Between Old Economy and the Next Big Thing

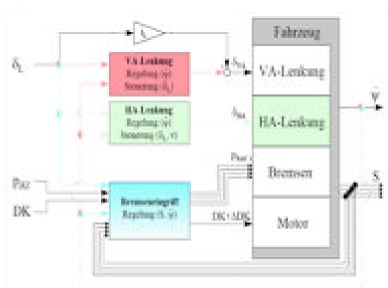
The Automobile on its Way to the Future

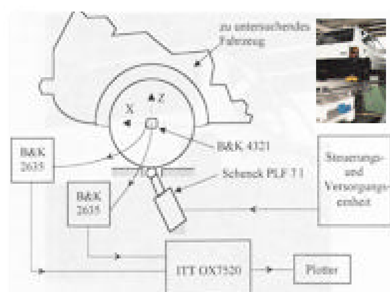
Sven A. Beiker – September 2010

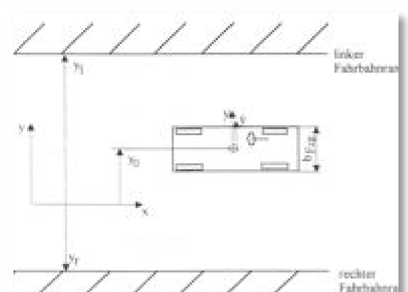
Introduction – Sven Beiker

- 20 years in automotive research, development, analysis
- 13 years with BMW R&D organizations in Germany, Silicon Valley, Michigan
- 2 years with Stanford University, Center for Automotive Research (CARS)
- PhD Thesis on Vehicle Dynamics Control Systems (at BMW)
- Diploma Thesis on Vehicle Acoustics / Quality Control (at Volkswagen)
- Innovation Management, Chassis Systems, Vehicle Dynamics, Hybrid Vehicles







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What does the future hold for the automobile?

…no one knows, but let's see what we can assume.

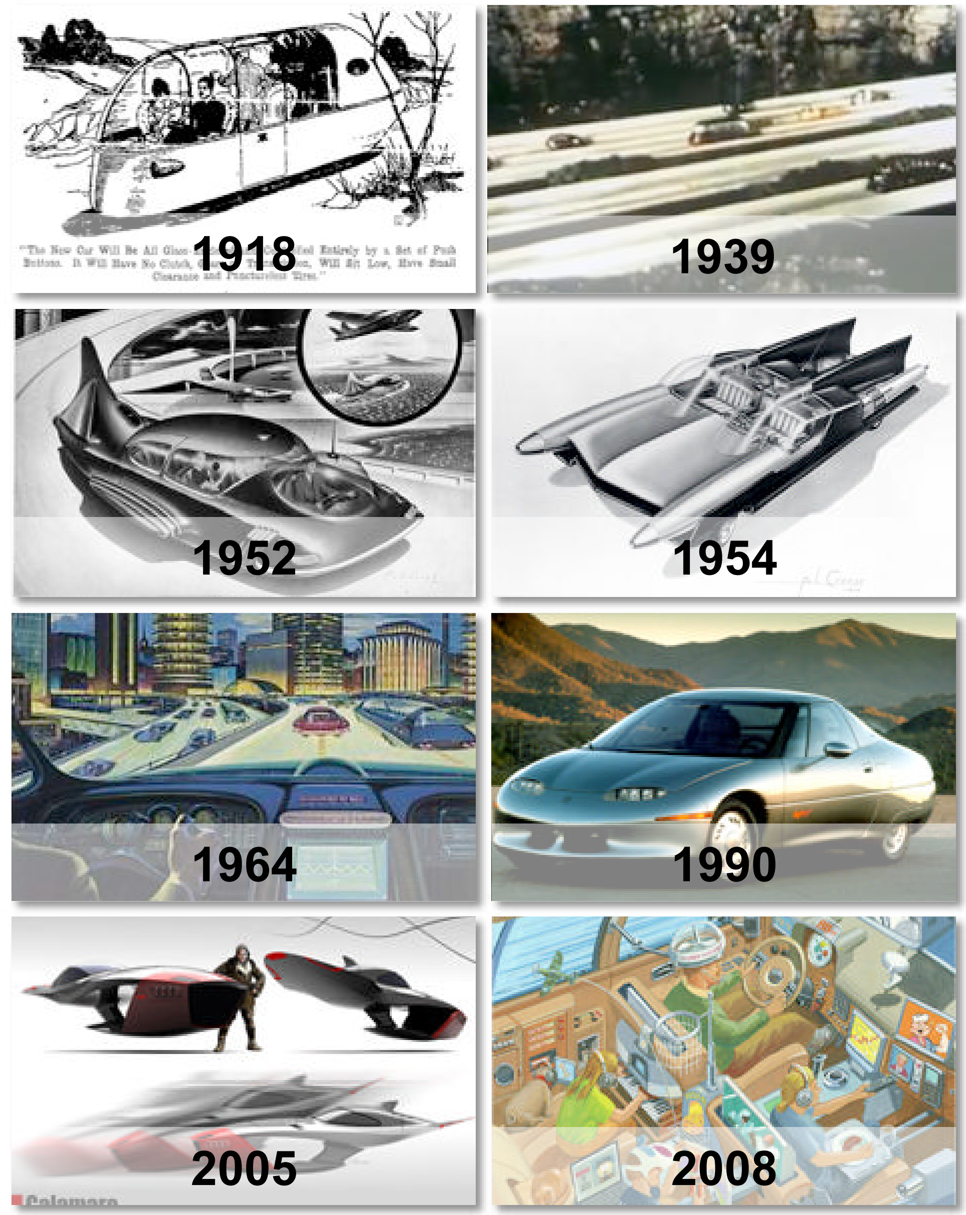
A Car Is A Car, Is A Car, Is A Car…

History of the Automobile[2-7]

1769 Self-propelled wheeled automobile: Cugnot
1839 Electric vehicle: Anderson
1860 Gasoline engine: Lenoir
1876 Four-stroke gasoline engine: Otto
1885 Automobile powered by gas engine: Benz
1892 Commercial product: Daimler, Maybach
1893 Carburetor: Bánki, Csonka
1895 Diesel engine: Diesel
1899 Self starter: Coleman (1911 Kettering)
1899 First recorded traffic fatality: Bliss, NYC.
1900 Steering wheel: Panhard, Levassor
1900 Hybrid powertrain: Porsche
1902 Magnetic ignition in production: Bosch
1901 Disc brakes: Lanchester
1902 Production-line manufacturing: Olds
1903 All wheel drive: Spyker
1903 Windshield wiper: Anderson
1920 Hydraulic brakes: Duesenberg
1948 Radial tires: Michelin
1951 Crumple zone: Mercedes-Benz
1967 Electronic fuel injection: Chrysler
1971 Brake-slip control system: Chrysler
1974 Airbag: GM
1974 Catalytic converter: GM
1978 Electronic ABS: Mercedes-Benz
1981 Navigation system: Honda
1995 Electronic Stability Control: Bosch
1995 Adaptive cruise control ACC: Mitsubishi
2001 Lane departure warning: Nissan
2002 Night vision: Toyota
2003 Automatic parallel parking: Toyota
2008 Traffic sign detection: BMW
2010 Pedestrian detection: Volvo

propulsion
powertrain, chassis
safety
clean tech
driver assistance

Cars of the Future[8-15]



Demand For Individual Mobility In The Future

Key Assumptions

- ✓ Basic need for personal mobility will continue to grow.[16]
- ✓ Consistent global population growth for at least 30 years.[17]
- ✓ Strong economic growth in countries with a large population.[18]

➔ more automobiles, more traffic, more challenges

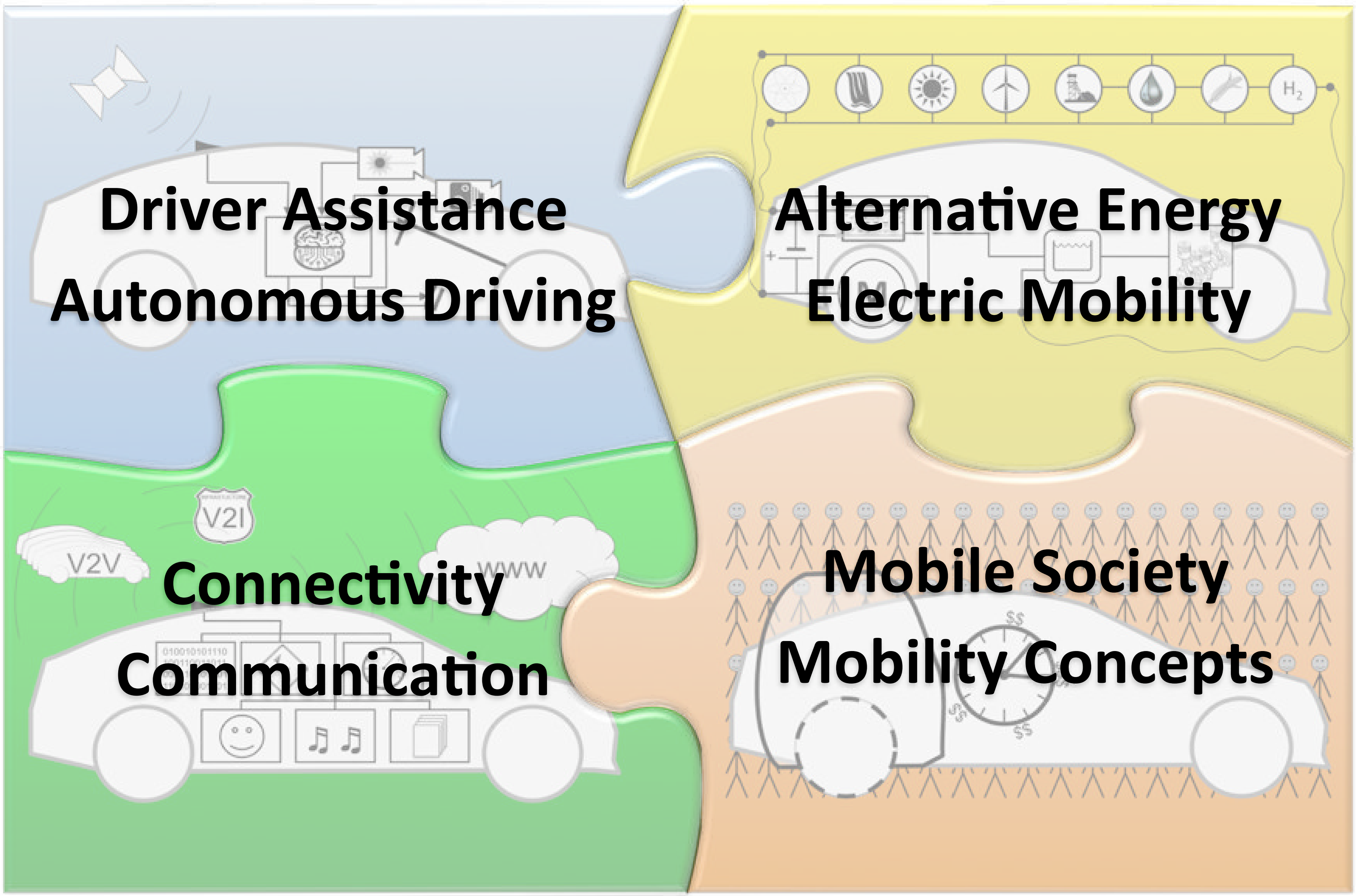
16. Mobility 2030: Meeting the challenges to sustainability, World Business Council for Sustainable Development, Geneva,, 2004
17. World Population to 2003, United Nations, New York, 2004
18. World Economic Outlook – April 2010, International Monetary Fund, Washington D.C., 2010

Challenges Of Individual Mobility

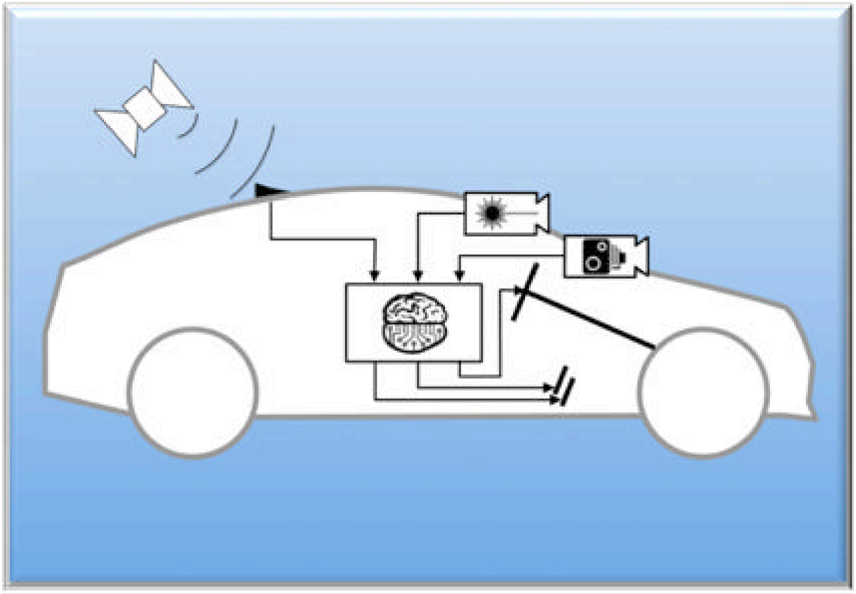
Safety:	Every year 34,000 people killed in motor vehicle traffic crashes in the United States in 2009[19], about 1,200,000 worldwide[20]
Efficiency:	Impact of traffic congestion in the U.S.: avg. commuter lost 36 hrs, 2.8B gal of fuel are wasted, overall loss $87.2B[22]
Pollution:	Transportation in the U.S. alone emits 1.9B tons of CO2 burning 4.7B barrels petroleum per year[21]
Cost:	Average annual cost per consumer spent on transportation: $8,758 (only second to housing)[23]

19. Early estimate of motor vehicle traffic fatalities in 2009, NHTSA, Washington, DC, 2010
20. National Highway Traffic Safety Administration, “2007 Traffic Safety Annual Assessment – Highlights”, Washington, DC, 2008
21. http://www.eia.doe.gov
22. “The 2009 Urban Mobility Report.” Texas Transportation Institute, Texas A&M University System, College Station, TX, 2009
23. Consumer Expenditures, U.S. Dept. of Labor, U.S. Bureau of Labor Statistics, April 2009

Solutions For The Challenges Of Individual Mobility



Driver Assistance – Autonomous Driving



Description

- Sensors (cameras, laser, radar, GPS…) capture the environment and location of the vehicle
- Computer algorithms process all sensor data, detect obstacles, categorize situations, plan path, and drive actuators
- System acts in addition to the driver to drive, brake, and steer the vehicle

Benefits[24, 25]

- Safety: Elimination of driver errors
- Efficiency: Anticipatory and integrated vehicle / traffic control
- Convenience: Driver can focus on other tasks while driving, elderly / impaired / young people can stay / become mobile

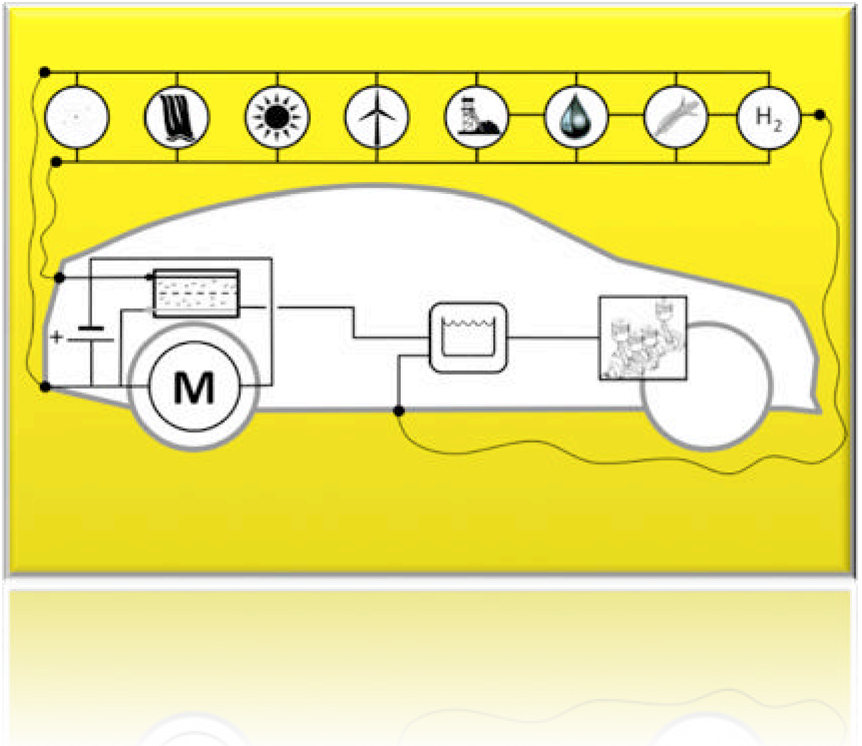
Challenges

- Technology: situation awareness, object classification (sensors, algorithms)
- Implementation: Transition from conventional to autonomous (esp. legal)

Status

- Autonomous cars have been proposed since the early 1900s and seriously researched since the 1960s
- Highly developed computing and sensing performance since the 1980s has lead to automated highways and autonomous vehicles in research, and now a variety of driver assistance systems in production

Alternative Energy – Electric Mobility



Benefits[24, 26]

- Environment: "No" emission from vehicle, other emissions can be captured centrally
- Efficiency: EV more efficient than ICE (however power transmission needs to be factored in), electricity can be generated from many different primary sources

Challenges

- Technology: Storage systems, efficiency / robustness of charging network
- Implementation: Infrastructure cost, consumer acceptance

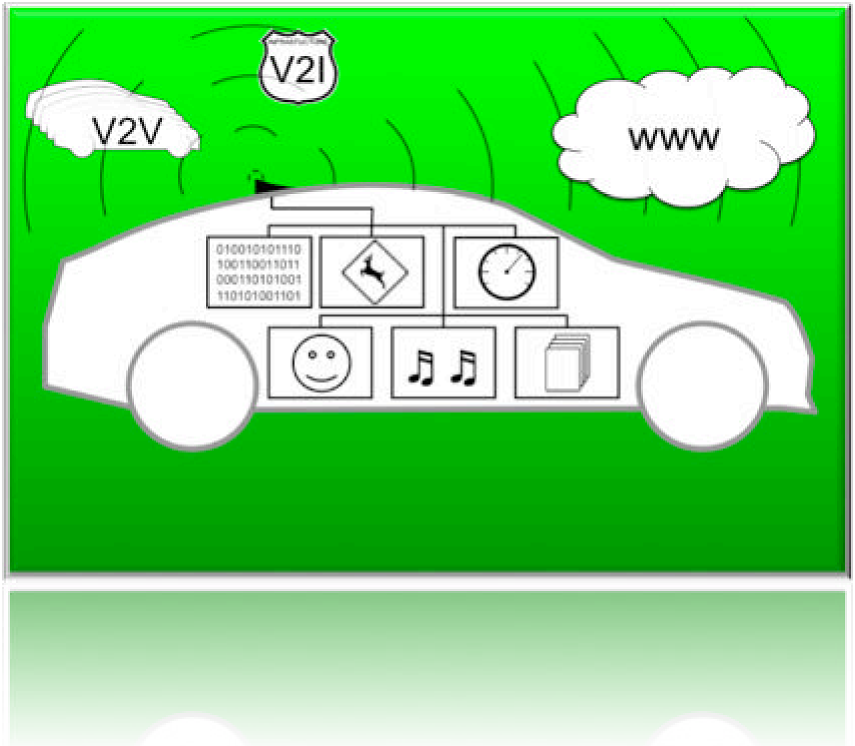
Description

- Current battery technology seems to permit a range of mobility that can satisfy many (but not all) consumer needs
- Fuel cells seem to offer the range of conventional vehicles with a lower (direct) impact on the environment
- Battery electric and fuel cell vehicles require a new infrastructure for charging

Status

- Propelling vehicles with other forms than gasoline or diesel is not new, electric and even hybrid-electric have been researched for many decades
- Recently, with concerns regarding oil depletion and global warming growing, alternative energies and electric vehicles are being reconsidered as automobiles

Connectivity – Communication



Benefits[27, 28]

- Safety: Time-location-situation accurate warnings (road condition, traffic, …)
- Efficiency: Time-location-situation accurate and route-relevant traffic info
- Convenience: Information / entertainment virtually unlimited, ext. mobility experience

Challenges

- Technology: Robust data connection
- Implementation: Infrastructure cost
- Safety: Driver distraction, data accuracy
- Legal: Data privacy

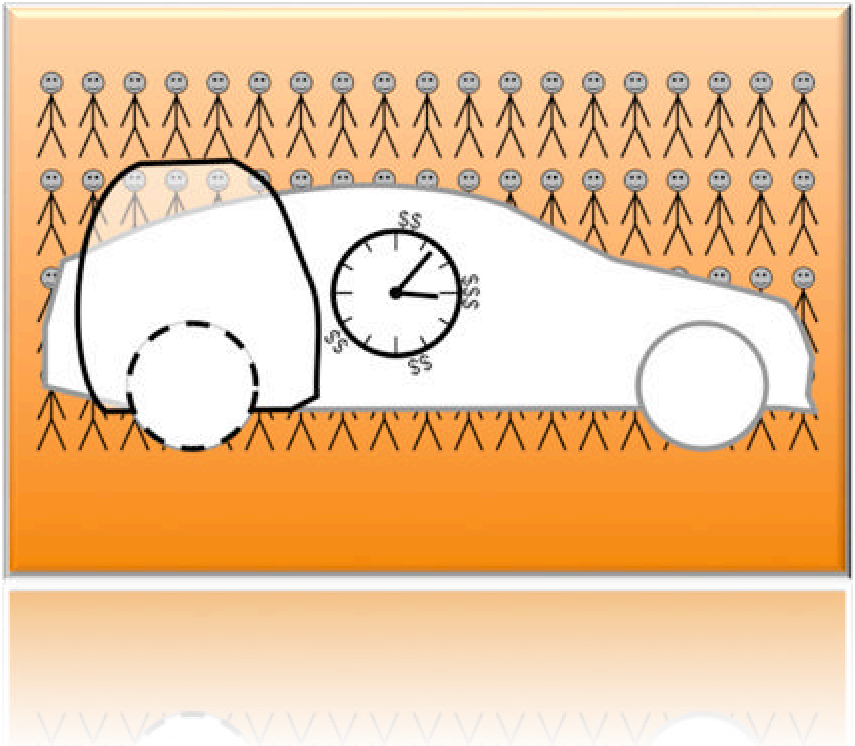
Description

- Dedicated frequency spectrum to be used for V2V and V2I communication – position, vehicle data, warnings, …
- Manufacturer operated portals offer specific safety / convenience features, general internet access basically possible
- Media-vehicle integration varies: “built-in, brought-in, beamed-in”

Status

- Vehicle-to-vehicle and to-infrastructure communication researched since 2000
- Wireless ubiquitous internet available since the mid 2000s through cell phone technology, bandwidth increasing
- First mobility-specific applications since mid 2000s with manufacturer operated portals, business case challenging

Mobile Society – Mobility Concepts



Benefits[29-32]

- Efficiency: Vehicle use more balanced, fewer vehicles not-used, use-oriented vehicles more efficient, more considerate personal vehicle use
- Cost: Potentially lower mobility expenses
- Convenience: Greater variety of choices

Challenges

- Implementation: Consumer acceptance unclear, for car-sharing / -pooling: critical mass necessary, independence and / or individuality might be compromised

Description

- Changing demographics permit elderly people to drive longer, and younger people to seek new values / preferences
- Car-sharing / -pooling programs in combination with internet-based apps to offer a convenient mobility alternative
- Variable, intelligent, light-weight vehicles to satisfy diverse transportation needs

Status

- Individual mobility is a basic human need, the automobile is today one of the most important means of transportation
- Today's trends of mass-urbanization, environmental challenges, aging societies, changing values, economic burdens let societies reconsider the personal car as "the ultimate" solution

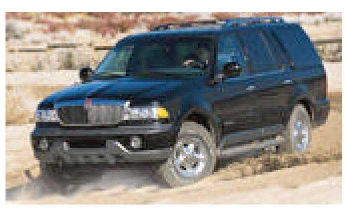
Key Factors Turning Innovation Into Success

Push Factors
- Technology creates opportunities
- Economics enable markets
- Mandates force change

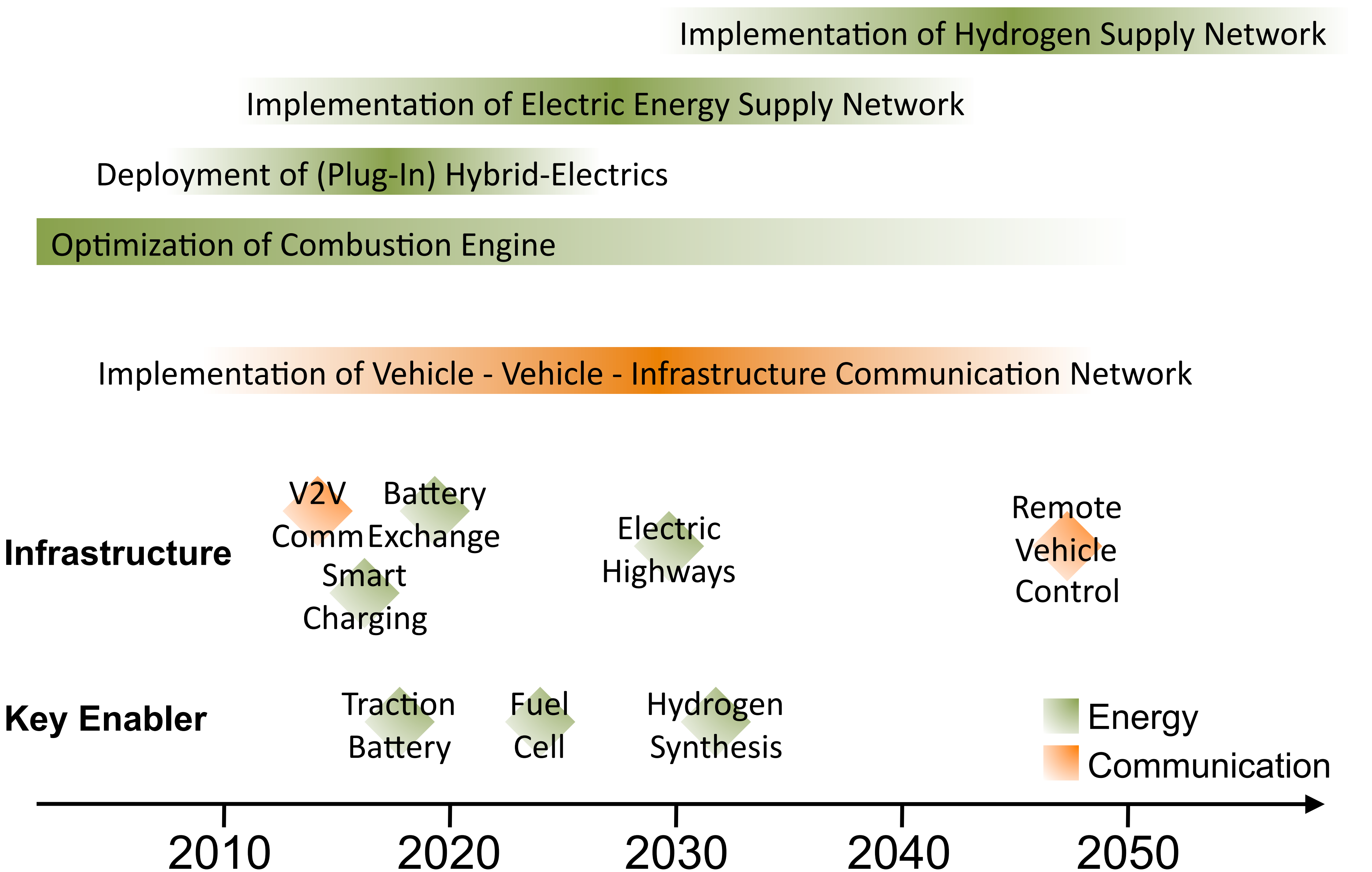
Pull Factors
-Consumers demand solutions
-Environment requires action
-Incentives ease change

➔ Politics / Policies can play crucial role and become tipping point

Why We Drive What We Drive – A Case Study

	1990's	2000's
Technology Design	Super Computing ➔ Engine / Chassis Control	Mobile Computing ➔ High Performance Batteries
Economics Business	Booming Economies, Pre-Burst ➔ Consumer spending high	Economic Crisis, High Oil Price ➔ Consumer spending low
Resources Environment	Andrew '92, El Niño, Cheap Oil ➔ …	Katrina / Rita '05, Glaciers, Peak Oil? ➔ Oil Usage more considerate
Psychology Sociology	Individualism, Counter-Culture ➔ Individual freedom essential	Grass Root Movements, CO2 Movies ➔ Green becomes mainstream
Politics Policies	Gulf War, ZEV Mandate ➔ …	Iraq / Afghanistan, HOV for HEV ➔ "Dependence on Foreign Oil"
Automobiles Defining the Decade		

The Road Ahead – Evolution Of Individual Mobility



(Author's Forecast)

Trends For The Automotive Future in the U.S.

Probable Trends (very likely)

2015: vehicle-to-vehicle communication for safety functions[36]
2017: 6% of all vehicles worldwide will have internet access[63]
2020: plug-in capability standard in about 10% of all new vehicles[37, 38, 39]
2025: vehicles in part actively controlled by roadside infrastructure[40]
2035: still more than 50% of all new vehicles have combustion engine[41]

Possible Trends (likely)

2020: carsharing membership increases 3% of all people who use a car[42]
2030: electric vehicles more than 20% of all new cars[37]
2030: electric systems replacing all mechanic chassis systems in new vehicles[43]

Plausible Trends (somewhat likely)

2030: fully autonomous driving, driver out of the loop[44, 45]
2035: hydrogen as transportation fuel for 5% of all new vehicles[38]

36. "Policy Roadmap for the IntelliDriveSM Safety Program", IntelliDrive USA, 2010
37. "Electrification Roadmap", Electrification Coalition, Washington, DC, 2009
38. "On the Road in 2035 - Reducing Transportation's Petroleum Consumption and GHG Emissions", MIT, MA, 2008
39. "Auto 2020 – Passenger Vehicles", AT Kearney, 2009
40. "Vehicle–Highway Automation: Directions, Challenges, and…", Lay, Saxton, U.S. Transportation Research Board, 2000
41. "The Cars of the Future", This Week In Petroleum, U.S. Energy Information Administration, March 3, 2010
42. "Carsharing: A Sustainable and Innovative Personal Transport Solution with…", Frost & Sullivan, January 28, 2010
43. "Steering Systems Report", Bharatbook, January 2009
44. " The Future of the Automobile?", S. Thrun, Stanford University, CA, August 2009
45. "Boss, The Urban Challenge and the Promise of Autonomous Vehicles", C. Urmson, CMU, PA, March 2009
63. "In-vehicle Internet grows slow and steady", EETIMES, Sep 2, 2010

(Author's Classification)

Resources And Credits

1. http://www.figarospeech.com/it-figures/2007/6/17/did-the-earth-move-for-you.html
2. http://www.car-history.org/
3. http://www.aa1car.com/library/timeline.htm
4. http://en.wikipedia.org/wiki/Timeline_of_historic_inventions
5. http://www.oppisworld.de/zeit/erfinder/eauto.html
6. http://de.wikipedia.org/wiki/Automobil
7. http://en.wikipedia.org/wiki/Advanced_driver_assistance_systems
8. http://www.paleofuture.com/blog/tag/push-button
9. http://www.youtube.com/watch?v=74cO9X4NMb4
10. http://io9.com/5019534/atomic-cars-of-the-1950s
11. http://www.motortrend.com/features/archive/112_0903_jet_powered_future_archive/index.html
12. http://io9.com/5019534/atomic-cars-of-the-1950s
13. http://en.wikipedia.org/wiki/General_Motors_EV1
14. http://www.pecoraio.com/works-inner.php?dir=calamaro
15. http://www.nytimes.com/2008/10/30/automobiles/autospecial2/30HOME.html?_r=2&oref=slogin
16. Mobility 2030: Meeting the challenges to sustainability, World Business Council for Sustainable Development, Geneva, Switzerland, 2004
17. World Population to 2003, United Nations, New York, 2004
18. World Economic Outlook – April 2010, International Monetary Fund, Washington D.C., 2010
19. Early estimate of motor vehicle traffic fatalities in 2009, NHTSA, Washington, DC, 2010
20. National Highway Traffic Safety Administration, “2007 Traffic Safety Annual Assessment – Highlights”, Washington, DC, 2008
21. http://www.eia.doe.gov
22. “The 2009 Urban Mobility Report.” Texas Transportation Institute, Texas A&M University System, College Station, TX, 2009
23. Consumer Expenditures, U.S. Dept. of Labor, U.S. Bureau of Labor Statistics, April 2009
24. “Automated Electric Transportation ”, Utah State University Energy Lab, Oak Ridge National Laboratory (2009)
25. “Vehicle Platooning and Automated Highways”, PATH Program, University of California (1998)
26. GCEP Workshop, November 2, 2007, http://gcep.stanford.edu/pdfs/iq9bO_1Ib0rRuH_ve0A2jA/kintner-meyer-20071102.pdf
27. http://www.intellidriveusa.org/benefits/safety.php
28. http://www.intellidriveusa.org/benefits/environment.php
29. http://move.rmi.org/markets-in-motion/case-studies/automotive/hypercar.html
30. http://www.goto2040.org/uploadedFiles/RCP/Strategy_Reports/CarSharing/CarSharing_WhitePaper.pdf”
31. “Greenhouse Gas Emission Impacts of Carsharing in North America”, Mineta Transportation Institute, San Jose State University, CA, 2010
32. “An Assessment of Advanced Transportation Research Opportunities”, GCEP Energy Assessment Analysis, Stanford University, CA, 2006
33. “The innovator's dilemma : when new technologies cause great firms to fail.”, Christensen, Clayton M., Harvard Business Press, 1997
34. “Automotive Safety Innovation in the eye of the Consumer”, AAA, 2010
35. “Hype Cycle for Automotive Electronics, 2010”, Gartner Inc, , 2010
36. “Policy Roadmap for the IntelliDriveSM Safety Program”, IntelliDrive USA, 2010
37. “Electrification Roadmap”, Electrification Coalition, Washington, DC, 2009
38. “On the Road in 2035 - Reducing Transportation’s Petroleum Consumption and GHG Emissions”, MIT, MA, 2008
39. “Auto 2020 – Passenger Vehicles”, AT Kearney, 2009
40. “Vehicle–Highway Automation: Directions, Challenges, and Contributing Factors”, Lay, Saxton, U.S. Transportation Research Board, 2000
41. “The Cars of the Future”, This Week In Petroleum, U.S. Energy Information Administration, March 3, 2010
42. “Carsharing: A Sustainable and Innovative Personal Transport Solution with Great Potential…”, Frost & Sullivan, January 28, 2010
43. “Steering Systems Report”, Bharatbook, January 2009
44. “ The Future of the Automobile?”, S. Thrun, Stanford University, CA, August 2009
45. “Boss, The Urban Challenge and the Promise of Autonomous Vehicles”, C. Urmson, Carnegie Mellon University, PA, March 2009
46. http://en.wikipedia.org/wiki/Automotive_industry
47. “The World’s Automotive Industry – Some Key Figures”, International Organisation of Motor Vehicles, 2007
48. http://www.ibike.org/library/statistics-data.htm
49. http://oica.net/category/production-statistics/
50. http://www.pwc.com/en_CZ/cz/tiskove-zpravy-2009/pwc-automotive-institute-analyst-note.pdf

Resources And Credits

51. http://en.wikipedia.org/wiki/Automotive_industry_crisis_of_2008–2010
52. "Obama Says Auto Industry Revival Justifies Bailouts", Businessweek, July 30, 2010
53. http://en.wikipedia.org/wiki/Tesla_Motors
54. http://www.thetruthaboutcars.com/car-sales-around-the-world-in-2009-mostly-down/
55. "Shifting Centers of Gravity – The End of the Automotive Industry As We Know It?", Arthur D. Little 2009
56. http://en.wikipedia.org/wiki/BYD_Auto
57. http://en.wikipedia.org/wiki/Tata_Motors
58. http://en.wikipedia.org/wiki/Geely_Automobile
59. http://en.wikipedia.org/wiki/Miles_electric
60. http://www.teslamotors.com/about/press/releases/tesla-motors-reports-second-quarter-results
61. "The Drivers - How to navigate the auto industry", Global Equity Research, Deutsche Bank, 2002
62. Automobile Industry Research, Aug 2010 - http://www.plunkettresearch .com/Industries /AutomobilesTrucks/tabid/76
63. "In-vehicle Internet grows slow and steady", EETIMES, Sep 2, 2010