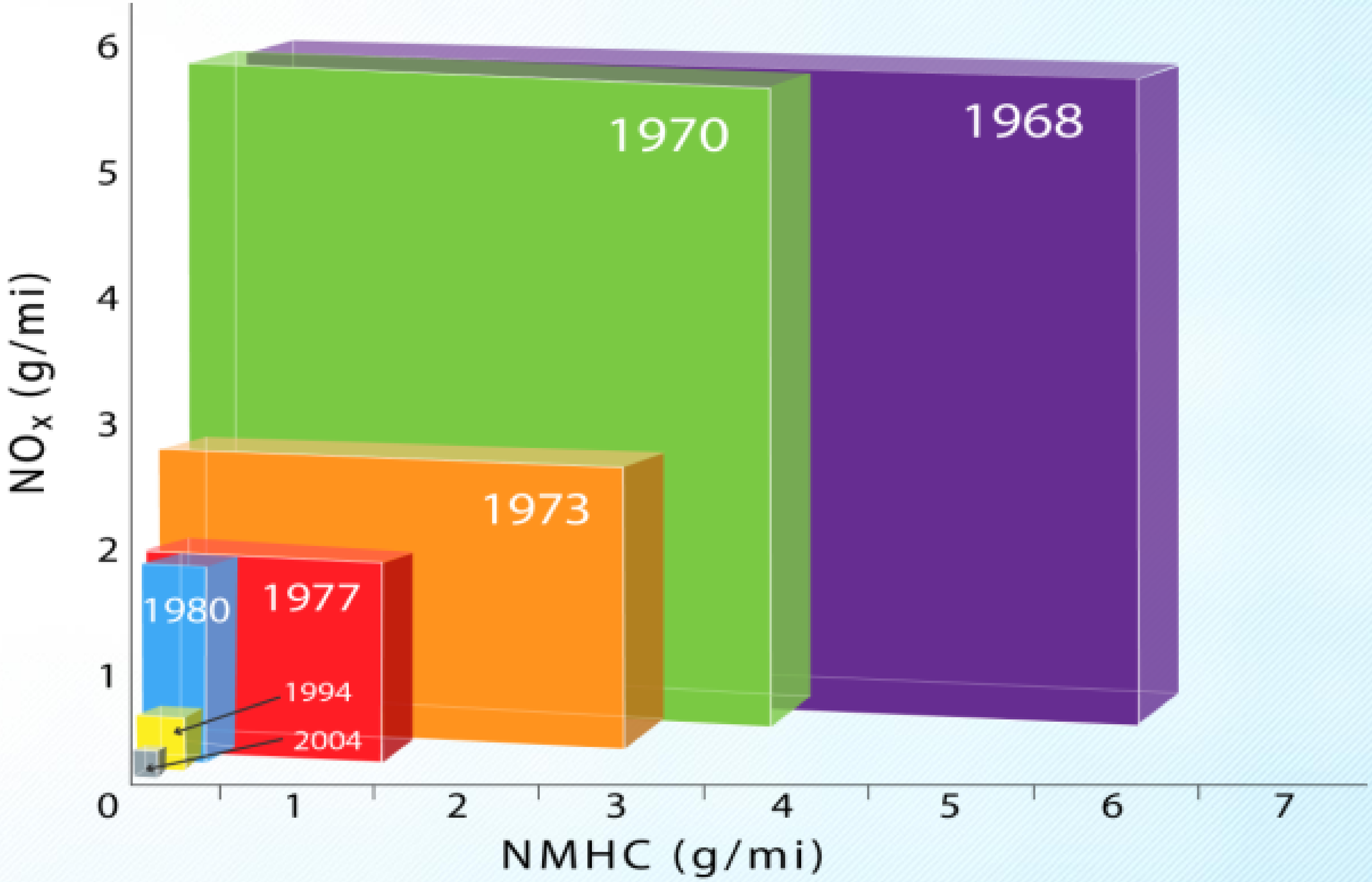
Multicore on Wheels

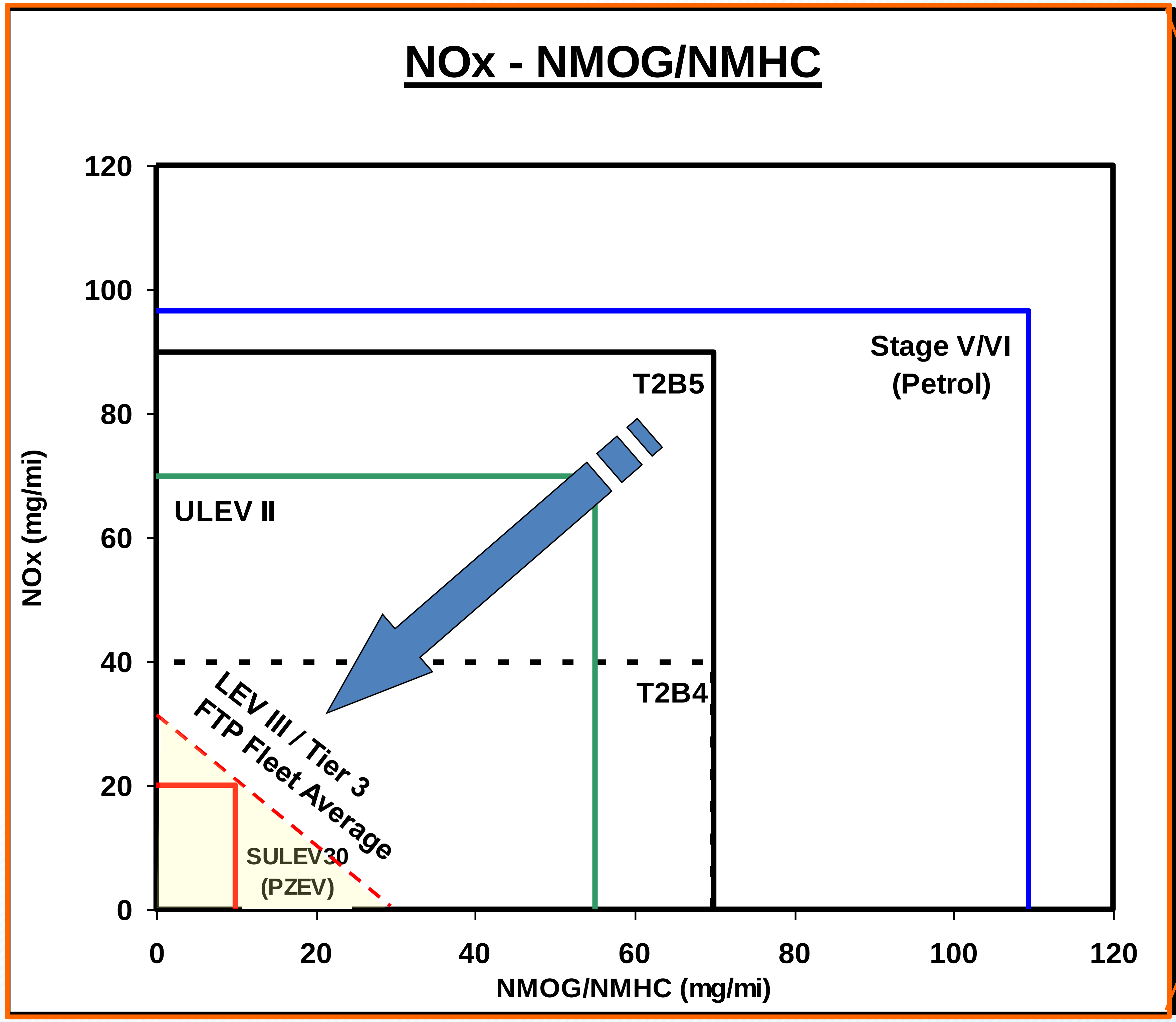
Craig Stephens

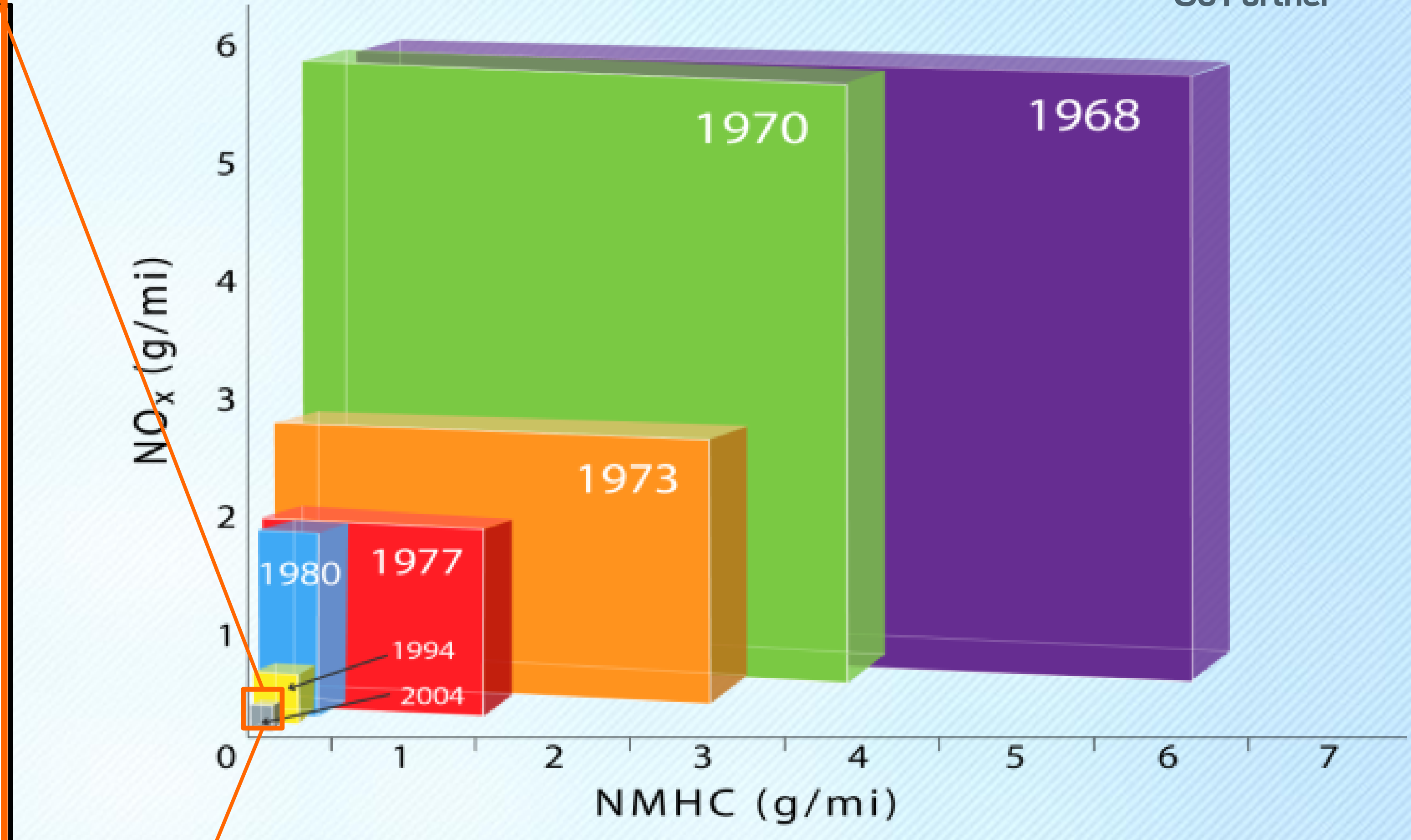
A Brief History of Automotive Controls

Emissions Requirements



Emissions Requirements



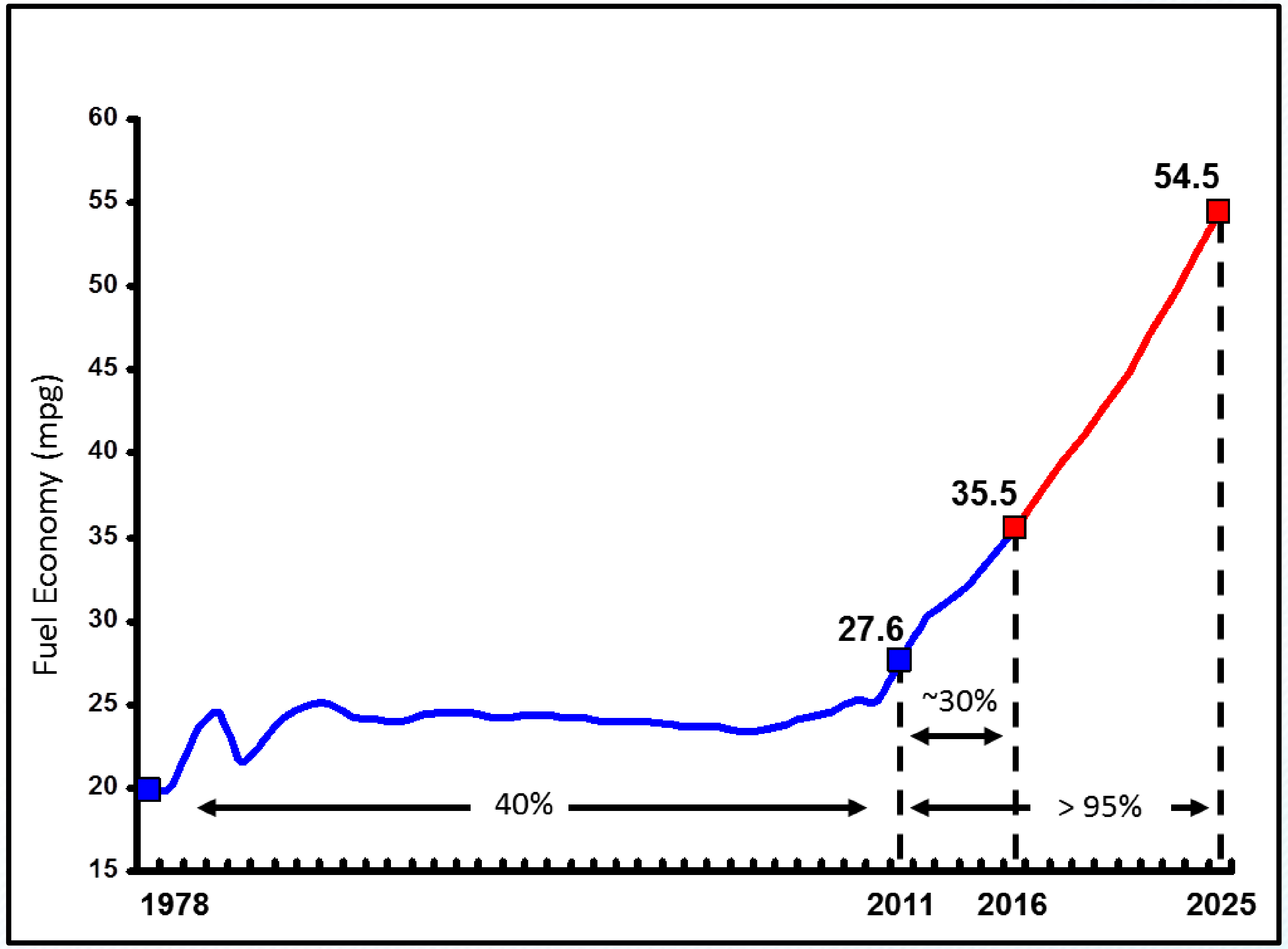


Go Further

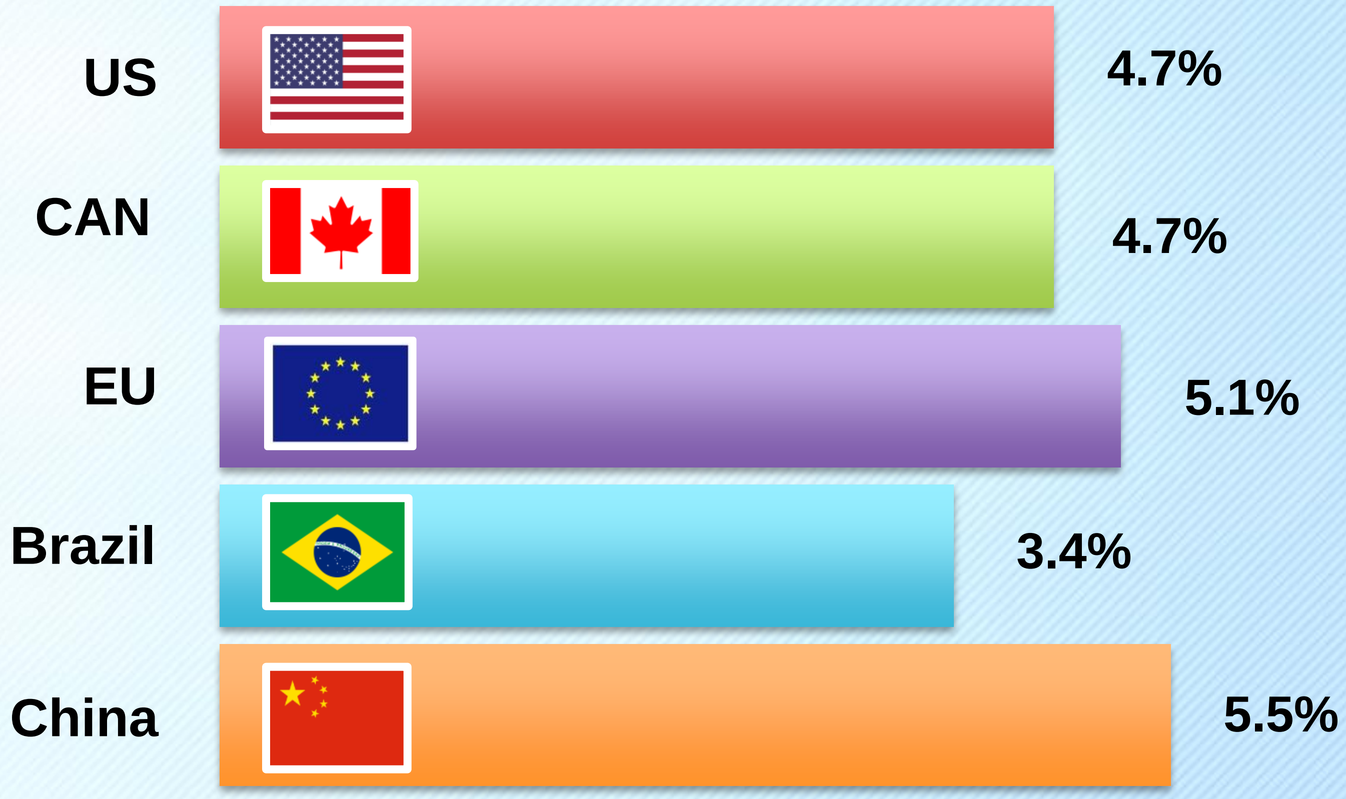
Fuel Economy Requirements

Go Further

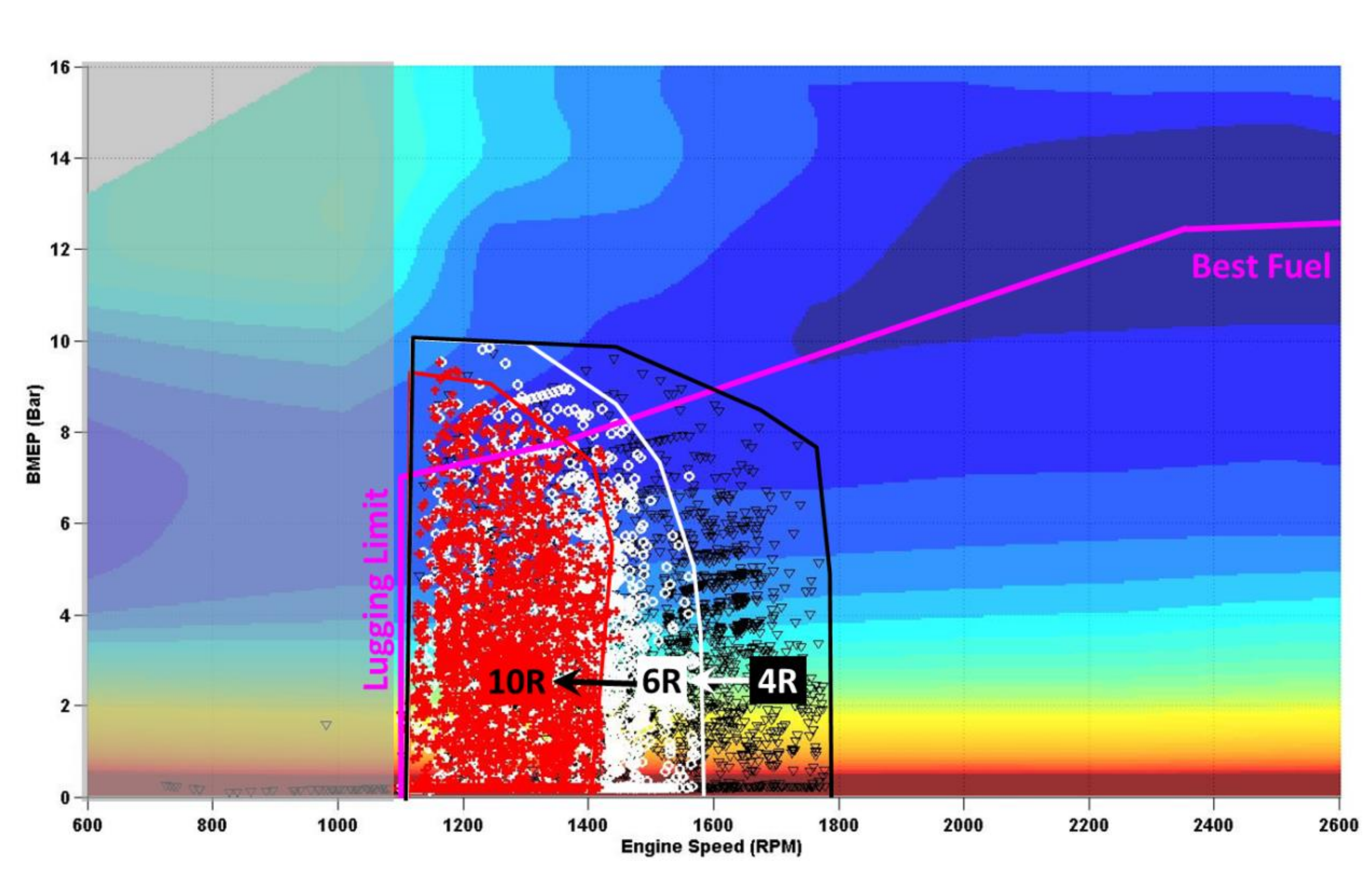
US MPG Regulatory Landscape



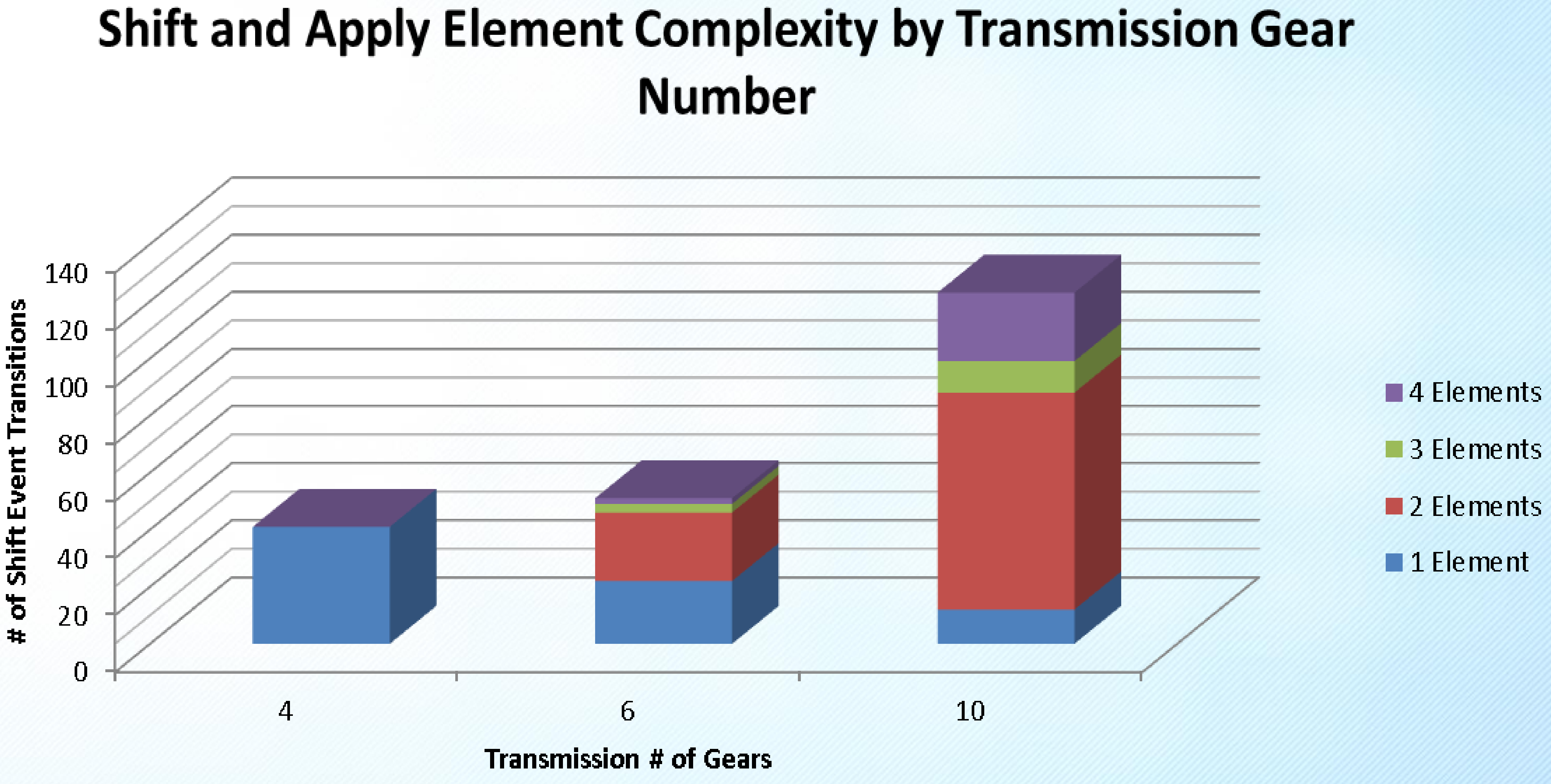
Average Annual CO_2 Improvement Required by Global Regulations (2015-2020)



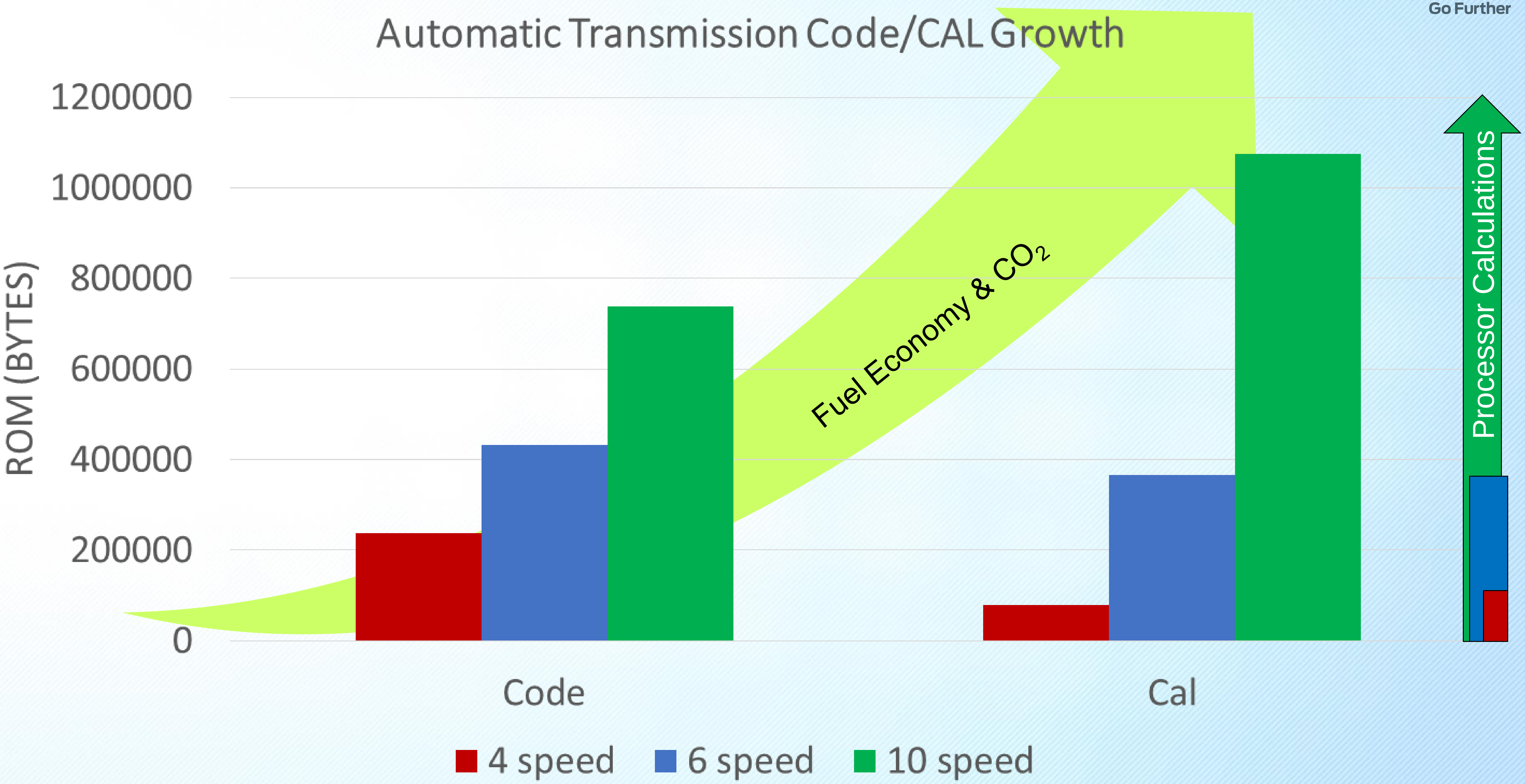
Impact of Increasing Gears on Shift Complexity



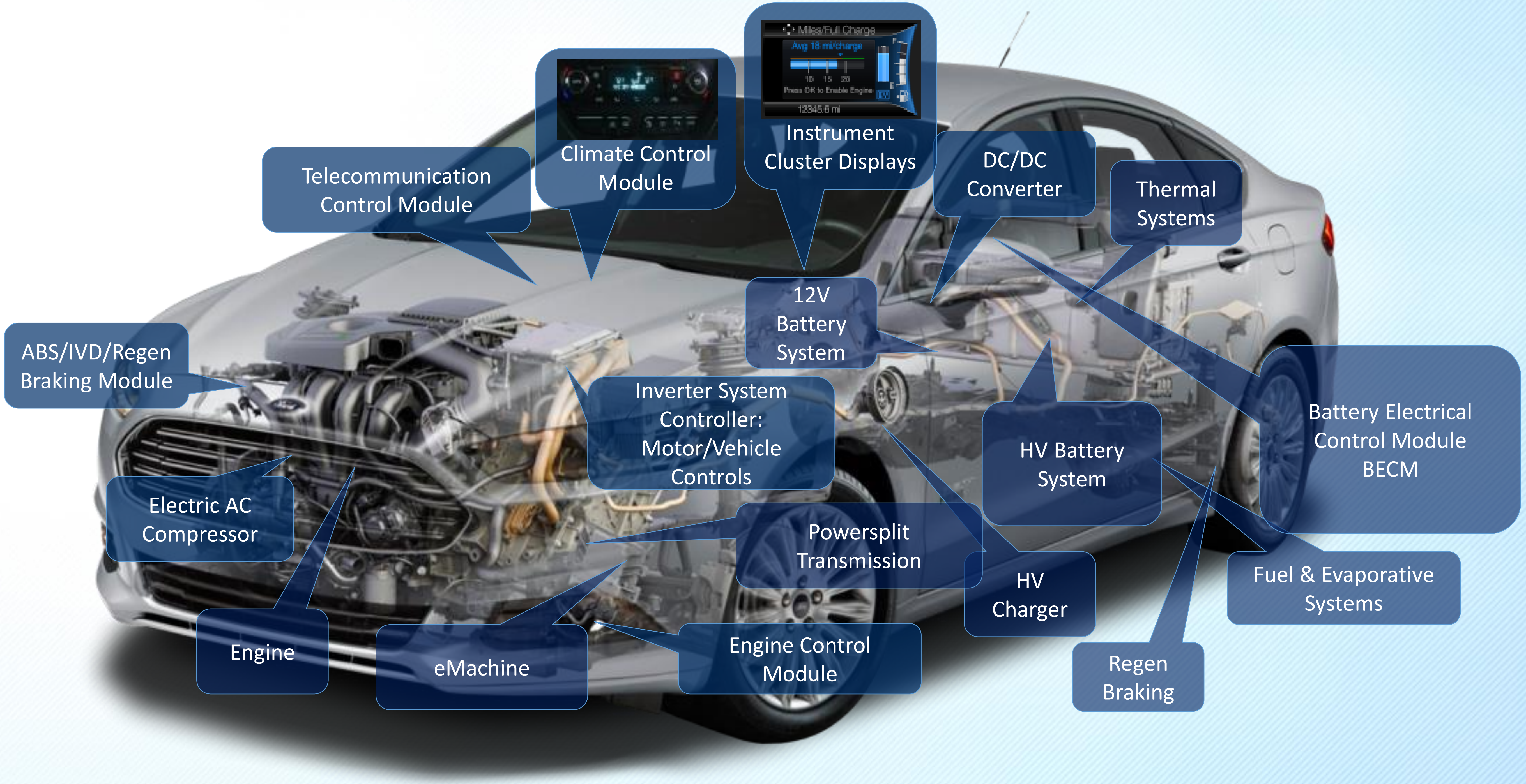
Impact of Increasing Gears on Shift Complexity



Impact of Increasing Gears on Memory



Electrified Vehicle Technology

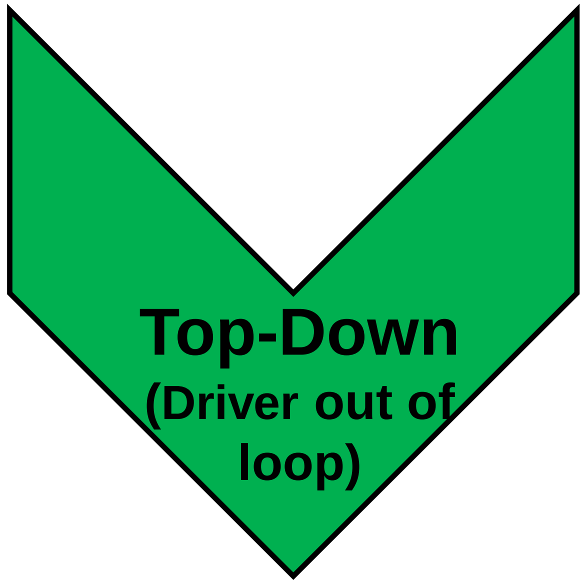


Driver Assistance and Active Safety

Go Further

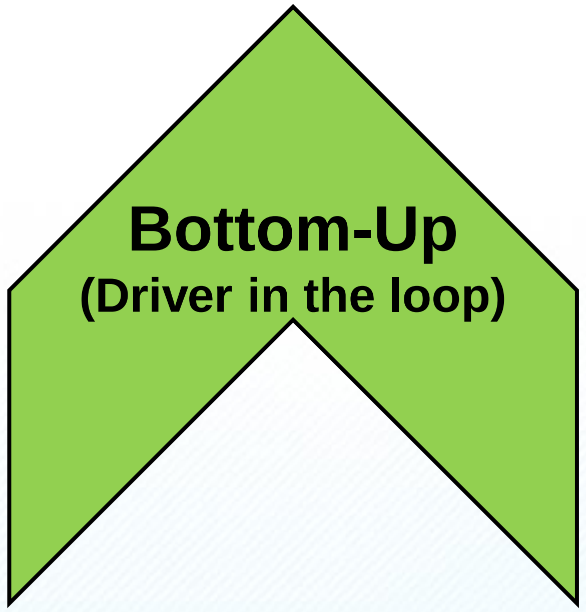
Active Park Assist	Adaptive Cruise Control	Active City Stop	Pedestrian Detection

Transition to Autonomous Driving



<u>Top-Down Workstream</u>

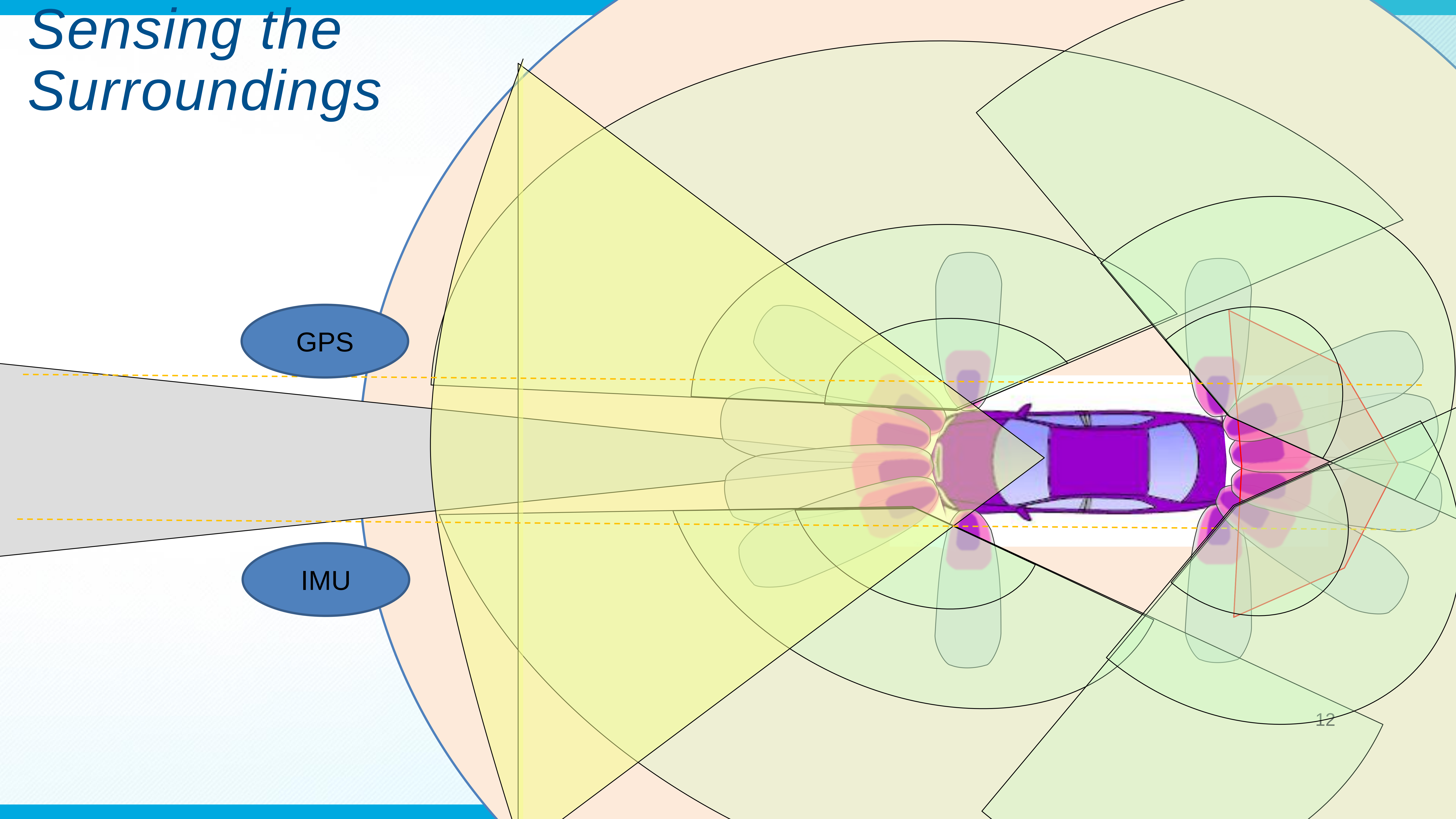
- Building on more than a decade of experience of research into Autonomous vehicles create a state-of-the-art Autonomous Driving platform.
- <u>Full Autonomy</u> emerges along with non-traditional business models based on Mobility solutions
- Advance alternate approaches to semi-autonomous features
- Driver may be taken out of the loop



<u>Bottom-Up Workstream</u>

- Increasingly capable <u>semi-autonomous</u> operation driven by Active Safety regulations and revenue opportunities for Driver Assistance technologies
- Enhancing sensors, algorithms and actuator technology to create new, increasingly-capable automated driving features
- Driver remains in the loop
- Capability may plateau over time

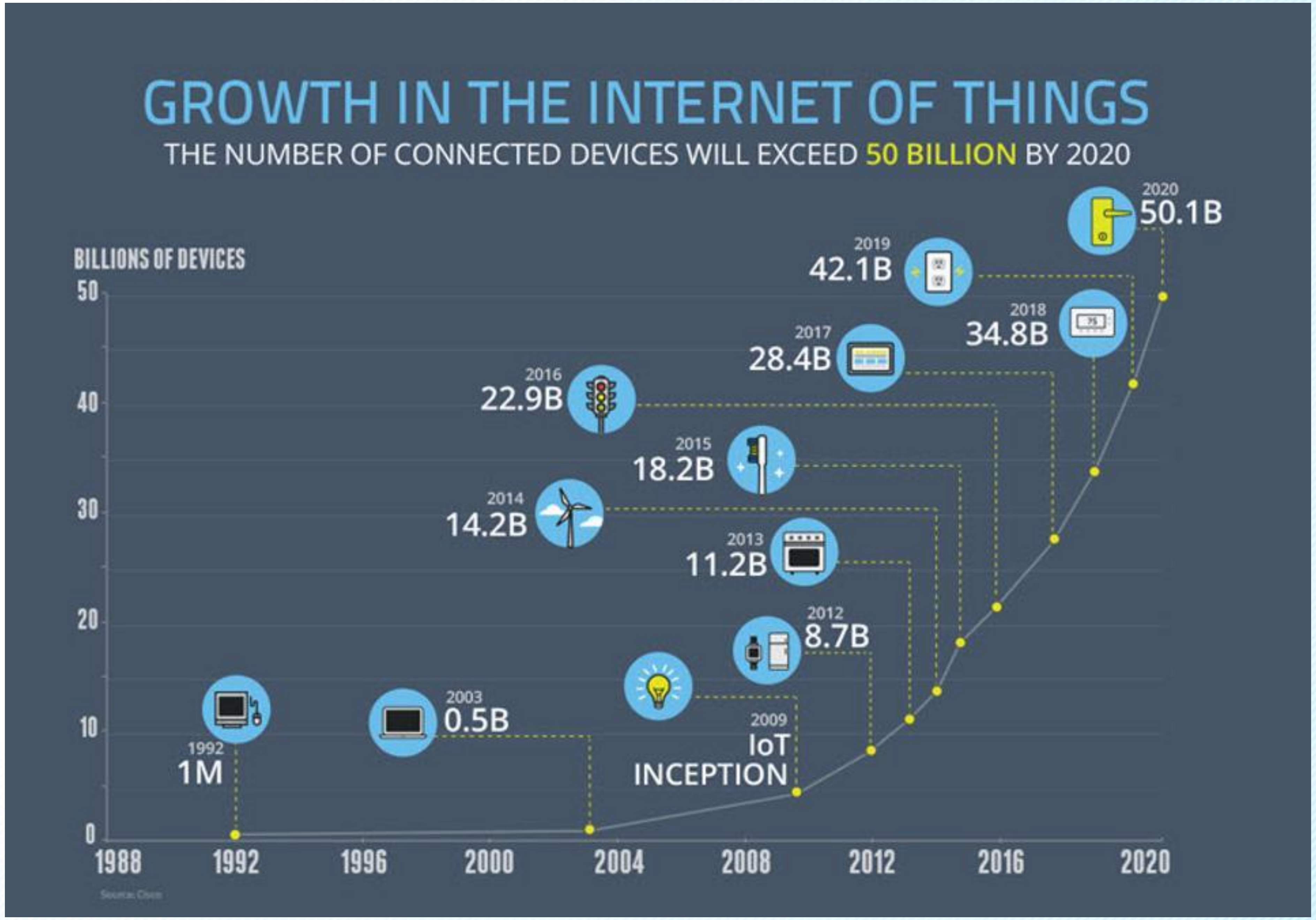
Sensing the Surroundings



Autonomous Vehicles

Go Further

Connected Vehicles

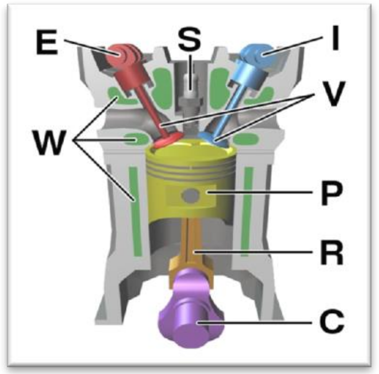


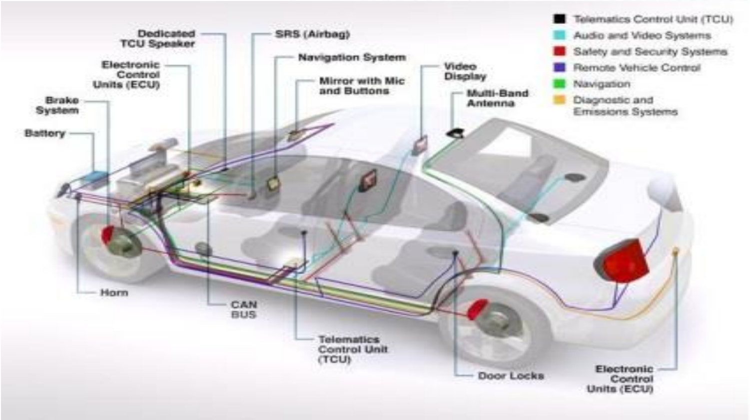
Source: World Economic Forum, Is this the future of the Internet of Things?, November 27, 2015

Vehicles comprise a small segment within the Internet of Things, but are an extremely impactful one now and in the future.

Evolution of Automotive Control

Go Further





Current State
Traditional Automotive Control

- Domain specific controls (PT, Chassis, EE, etc)
- PID and look-up tables.
- Driver in the loop.
- Functional organisation specific business models.

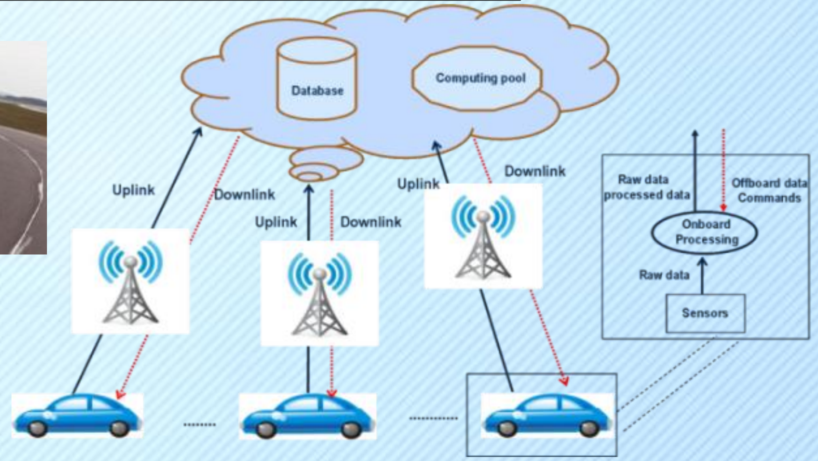
Foundation

Drivers for Change

- Emissions and Fuel Economy
- Driver Assistance and Active Safety
- Autonomous Vehicles
- Connectrivity
- Substantial increase in system interactions & complexity.
- Progress in AI methods & tools

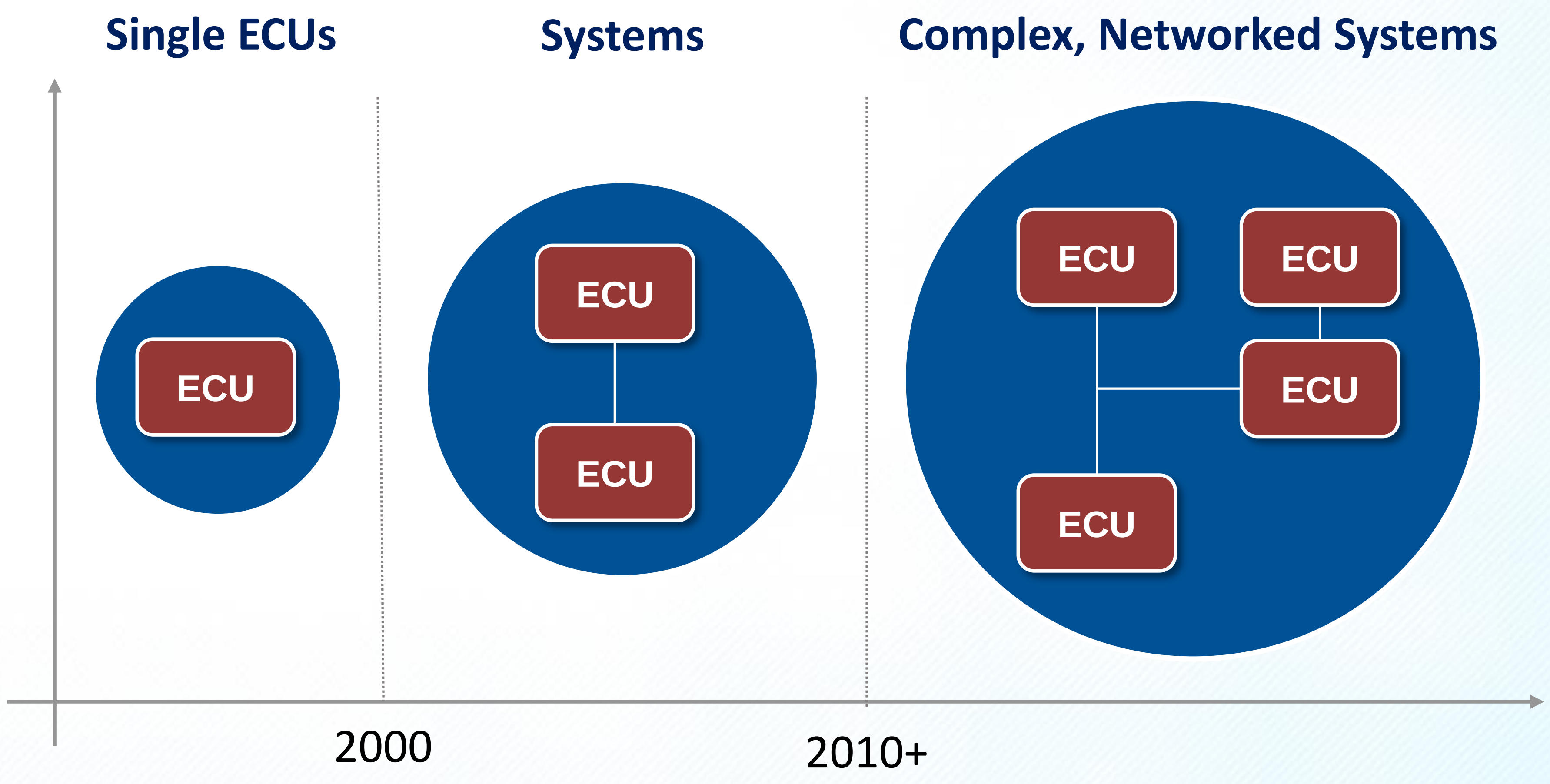
Future State
Advanced Automotive Control:

- New computational platforms
- Driver increasingly out of the loop
- Smart use of MPC, adaptive, & optimal control
- Expanding control incl. AI & robotic tools & techniques
- Increasing role of preview & cloud based control,
- Cyber-security. & Functional Safety
- Flexible functional and S/W architectures
- Upgradable control S/W



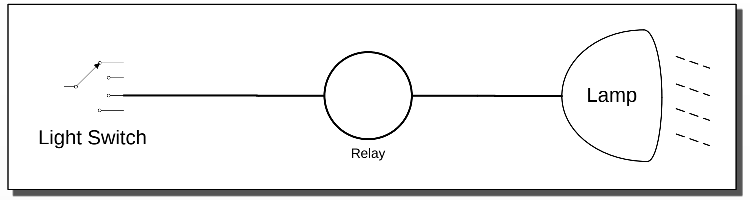
Implications

Component Delivered Value to Systems and Systems of Systems

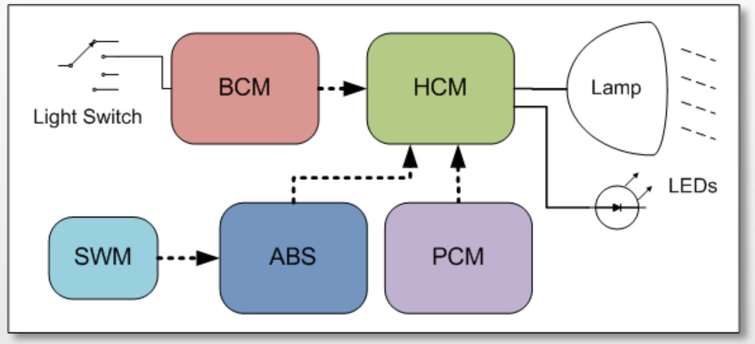


EXAMPLE: FRONT LIGHTING

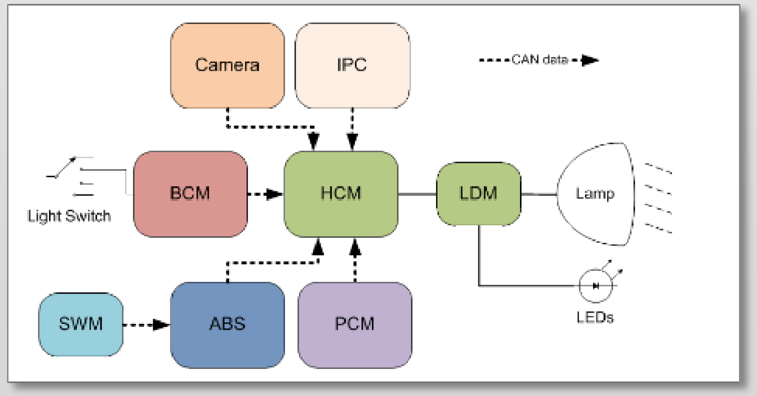
Simple Lights (1995)



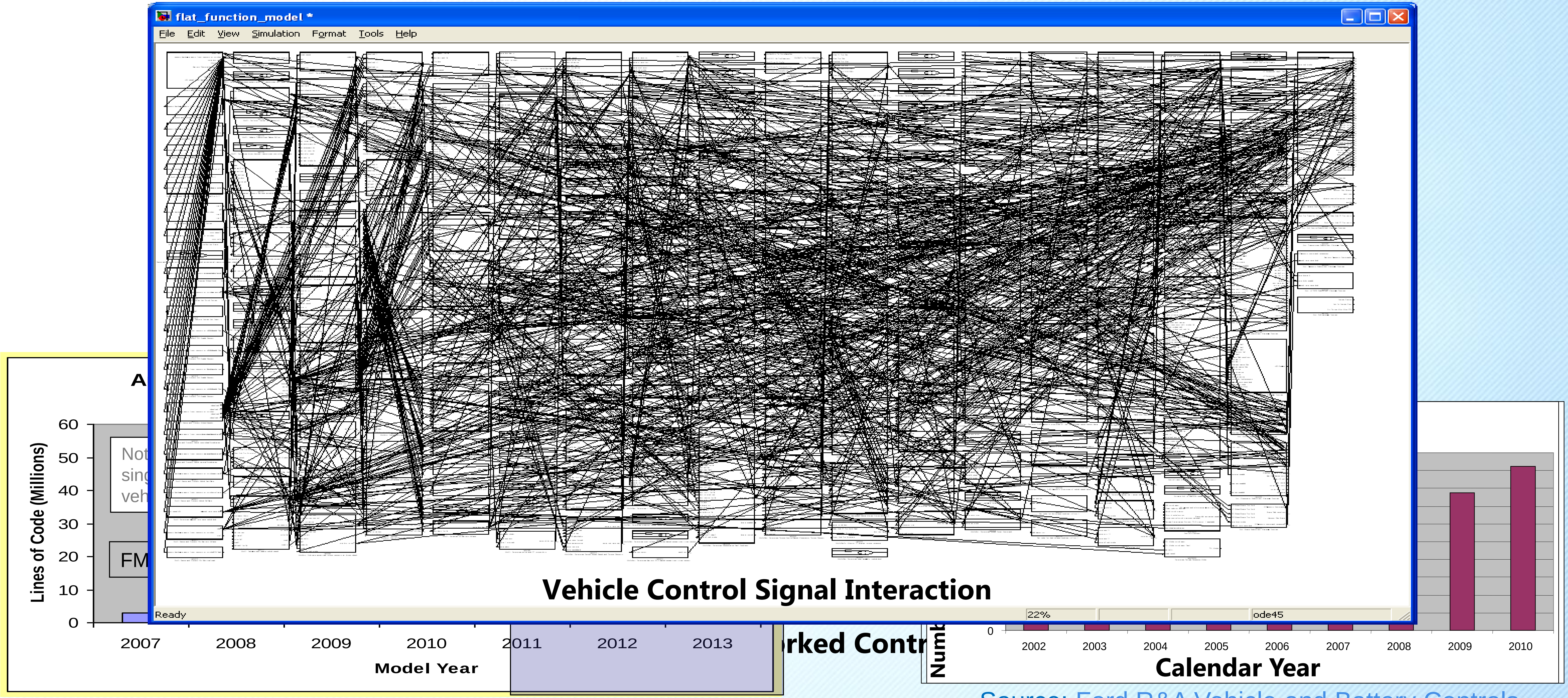
Adaptive Front Lighting (2005)



Glare Free High Beam System (2015)

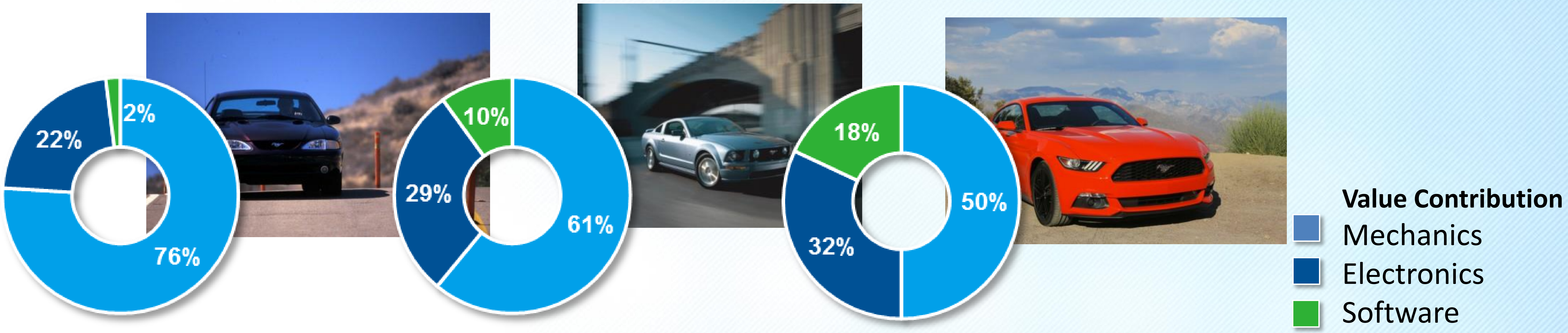


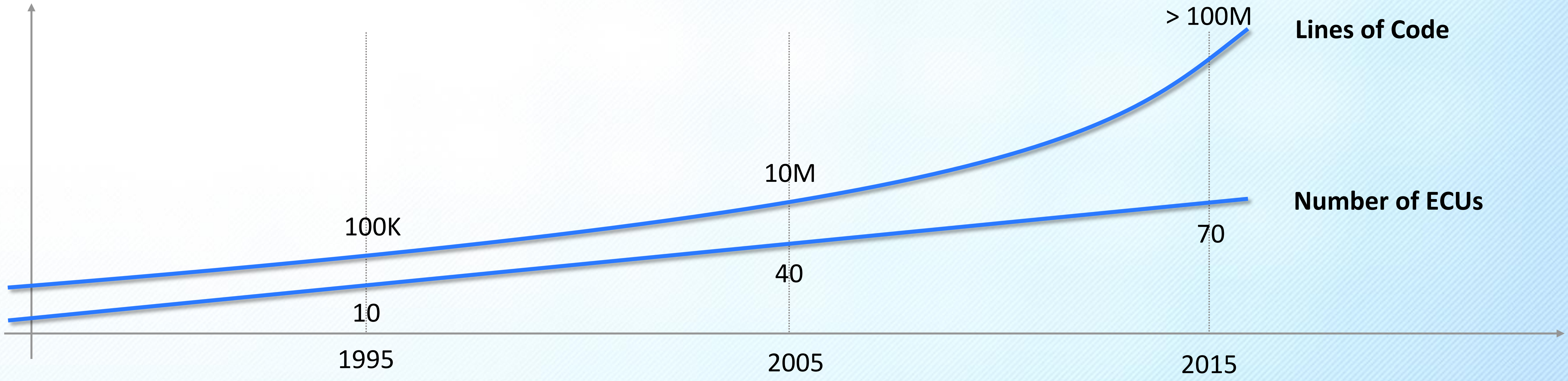
Complexity



Source: Ford R&A Vehicle and Battery Controls

TRENDS...On Board Value is Shifting





MultiCore: The Logical Next Step

Go Further

How Did we Approach MultiCore

Go Further

Experimentation in Research and Advanced Engineering.

- Early Evaluation Boards.
- Build the SW environment.
- Simple experiments with partitioning.
- Working with Tier 1’s and MultiCore Manufacturers (progress and fast feedback)

What did we learn:

- Obvious physical partitioning is pretty easy.
- Control needs (cohesion and coupling) tend to work against each other and degrade the ability to gain the same advantage that MultiCore provided in the PC world.
- MultiCore was mature and stable – not so for the tools, processes and implementation.
- Choices had to be made on what SW can run on the different cores (especially true of initial MultiCore designs where core 2 did not have a checker core).
- Lessons learned on checker cores, memory performance influenced future hardware generations

Summary

Go Further

Trends Driving Computing Infrastructure

Controls:

- Online adaptation and optimisation.
- Advanced control methods (MPC, AI/ML)

Automotive Technology Trends

- Ever increasing functionality.
- Ubiquitous data.
- Always connected.
- SW Updates.
- Functional Safety.
- Security & privacy.

Business

- New suppliers, new partners and new competitors.
- Consumer electronics.

Future Outlook

Go Further

- MultiCore was a big step but the steps that are coming are much bigger.
- A revolution in automotive computing.
- Massive on-board and off-board computational resources.
- Heterogeneous on board computing platforms; MultiCore, GPU’s, FPGA’s, SoC’s.

The next steps need a lot more upfront work on process, tools and methods

Go Further

Thank You