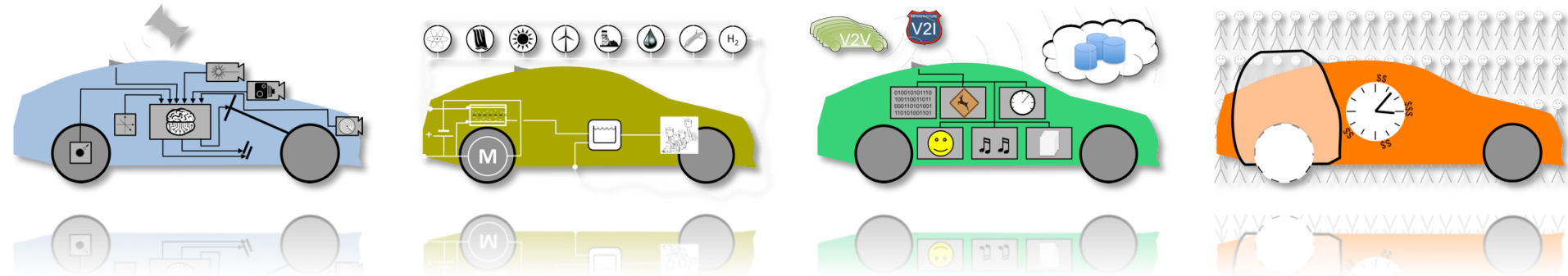


# The Automobile of the Future

Just a computer on wheels or the next big thing in computing?



**17<sup>th</sup> International Forum on Advanced Microsystems for Automotive Applications**  
**Smart Systems for Safe and Green Vehicles**

Kaiserin Friedrich-Haus, Berlin, Germany

17-18 June, 2013

**Dr. Sven A. Beiker**

Executive Director, Center for Automotive Research at Stanford - CARS  
416 Escondido Mall, Bldg 550/Room 131, Stanford, CA 94305-4021, USA  
(+1)650 736-1504, [beiker@stanford.edu](mailto:beiker@stanford.edu), <http://automotive.stanford.edu>

# The Automobile of the Future – A Done Deal?

The  
Economist

APRIL 20TH – 26TH 2013

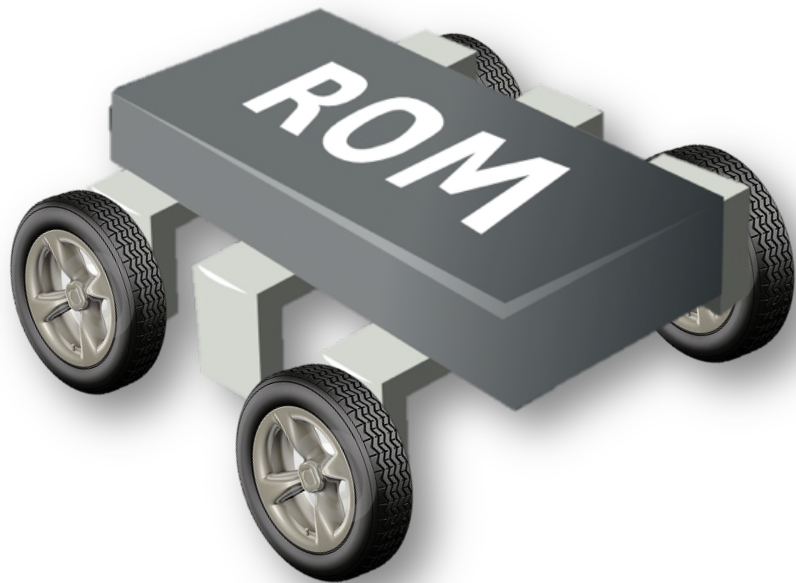
Clean, safe and it  
drives itself

A special report on the future of the car



Jon Berkeley

# Computer on Wheels or Next Big Thing?

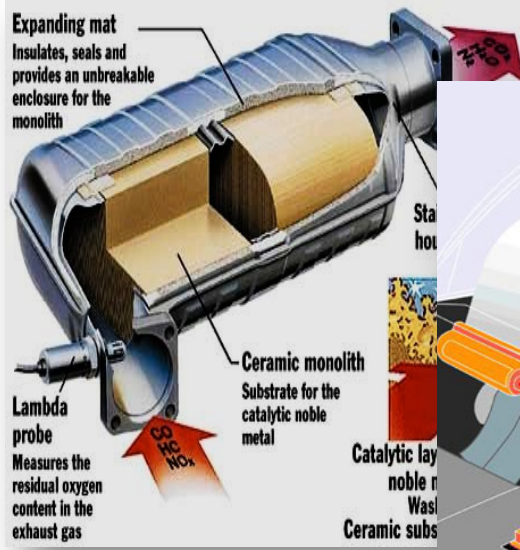


**Say hello to iAuto.**

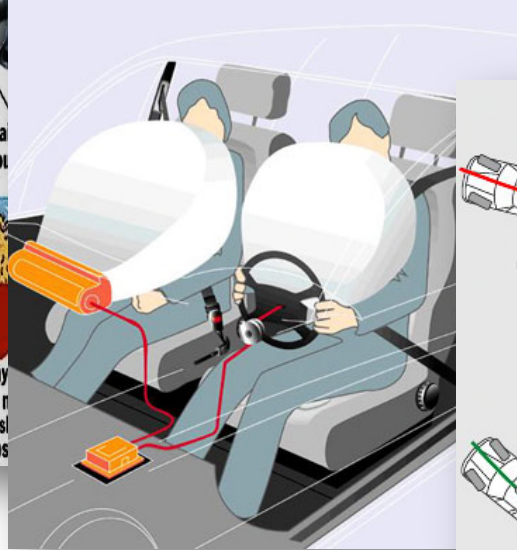


**There's a lot to look forward to...**

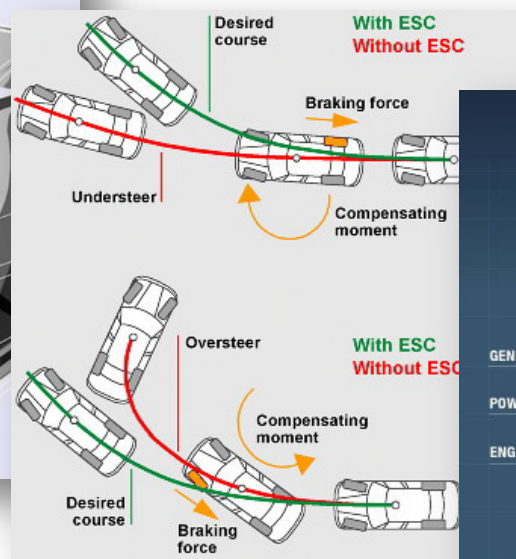
# Smart Systems for Safe and Green Vehicles



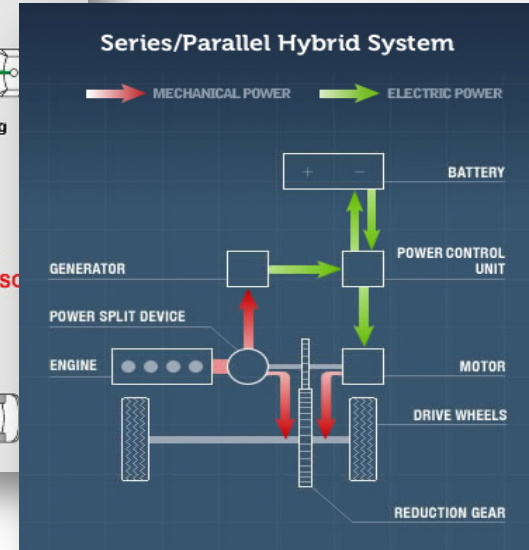
Catalytic Converter



Airbag

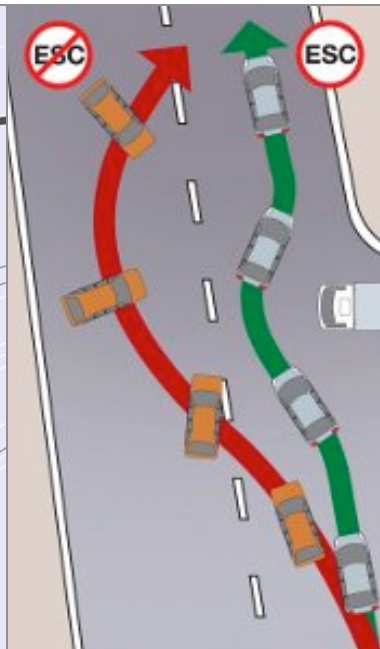
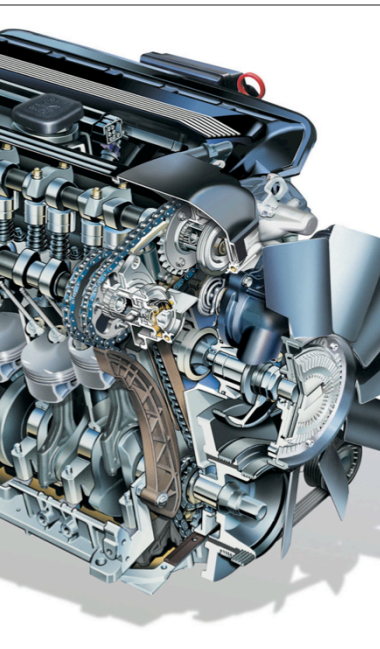


Stability Control



Hybrid Powertrain

# MEMS in Automobiles, Consumer Electronics



≈ 90% of all new cars use MEMS **pressure sensors** for engine control

≈ 90% of all new cars use MEMS **accelerometers** for SRS deployment

≈ 50% of all new cars use MEMS **gyroscopes** for stability control

≈ 50% of all new phones use MEMS **accelerometers** for motion detection

≈ 40% of all new cameras use MEMS **gyroscopes** for img stabilization

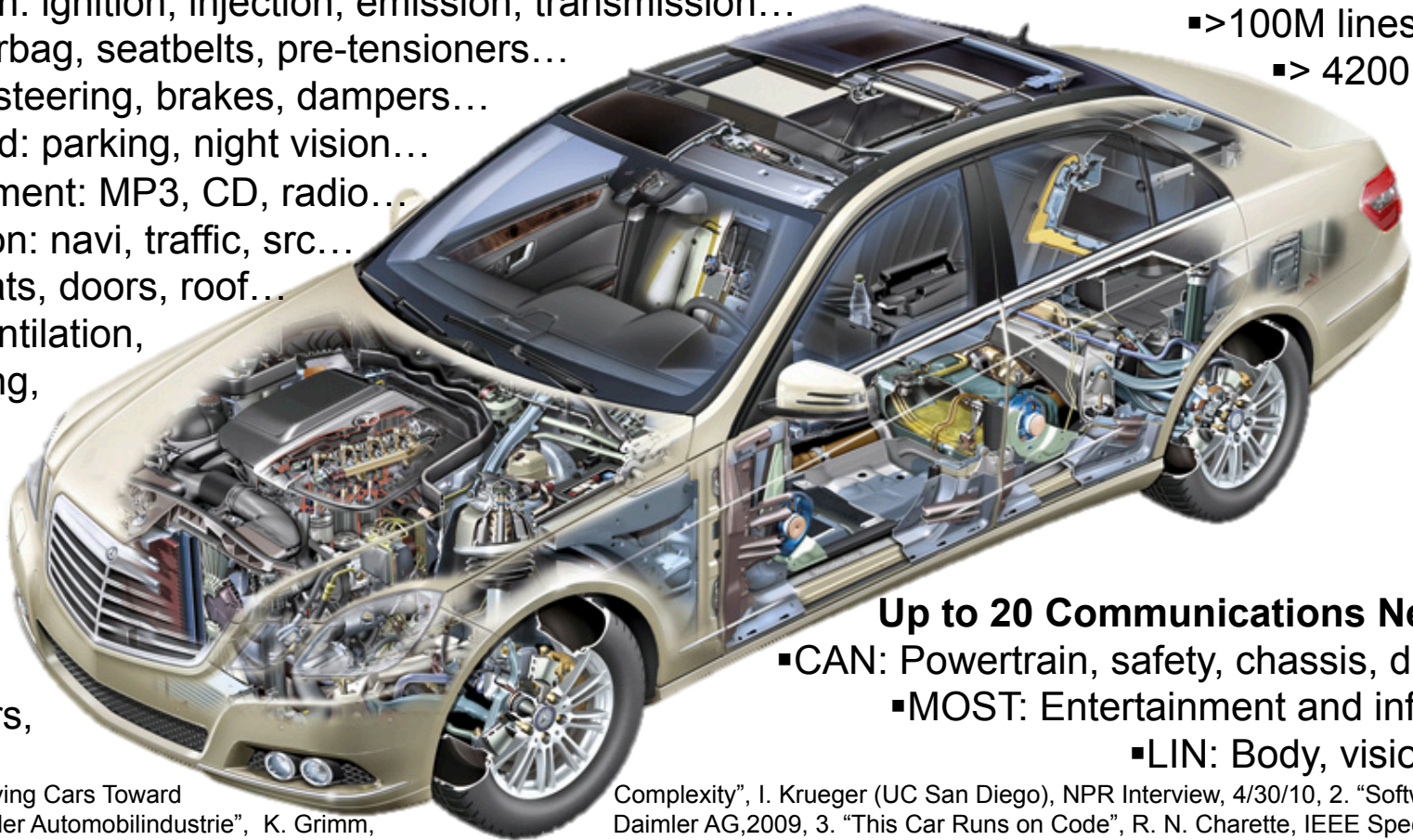
# Vehicle Control and Communication Systems

## Up to 80 controllers<sup>1</sup>

- Powertrain: ignition, injection, emission, transmission...
- Safety: airbag, seatbelts, pre-tensioners...
- Chassis: steering, brakes, dampers...
- Driving Aid: parking, night vision...
- Entertainment: MP3, CD, radio...
- Information: navi, traffic, src...
- Body: seats, doors, roof...
- Cabin: ventilation, heating, cooling, filtering, ...
- Vision: lights, wipers, mirrors, ...

## Up to 35-40% of vehicle cost<sup>3</sup>

- >100M lines of code
- > 4200 signals<sup>1</sup>



## Up to 20 Communications Networks<sup>2</sup>

- CAN: Powertrain, safety, chassis, driving aid
- MOST: Entertainment and information
- LIN: Body, vision, HVAC

Sources: 1. "Driving Cars Toward Complexity", I. Krueger (UC San Diego), NPR Interview, 4/30/10, 2. "Softwaretechnologie in der Automobilindustrie", K. Grimm,

Complexity", I. Krueger (UC San Diego), NPR Interview, 4/30/10, 2. "Softwaretechnologie in der Automobilindustrie", K. Grimm, Daimler AG, 2009, 3. "This Car Runs on Code", R. N. Charette, IEEE Spectrum, 2/11/13

# Innovation Through Microsystems: ToDo List



**OPTIMIZE RELIABILITY**



**MAXIMIZE SECURITY**



**MANAGE COMPLEXITY**



**DRIVE STANDARDIZATION**



**ENABLE INTEROPERABILITY**



# The Car – Next Big Thing in Silicon Valley!?





# Automotive in Silicon Valley – New Detroit?



- PG&E
- EA
- Volkswagen Group of America
- ORACLE
- NOVARIANT
- ecoality
- Getaround
- Allstate
- facebook
- Willow
- CalCars THE CALIFORNIA
- LOCAL MOTION
- Wheelz
- HYUNDAI
- IDEO
- Mercedes-Benz
- GM
- waze
- Ford
- Venrock
- CHARLES RIVER VENTURES
- MDV MOHR DAVIDOW VENTURES
- aha
- BOSCH
- hp
- Google
- NASA
- RENAULT
- NISSAN
- CISCO
- TOYOTA
- NOKIA
- EMC
- intel
- SIEMENS
- vmware
- SAP
- Microsoft
- LOCKHEED MARTIN
- National Semiconductor
- NETFLIX
- McAfee
- TIAX
- Coala Tech
- symantec
- Apple
- DELPHI
- NVIDIA
- OptaMotive
- SABA Motors
- LELAND STANFORD JUNIOR UNIVERSITY
- SPACESHIP LORAL
- YAHOO!
- HONDA
- eBay
- KLEENSPEED technology
- Trimble
- telenav
- Crossbow TECHNOLOGY

Note: Not all corporations shown here are affiliated with Stanford University. Map copyright by Google

# Problems Resulting from Personal Mobility

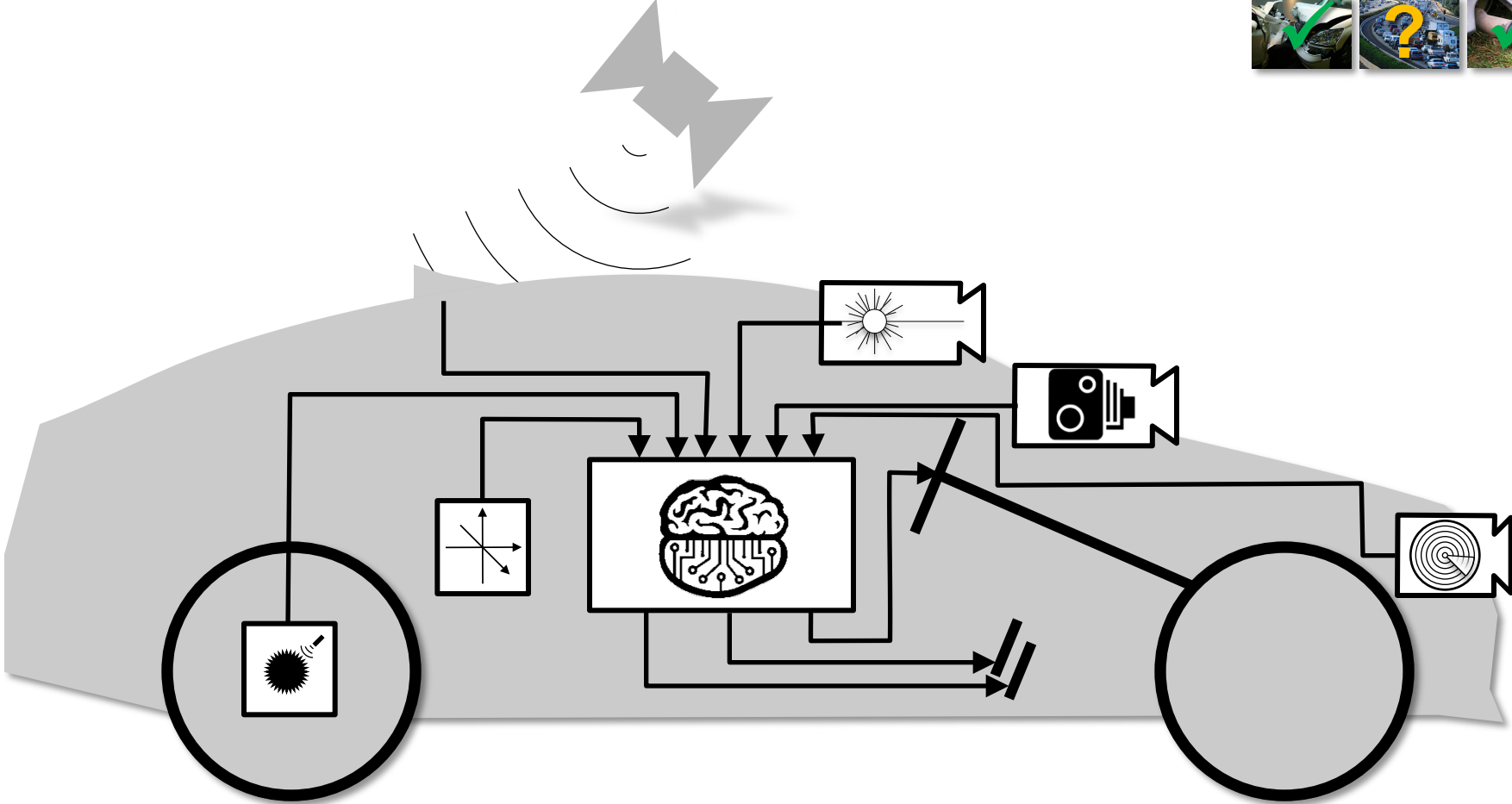
**Injuries:** Motor vehicle crashes led to 32,788 fatalities in 2010, in 95% of the cases human error was at least a contributing factor<sup>1,2</sup>

**Congestion:** Average commuter gets delayed 36 hrs per year due to congestion, total 2.8b gal of fuel wasted, overall loss \$87.2b<sup>3</sup>

**Pollution:** Health damages from motor vehicle emissions over \$40b per year<sup>4</sup>, 15% of all global petroleum consumed as U.S. gasoline<sup>5</sup>



# Future of the Automobile: Automated

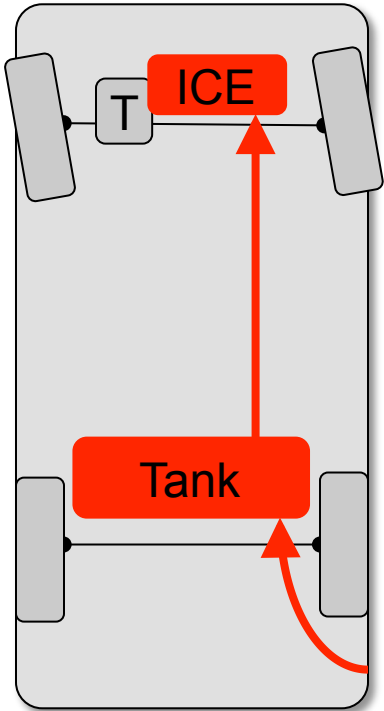




# Future of the Automobile: Electrified

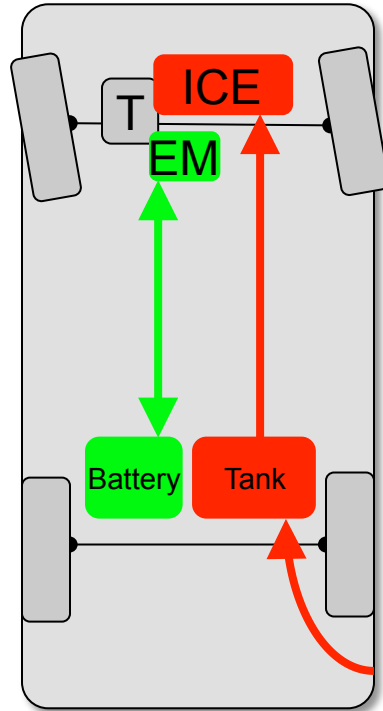


## Conventional

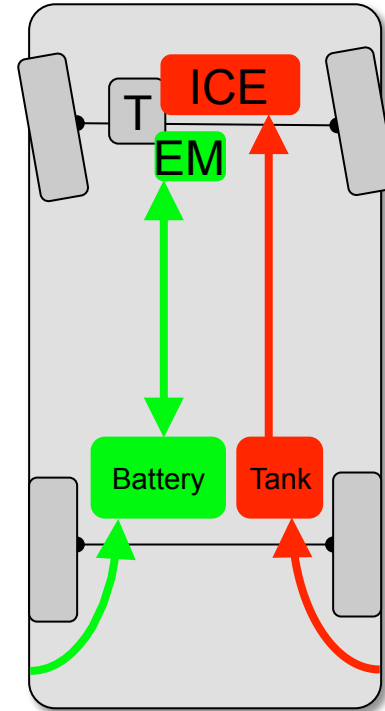


ICE Powered Vehicle (CV)

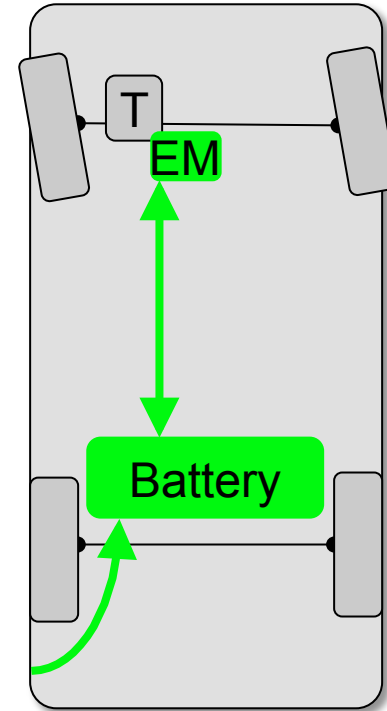
## Electrified



Hybrid Electric Vehicle (HEV)

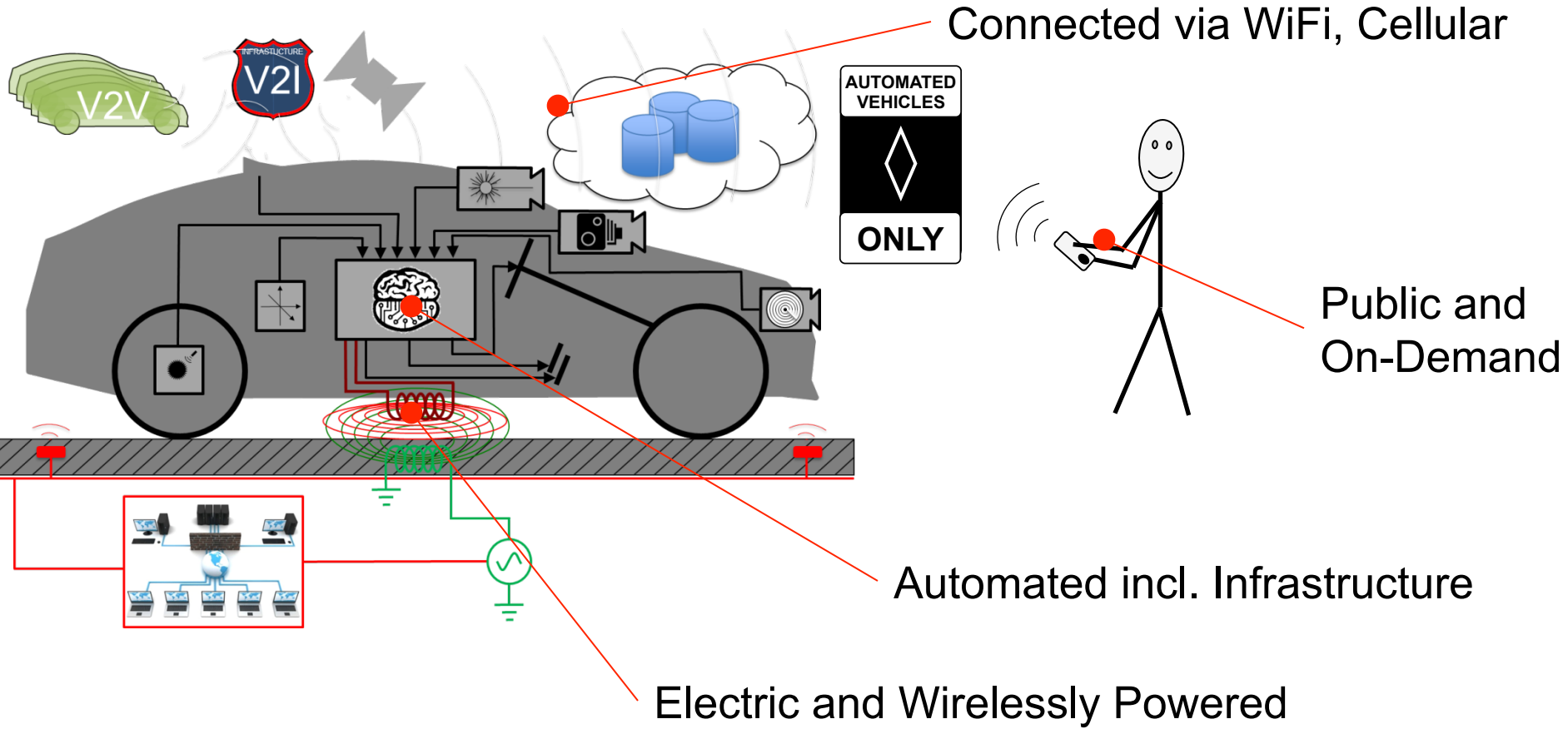


Plug-In Hybrid Electric Vehicle (PHEV)

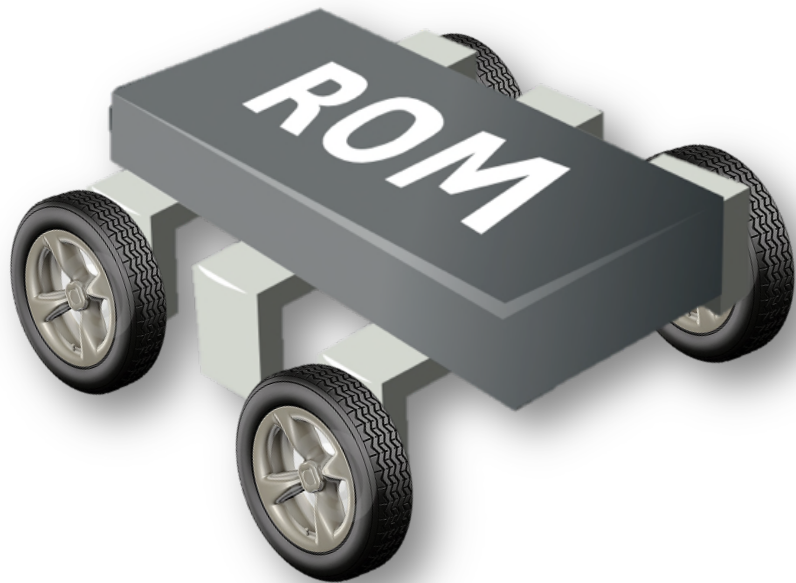


Battery Electric Vehicle (BEV)

# Vision: Electric-Automated-Connected-Public



# Computer on Wheels or Next Big Thing?



**Say hello to iAuto.**



**There's a lot to look forward to...**

**And finally there will be...**



**The egg-laying wool-milk sow  
... enabled through Advanced Microsystems  
for Automotive Applications**