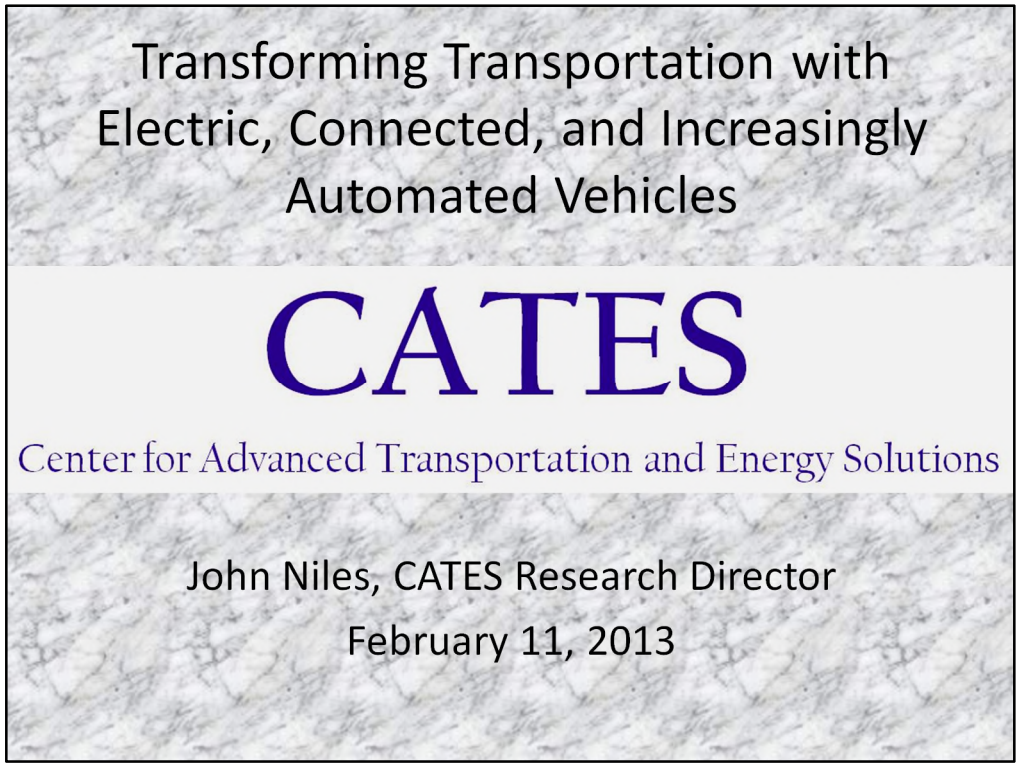
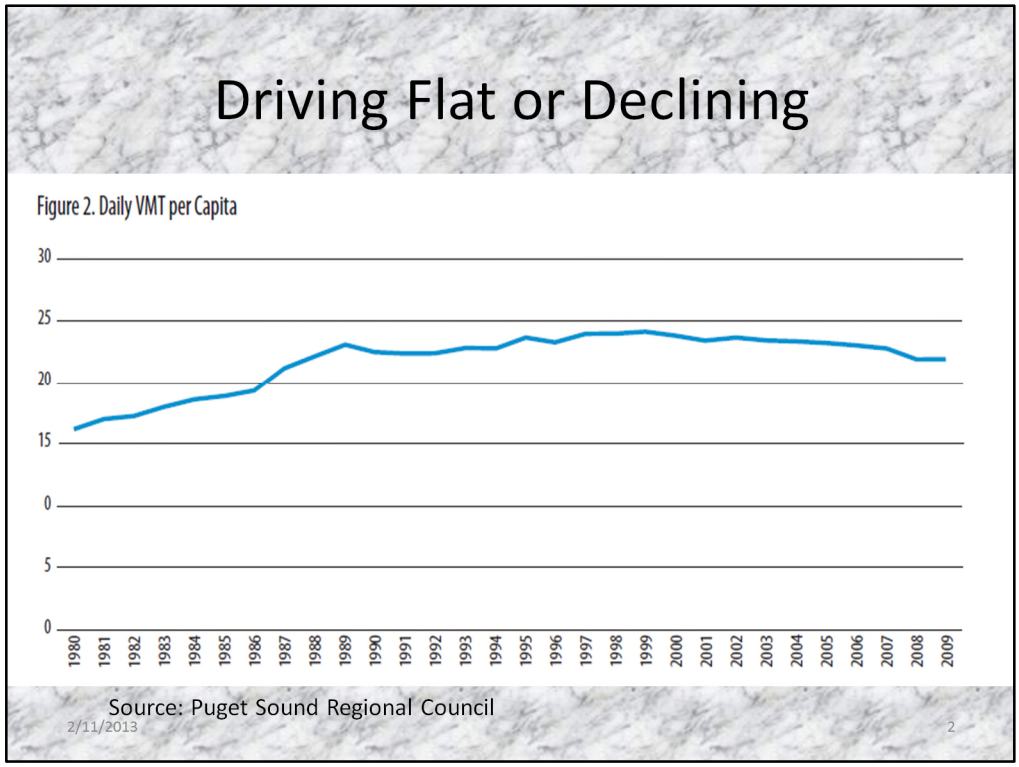


The Center for Advanced Transportation and Energy Solutions -- CATES -- is working on making motor vehicles more sustainable across all the dimensions of sustainability, the three Es: environment, economics, and equity, both for today, as well as for future generations.

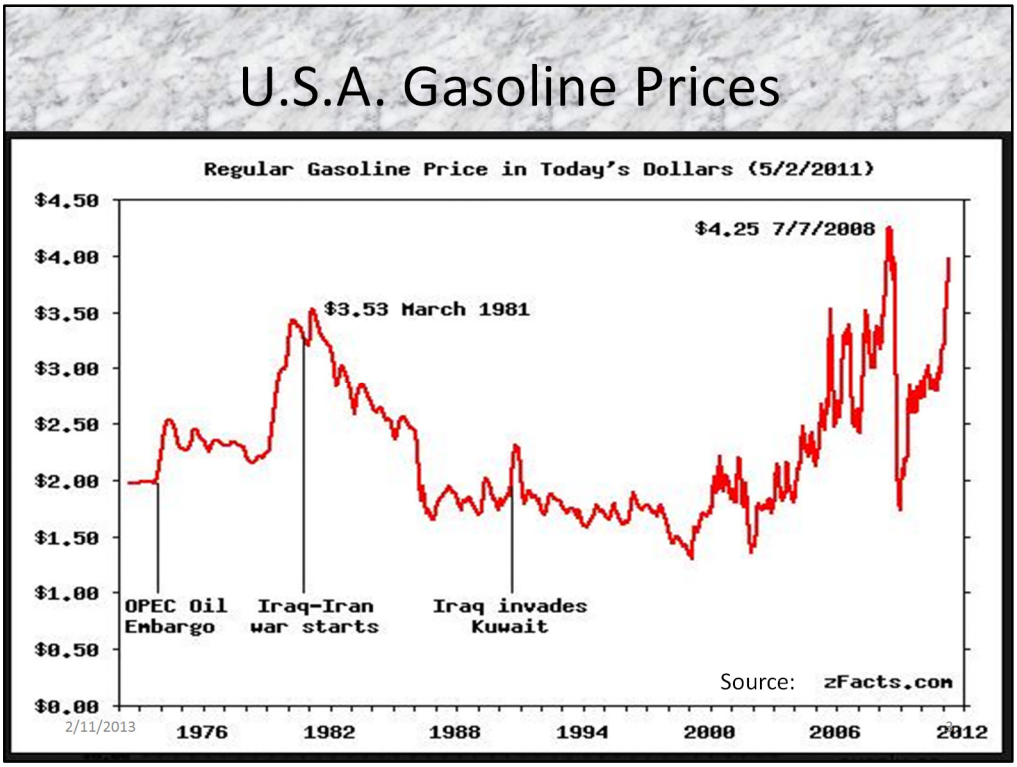
Car usage is not a love affair or an addiction, but more a matter of practicality for many trips beyond a 1/4 mile distance: door-to-door travel, any origin, any destination. Usually fast and reliable. Flexible routing and stops controlled by you. Flexible start and arrival times that you have a fighting chance of controlling. Private, customized space while traveling. A feeling of higher safety & security. Protection from heat, cold & rain. Ease of bringing family, friends, & cargo. And I wouldn't discount the emotional sensations related to control, style, and wealth.

Other modes? If there's a bus or a train that works better for any reason, take it; that's what I do.

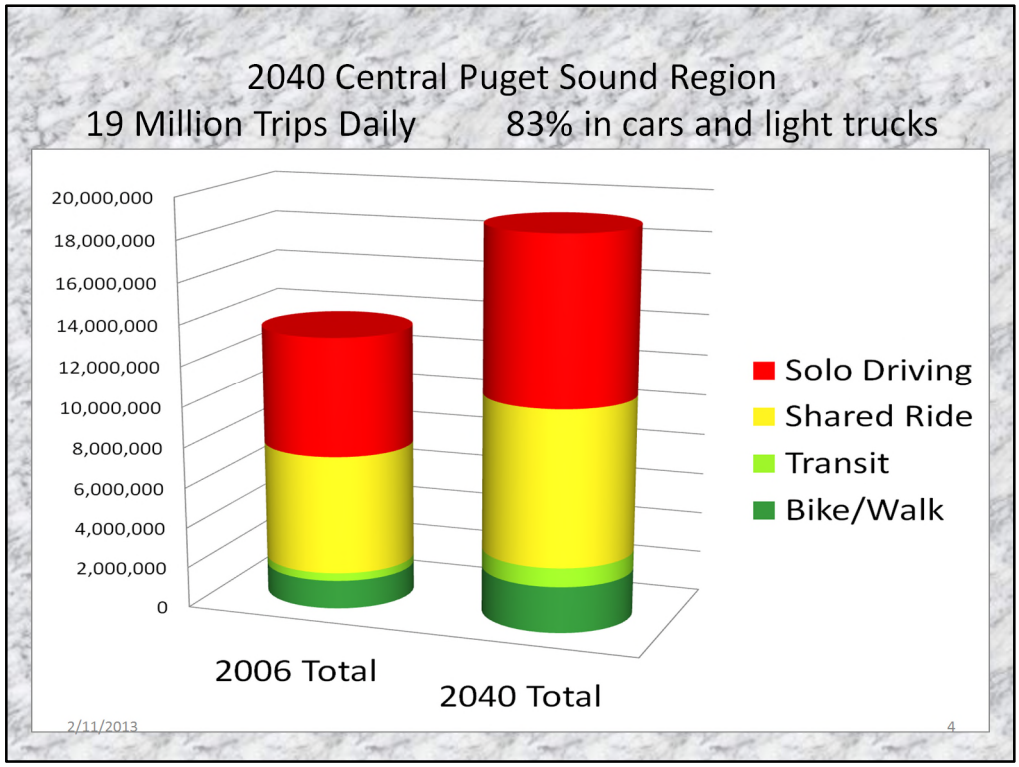


As the first chart shows, the daily average amount of driving per regional citizen is now declining slowly, but of course population increase can easily overwhelm a small percentage drop in driving per capita. Also, the 1960s, 70s, and 80s were decades of rapid growth in driving, perhaps overshooting what will emerge as the new normal.

U.S.A. Gasoline Prices



An obvious first cause of the amount of car driving falling off is the price of fuel, which after dropping in real terms in the 1980s and 90s has increased sharply since the turn of the century. Now car makers are scrambling to increase fuel efficiency, and the frackers are scrambling to find more domestic oil to turn into fuel.

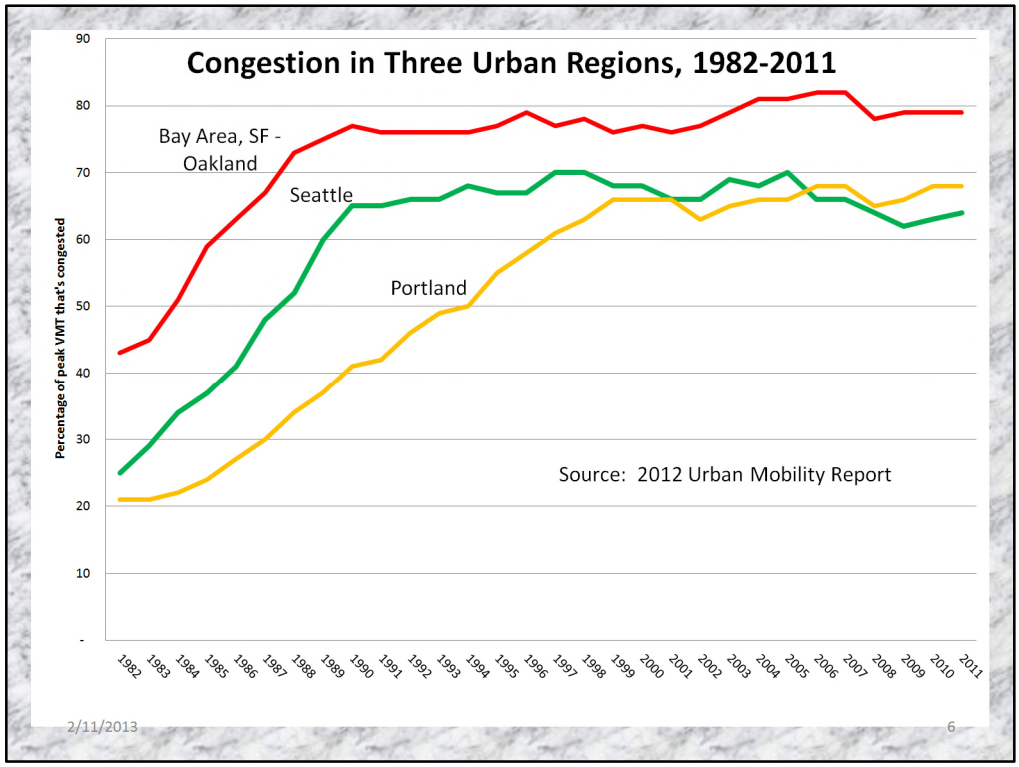


Although car driving per person may stay flat or decline, the official forecasts for the Puget Sound Region based on all factors show an ever increasing number of car trips in this region over the next few decades. 13 million trips daily in the 2006 baseline with 86% in cars; 19 million trips in 2040 forecast, with 83% in cars. This forecast assumes Sound Transit Phase 3 light rail extensions funded and built.

Fortunately the automobile is being reinvented. To learn how that could go, you couldn't do better than to read *Reinventing the Automobile* by William Mitchell, Chris Borroni-Bird, and Larry Burns.

Notice the vehicles on the cover which certainly indicate some re-inventing going on. That little job on the far left is actually the unfolded version of car number 3 two spaces farther to the right.

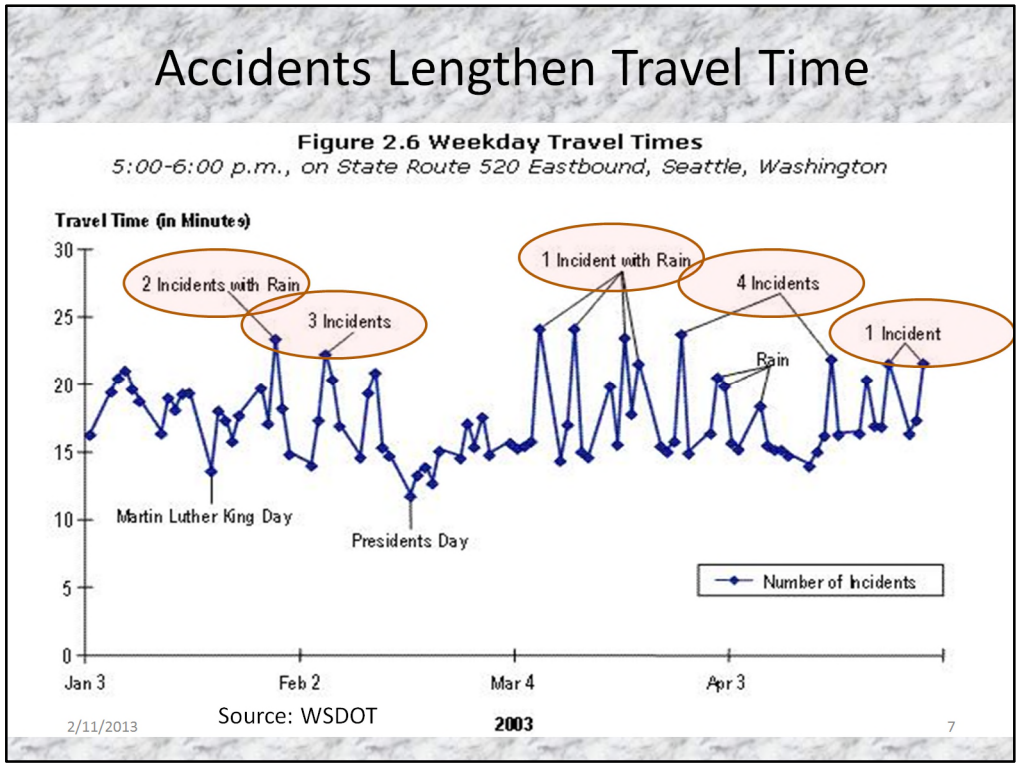
The presentation that follows will elaborate on two aspects of the reinvented car -- automation and electrification.



A main message of the Reinventing book is that the several environmental problems of cars can be fixed with technology. I'll start with perhaps the least serious of them -- traffic congestion.

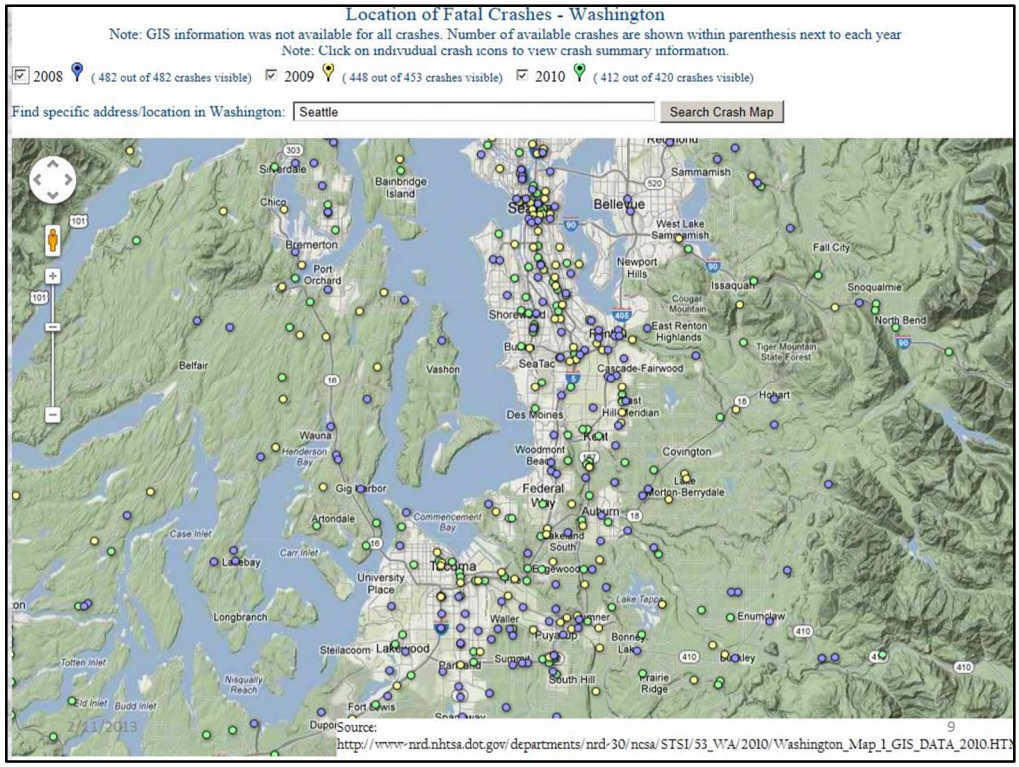
As the green line on the chart shows, Seattle area congestion went from OK and better than San Francisco to much worse in the early 1990s, up to a permanently bad level of congestion between 60 and 70 percent of the time.

Portland, Oregon with its bikes and light rail is now a bit worse.



One causal factor in congestion is crashes. As this chart from Washington State DOT shows, the worst travel times are on days with crashes.

But causing congestion is not the worst result of car crashes. What's really awful is the death, injury and destruction. Car fatalities are at 1.3 million per year around the planet. It's the leading cause of death for young people 15 to 29 in all countries, including ours. The National Highway Traffic Safety Administration reports that in 2010 in the USA there were 32,885 motor vehicle deaths and 2.24 million people injured. The cost of these deaths and injuries in the U.S. alone exceeds $70 billion a year.



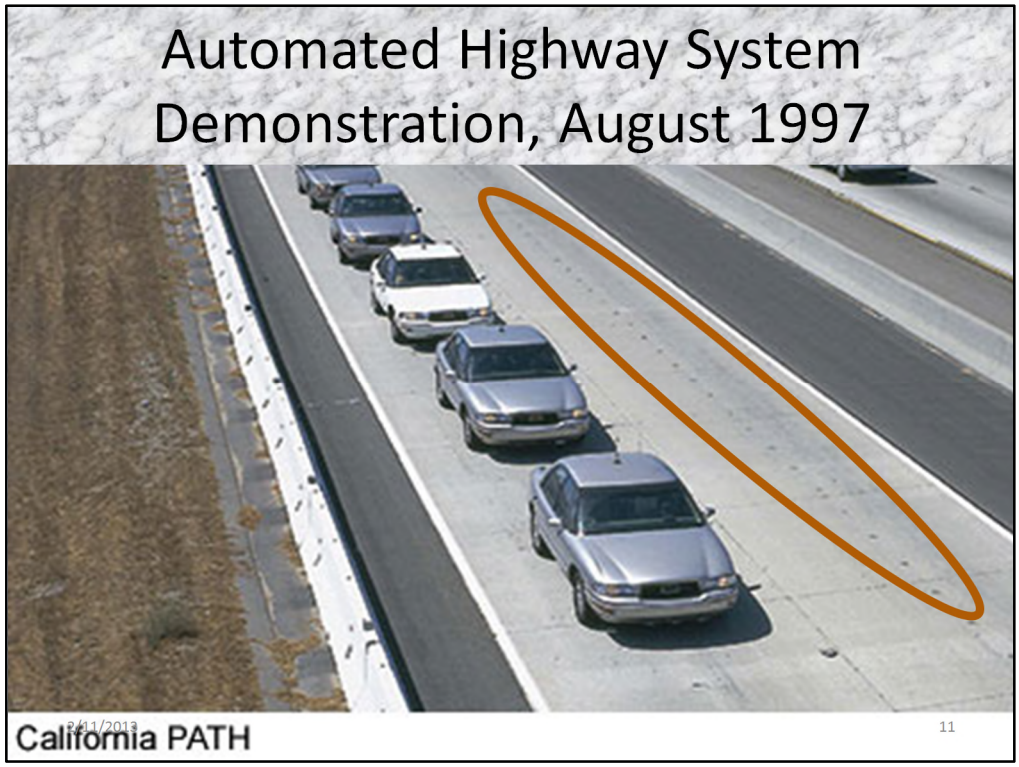
Just to be clear I'm talking about our neighbors, this is a map of dots for three years worth of crashes in the Seattle-Tacoma region, 2008 to 2010, about 1300 dots across Washington State, one dot for each fatal crash. Fortunately, by reinventing automobility with automation, crashes can be reduced considerably, just like reducing the number of horses in urban transportation cut down on horse manure, smell, flies, and disease.

Could Our Cars Be Better?

Needed: Personal urban mobility without oil, accidents, and congestion

Solution: Electric, connected, increasingly automated vehicles. Eventually, autonomous.

When I was a little boy in the 1950, this was a picture in a magazine ad that grabbed my imagination. A happy family is playing dominoes in a self-driving car. It's taken 60 years, but we are almost there.



When the automated highway came to my attention in the mid-1990s, the technology was based on devices embedded in the road and beside the road. Back in 1991 the Highway Bill called ISTEA set up a multi-year team effort of car makers, road builder, DOTs, academics, and high-tech firms to build something that worked, and they did, shown here.

Their work demonstrated in August 1997 on temporarily repurposed HOV lanes on a San Diego Interstate that cars spaced 21 feet apart could travel at 65 mph guided by magnetic spikes in the road and radar for close separation. The spikes are visible within the red oval.

It was shown then, and the belief still holds today, that platooned vehicles can expand expressway capacity by two times or even three fold.

While USDOT interest in automated highways waned for a decade after that, the platoon idea was advanced in Europe by Volvo and others, with magnetic spikes replaced by a truck that cars can follow via electronic tethering. Within the last year, this kind of road train traveled safely all over Spain.

Enter the U.S. Defense Dept. For over a decade now the U.S. military has been dealing with a Congressional mandate from year 2000 that by 2015 one-third of the operational ground combat vehicles are to be unmanned. This would be motivated partially by the wars we find ourselves in, with roadside bombs a main killer of our troops.

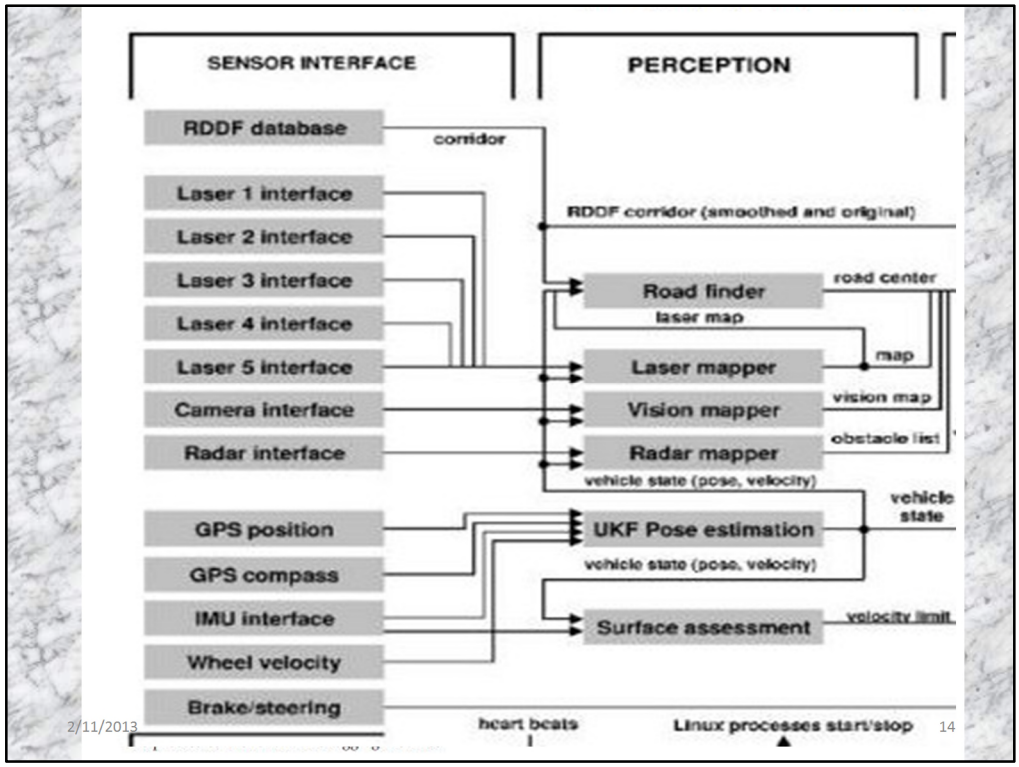
The DoD had been working toward automated vehicles since the 1980s by letting hundreds of millions in defense contracts. But in 2003 the Defense Advanced Research Project Agency, DARPA, took a different path and set up a series of competitions called Grand Challenges, unfunded except for million dollar prizes.

The challenges seemed unbelievably tough. The first of them in March 2004 was for a robotic vehicle with nobody in it to travel a 150 mile path through the Mojave Desert. Dozens tried, nobody made it. DARPA had to reboot the contest for a second try.

Back to the drawing board. 195 teams signed up for the second run in October 2005. After many screening processes, several dozen were allowed to try the desert course. All the top finalists that failed the first time had made modifications and five vehicles made it through 132 miles of desert road in about seven hours. The winner was Stanford University's diesel Volkswagen.

That a team could work for years, send a car off on a hundred mile trip, drink coffee and lunch, and then watch the car return all by itself hours later, is close to magic, but it's actually just sensors and computers programmed with so-called artificial intelligence processes to interpret what the sensors are seeing.

It's a lot more than GPS, by the way. The desert road itself had to be detected.



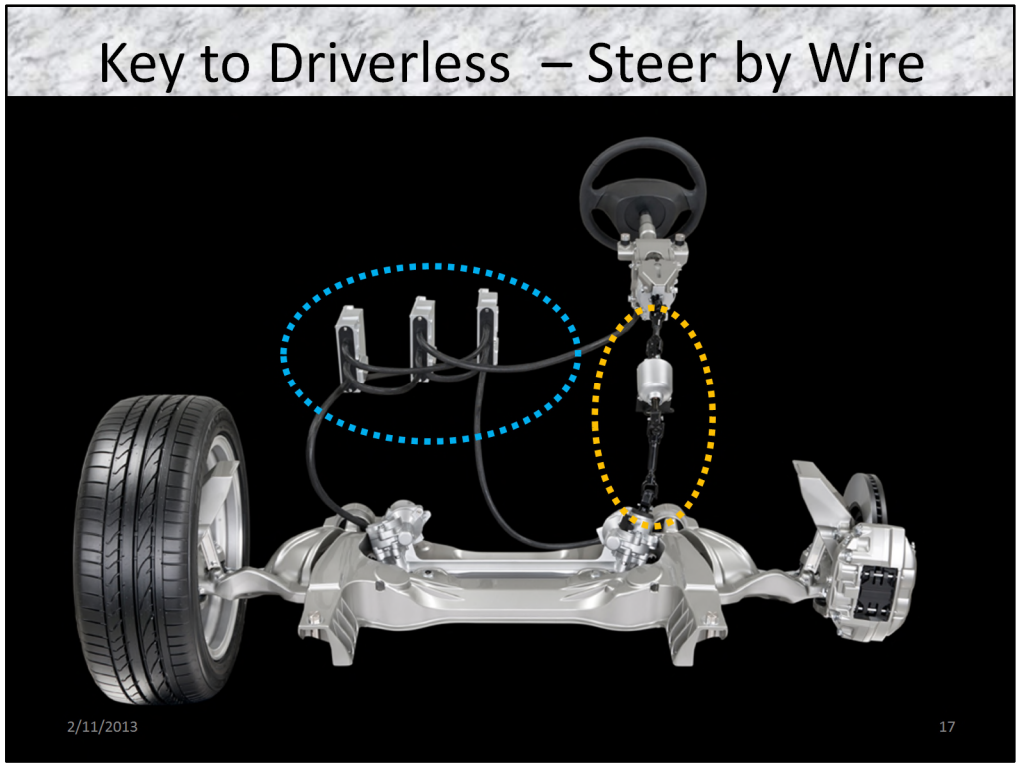
Very sophisticated radar and laser and camera sensing sees all, including small animals and sagebrush on the road. This is a view of the software functional flow chart. Notice the multiple sensors.

After five cars and a big truck went over a hundred miles on a desert dirt road, a harder challenge was posed; the 2007 DARPA Urban Challenge, to see if robotic vehicles could navigate a network of city-like streets on an abandoned Air Force base in California, mixing with other vehicles, some human driven, some competing robo-cars.

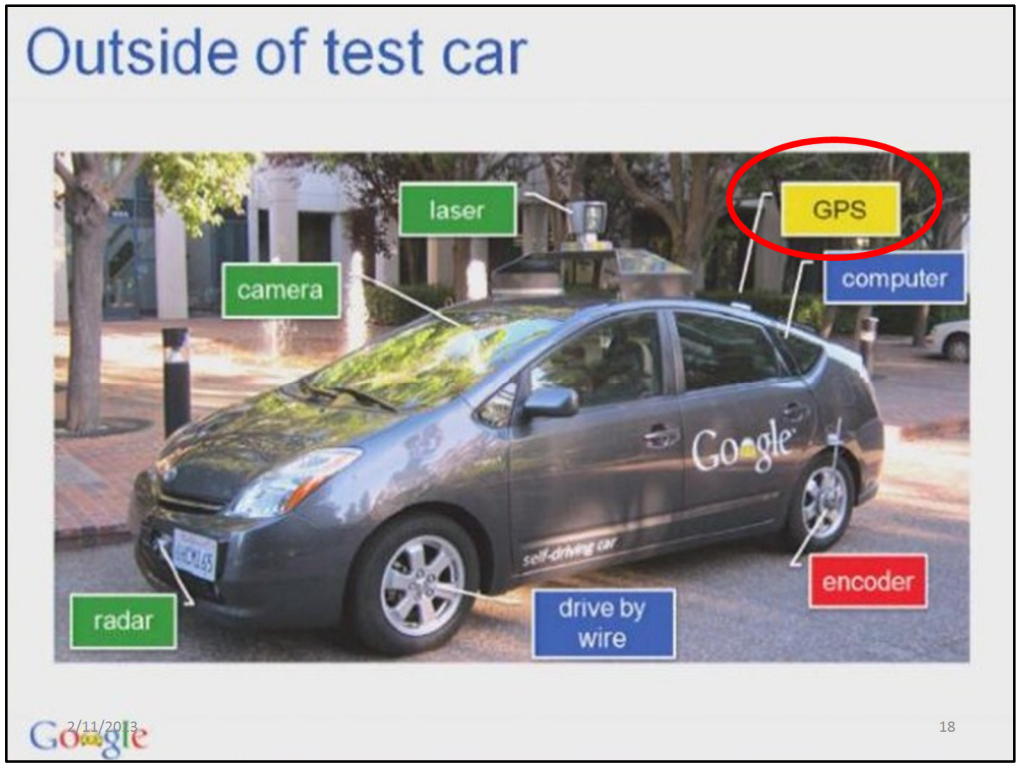
A map of the course was provided just 24 hours in advance. Sixty miles needed to be covered in less than 6 hours, with all traffic laws obeyed. The robotic cars had to interact responsibly with each other at intersections that included four-way stops. 53 teams started the qualifying process, but in the end following intermediate tests only 11 were permitted to run the course in November 2007.

This time the Carnegie-Mellon University Chevy Tahoe came in first and a different Stanford Volkswagen from the last Challenge was second. Average speeds were 14 mph. Nobody died. But the contest involved no traffic lights, and no pedestrians were allowed to jump in front of moving cars.

Equipment that guided one of the winners in the Urban Challenge.



Steering by wire is an important capability in automated vehicles. This is a picture of the triple redundant system being installed soon in the Nissan Infiniti.



Google soon thereafter engaged Stanford Professor Sebastian Thrun and others from several of the winning teams to work for Google to carry on development of self-driving cars. There was a several year period of quiet, although work was going on around the world based on results of the DARPA competition. There was a significant amount of publication and professional communication about what works.

A few years later in October 2010, Sebastian Thrun announced the Google Car to a stunned world that was not waiting. A Google team had come up with an enhanced version of the automated vehicles that did well in the Urban Challenge. Professor Thrun noted in a blog posting that the goal for working on driverless cars is "to help prevent traffic accidents, free up people's time and reduce carbon emissions by fundamentally changing car use."

The Google self-driving cars use video cameras, radar, laser range finding called LIDAR, and very detailed Super Google maps with street view information about anything a car has to avoid hitting that's not moving. Information is fused from different sensors. During the testing phase, the cars always have somebody in the driving position to grab the controls if needed. A software engineer is in the shotgun position holding a laptop computer instead of a gun.

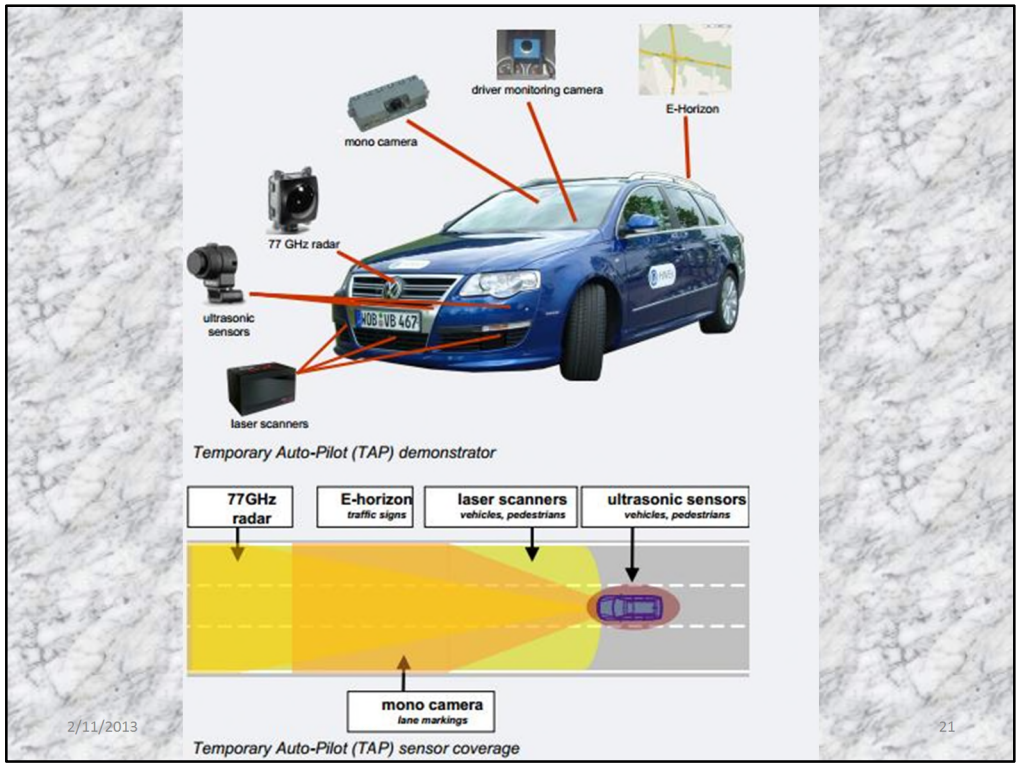
As of early 2013 Google has a fleet of about a dozen cars. The above picture from early 2013 shows a Lexus RX 450h $46,000 MSRP Has an EV mode for short distances. 3 or 2 electric motors depending on all-wheel or not.
http://www.edmunds.com/lexus/rx-450h/2013/

As of Google's first announcement in October 2010, a few of these cars had already been driven hands free 140,000 miles on California highways. The mileage traveled is now at 400,000.

Google thinks robotic driving can cut traffic fatalities in half or more. Sebastian Thrun also thinks non-driving activities like reading and texting may be more productive for the driver to focus on than driving on the same old daily commuting route every day.

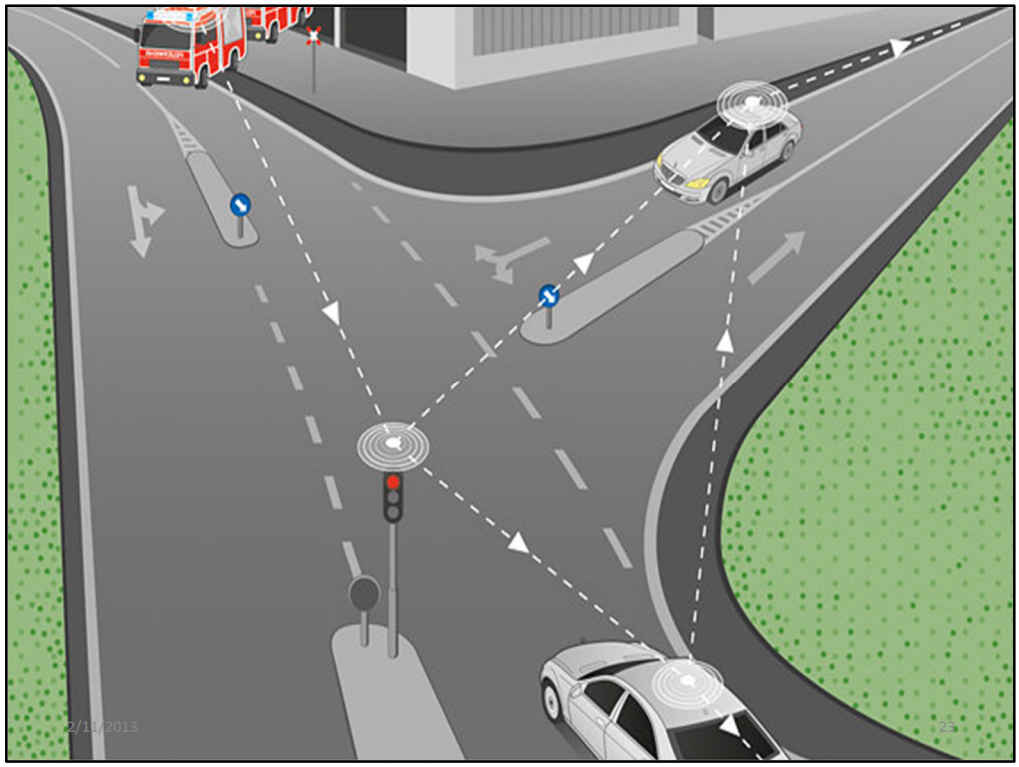
Back in 1997, Robert Ferlis of Federal Highways noted, "The inherent capability of an automated highway to accommodate much more travel efficiently could encourage more travel and aggravate existing tendencies for urban sprawl, as people will be able to travel farther."

On the other hand, Sebastian Thrun is "confident that self-driving cars will transform car sharing, significantly reducing car usage."



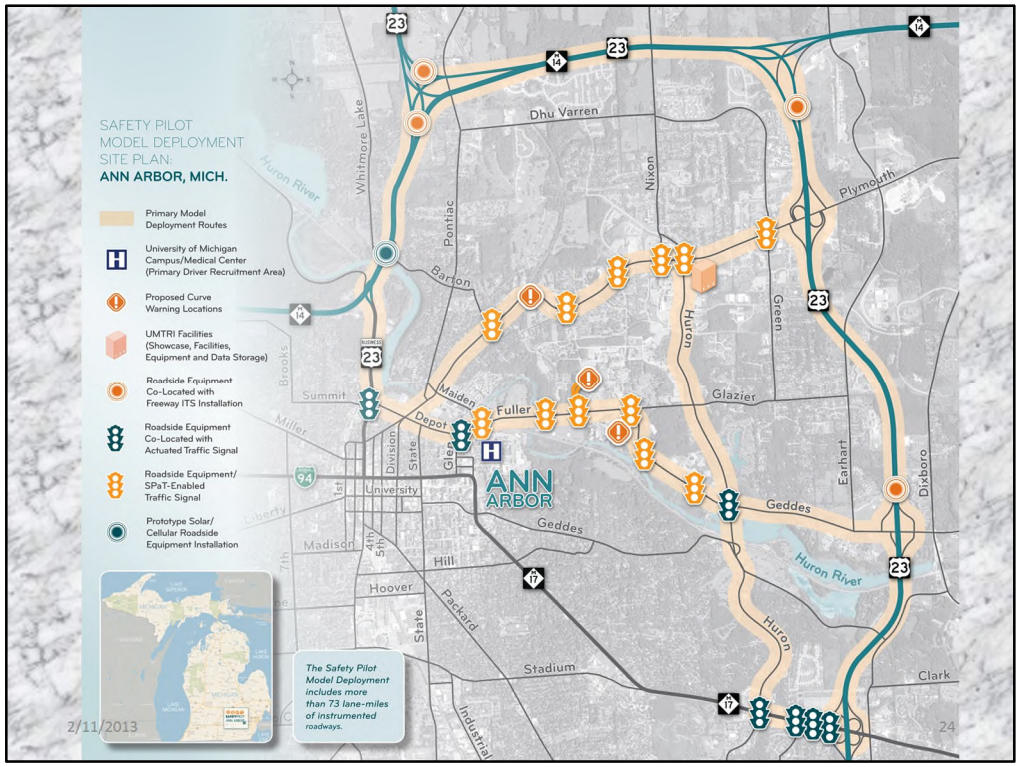
Robotic driving is likely to be introduced gradually. Volkswagen in Europe -- but also with labs in California near Stanford and Google -- has been working on a “Temporary Auto Pilot” capability where the driver can let go of the steering wheel on a limited access highway at any speed and the car steers itself in one lane. The driver takes over control for passing another car.

Look at all the steps toward automation not available in the 2013 Ford Fusion.



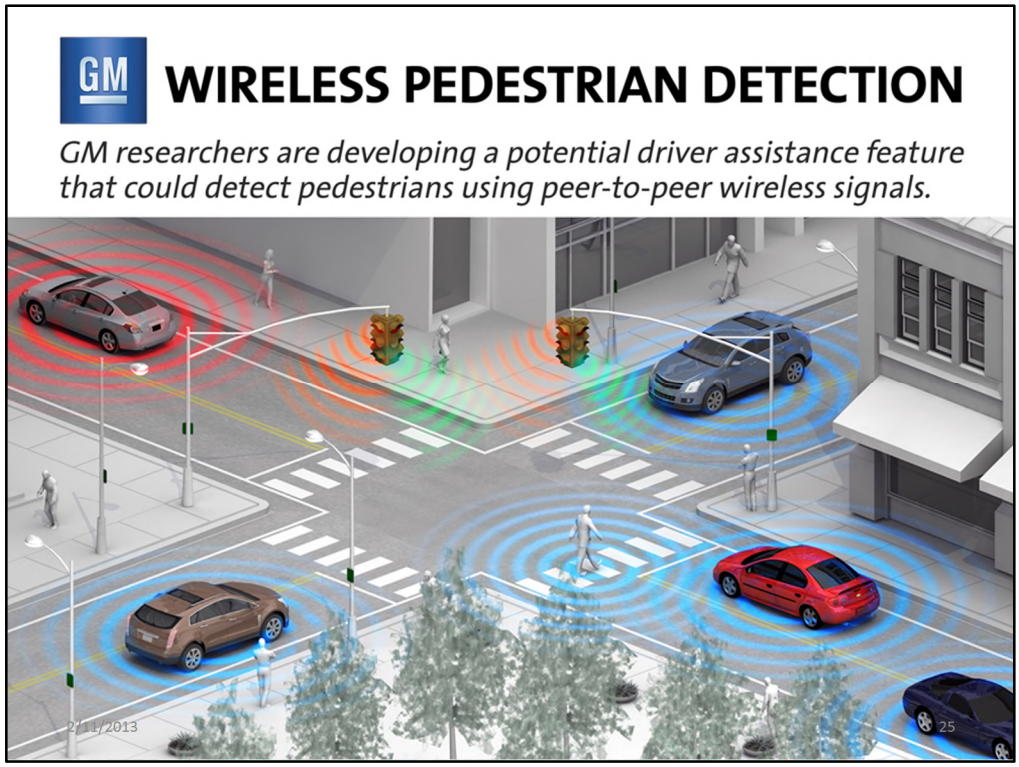
Google is not requiring any infrastructure changes and the vehicles they are testing are capable of mixing in a friendly way with cars driven by us people, although Google cars tend to drive within the speed limit which, would irritate those of us who drive at 5 mph over the legal limit.

Other researchers have pointed out that wireless connectivity would add some additional functionality to a robotic car. For example, in a road train of fast moving cars, it would be good to know by electronic signal to all following that the brakes of somebody up ahead had been pushed hard. It would be good to know what's happening with the timing of the traffic signals up the road, which could result in speed optimization.



Quite apart from Google Car robotics, U.S. DOT has been working on Vehicle to Infrastructure and Vehicle to Vehicle communication standards aimed at reducing collisions by 80% even if a human driver is reacting to messages delivered as beeps and buzzers instead of computers doing the driving.

This map illustrates a section of Ann Arbor Michigan, a college town just west of Detroit where a year-long pilot demonstration of 3,000 cars communicating with 15 traffic signals and with other cars to see if fewer accidents arise.



We can look forward to cars becoming aware of pedestrians and bicycles not only by sensing them with lasers but also with wireless signals in case the view is blocked. This is a picture from General Motors' work in progress.

While there are legal issues to work out as cars become more self-driving, it appears to some lawyers that the existing legal framework is adequate to get started.

Automation will come incrementally enough that the law and insurance will be able to keep up.

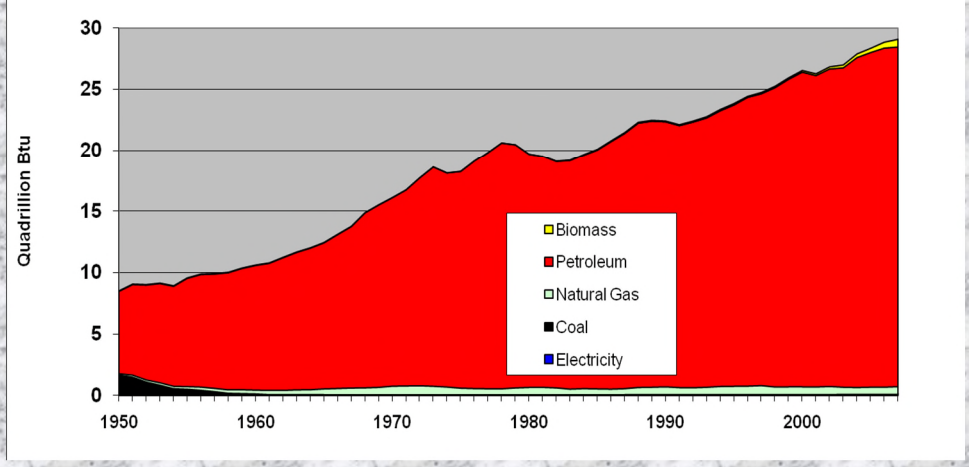
The authorizing law in several states emphasizes obvious precautions for the early testing.

CATES is working hand-in-hand with the University of Michigan's Connected Vehicle Proving Center on an integrated assessment of car technology as related to sustainable mobility, with funding from the Graham Environmental Policy Institute at the same university.

Moving along to a different topic, oil dependence in transportation is bad and I'm not only talking about the rising price of gas.

Much of what I'm going to talk about next was covered in a conference organized by CATES last September. The entire event was put on video and is now available at http://www.aboutcates.org in a series of individual chapters. There is also a short written conference report summary of key points made.

Transportation Energy Mostly Oil



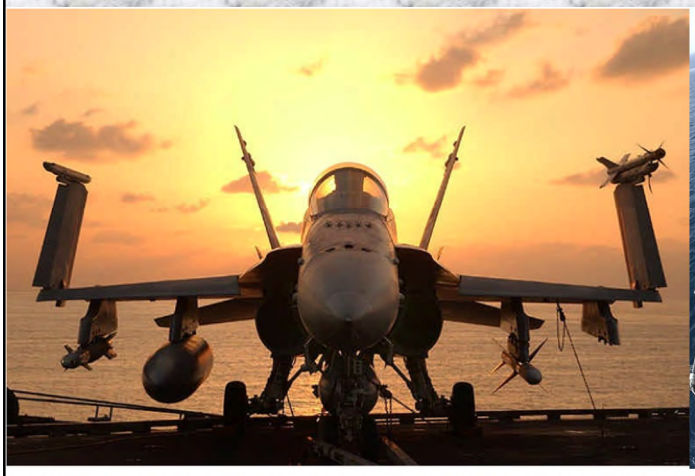
Source: Steve Marshall at Center for Advanced Transportation and Energy Solutions

The US transportation system uses oil at the rate of over **6,300** gallons per second, more than any nation's total use.

Oil fuels 97 percent of U.S. transportation .

This harms national security, the economy, and the environment

Another Part of What Oil Costs Us

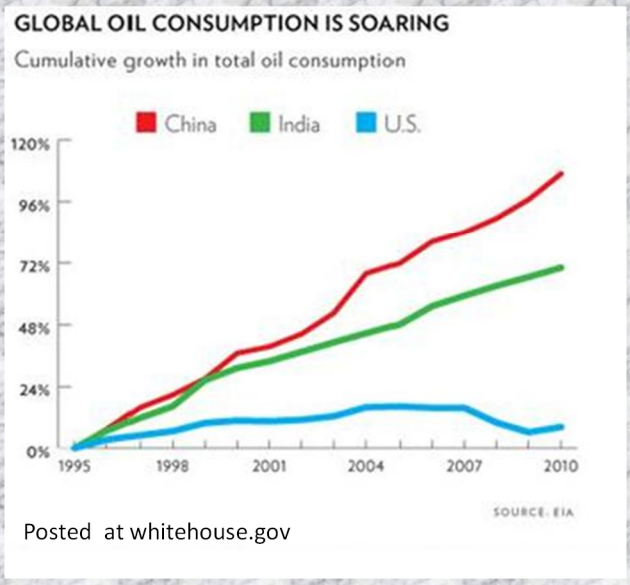


December 18, 2001 - After an early morning round of flight operations, an F/A-18 Hornet awaits the next round of combat flight operations aboard the USS John C. Stennis (CVN 74). Stennis and her embarked Carrier Air Wing Nine (CVW-9) are supporting Operation Enduring Freedom. U.S. Navy photo by Photographer's Mate 3rd Class Jayme Pastoric

Photos from the U.S. Navy

Annual U.S. military cost to protect world oil supply lines exceeds $80 billion.

China & India Have a Taste for Cars

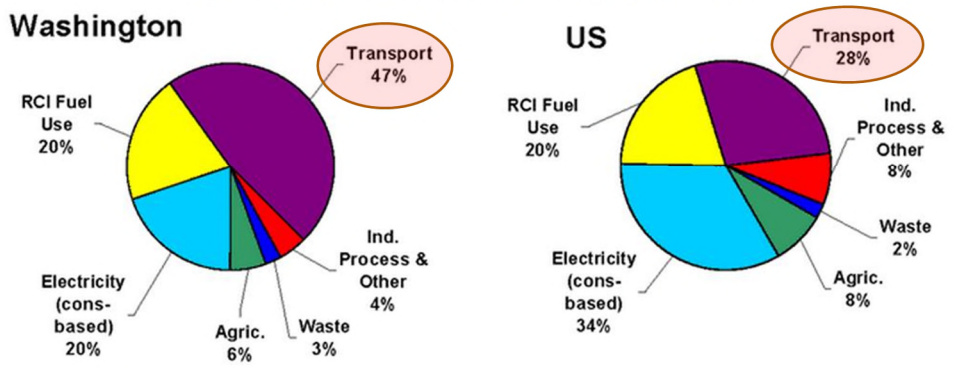


Posted at whitehouse.gov

Oil consumption is a world problem, in a world headed toward 2 billion cars

Greenhouse Gas – Much From Cars

Figure 1-1 Gross Greenhouse Gas Emissions by Sector, 2005, Washington and US



Source: Washington State Greenhouse Gas Inventory and Reference Case Projections, 1990-2020, December 2007, Center for Climate Strategies for Washington Department of Ecology and Department of Community, Trade, and Economic Development

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Burning oil is USA's largest man-made cause of greenhouse gas (GHG) and urban pollution.

Originally published September 6, 2012 at 5:04 PM | Page modified September 6, 2012 at 5:04 PM

Op-ed: What the next governor can do to reduce oil dependence

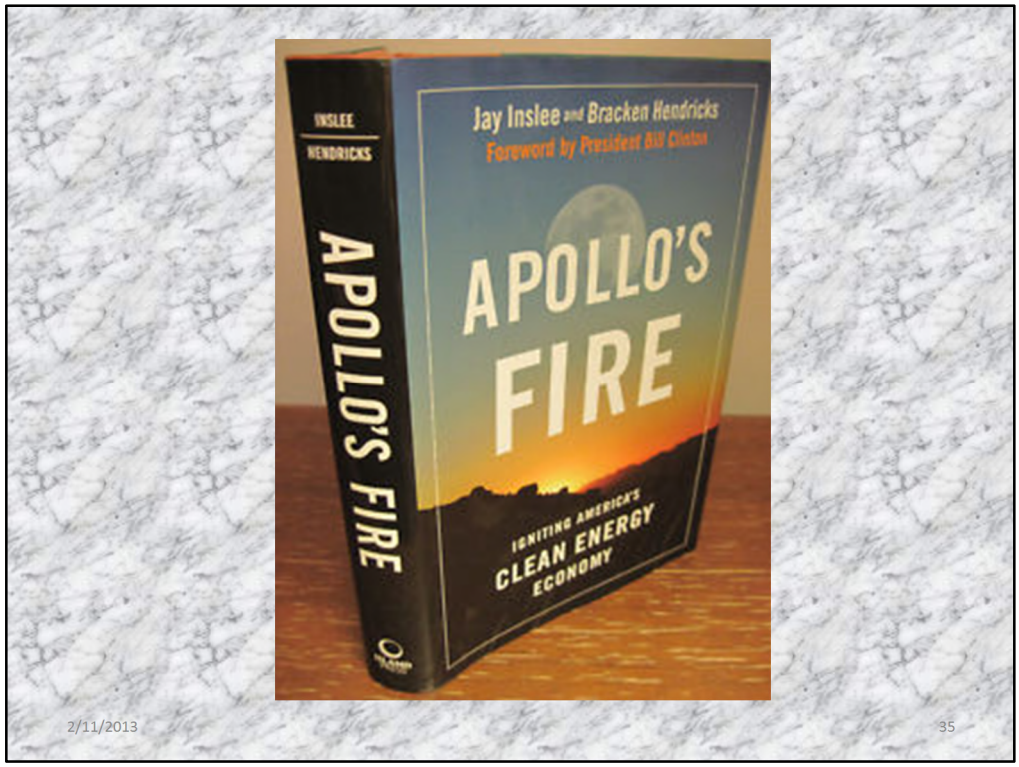
The next Washington governor should start thinking about how to reduce our dependence on oil, writes guest columnist Steve Marshall.

By Steve Marshall
Special to The Times

A REFINERY fire in California early in July pushed gasoline prices back into the $4 a gallon range. It shows again that we are hostage to oil prices.

Washington state imports all of the oil we use; we have no oil resources of our own to tap. According to the 2012 Washington State Energy Strategy, drivers in our state spent $16 billion in 2009 on gasoline, diesel and oil. Because oil has a virtual

CATES is now working with Washington Governor Jay Inslee.



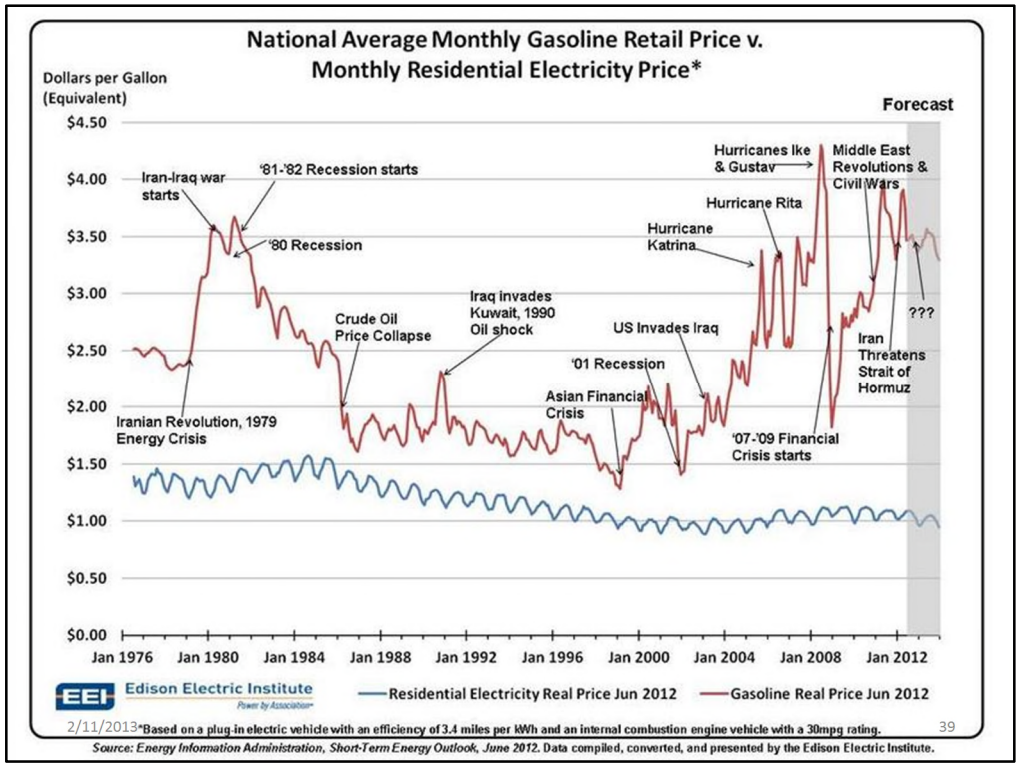
Chapter 2 of Governor Inslee's book is about electric cars.

Electric vehicles are coming. 53,000 plug-in cars were sold in USA in 2012

Beginning with 2007 executive order on the Freedom Car from President Bush, and then an extension from President Obama's administration, into the DRIVE program, there has been Federal policy support for EVs. Obama accelerated investment in EV research & development.

First mass production EV available for purchase was the Tesla Roadster in 2008, powered by laptop computer batteries. Price around $100,000. Range, 244 miles. Late 2010, the Nissan Leaf came out, about $35,000 with 73 miles range and also the Chevrolet Volt with an all-electric range of 35 miles and a gasoline engine for range extension, about $40,000. By 2013 about 15 plug-in battery only or hybrid offerings are available.

New plug-in Prius. The hybrid Prius without a plug-in has been a best seller in the Pacific NW and California.



Electric motors are 85% efficient; internal combustion engines (ICEs) are just 20-25% efficient. Even with coal-generated electricity, life-cycle analysis shows that EVs generate less GHG than ICEs.

EVs reduce dependence on foreign oil; efficient electric distribution exists and EV range issues are going away as batteries improve.

In the meantime, cars like the Chevy Volt have a back-up gasoline engine to keep the battery charged.

12,000 EV charging stations exist in the USA, but home charging and work place charging are key while waiting for batteries to provide more range at an affordable price.

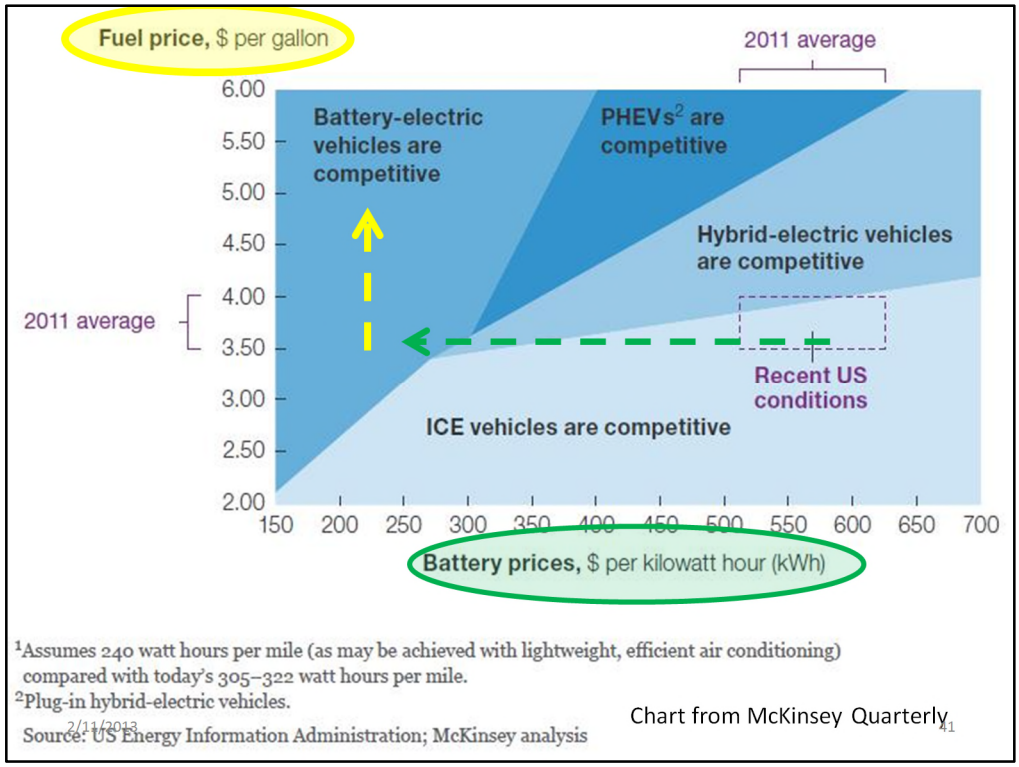
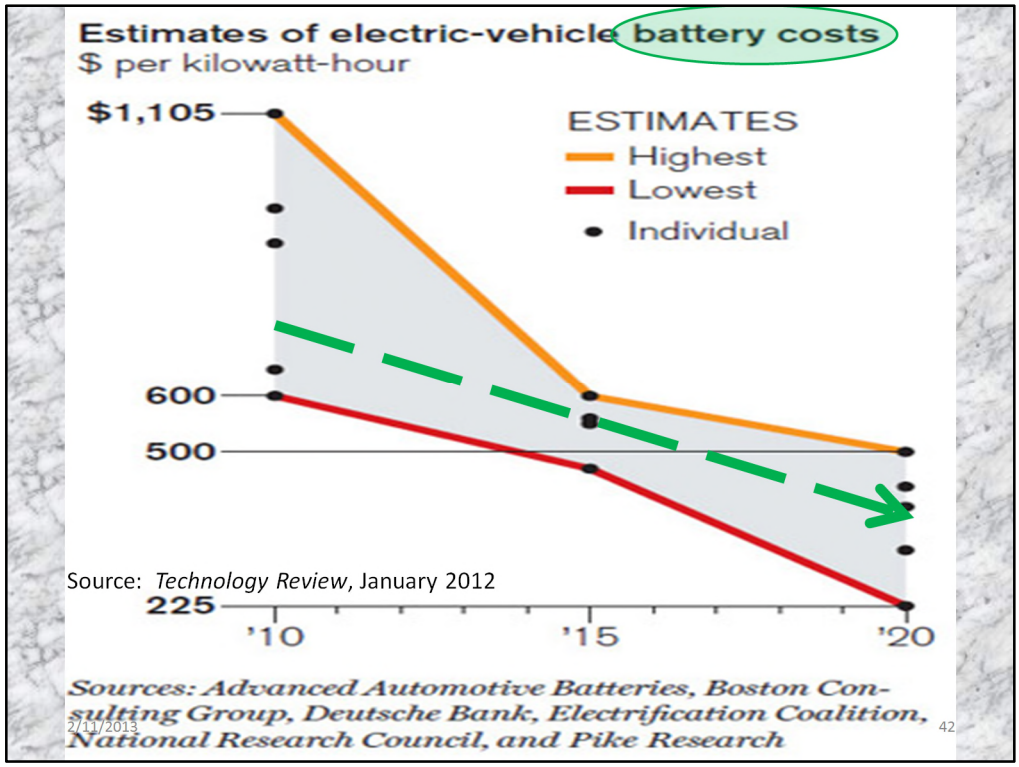


Chart from McKinsey Quarterly

This illustrates the sweet spot for battery cars.



http://www.greencarreports.com/news/1074183_how-much-and-how-fast-will-electric-car-battery-costs-fall

Picture is from Technology Review, January 2012

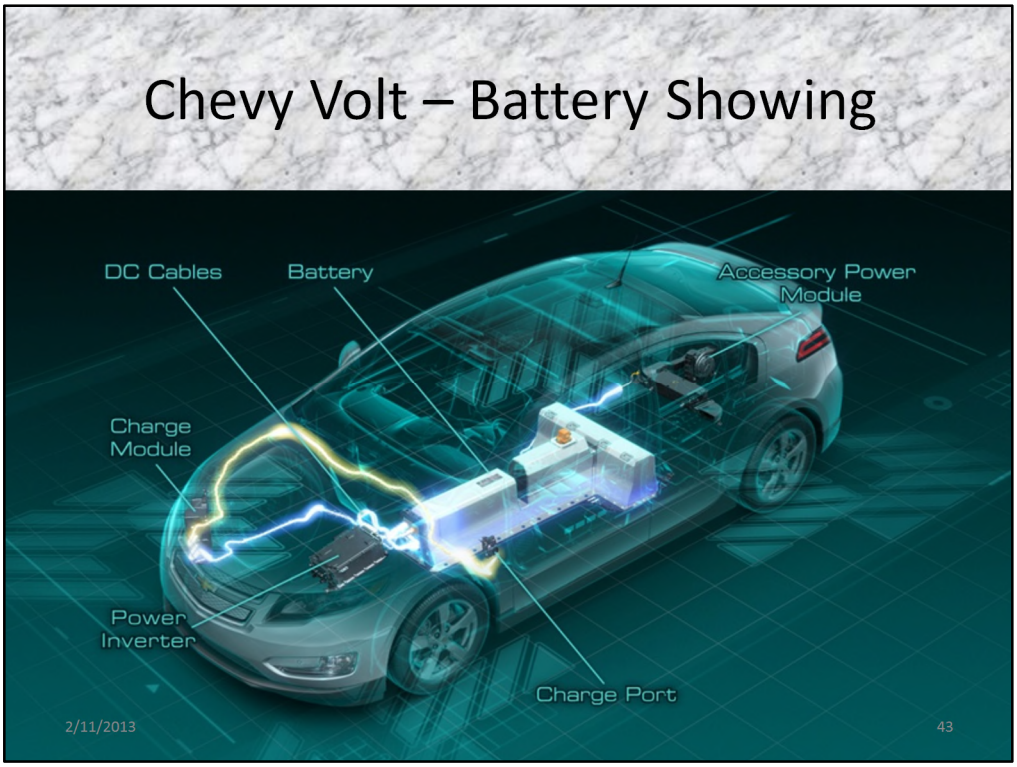
Batteries improving at 5 to 8 % per year.

How battery improvements will revolutionize the design of the electric car by Katie Fehrenbacher
Feb. 10, 2013
http://gigaom.com/2013/02/10/how-battery-improvements-will-revolutionize-the-design-of-the-electric-car/

Quoting:

"Battery innovation isn't as slow as many people think it is, and the continued pace of battery improvement enables entirely new types of electric car design, according to Tesla co-founder and CTO JB Straubel.

"While battery innovation appears gradual, the incremental leaps add up over time. Battery innovation is improving around 5 to 8 percent per year, which can deliver a doubling in core performance metrics every ten years, which is ultimately really "revolutionary" said Straubel. Because of the large size and heavy physical weight of batteries involved with electric cars, the impact of battery innovation on the design of the car can be even more significant than Moore's Law has on some computing products, added Straubel.
For car design, "It's almost as if the properties of steel were improving at a rate of 5 to 8 percent per year," said Straubel."

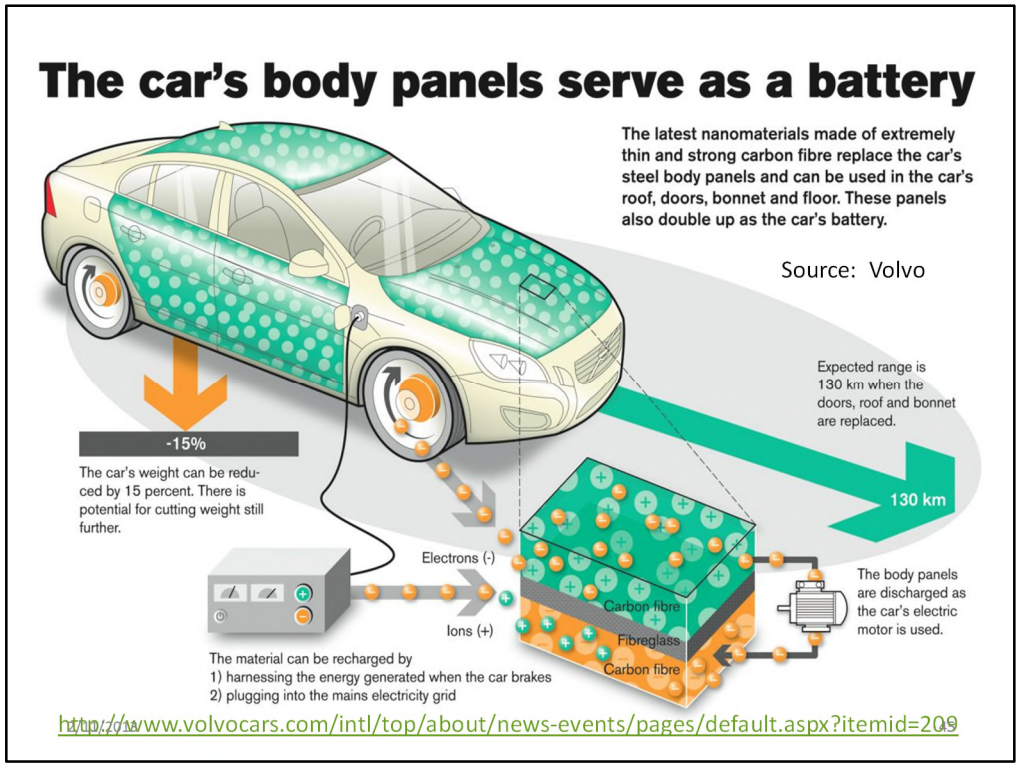


Battery development is ongoing.

General Motors in a new pass at creating a modern electric vehicle came up with the Chevy Volt that features a gasoline motor that keeps the car going when the battery runs down and there's no time to recharge it.

The vehicle is technologically complex. It operates with more lines of computer software code than a Boeing Dreamliner.

Plug-in Chevrolet Volt.



Volvo is working on batteries embedded in the body panels of the car.

http://www.volvocars.com/intl/top/about/news-events/pages/default.aspx?itemid=209

New Tesla Model S has 40, 60, and 85 kilowatt-hour battery options with 160, 230, and 300 mile range respectively. The price of each is $52K, $62K, or $72K after the $7,500 U.S. Federal tax credit.

http://www.teslamotors.com/models/options

Nissan Leaf, King County “Vanpool”

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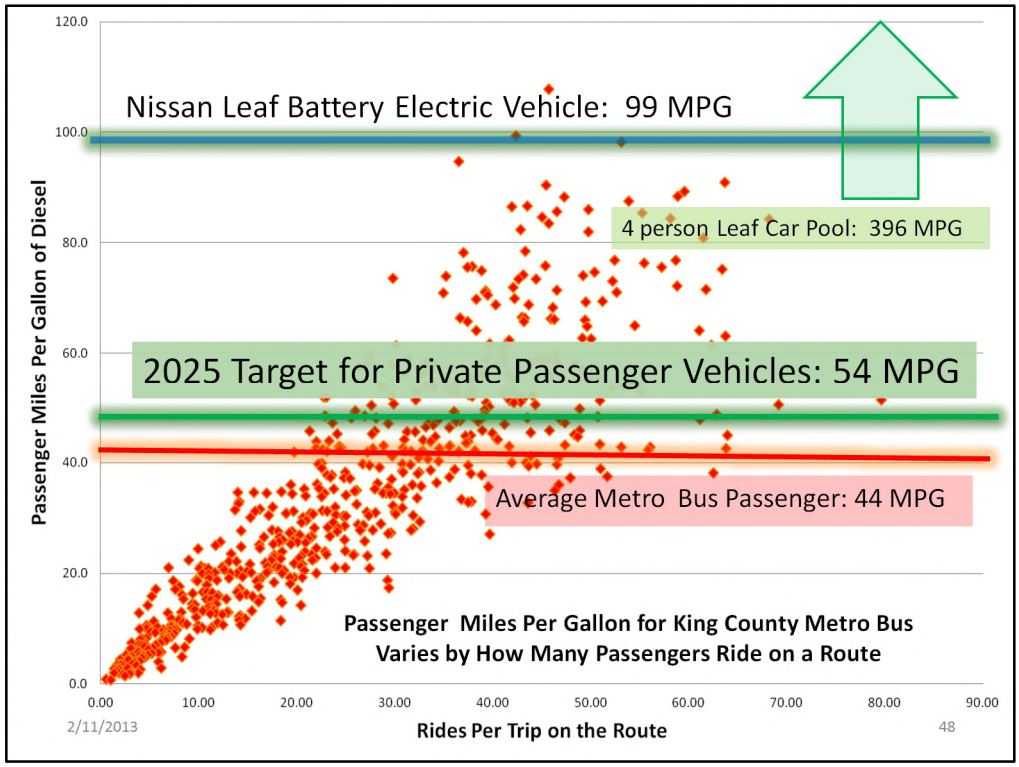
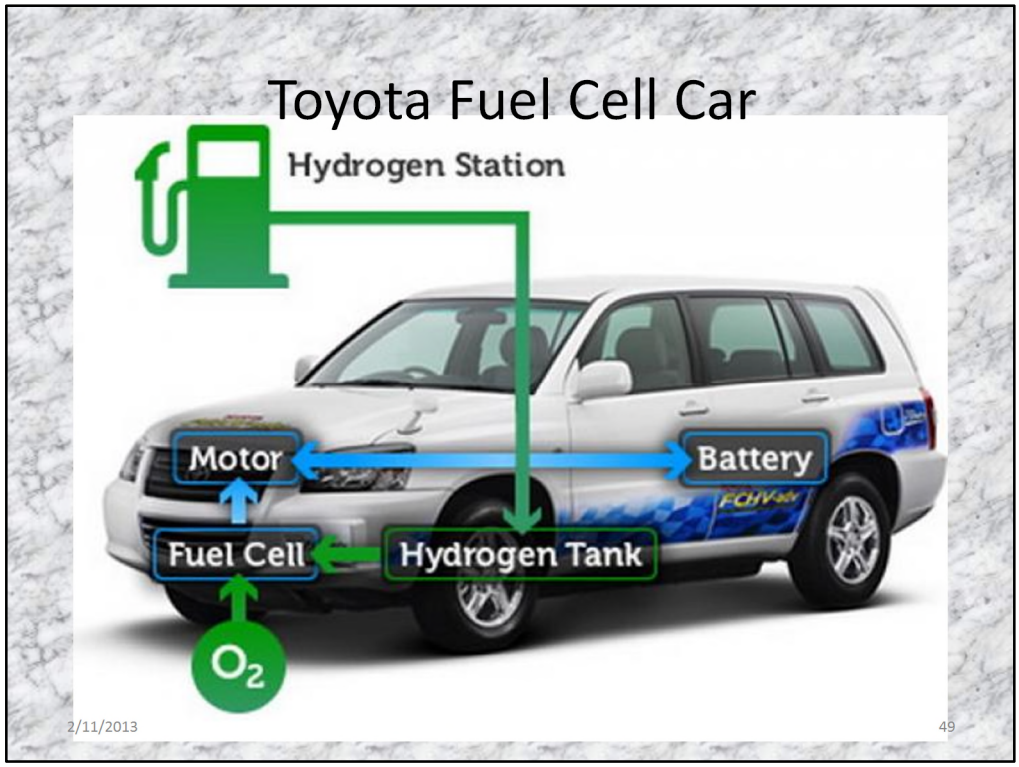
FAQ: King County is pursuing alternative fuel vehicles, specifically electric vehicles (EV's), to cut fuel consumption and carbon emissions – a leading cause of air pollution. Metro Rideshare Operation has purchased 25 Nissan Leafs to pilot EV technology in a commuter application called “metropool” and coordinate the installation of charging stations at major employer sites and multi-modal transportation hubs such as park & ride lots and ferry terminals.



Data Source is King County Metro Transit spreadsheet of performance by route. Calculated 3.06 revenue miles per gallon of diesel is an average calculated from system wide average in 2009. Chart by John Niles, Center for Advanced Transportation Solutions.



Fuel cell cars running on hydrogen are thought by many to be the strongest approach to zero emission vehicles in the long-run.

Reinventing the Automobile, the book, describes the potential in very small urban vehicles like the GM EnV. Small is safe if the probability of a crash is brought down with automation.

CATES

Center for Advanced Transportation and Energy Solutions

What's Next:

- Sign up to participate with CATES and others in transforming transportation.
- Respond to our integrated assessment of technology's contribution to solutions for existing wicked problems.
- Learn from us and others about vehicle automation and EVs.
- Tell us what you know that we don't get. Contact options:
  - Email John@JohnNiles.com
  - Call John at 206-781-4475
  - Learn more at www.aboutcates.com
- **Thank you very much!**

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