

CPs

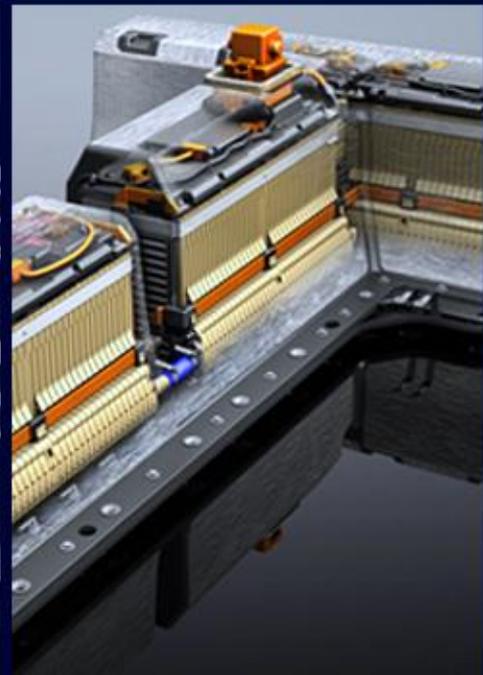
and

the Automotive Industry



Joseph D'Ambrosio

Lab Group Manager, Electrical & Control Integration Research Lab



Cyber-Physical Systems (CPS)

- Smart systems featuring a tight combination of, and coordination between, the system's computational (SW & HW) and physical elements (engine, steering, braking, etc.)
- Must operate with high levels of reliability, safety, security, and usability
- Foundational technology to future *Intelligent Transportation Systems*

TECHNOLOGY DRIVERS FOR THE 2ND CENTURY OF PERSONAL MOBILITY

Challenges

Stretch Goals

■ Energy

High-efficiency vehicles
using low-cost renewable energy

■ Emissions

No tailpipe environmental impact

■ Safety

Vehicles that don't crash

■ Congestion

Congestion-free routing
Megacity parking

■ Affordability

Personal mobility “for every purse
and purpose”

ZEROemissions

Auto Industry Progress



Same DNA
for **100** years



Traditional Automotive DNA

- Mechanically driven
- Energized by petroleum
- Powered by internal combustion
- Controlled mechanically
- Stand-alone
- Mass produced



New Automotive DNA



Automotive DNA

- Energized by petroleum
 - Powered by internal combustion
 - Controlled mechanically
 - Stand-alone
 - Mass produced
- Energized by electricity and hydrogen
 - Powered by electric motors
 - Controlled electronically
 - “By-wire”
 - “Connected”
 - Personalized

Cyber-physical

New DNA Is Cyber-Physical!

- Deep physical interactions
- Deeply embedded electronics
- High degrees of computation
- Rich needs to communicate
- Pervasive integrations (cyber and physical)
- Highly coupled with driver behavior & environment

TECHNOLOGY DRIVERS FOR THE 2ND CENTURY OF PERSONAL MOBILITY

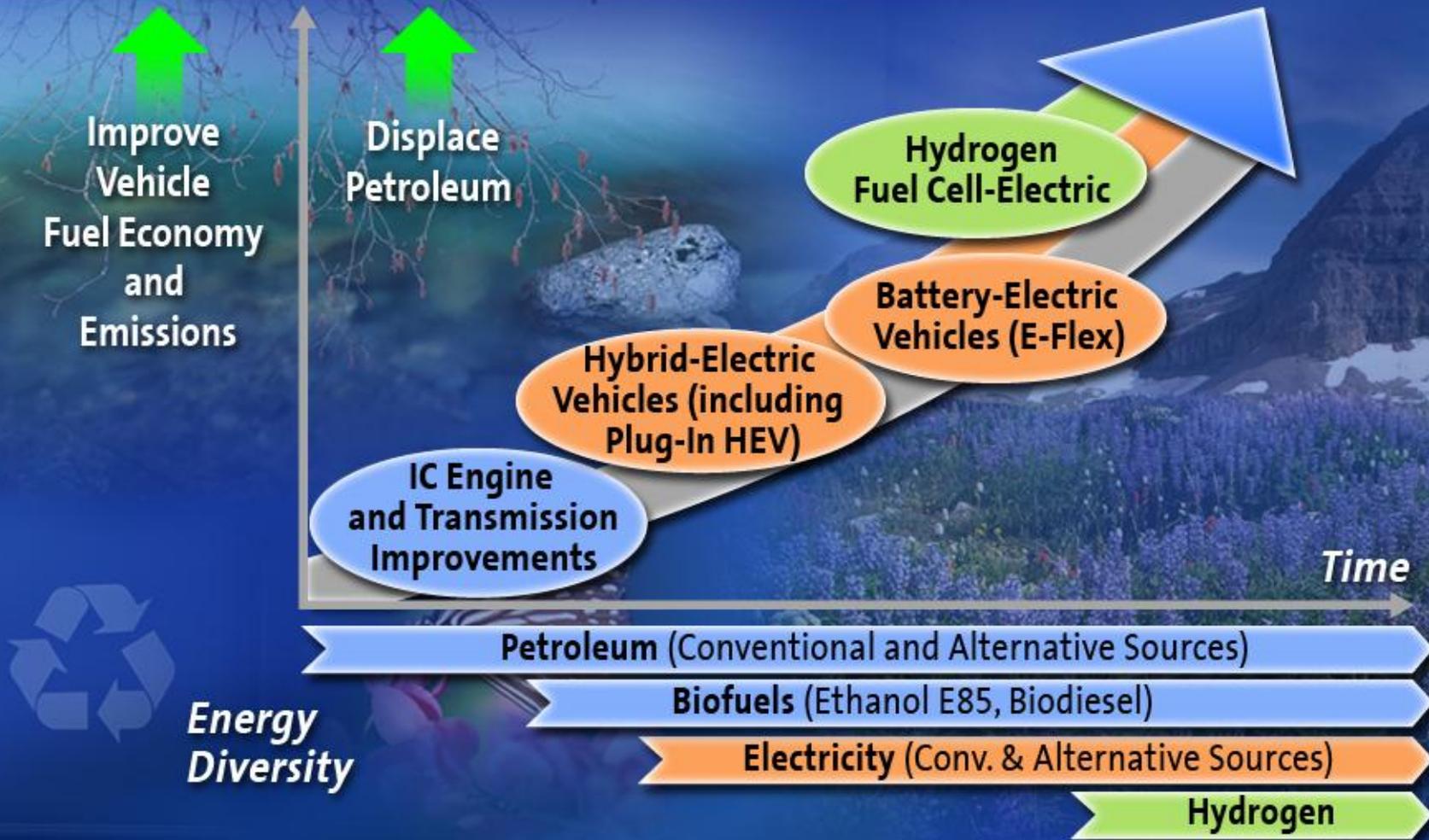
Challenges

Stretch Goals

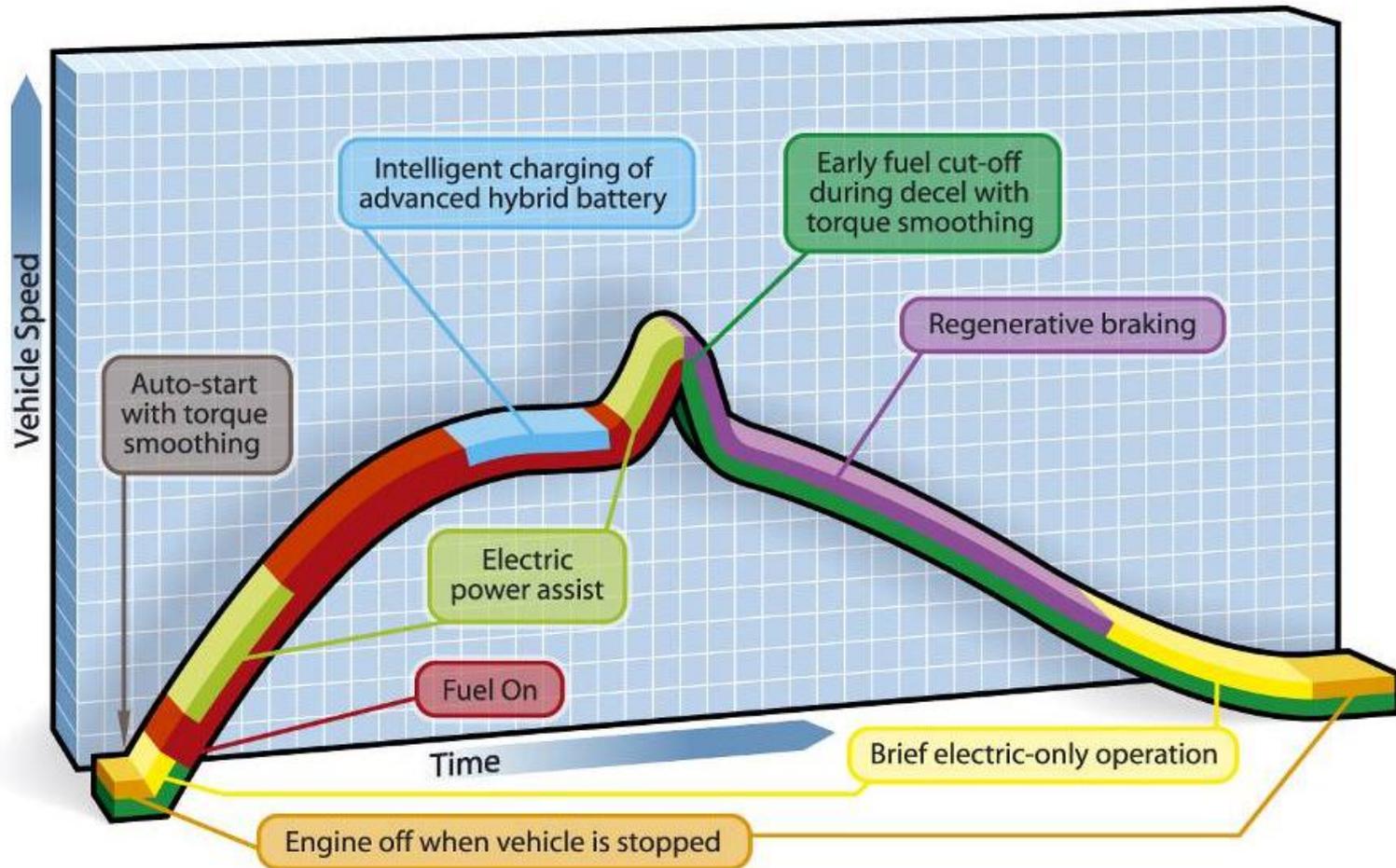
- | | |
|-----------------|--|
| ■ Energy | High-efficiency vehicles using low-cost renewable energy |
| ■ Emissions | No tailpipe environmental impact |
| ■ Safety | Vehicles that don't crash |
| ■ Congestion | Congestion-free routing
Megacity parking |
| ■ Affordability | Personal mobility “for every purse and purpose” |

ZEROemissions

Advanced Propulsion Technology



Driving the GM Hybrid System



TECHNOLOGY DRIVERS FOR THE 2ND CENTURY OF PERSONAL MOBILITY

Challenges

Stretch Goals

- | | |
|-----------------|--|
| ■ Energy | High-efficiency vehicles using low-cost renewable energy |
| ■ Emissions | No tailpipe environmental impact |
| ■ Safety | Vehicles that don't crash |
| ■ Congestion | Congestion-free routing
Megacity parking |
| ■ Affordability | Personal mobility “for every purse and purpose” |

ZEROemissions

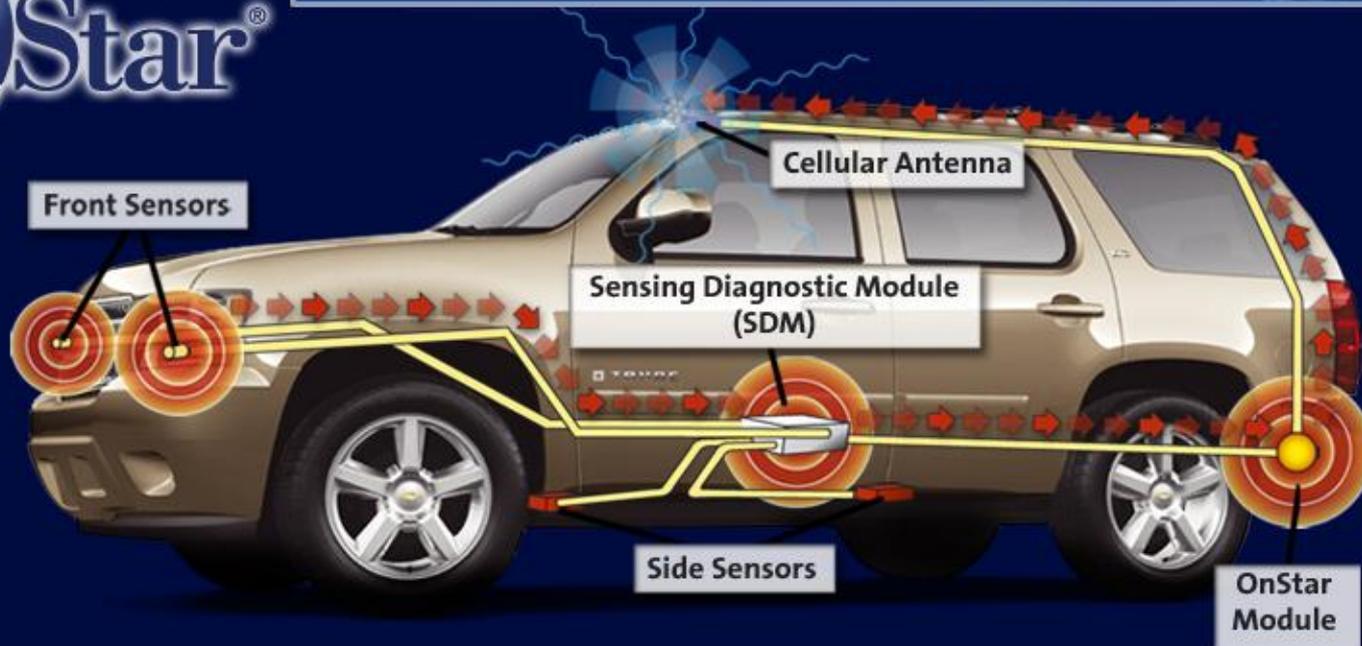
“CONNECTED VEHICLES” SINCE 1996



6,000,000
SUBSCRIBERS



SAFETY AND SECURITY



CRASH AVOIDANCE TECHNOLOGIES ON CURRENT GM MODELS

Lane Departure Warning



Cadillac DTS
Cadillac STS



Buick Lucerne

LDW w/Traffic Sign Recognition

"Opel Eye"



Opel Insignia
Opel Astra

Side Blind Zone Alert



Cadillac DTS
Cadillac STS
Cadillac Escalade



Buick Lucerne
Buick LaCrosse



GMC Yukon/
Yukon Denali



Chevrolet Tahoe/
Suburban

Dual Feature Front Camera: Lane Departure Warning and Forward Collision Alert



Chevrolet Equinox



GMC Terrain



Speed/Curve Advisor



Cadillac STS
Cadillac DTS
Cadillac SRX

Adaptive Cruise Control w/Forward Collision Alert



Cadillac DTS
Cadillac STS

Rear Back-Up Video



Many Models

Electronic Stability Control



Many Models

Side Blind Zone Spotter Mirror

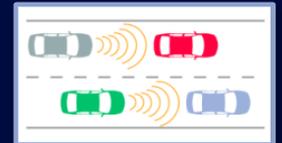


Chevrolet Traverse

Adaptive Cruise Control and Auto Collision Mitigation Braking

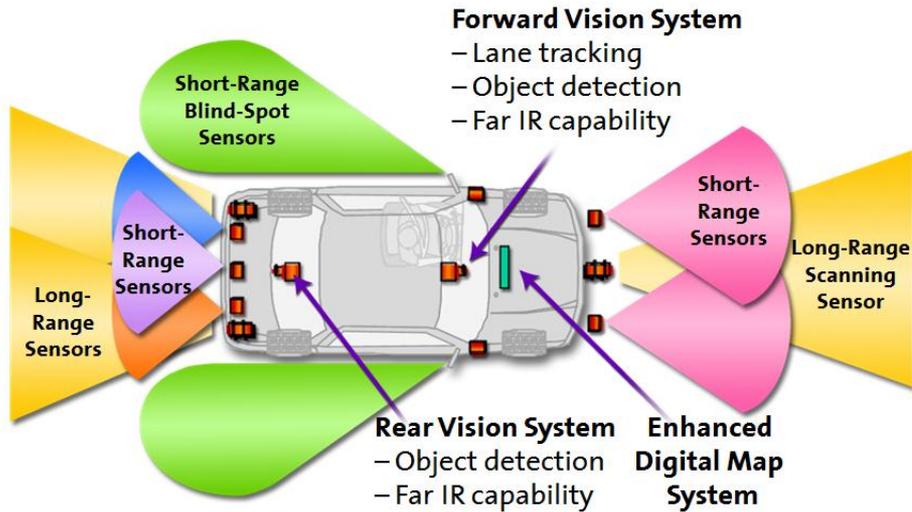


Opel Zafira

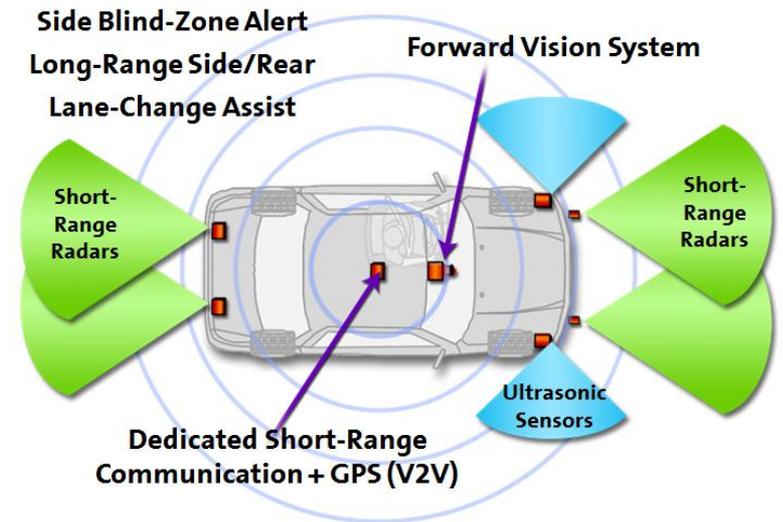


360° SENSING CAPABILITY

TODAY



FUTURE



V2X TRANSPONDER INTEGRATION

APPLICATIONS

■ Forward Collision Warning

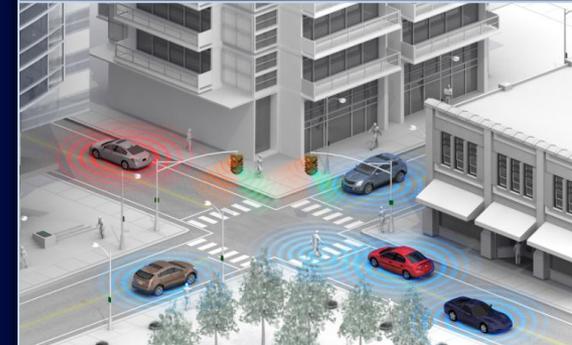
- Detected 
- Caution 
- Warning 



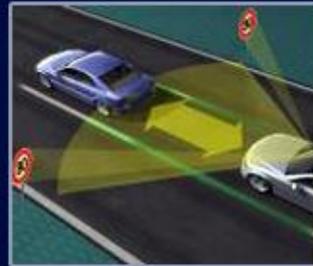
■ Intersection Collision Warning



■ Hard Braking Vehicle Ahead



CARS THAT DON'T CRASH



VEHICLES THAT DRIVE THEMSELVES



TECHNOLOGY DRIVERS FOR THE 2ND CENTURY OF PERSONAL MOBILITY

Challenges

Stretch Goals

- Energy

High-efficiency vehicles using low-cost renewable energy

- Emissions

No tailpipe environmental impact

- Safety

Vehicles that don't crash
Autonomous driving

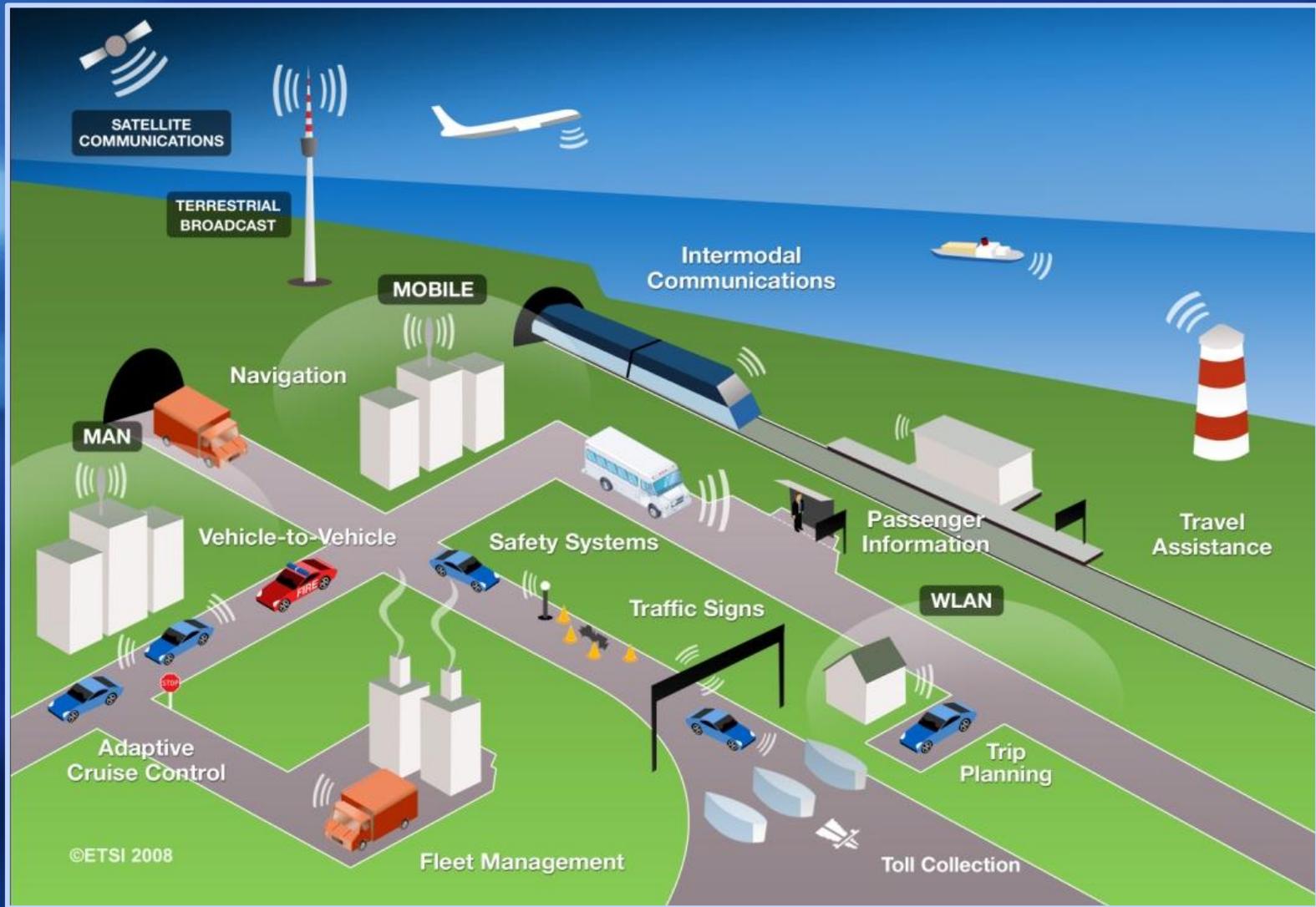
- Congestion

Congestion-free routing
Megacity parking

- Affordability

Personal mobility “for every purse and purpose”

ELECTRIC, CONNECTED, AUTONOMOUS

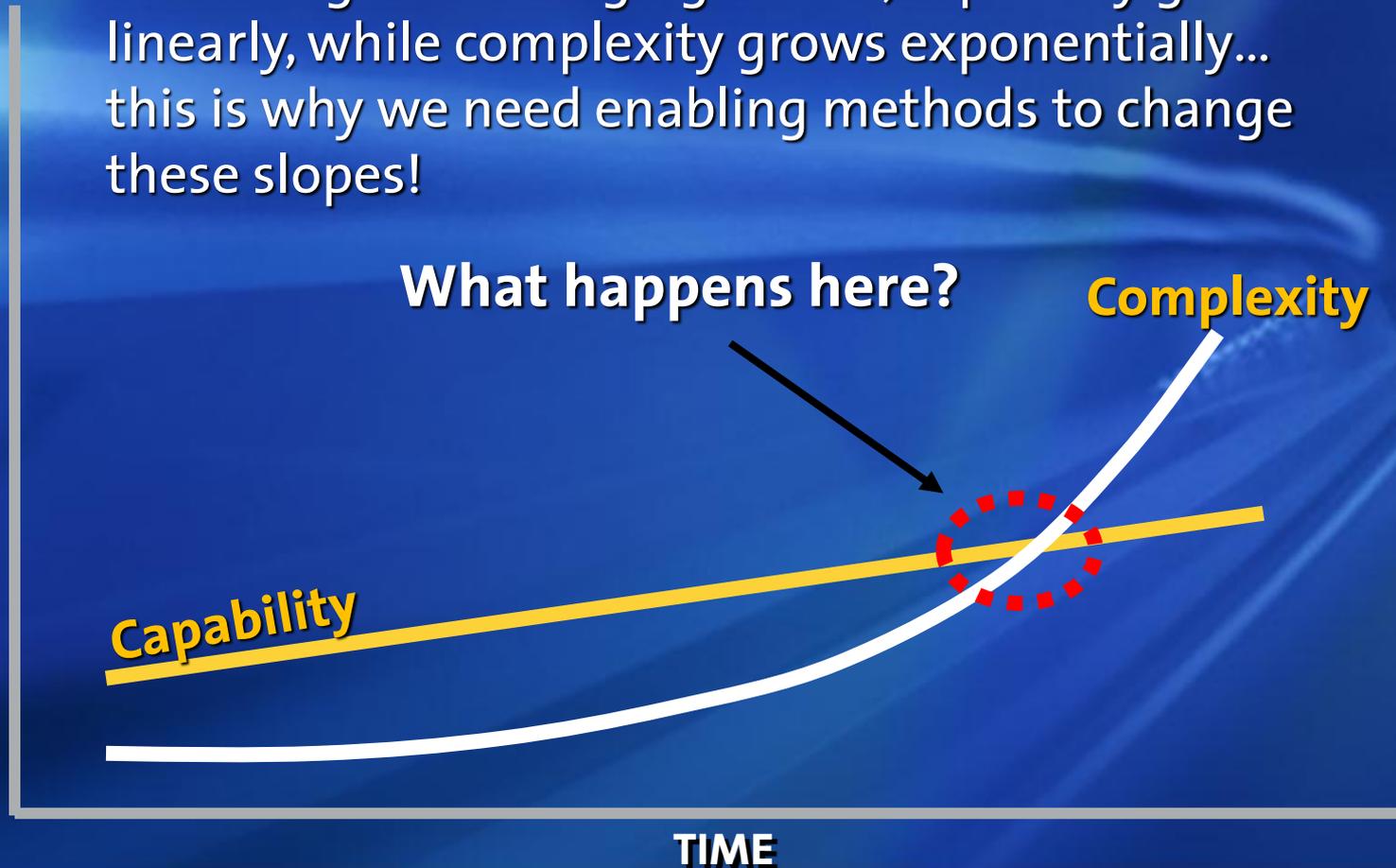


CPS Research Challenges

- Formal methods for designing reliable software
- Reliable sensors, communications, actuators, and computational methods
- Security
- “Fail-soft” technologies
- Diagnostics and prognostics
- Energy storage and recovery
- Complexity management
- Integration into the vehicle, development processes, and plant and supply chain processes

CPS Is “Challenging” Our Workforce

Without game-changing events, capability grows linearly, while complexity grows exponentially... this is why we need enabling methods to change these slopes!



“Upgrading” the Workforce

- Need to bring the technology advances to the active automotive engineer
- Need to bring the concept of “CPS” to the undergraduate engineering curriculum

Conclusions

The automobile is the most widely distributed cyber-physical system

Automotive CPS has huge potential to impact industry and society!

