Center for Advanced Automotive Technology

C · A · A · T

The Technology of Automated and Connected Vehicles

CAAT Webinar

August 26, 2015

Macomb Community College

Education • Enrichment • Economic Development

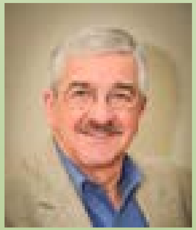
Discover. Connect. *Advance.*

NSF

WAYNE STATE

Presenters

Doug Fertuck, Assistant Director for Energy and Automotive Programs, Macomb Community College



Bob Feldmaier, Director of the CAAT, Macomb Community College

Miguel Hurtado, Systems Engineer of Advanced Driving Assistance projects and Technology Transfer support for Europe and North America, Valeo

Webinar Roadmap

- Who we are (Center For Advanced Automotive Technology)
- Backgrounder on Connected and Automated vehicles (Doug Fertuck)
- Report on the Industry Priorities for Connected and Automated Vehicles (Bob Feldmaier)
- The Perspective of Valeo, an Automotive Supplier of Advanced Technologies (Miguel Hurtado)
- Panel discussion on the skills and education implications for technicians and engineers (All)

About the Center for Advanced Automotive Technology (CAAT)

- Located at Macomb Community College South Campus
- Partnered with Wayne State University
- Became an Advanced Technological Education Center in 2010 funded by the National Science Foundation ($2.8M Grant)
- Mission
  - Advance the preparation of skilled technicians for the automotive industry's more environmentally friendly and safer vehicles.
  - Be a regional resource for developing and disseminating advanced automotive technology education.

CAAT's Priorities

- Preparing automotive technicians and designers in community colleges for advanced technology jobs
- Increasing the flow of students through the pipeline to jobs
- Collaborating and sharing across educational institutions
- Partnering with industry to understand their needs

CAAT's NSF Grant is Renewed for 3 More Years

- Received additional NSF funding of $2.0M through July 31, 2017.
- Mission remains preparing technicians and technologists to work on advanced automotive technology
- Technical scope is extended to include the materials lightweighting and automated and connected vehicles

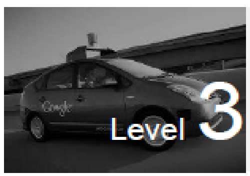
Sorting Out Levels of Automated and Autonomous Vehicles

The expression "Autonomous vehicle" describes a technological path with "partial" autonomous vehicles already commercially available

Increasing levels of autonomous operations

Full Self-Driving Automation
Vehicle performs all safety-critical driving functions and monitors roadway conditions for an entire trip. The driver is not expected to be available for control at any time during the trip

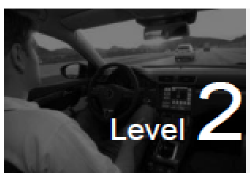
AV



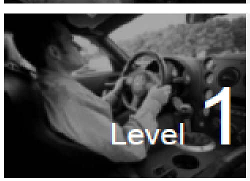
Limited Self-Driving Automation
The driver is allowed to cede full control of all safety-critical functions under some conditions and rely heavily on the vehicle to monitor conditions requiring transition back to driver control with transition time

ADAS

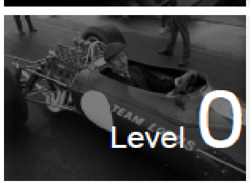
Commonly available today



Combined Function Automation
Automation of at least two primary control functions designed to work in unison to relieve the driver of control of those functions



Function-specific Automation
One or more control functions are automated, as electronic stability control or pre-charged brakes, where the vehicle automatically assists with braking or to stop faster than possible by driver alone



No-Automation
The driver is in complete and sole control of the primary vehicle controls – brake, steering, throttle, and motive power – at all times

SAE System for Categorization of Driving Automation

Summary of Levels of Driving Automation for On-Road Vehicles

This table summarizes SAE International's levels of *driving* automation for on-road vehicles. Information Report J3016 provides full definitions for these levels and for the italicized terms used therein. The levels are descriptive rather than normative and technical rather than legal. Elements indicate minimum rather than maximum capabilities for each level. "System" refers to the driver assistance system, combination of driver assistance systems, or *automated driving system*, as appropriate.

The table also shows how SAE's levels definitively correspond to those developed by the Germany Federal Highway Research Institute (BASt) and approximately correspond to those described by the US National Highway Traffic Safety Administration (NHTSA) in its "Preliminary Statement of Policy Concerning Automated Vehicles" of May 30, 2013.

Level	Name	Narrative definition	Execution of steering and acceleration/ deceleration	Monitoring of driving environment	Fallback performance of *dynamic driving task*	System capability (*driving modes*)	BASt level	NHTSA level
***Human driver* monitors the driving environment**								
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a	Driver only	0
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes	Assisted	1
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes	Partially automated	2
***Automated driving system* ("system") monitors the driving environment**								
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes	Highly automated	3
4	High Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes	Fully automated	3/4
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**	-	

Introducing the Concept of “Connected” Vehicles

What’s the difference: Connected versus Autonomous Car?

An Autonomous Car needs information – lot’s of it!

- Location and positioning
- Map data
- Traffic information
- Weather data
- V2X
    - Car2Car
    - Traffic lights
    - Local road conditions
    - Police and emergency vehicles

This information is fused with the local sensors and processed to drive the car, autonomously.

The Autonomous Car IS Connected!

Potential Benefits of Vehicle Automation

"Autonomous cars may seem like a gimmick, he begins, but when you consider all the **time** that people won't be devoting to their rear view mirrors, and all the **efficiencies** that come from cars that could be zipping between errands rather than idling in parking lots, the world looks like a very different place. Car ownership would be unnecessary, because your car (maybe **shared** with your neighbors) will act like a taxi that's summoned when needed. The **elderly** and the **blind** could be thoroughly integrated into society. **Traffic deaths could be eradicated**. Every person could gain lost hours back for working, reading, talking, or searching the Internet."

Google co-founder Sergey Brin as reported by Brad Stone of Bloomberg Business Week – May 22, 2013

The Impact of Car Crashes on the Economy beyond 34,000 Deaths per Year in the US Alone

~1 Million

Days spent in the hospital each year from crash injuries

~2.5 Million

People in the US that went to the ER for crash injuries in 2012 of which nearly 200,000 were hospitalized

$212 Billions

Cost of roadway crashes for the US economy each year[1]

$180-190 Billions

The maximum potential saving per year in the US if you believe that ADAS and AVs can succeed in reducing car accidents by 90%

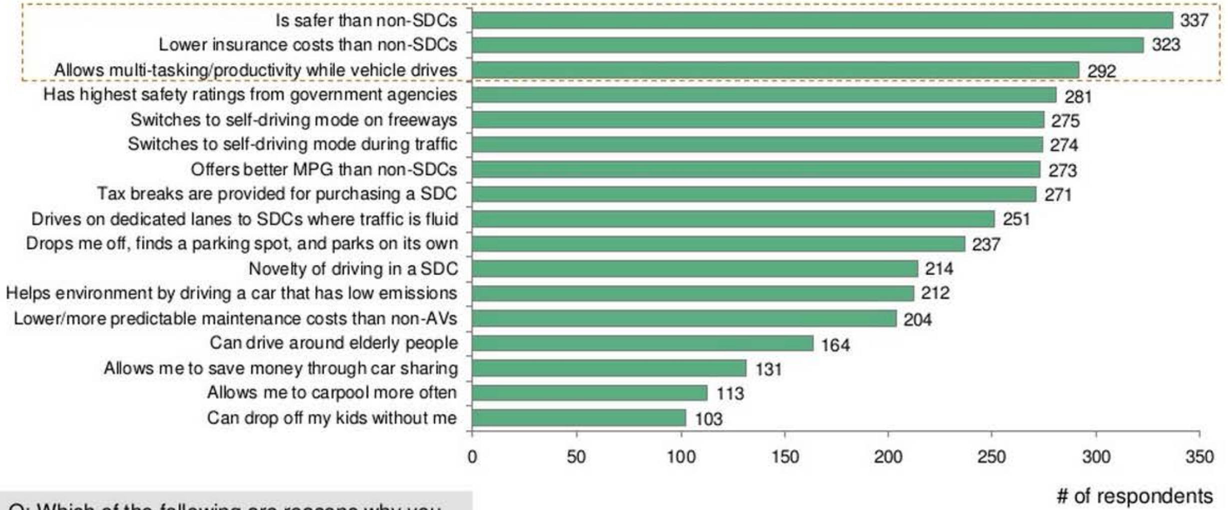
For every **1** person killed in a motor vehicle crash

8 people were hospitalized

100 people were treated and released from the Emergency Department

Consumers Recognize the Safety Benefits of Vehicle Automation

Similarly, increased safety, lower insurance, and higher productivity are top reasons to buy full AVs in the next ~10 yrs



Q: Which of the following are reasons why you said you are [very likely/likely/neutral] to purchase a **fully** self-driving car?

Note: n=983
Source: BCG U.S. self-driving cars survey, 2014

THE BOSTON CONSULTING GROUP

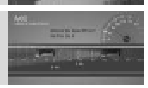
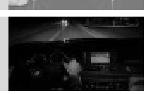
Some of Today's
Advanced Driver Assistance Technologies

ADAS system comprises of passive and active safety system depending on the level of human intervention in driving

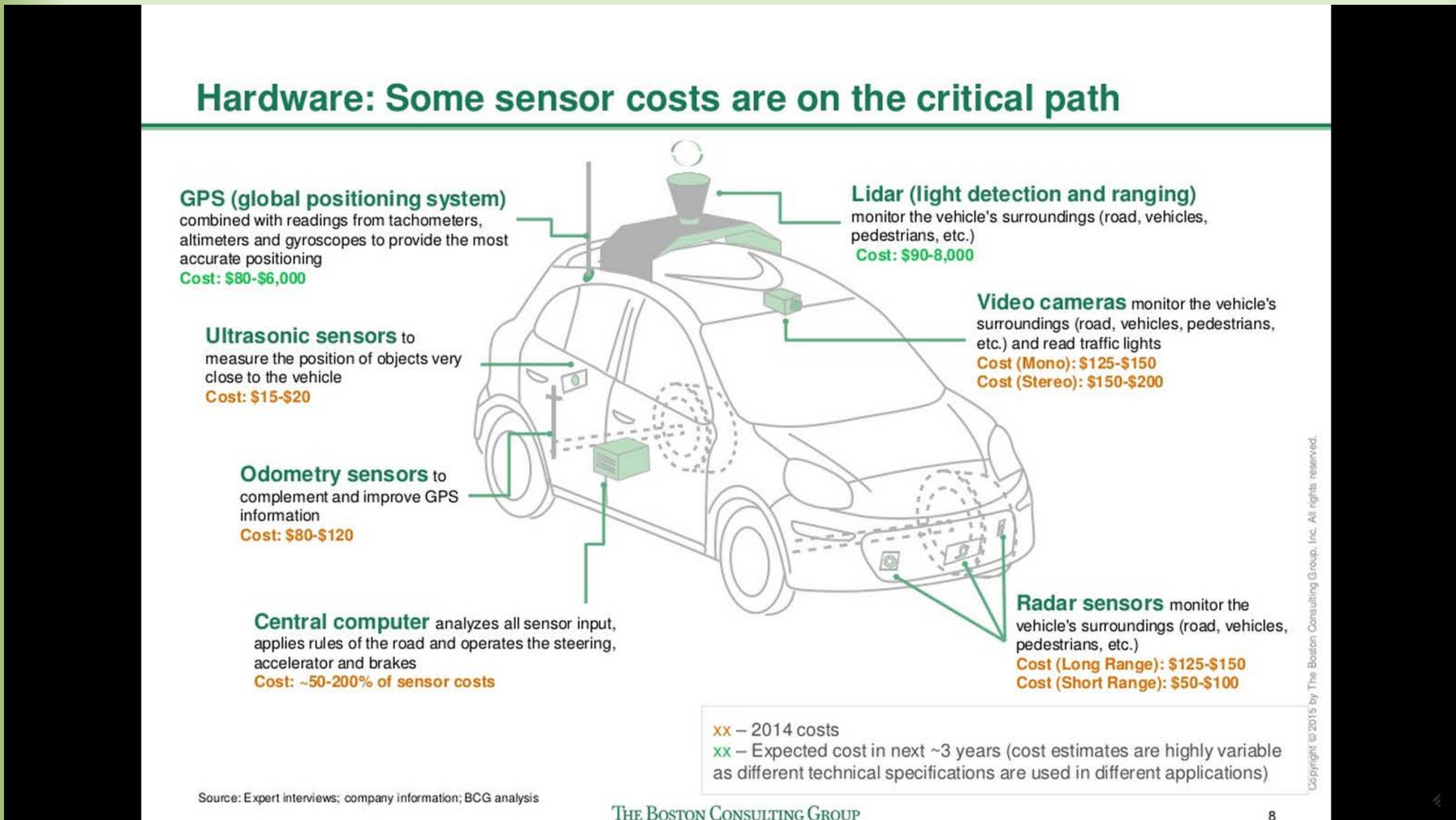
Major ADAS systems

Active safety system — Actively engaging/ intervening driving to prevent accident

Passive safety system — Monitoring and warning drivers to prevent accidents

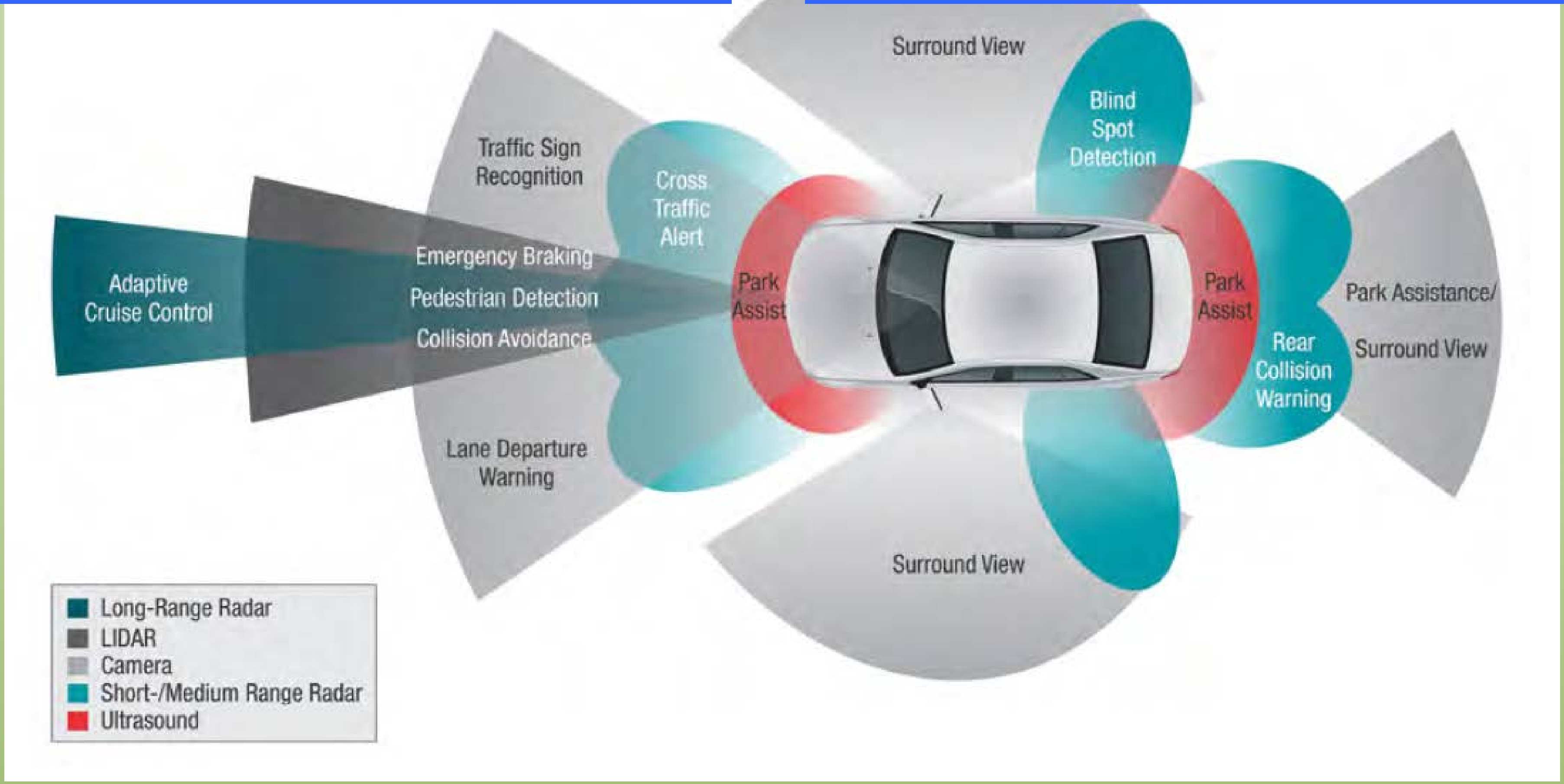
Autonomous emergency braking		▪ Activated when collision risk detected using same sensors as Adaptive Cruise Control
Adaptive cruise control		▪ Adjusts speed to maintain safe distance between cars using long & short distance radar sensors (e.g., LiDAR)
Forward collision warning		▪ Detects obstacles in front and issues warning on screens using same sensors as ACC
Lane departure warning		▪ Detects and warns against lane departure ▪ Some functions even offer autonomous return to original lane
Parking assistance		▪ Aids parking in varying degrees: simple warning against obstacles → complete autonomous parking
Blind spot monitoring		▪ Warns against lane departure by detecting blind sports during lane change
Rear cross traffic alert		▪ Warns for proximity to vehicle when backing up
Night vision & pedestrian detection		▪ Expands scope of detection via infrared camera installed under the bumper or rear view mirrors
Traffic sign recognition		▪ Reads speed limit signs using cameras mainly installed on back of rear view mirrors
Driver Monitoring		▪ Issues warnings on fatigue level using camera sensors that monitor driver and his/her driving patterns

The Array of Automated Vehicle Sensors and Their Costs



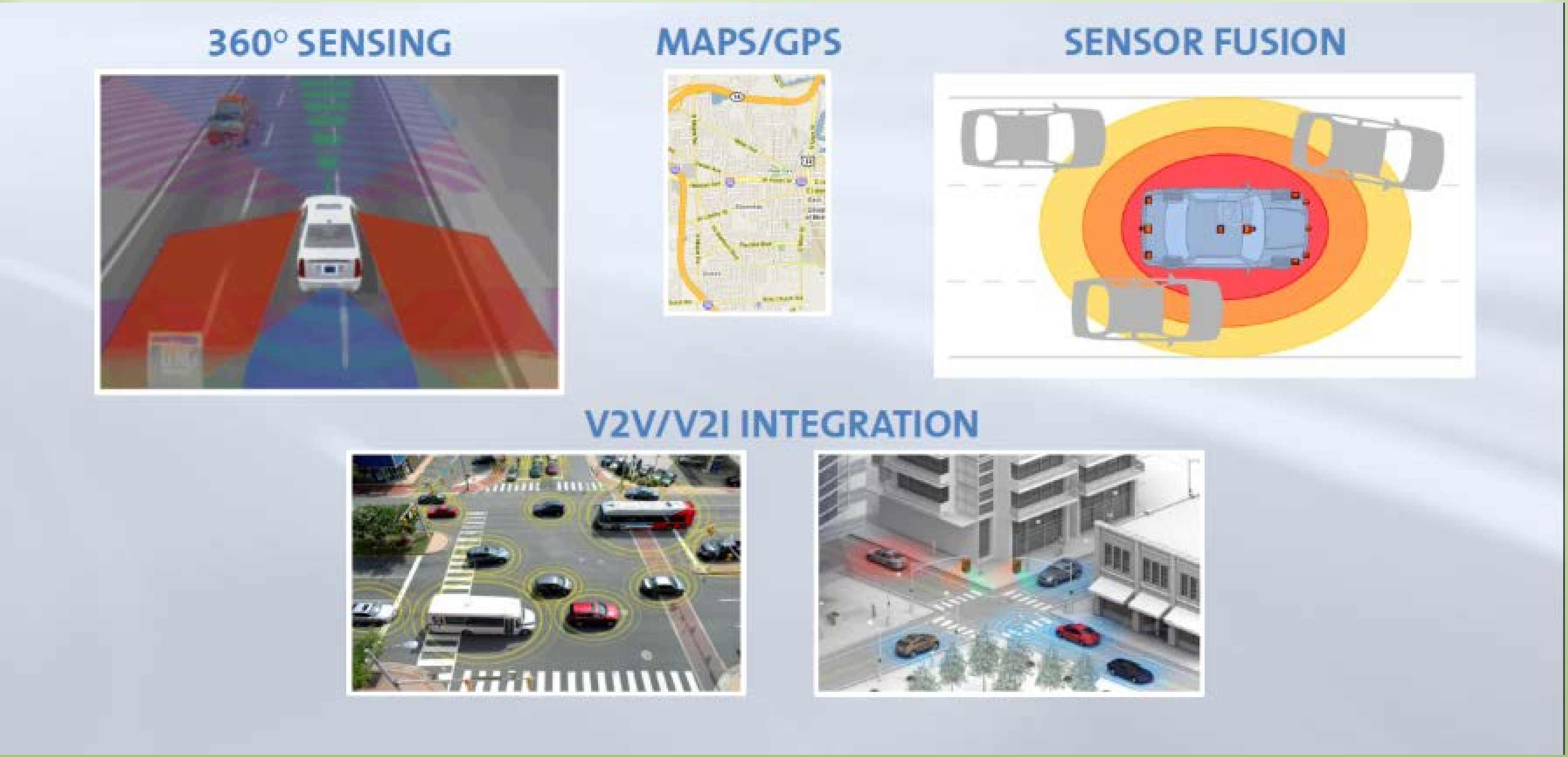
Automated Driving:
Enabling and *Supporting* Technology

HIGH DEFINITION MAPS | **V2X COMMUNICATIONS**



Source: Texas Instruments ADAS Solutions Guide

Integrated Systems Approach to Vehicle Automation



Coming application: 2017 Cadillac “Super Cruise”

Mcity at U of M: the First Extensive Testing Facility Built for Automated Vehicles

- https://www.youtube.com/watch?v=gfSNlIQ5KN8

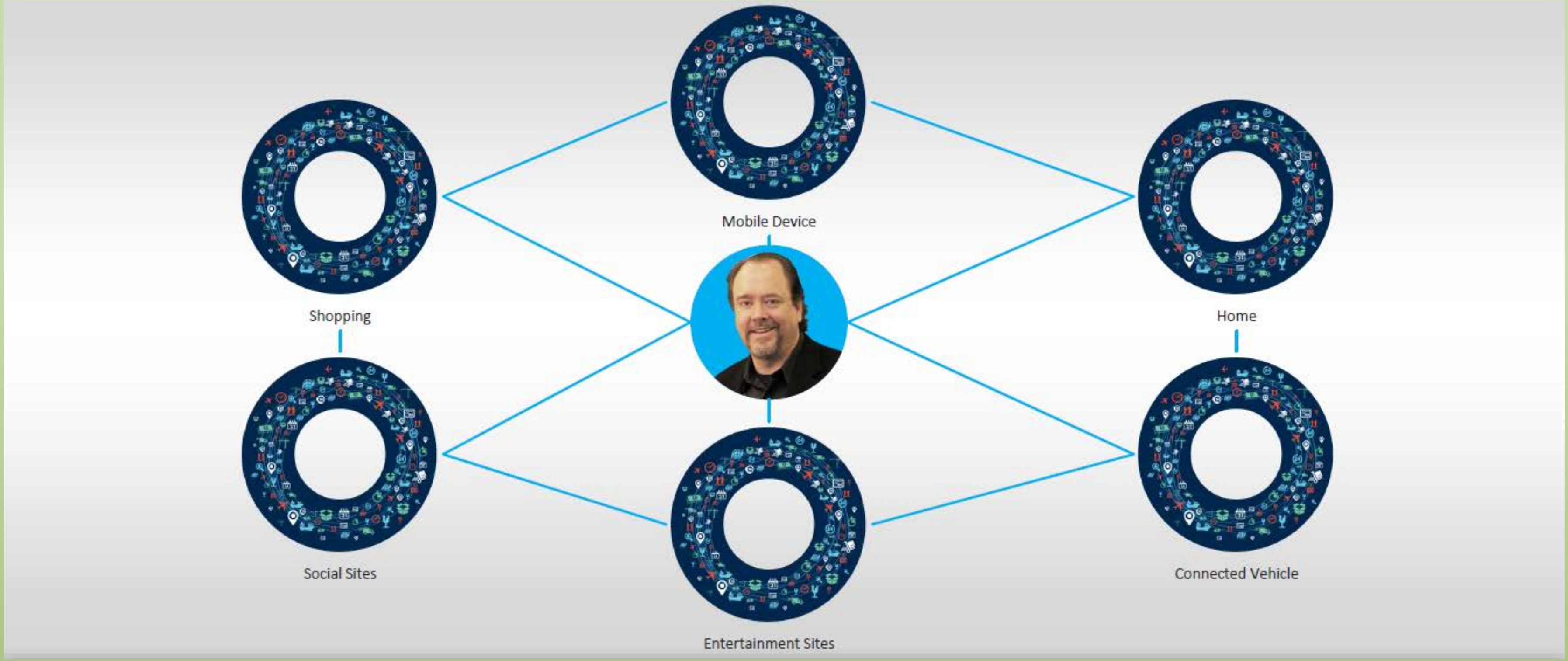
Once a Vehicle is Connected, Many More Features Become Available

Connected Car bonuses

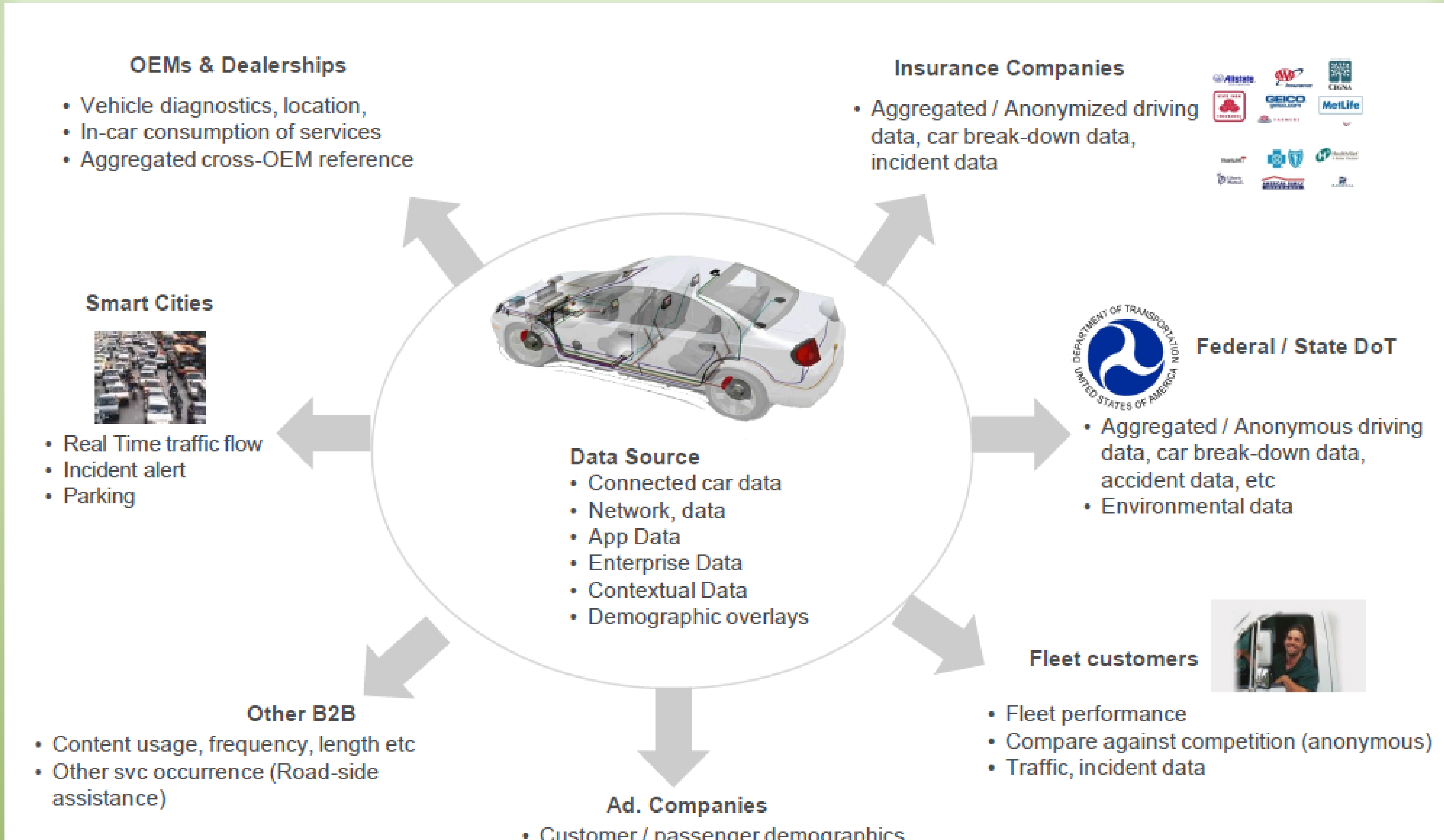
- Communication technologies enables…
  - Connected Car
  - Infotainment
  - Productivity systems
  - Traditional telematics
    - eCall/bCall/Diagnostics
  - Hands free calling
- Same technologies for many tasks =
  ease of use, integration and cost effectiveness

Autonomous Car users will demand even more productivity and entertainment as they are free from the task of driving

The Vehicle Becomes Integrated with the Web of Everything



With Connectivity, Data Becomes "Bigger"



With More Data and Connectivity Comes More Vulnerability of Cybersecurity

verizon

Security involves multiple layers

Governance, Risk and Compliance

Prepare to Manage Risk

- Access Governance
- Threat Vector Analysis
- Penetration Testing
- Partner Security Program
- PCI Compliance Program

Threat Management

Protect the Perimeter

- Security Configuration Management
- Vulnerability Scanning
- Application Scanning
- Content Scanning
- Cloud- assessment

Authentication and Privacy

Trust the Ecosystem

- Data Discovery
- M2M Security
- Managed Certificate
- Application Security
- Smart Credentials
- SSL Certificates

Professional Security Services

Respond to the Threats

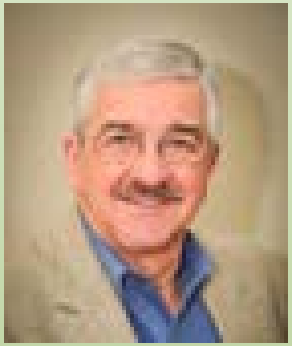
- Rapid Response Services
- Digital Forensics

Summary of Major Advantages

- Fewer traffic collisions
- Increased roadway capacity and reduced congestion
- Relief for occupants from driving and navigation
- Removal of constraints on occupants' state
- Lighter more fuel efficient vehicles
- Reduced insurance costs
- Higher speed limits
- Increased productivity

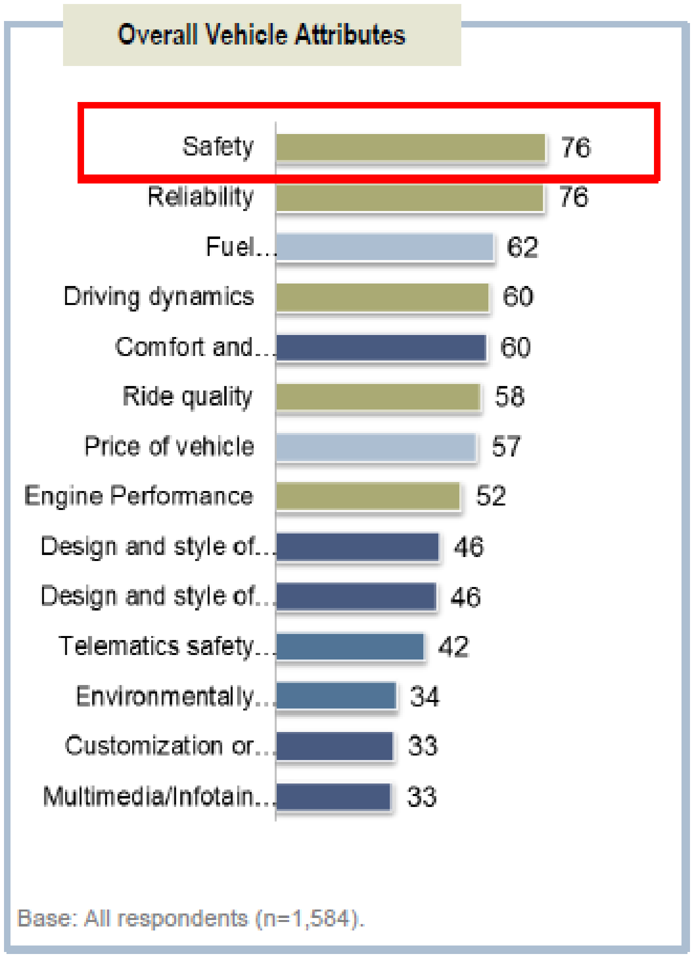
Questions?

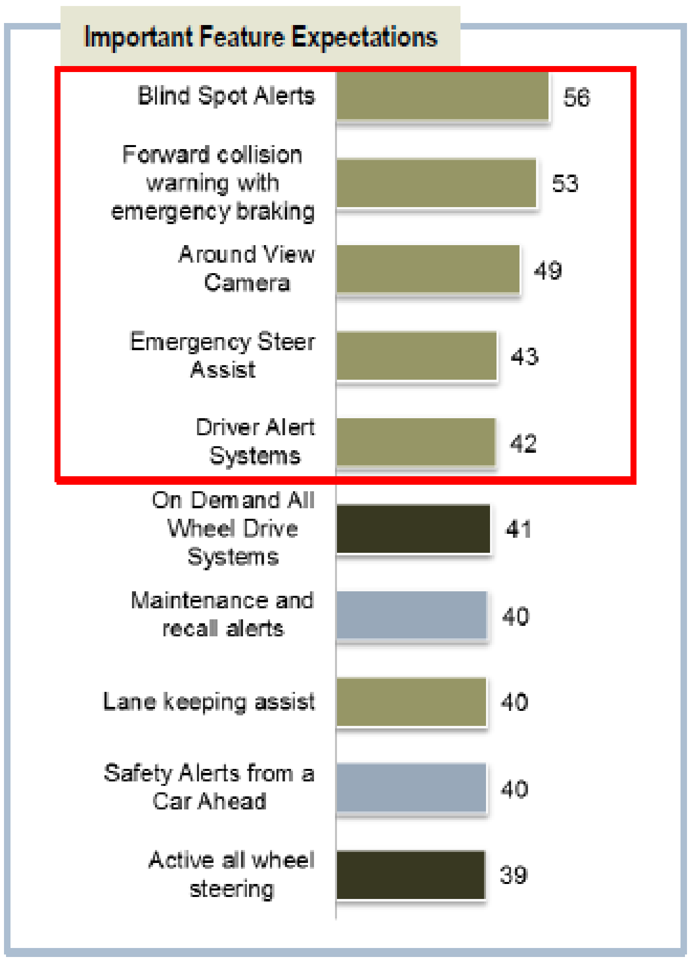
Next Presenter



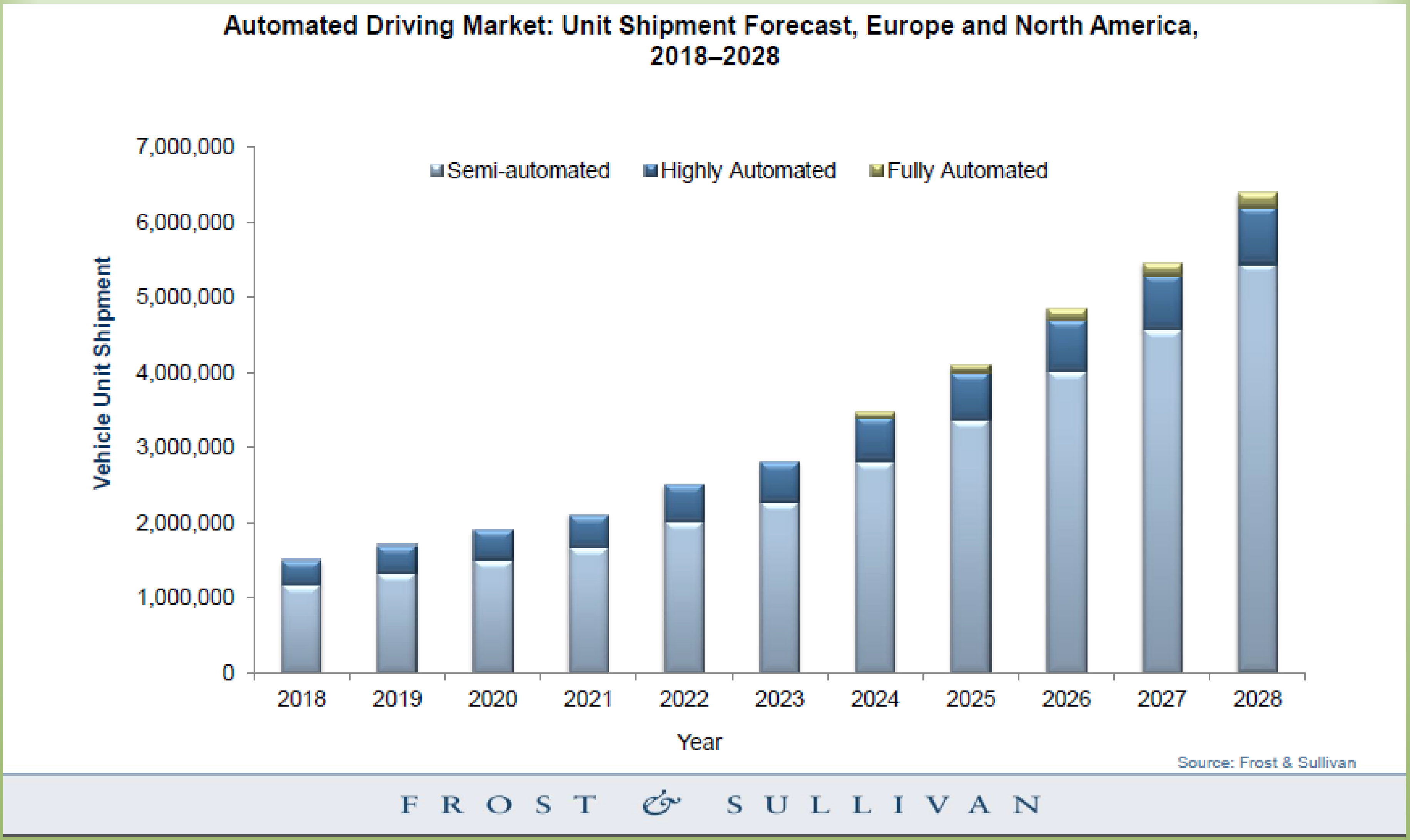
Bob Feldmaier
Director of the Center for Advanced Automotive Technology
Macomb Community College

US Consumers Rate Safety and Advanced Driver Assistance Technologies Most Important





By 2020, Major Industry Forecaster Expects 6.2 Million Vehicles to Have Automated Features



Important Challenges

- In-car intelligence
- HMI (Human-Machine Interface)
- Vehicle Systems
- Social involvements
- 3D maps

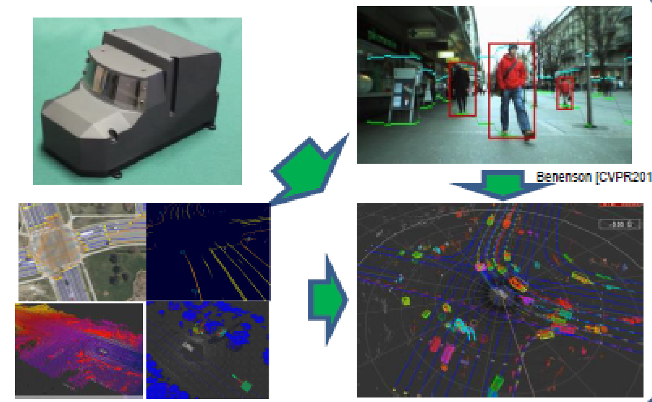
Toyota's Assessment of Automated Vehicle Technology

Important Challenges Toward the Goal

1. In-car Intelligence

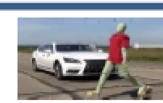
Highly Reliable Perception and Understanding

① Advanced sensors (Lidar, Radar and Camera)
② 3D maps for real time driving control
③ State-of-the-art Recognition Technologies
④ Decision making for safety
⑤ Complementary information (ITS, Infrastructure)



2. Human Factors

CSRC Collaborative Safety Research Center TOYOTA



Cooperation of driver and system
for Highly automated system and Complex traffic situations

① Avoid overconfidence and misleading
② Mind sharing between driver and system
③ Handover process from/to human driver and system

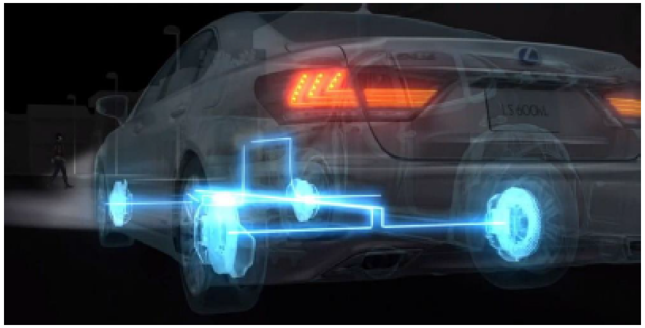
Toyota's Assessment (Continued)

Important Challenges Toward the Goal

3. Vehicle system

Vehicle Dynamics control, System Reliability and ECUs

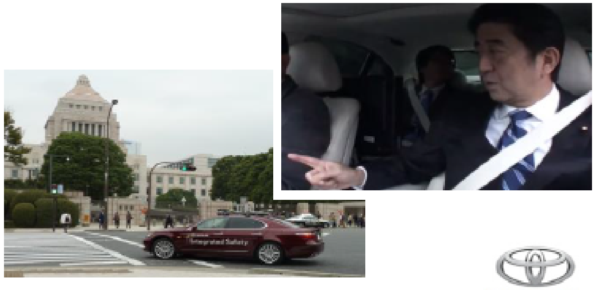
① Advanced vehicle control system
② Highly reliable system design and components
③ Advanced electronics platform (CPU, Communication etc.)
④ Safe Operation System and Cyber Security



4. Social involvements

Need wide discussions with stakeholders

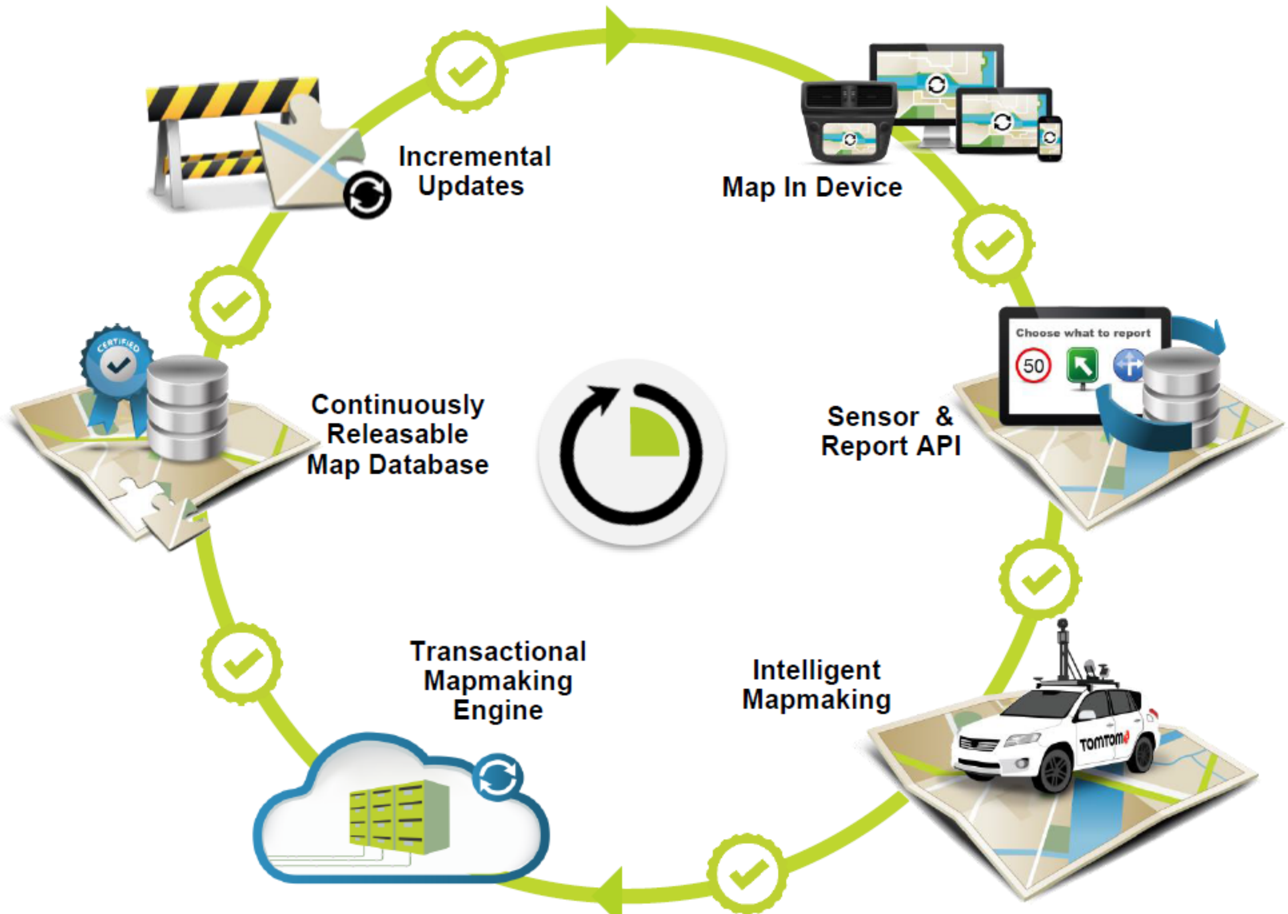
① Public understanding of the technology
② Rules and regulations
③ Harmonization



Let's Go Places

The Process of Delivering Real-Time Maps

Delivering real-time maps



Quality Assurance

TOMTOM

Many Issues Confront the Industry in the Business of Automated Vehicles

Margin Impact	1	As collision avoidance ADAS technologies move into standard fitment space, a high margin optional business will be impacted
Low Cost CMOS Strategy	2	Pureplay CMOS strategy wont work from a redundancy level as the portfolio of ADAS and automation features improve
Addressing Human Factors	3	Handoff is still an extremely tricky situation- drastic differences between L3 and L4. L3 handoffs between driver and vehicle is a big tech challenge
Need to Evolve HMI	4	Need to augment drivers with more layers of useful alerts/information – need for improved HUD systems with AR without increasing complexity
Security	5	Besides the SPYCar act, the industry still needs more than the present band-aid approach to protect V2X channels and the heart of automation

Questions?

Next Presenter

Miguel Hurtado, PhD
Systems Engineer of Advanced Driving Assistance Projects and Technology Transfer Support for Europe and North America
Valeo

Automated Vehicle

Sensing Technologies and Valet Park4U

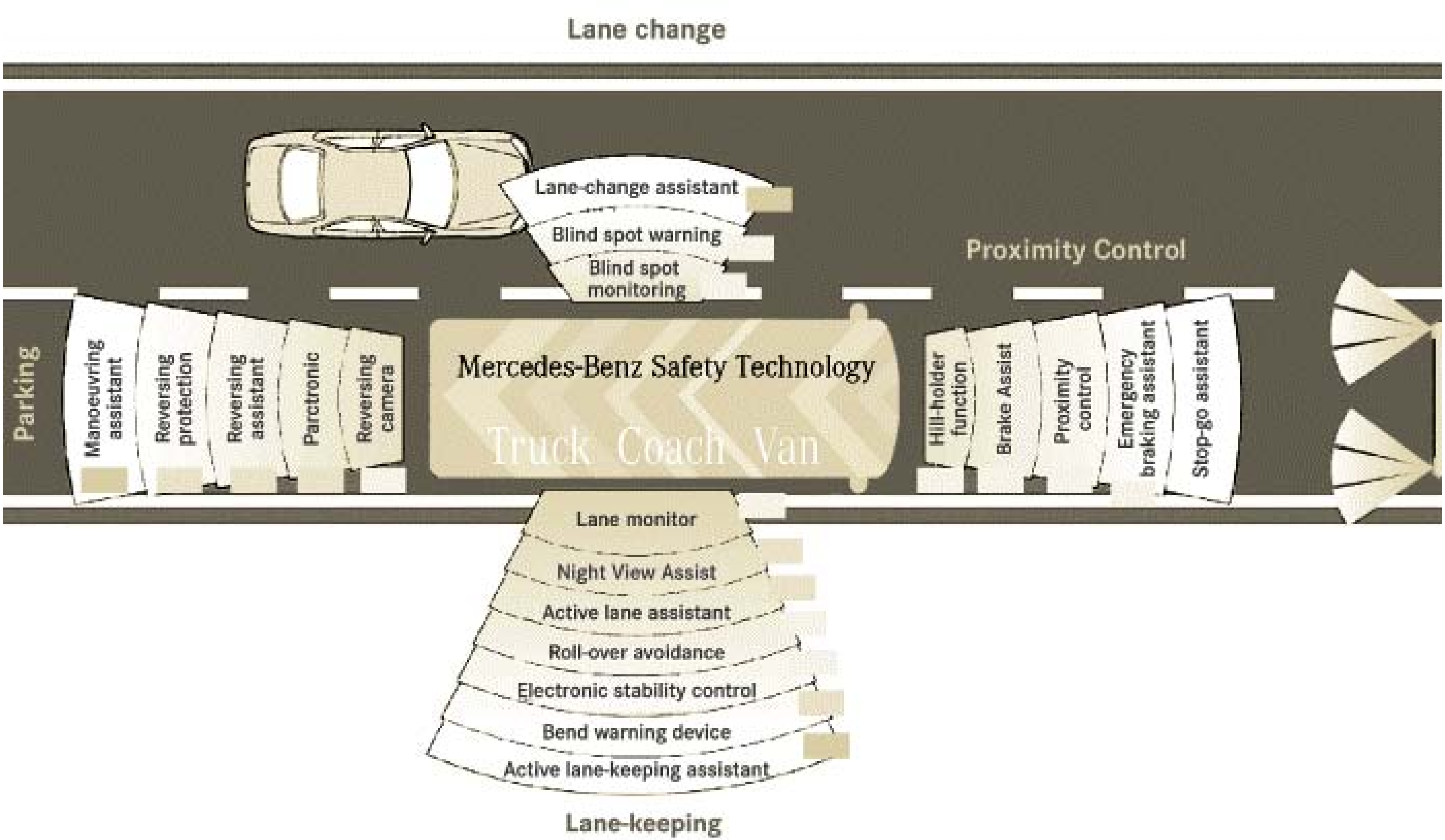
Miguel HURTADO

August 26, 2015

AGENDA

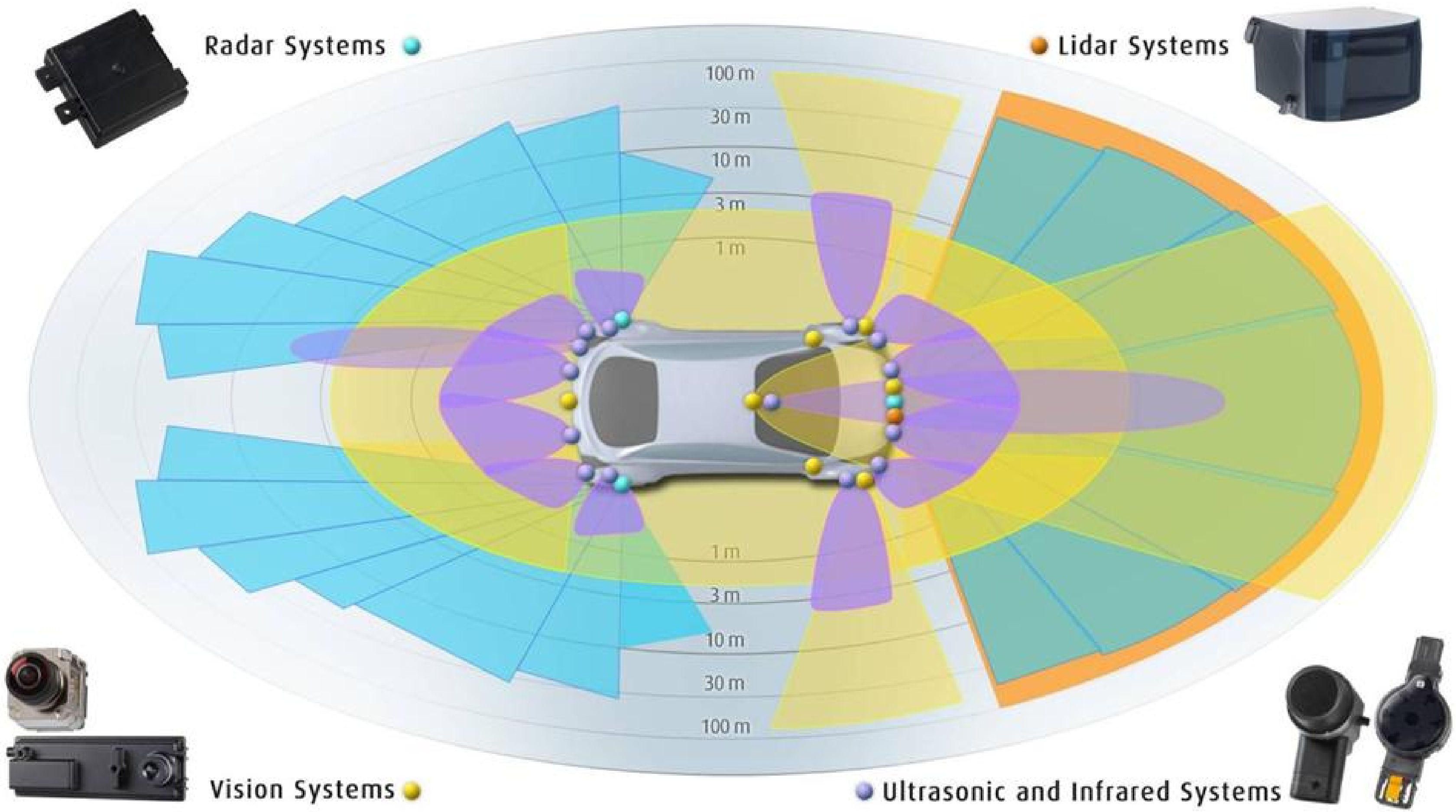
- Active Safety and Comfort Applications
- Valeo Environment Sensing and Comfort Applications
  - Camera Systems in the Automated Vehicle
- Sensor Fusion and Redundancy of Systems
- Distributed Architecture in Sensors Fusion
- Advantages of Redundant Sensor Fusion
- Reliability vs Redundancy
- Valet Park4U
  - Architecture: Sensors and Actuators
  - Application Exampe

Mercedes-Benz:
Active Safety and Comfort Applications



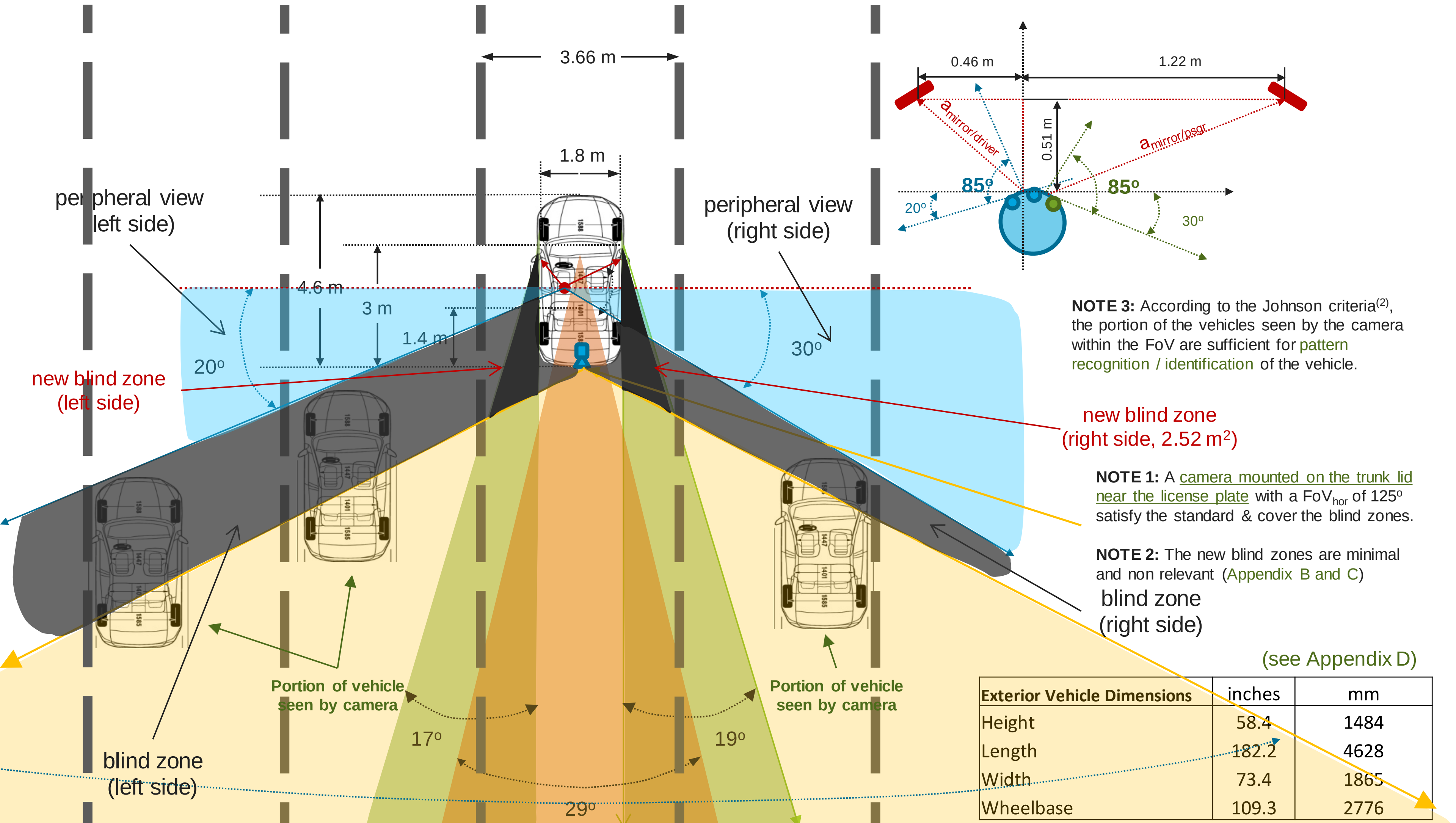
valeo

Valeo Environment Sensing: Active Safety and Comfort Applications



Camera Systems

NOTE: Similar analysis of blind zones can be done per ECE-R46 Regulation (see Appendix A)



NOTE 3: According to the Johnson criteria[2], the portion of the vehicles seen by the camera within the FoV are sufficient for pattern recognition / identification of the vehicle.

NOTE 1: A camera mounted on the trunk lid near the license plate with a FoV_{hor} of 125º satisfy the standard & cover the blind zones.

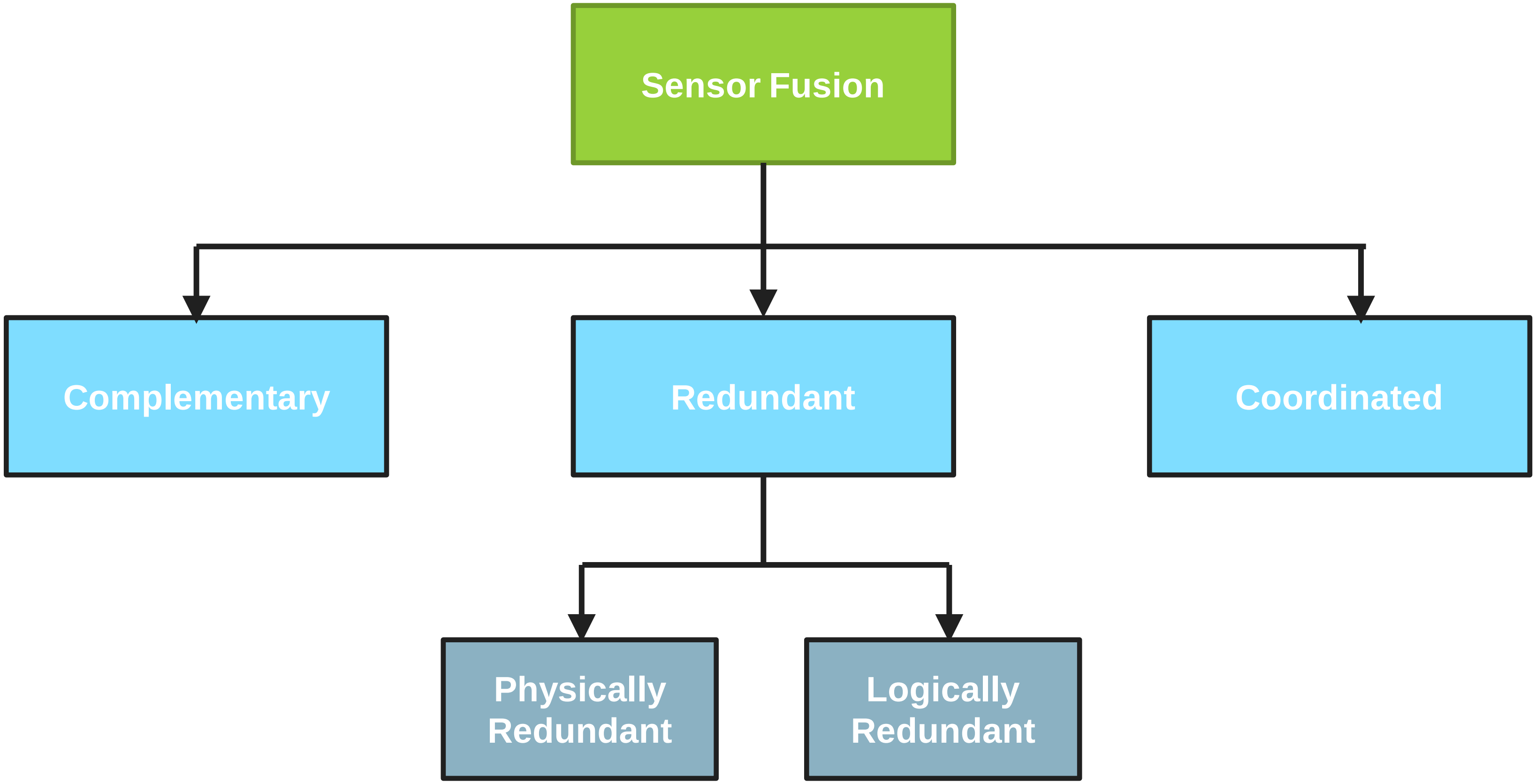
NOTE 2: The new blind zones are minimal and non relevant (Appendix B and C)

(see Appendix D)

Exterior Vehicle Dimensions	inches	mm
Height	58.4	1484
Length	182.2	4628
Width	73.4	1865
Wheelbase	109.3	2776

[2] Leachtenauer, J. C, "Resolution requirements and the Johnson criteria revisited", Proc. SPIE 5076, Infrared Imaging Systems: Design, Analysis, Modeling, and Testing XIV, 1, August 25, 2003.

Types of Sensor Fusion 1/2

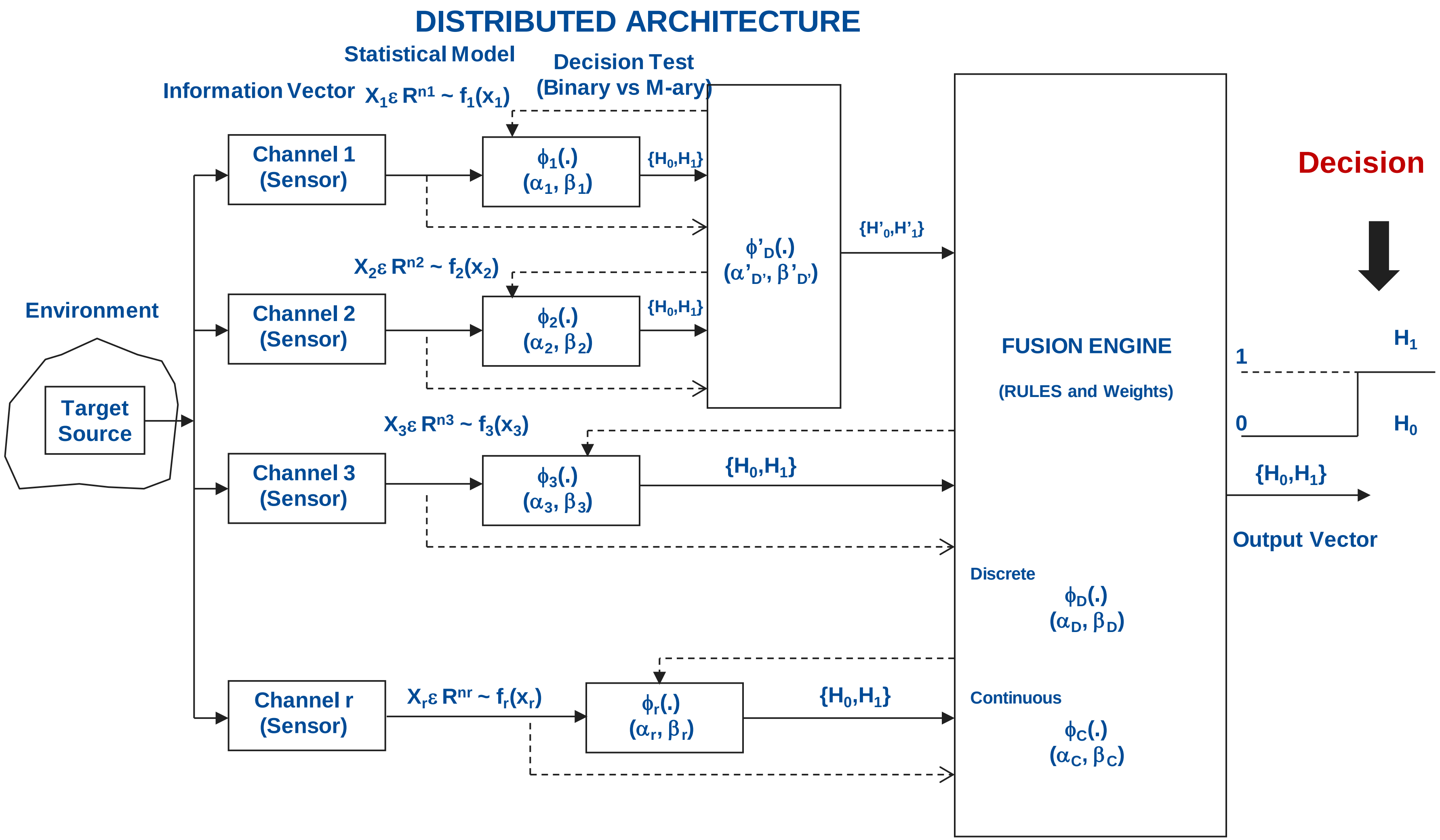


Types of Sensor Fusion 2/2

- Redundant: Sensors return same type of information from the environment, i.e. same percept
  - Physical redundancy – Usually same sensor technology detecting same attribute (i.e. 4-channel ultrasonic sensor returning distance information)
  - Logical redundancy – Usually different technology returning same percepts, but using different processing algorithms (i.e. stereo camera vs Lidar returning distance information)
- Complimentary: Provide disjoint types of information about a percept that complement inferences about the environment
  - A camera used for color, texture, motion and a ranging sensor to provide distance information
- Coordinated: Use a sequence of sensors to adapt the sensing under changing conditions of the environment.
  - One or more sensors give space to more accurate sensors to fine tune the search of vessels in the Ocean

Reference:
Murphy, Robin R., "Introduction to AI Robotics", The MIT Press, Cambridge, Massachusetts 2000.

Distributed Architecture in Sensor Fusion



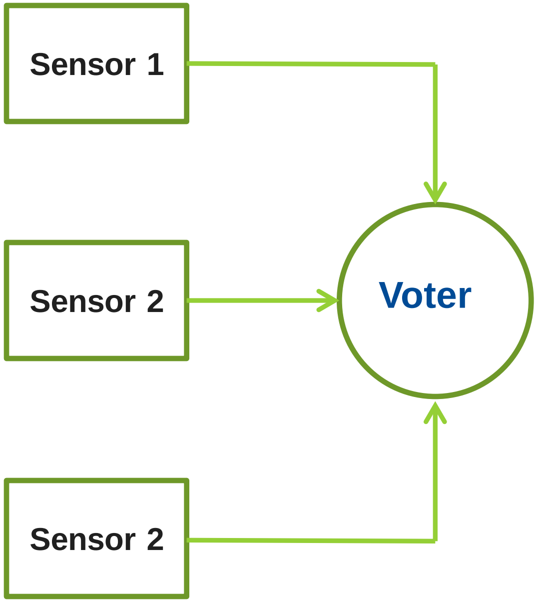
Reference:
Hurtado, Miguel A., "Statistical Modeling and Data Fusion of Automotive Sensors for Object Detection Applications in a Driving Environments", Doctoral Dissertation, Purdue University, July 2010.

Advantages of Redundant Sensor Fusion

- Probability of correct Detection / Classification[1]
  - Marginal gain of correct classification increases with additional sensors
  - Better gains when individual probabilities of correct detection for each sensor falls in the range $0.5 < p < 0.9$
  - Marginal gain is not improved if sensor are extremely weak, i.e. $p < 0.5$ or when sensors are extremely accurate, i.e. $p > 0.95$
  - Marginal gains not as big for more than 5 sensors
- Reliability of systems[2]
  - Adding more sensors increases the reliability of the overall system
  - Mean time to failure of a system with more sensors is increased

References:
[1]Hall, David L., "Mathematical Techniques in Multisensor Data Fusion", Artech House Information Warfare Library, February 26, 2004
[2]Deyst, John, "Real Time Systems for Aerospace Vehicles", MIT 16.840 Aeronautics & Astronautics Course Notes, Spring 1999

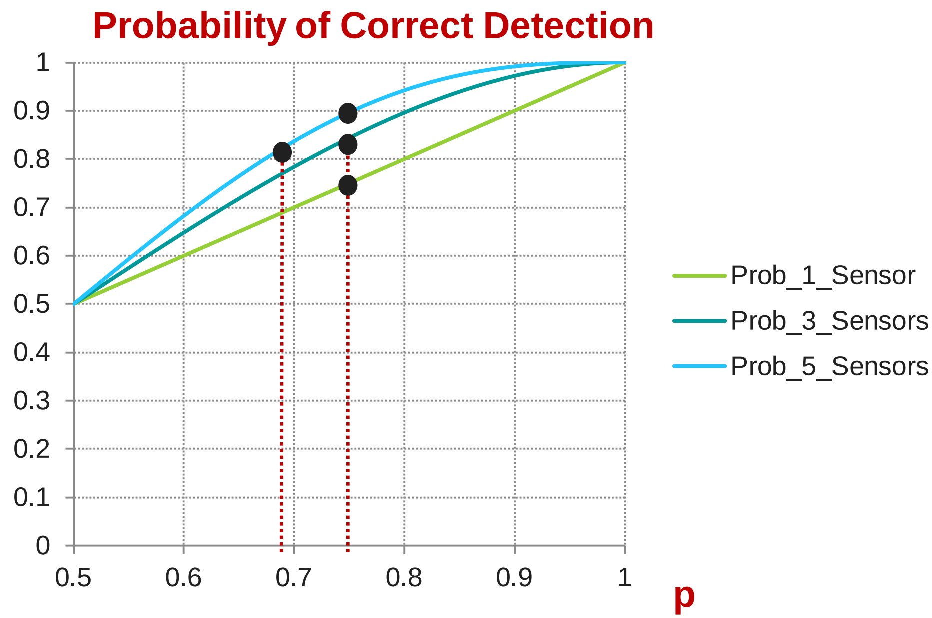
Example of Probability of correct Detection 1/3



ASSUMPTIONS

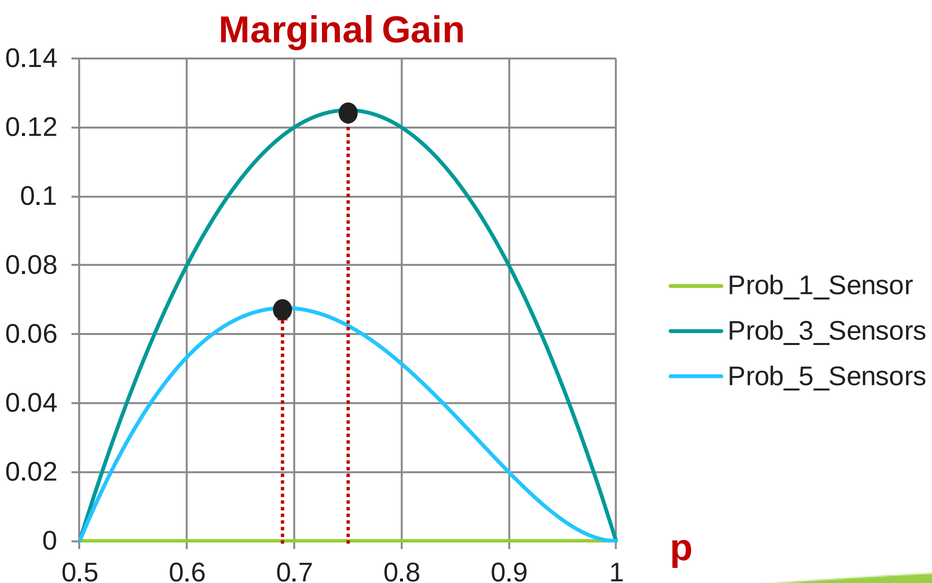
- Triply redundant system
- Vote is “always” correct
- Sensors are statistically independent of each other
- A-priory information is the same
- Sensors are identical and observe same phenomenon

Example of Probability of correct Detection 3/3



$$
\left\{
\begin{aligned}
&p^* = 0.75\\
&P^*_{3sensor\_correct\_classification} = f_{3sensor}(0.75) = 0.84375\\
&MGain^*_{3sensor} = g_{3sensor}(0.75) = 0.125
\end{aligned}
\right.
$$

$$
\left\{
\begin{aligned}
&P_{5sensor\_correct\_classification} = f_{5sensor}(0.75) = 0.896\\
&MGain_{5sensor} = g_{5sensor}(0.75) = 0.0625\\
&\\
&P^*_{5sensor\_correct\_classification} = f_{5sensor}(0.691) = 0.825\\
&MGain^*_{5sensor} = g_{5sensor}(0.691) = 0.067
\end{aligned}
\right.
$$

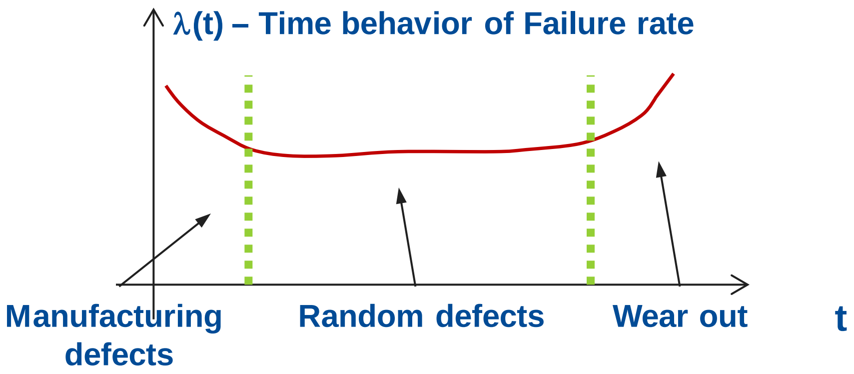


$$MGain_{3sensor} < MGain^*_{3sensor}$$

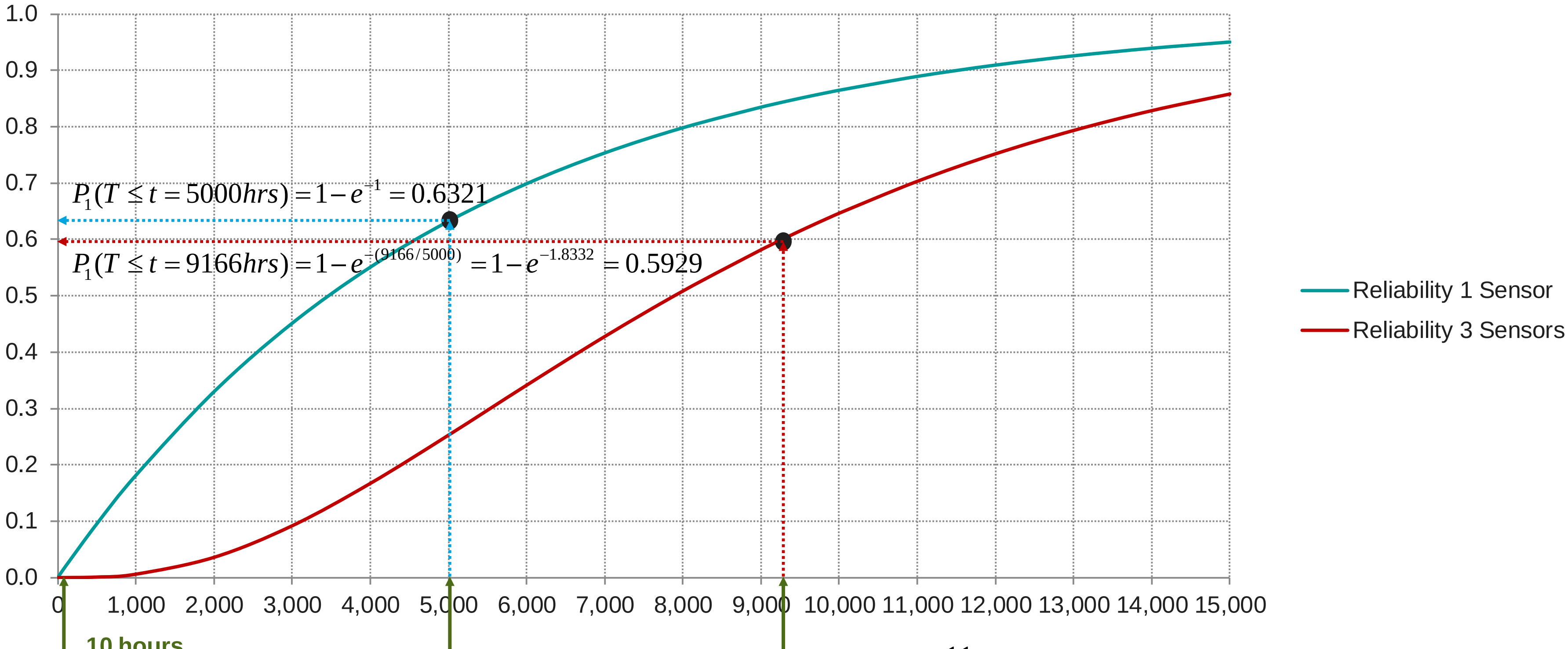
Example of Reliability 1/4

ASSUMPTIONS

- Assume First Order Markov Model ⇨ $$R_1(t) = P_1(t < T) = R_1(t_0)e^{-\int_{-t_0}^{t} \lambda(\tau)d\tau}$$
- Reliability is the probability that the system has NOT failed at time T
- Unreliability is the probability that the system has failed at time T
- Reliability and Unreliability are complementary
  - Reliability + Unreliability = 1
- Inverse of Failure Mode lambda is the Mean Time to Failure



Example of Reliability 4/4



$$P_1(T \le t = 5000hrs) = 1 - e^{-1} = 0.6321$$

$$P_1(T \le t = 9166hrs) = 1 - e^{-(9166/5000)} = 1 - e^{-1.8332} = 0.5929$$

10 hours

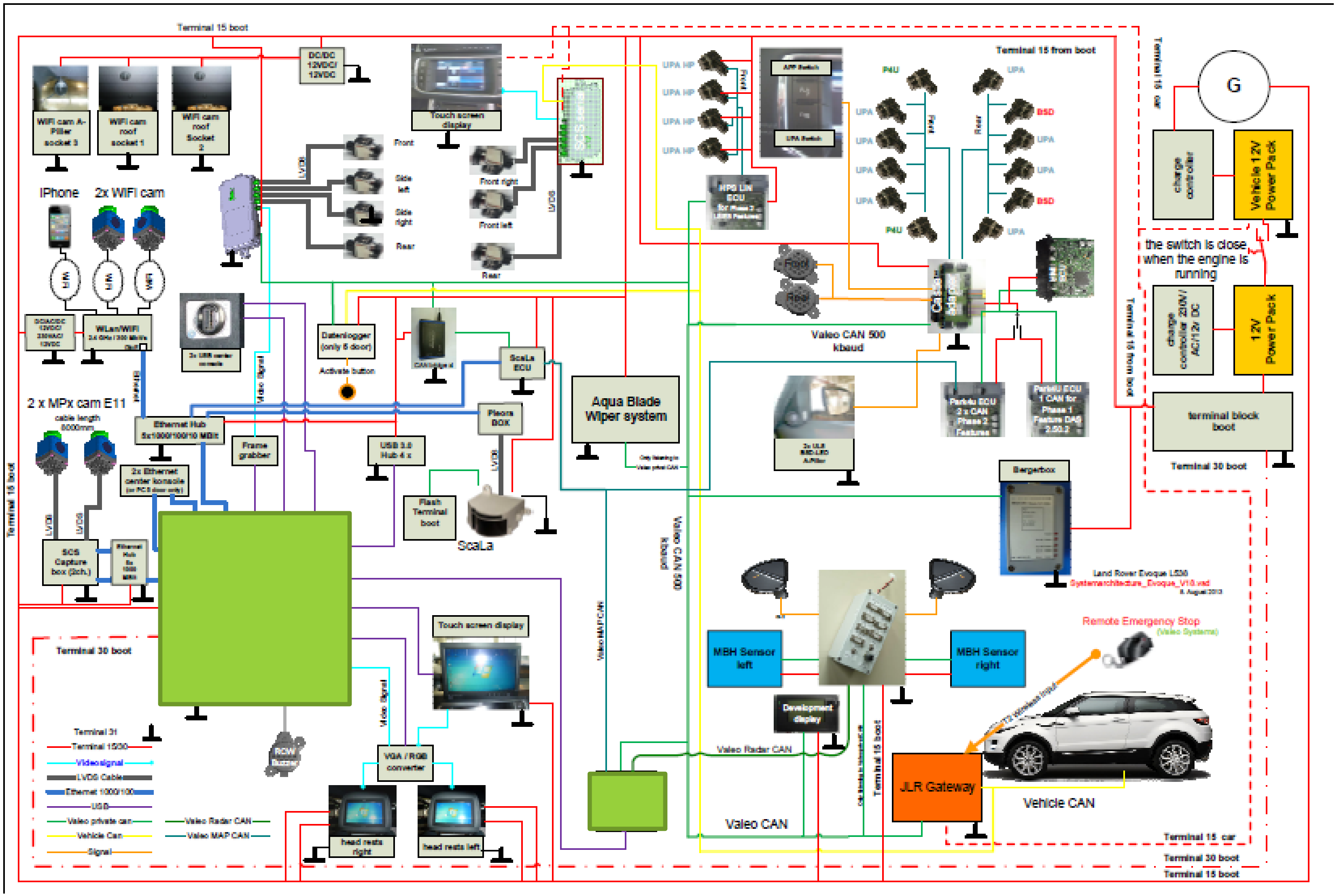
$$P_1(T \le t = 10hrs) = 0.002$$

$$P_3(T \le t = 10hrs) = 8*10^{-9}$$

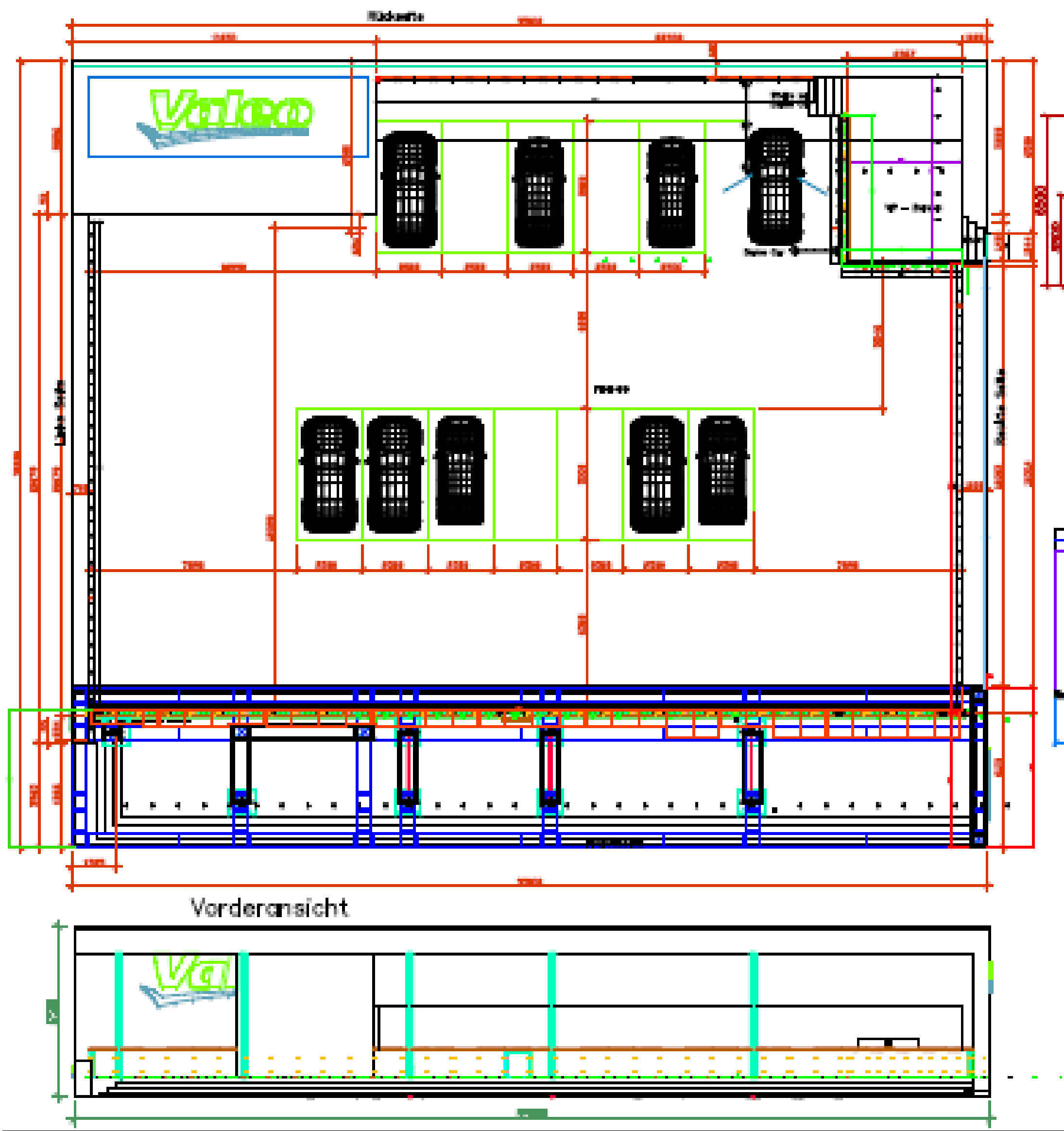
$$MTTF_{1sensor} = \frac{1}{\lambda} = 5000hrs$$

$$MTTF_{3sensor} = \frac{11}{6\lambda} = 9166hrs$$

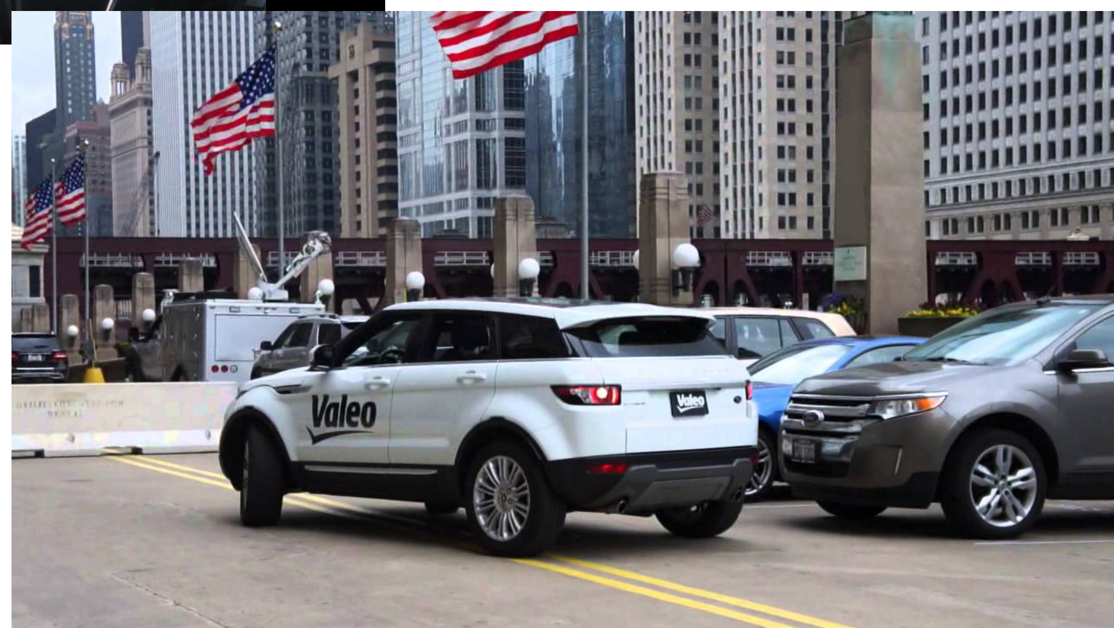
Valeo Valet Park4U



Valeo Valet Park4U Application



Valeo Valet Park4U



Valeo Valet Park4U

- https://www.youtube.com/watch?v=QPH8j2mrepM

Valeo

Automotive technology, naturally

Questions?

Discussion of Worker Skills Required in the Field of Automated Vehicles

- Working knowledge of wired and wireless protocols for vehicle-to-vehicle and vehicle-to-infrastructure communication devices
- Network programming knowledge in developing automation scripts
- Configuring and operating wired and wireless switches, routers, firewalls, and security systems
- Fluency in software such as Windows, Linex, VPN, SFTP/FTP, etc.
- Ability to conduct interoperability testing for automotive communication systems
- Basic knowledge of automotive build, diagnosis, and repair

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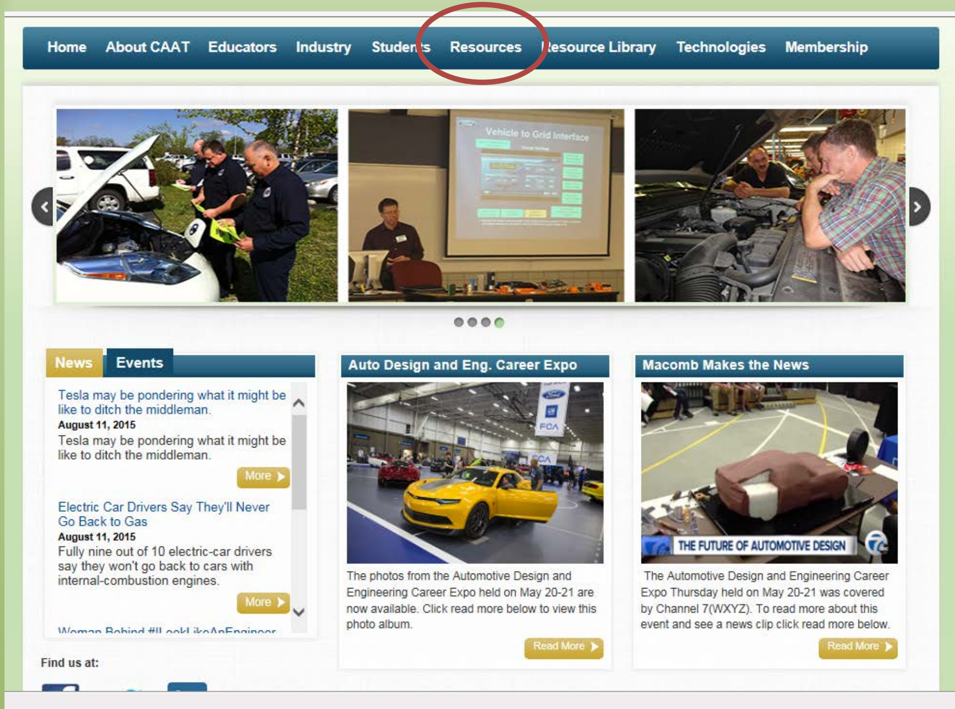

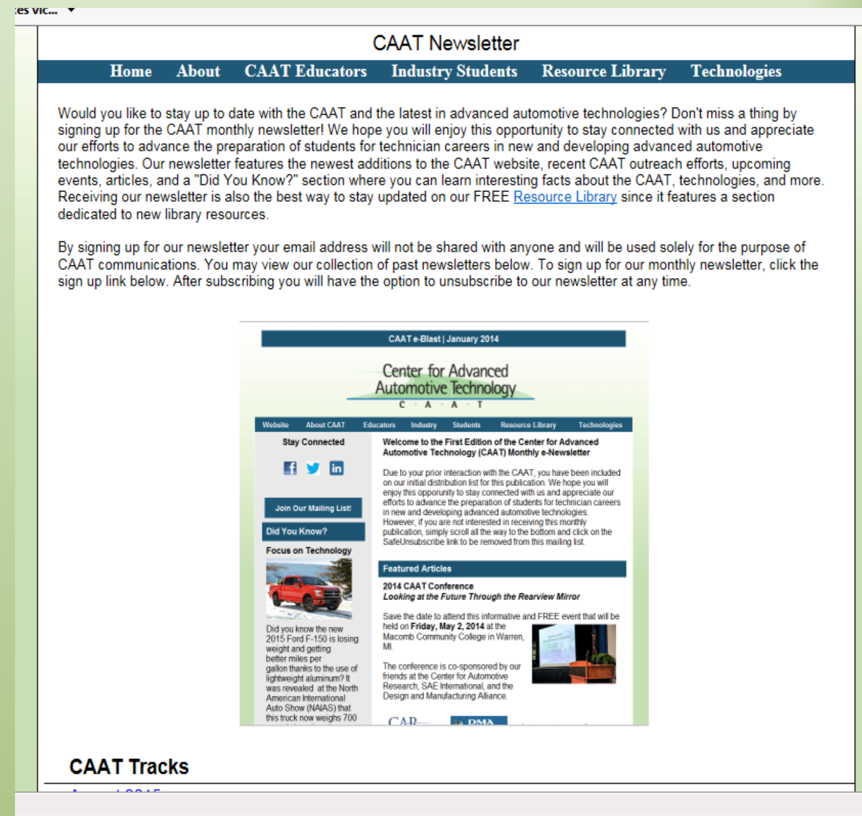

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Home > Technologies > Automated and Connected Vehicles

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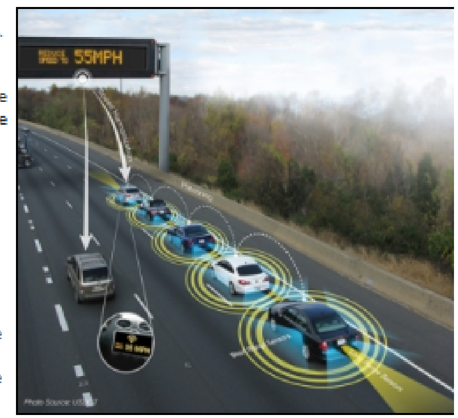
Automated and Connected Vehicles

Automated and connected vehicle technologies are becoming some of the most heavily researched automotive technologies. Currently, some automated and connected vehicle technologies are available, but are only a fraction of what will be available in the future. Although this page contains separate sections for connected and automated vehicle technologies, be aware that many of the technologies overlap. For instance, to have a fully automated vehicle, the vehicle must also be a connected vehicle.



Click the image above to view a larger version

Connected Vehicles

Source:Center for Automotive Research (CAR) Publications

Connected vehicles are vehicles that use any of a number of different communication technologies to communicate with the driver, other cars on the road (vehicle-to-vehicle [V2V]), roadside infrastructure (vehicle-to-infrastructure [V2I]), and the "Cloud." This technology can be used to not only improve vehicle safety, but also to improve vehicle efficiency and commute times. Listed below are some of the benefits of connected vehicles:

Crash Elimination: Crash-free driving and improved vehicle safety could change the concept of a vehicle as we know it

Reduced Need for New Infrastructure: Self-driving can reduce the need for building new infrastructure and reduce maintenance costs

Travel Time Dependability: Convergence can substantially reduce uncertainty in travel times via real-time, predictive assessment of travel times on all routes

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CAAT Tracks

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August 2015

Register Now for the CAAT's Next Webinar: The Technology of Automated & Connected Vehicles!

Self-driving vehicles? Are they for real in our lifetimes?

Please join the Center for Advanced Automotive Technology (CAAT) of Macomb Community College for a webinar on August 26, 2015, entitled "The Technology of Connected, Automated, and Self-Driving Vehicles." Many of the technologies required to enable automobiles to be self-driving and connected in multiple ways to other vehicles, the cloud, and roadside infrastructure, are already here, and will become even more complex and advanced in coming years. What will this mean for the education and preparation of the technicians who will be needed to develop, build, and service these technically advanced vehicles?

The webinar will lay out the basic definitions and concepts needed

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The CAAT is pleased to announce that our FREE Resource Library now offers users the ability to provide a rating and review for all resource library items!

If you haven't yet visited the FREE CAAT Resource Library, we encourage you to check it out today. If you provide us with an email address (optional) when downloading a resource, you will receive an email from us about a week later inviting you to share your thoughts about the resource with us by providing a rating and

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