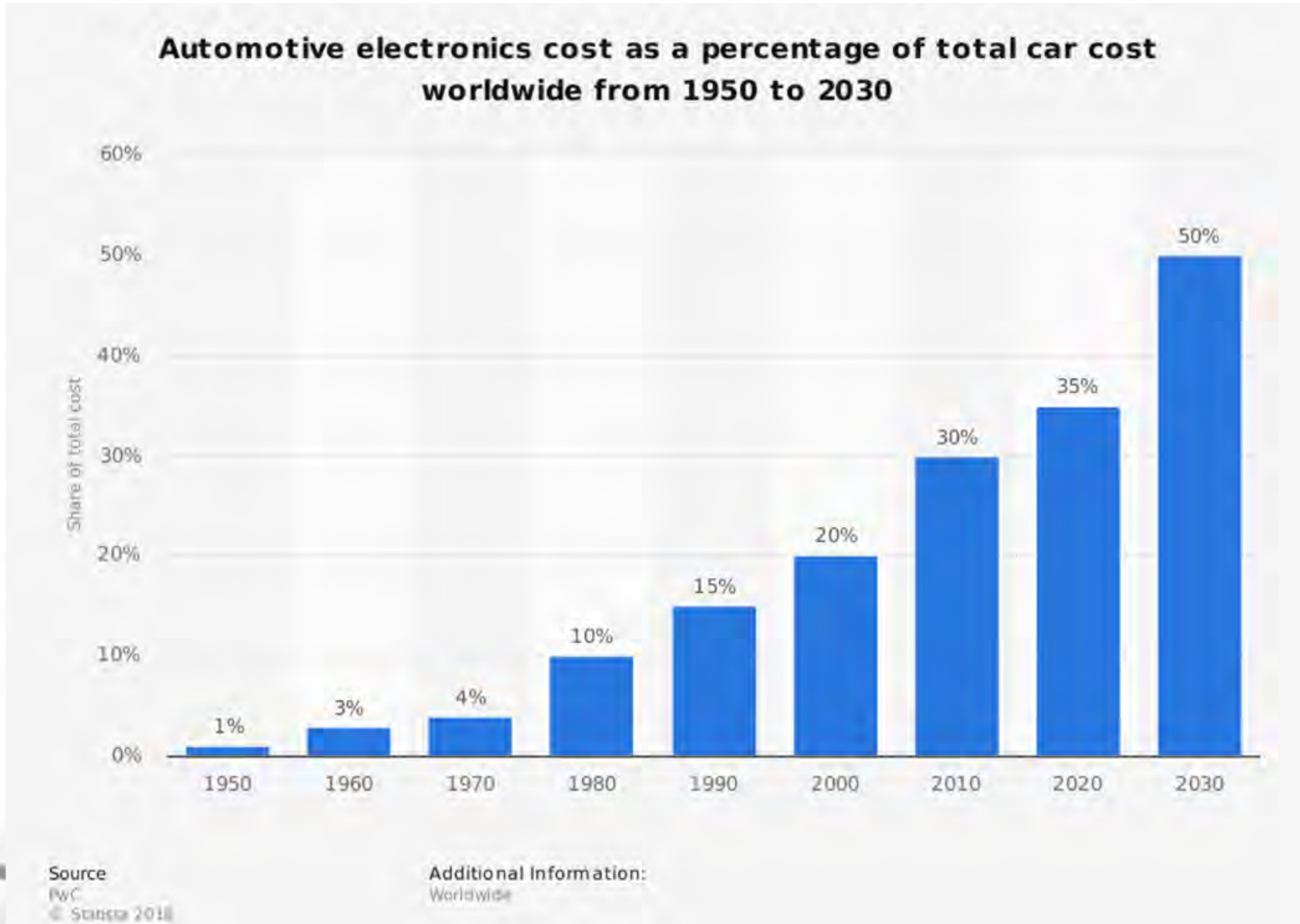
- The avionics system in the F-22 Raptor, the current USAF jet fighter, consists of about 1.7 million lines of software code.
- The F-35 Joint Strike Fighter, now operational, has 5.7 million lines of code.
- Boeing's new 787 Dreamliner, requires about 6.5 million lines of software code to operate its avionics and onboard support systems.
- "If you bought a premium-class automobile recently, it contains 100 million lines of software code," -- *Manfred Broy, professor at Technical University, Munich*.
- All that software executes on 70 ~ 100 microprocessor-based ECUs networked throughout the body of your car.

a. https://www.technologyreview.com/s/508231/many-cars-have-a-hundred-million-lines-of-code/
b. https://spectrum.ieee.org/transportation/systems/this-car-runs-on-code

Computing Area (5): Overlooked Aspects

- Clearly software engineering practices, are a critical part of all this
- Today all the vast automotive related companies are heavily engaged in this and will only get more complex.
- Plan to offer professional software measurement and management in future events

Computing Area (5): Overlooked Aspects

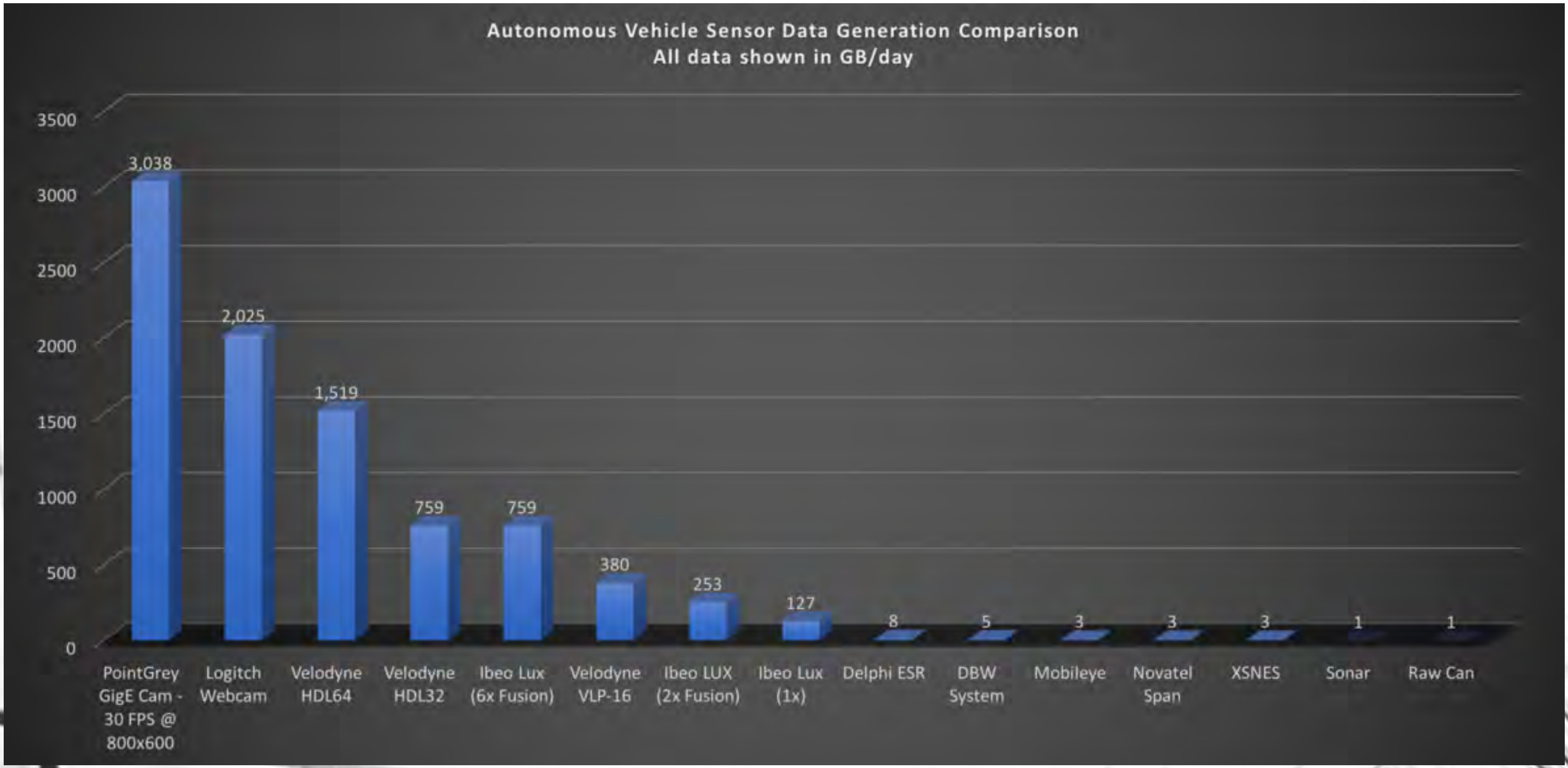


Computing Area (5): Overlooked Aspects

- Electric cars aka BEV (Battery Electric Vehicles), an unknown term in 2011
- Now yet mainstream, everyone waiting and watching
- Tesla, a tech company trying to become an auto company – *Mike Ramsey*
- If 100% of vehicles sold per year in the US were BEVs (approximately 16 million), it would require the construction of approximately ten additional full size 1000 MW power plants every year. Restated: for every 10% of US vehicle sales that are BEVs, another 1000 MW power plant will be required per year.
- Morgan Stanley estimates that if all US vehicles were BEVs, it would require 1/3 of the entire US generating capacity to power them

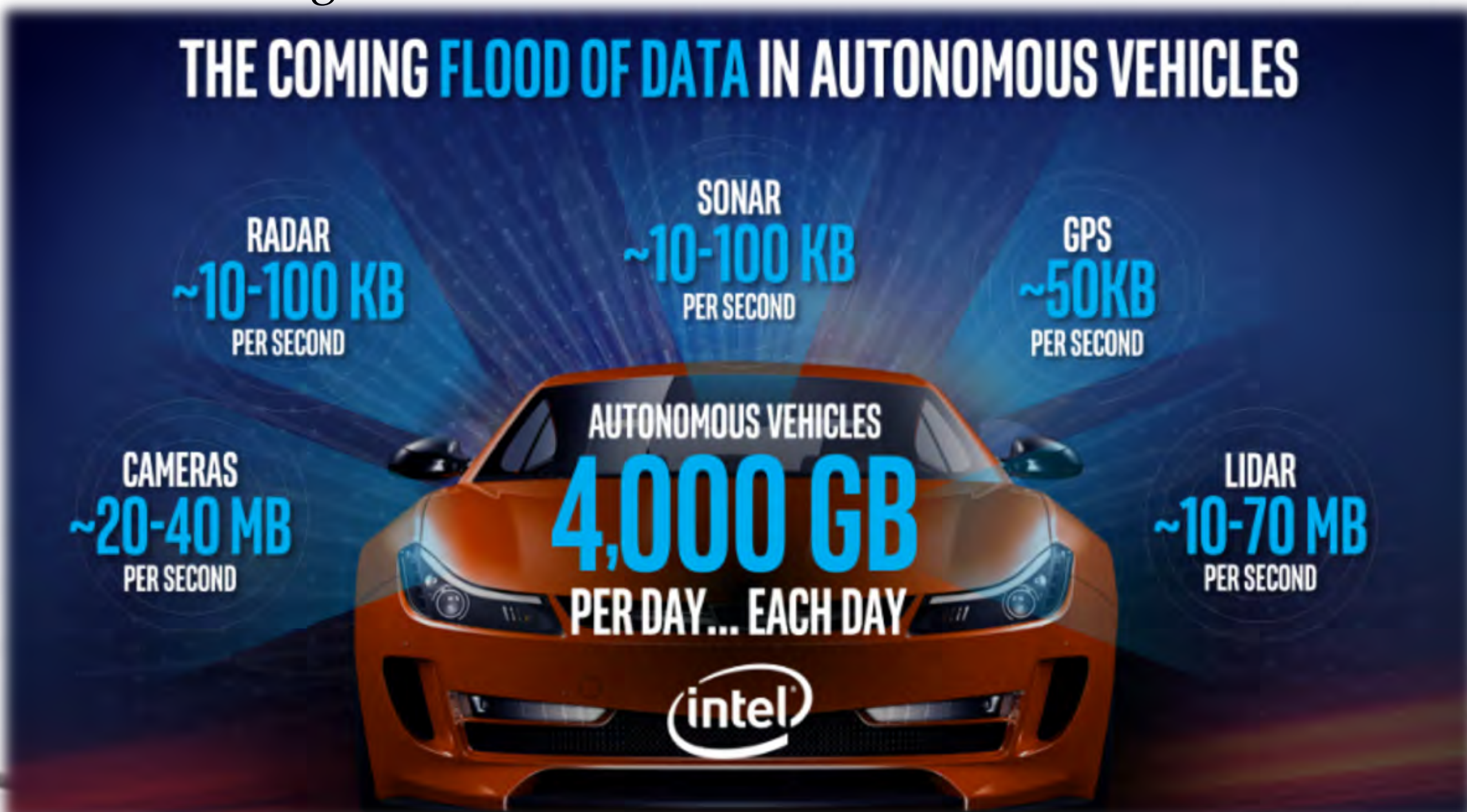
Computing Area (6): The Looming problem

- The Second Deluge!



Computing Area (6): Data Deluge

- The Second Deluge!

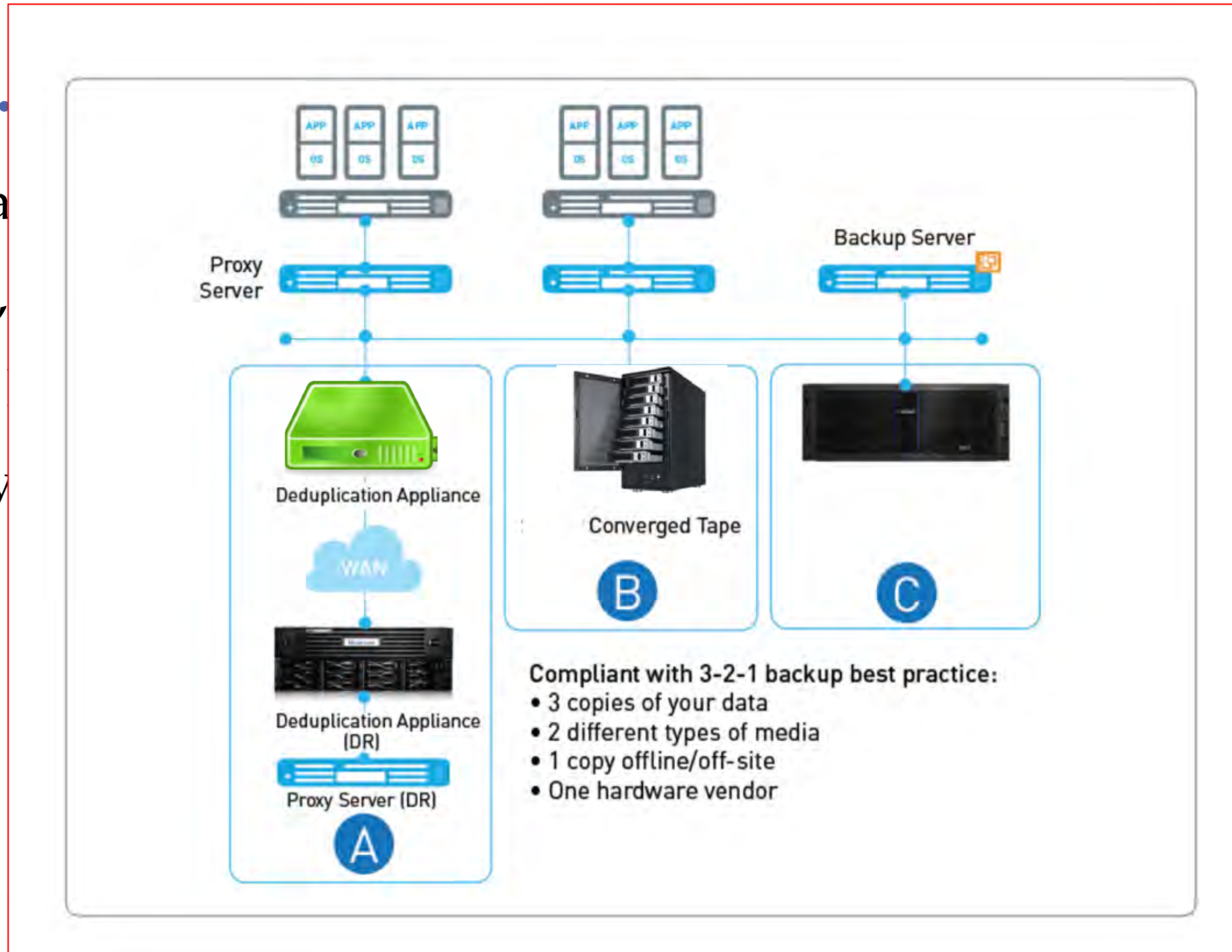


The solution?....

- Implement a 3-2-1 approach
- 3 copies of the data, usually with high speed flash storage
- 2 backup copies on low cost tiered storage (includes HSM tape)
- 1 archival/summary copy (integrated with HSM!)

The solution?....

- Implement a 3-2-1 a
- 3 copies of the data,
- 2 backup copies on
- 1 archival/summary



Why tape?….

- Not your father's tape….!
- Since 2005 onwards, tape technology has re-architected itself
- Physical issues: tape damage, war, tear, stretch, contamination, etc have been addressed, using embedded servo tracks

Why tape?....

- Tape is cheaper ($/TB) to acquire than disk
- Tape is less costly to operate than disk
- We already mentioned increase in reliability
- Tape performance has vastly improved
- Roadmap for tape is quite well laid out

Tape Reliability

Storage Device Reliability Ratings	BER (Bit Error Rate) Bits read before permanent error
Enterprise Tape (T10000x, TS11xx, LTO-8)	$1 \times 10E^{19}$ bits
LTO-5-7, SSD	$1 \times 10E^{17}$ bits
Enterprise HDD (FC/SAS)	$1 \times 10E^{16}$ bits
Enterprise HDD (SATA)	$1 \times 10E^{15}$ bits
Desktop HDD (SATA)	$1 \times 10E^{14}$ bits

Summary

- ❑ Rising amount of compute and data in the auto world is a problem
- ❑ Dealing with data requires planning & pro active approach
- ❑ Solutions can be scaled and tailored to other similar problems (IoT?)
- ❑ Modern tape based systems expected to provide some relief
- ❑ Old Maxim → Reliability, Speed, Cost : Choose any two!
- ❑ My preference→ I can have all 3!

Thank you!

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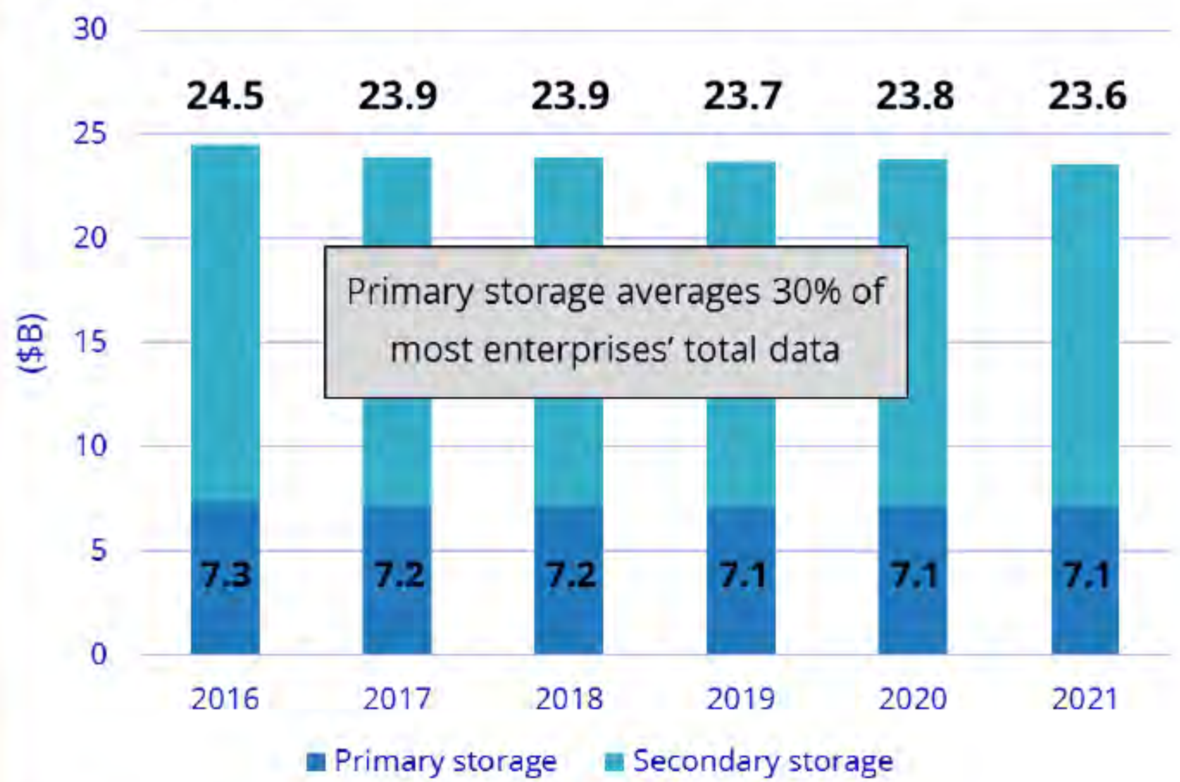
Backup material

FIGURE 1

External Enterprise Storage Revenue by Primary and Secondary Storage, 2016-2021

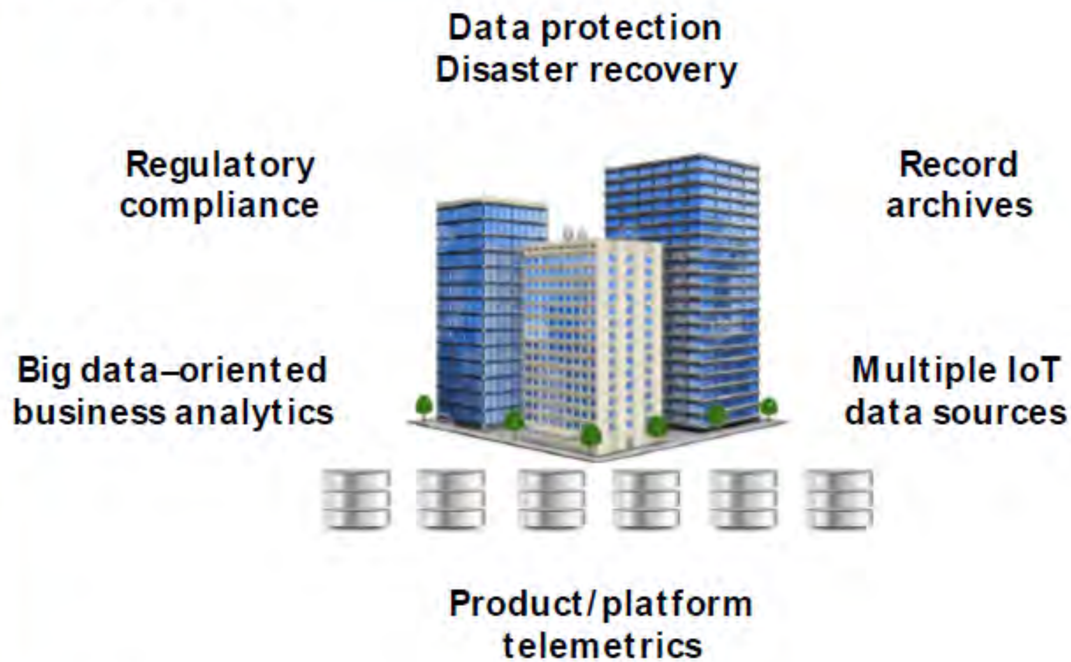


Source: IDC, 2018

Backup material

FIGURE 2

Sources of Big Data



Source: IDC, 2018