CONNECTED AND AUTOMATED VEHICLES AND ADVANCES IN POWERTRAIN CONTROL TO ACHIEVE IMPROVED FUEL ECONOMY

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June 23rd 2016

IFAC
INTERNATIONAL FEDERATION OF AUTOMATIC CONTROL

THE OHIO STATE UNIVERSITY
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ACKNOWLEDGMENT

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EDUCATING FUTURE LEADERS

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"Tomorrow's university will be different than today's. Only those who thrive in multiple dimensions, not just research or traditional education, will succeed."

-Giorgio Rizzoni
CAR Director

CREATING THE ENVIRONMENT

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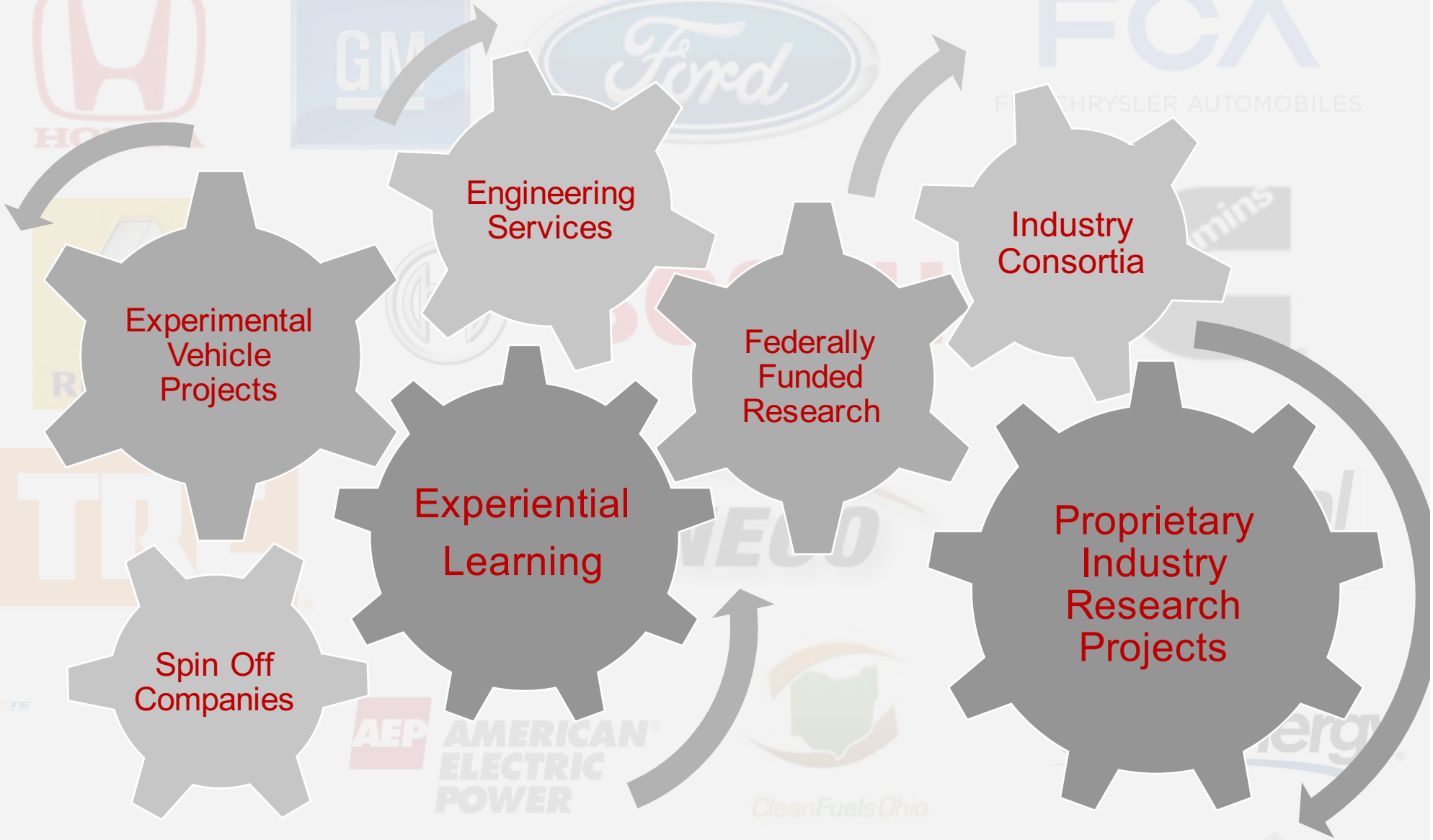

UNDERGRADUATE EXPERIENCE

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CAR provides experiential learning opportunities to over 250 undergraduate and graduate students each academic year.

In line with the *College of Engineering's strategic objective* to "build on our strength in experiential learning to establish national leadership in this area for Ohio State"

GRADUATE EDUCATION

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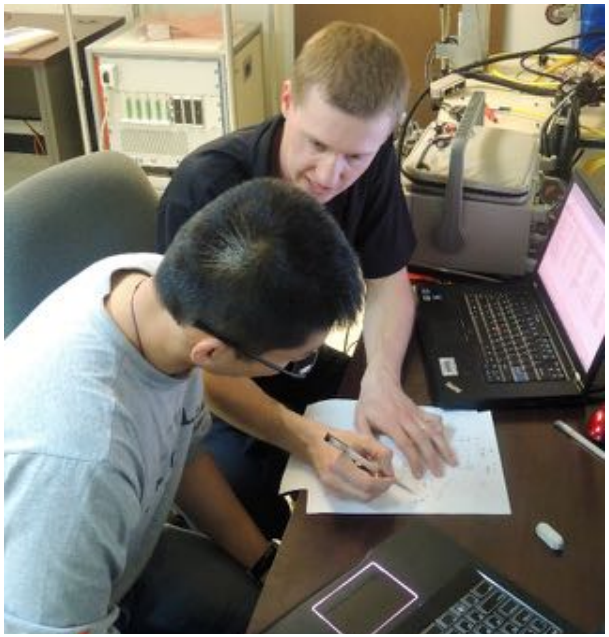
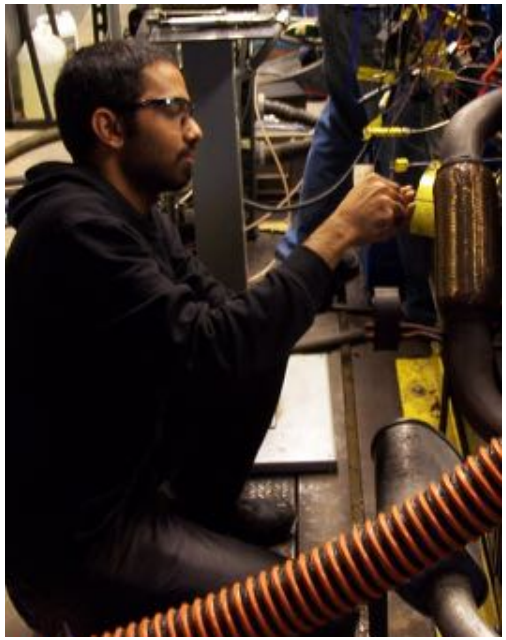
In partnership with the academic departments, CAR contributes to and continuously improves a **graduate curriculum** with focus on **automotive systems engineering**, taught by CAR-affiliated faculty.

This is in line with the *College of Engineering's goal* to "produce graduates with advanced degrees who become national and international leaders in their field."





SNAPSHOT OF CAR – FY 2015

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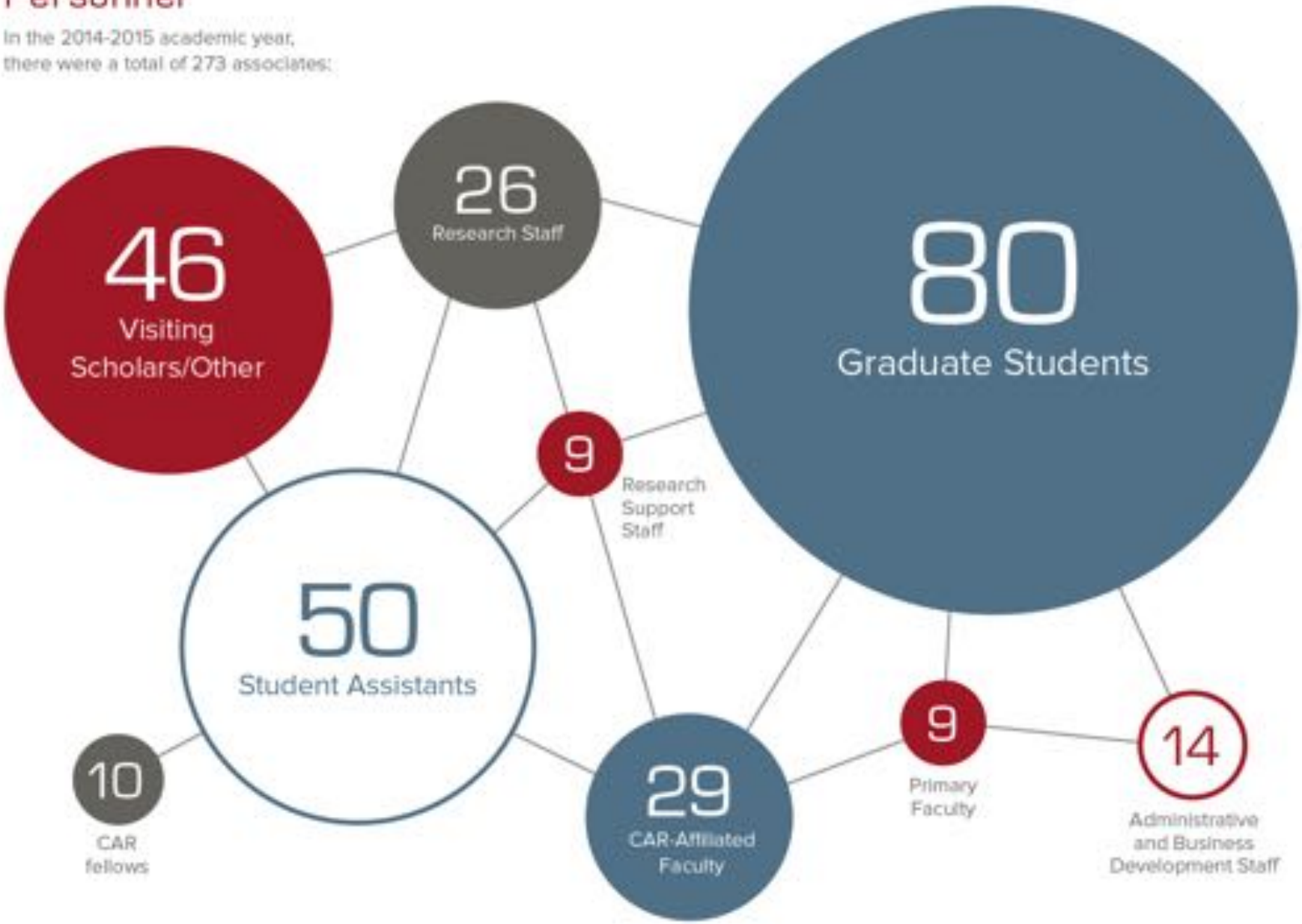
Personnel

In the 2014-2015 academic year, there were a total of 273 associates:



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CONNECTED AND AUTOMATED VEHICLES AND ADVANCES IN POWERTRAIN CONTROL TO ACHIEVE IMPROVED FUEL ECONOMY

OUTLINE

1. Motivation
2. Eco-Driving, Eco-Routing
3. An example: Cloud-based Velocity Profile Optimization
4. What can be done under the hood (powertrain and accessories)?
5. How can recent advances in connected and automated vehicles be integrated into powertrain control?

SUMMARY

- **Two important technology trends have developed in recent years in the passenger and commercial vehicle industries:**
  i. the push towards significantly reduced CO_2 emissions and improved fuel economy (FE)
  ii. the development and introduction into the market of connected and automated vehicle (CAV) technologies.
- **The aim of this talk is to:**
  i. review recent research advances in leveraging CAV technologies to enhance vehicle FE
  ii. to explore opportunities that will enable closer integration of CAV technologies with powertrain control to further extract the maximum benefit that can be achieved by the merger of vehicle connectivity and automation with powertrain control.
- The presentation outlines how vehicle engine, transmission, hybrid powertrain, and accessory management can benefit from vehicle-level information (local range sensors, navigation systems, V2X communications), system level information (traffic, geography, weather and road conditions), and cloud level processing.

The merger of these two rich areas of research and development will continue to provide rich opportunities for our research community, and is especially relevant to this Symposium

MOTIVATION

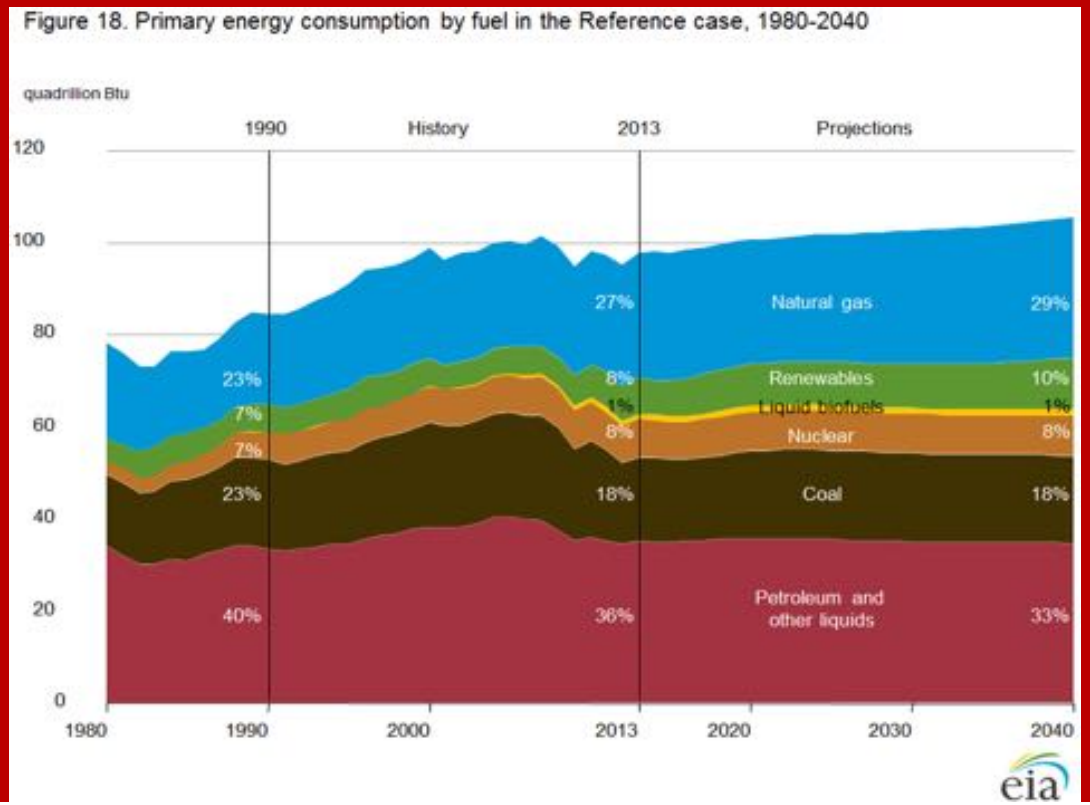
Figure 18. Primary energy consumption by fuel in the Reference case, 1980-2040
quadrillion Btu
1990
History
2013
Projections
120
100
80
60
40
20
0
1980
1990
2000
2013
2020
2030
2040
23%
7%
7%
23%
40%
27%
8%
1%
8%
18%
36%
Natural gas
29%
Renewables
10%
Liquid biofuels
1%
Nuclear
8%
Coal
18%
Petroleum and other liquids
33%
eia

UNITED STATES' ENERGY USE IN 2014

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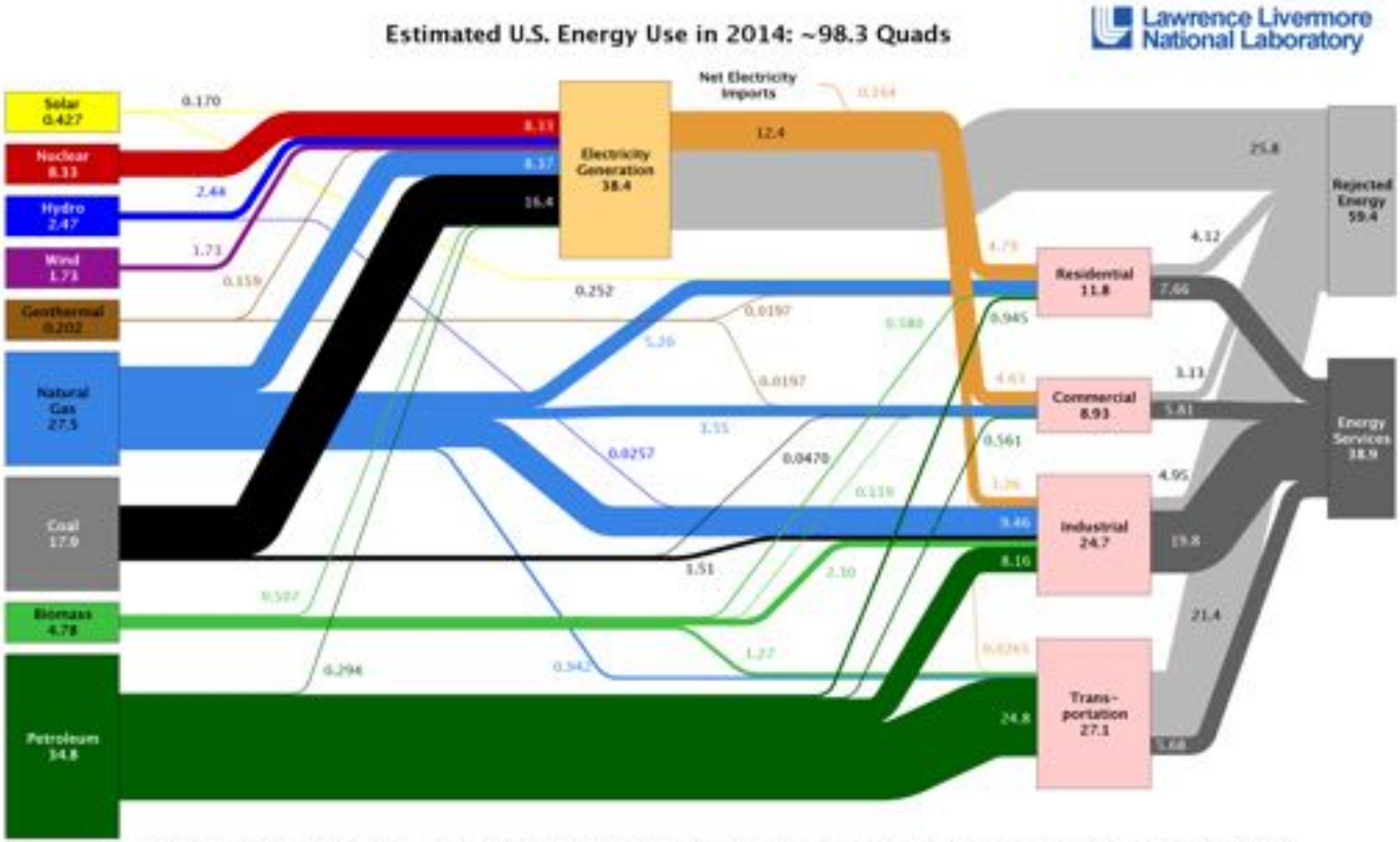

Source: LLNL 2015. Data is based on DOE/EIA-0035(2015-03), March, 2014. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors, 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

SWEDEN ENERGY SUPPLY HISTORY

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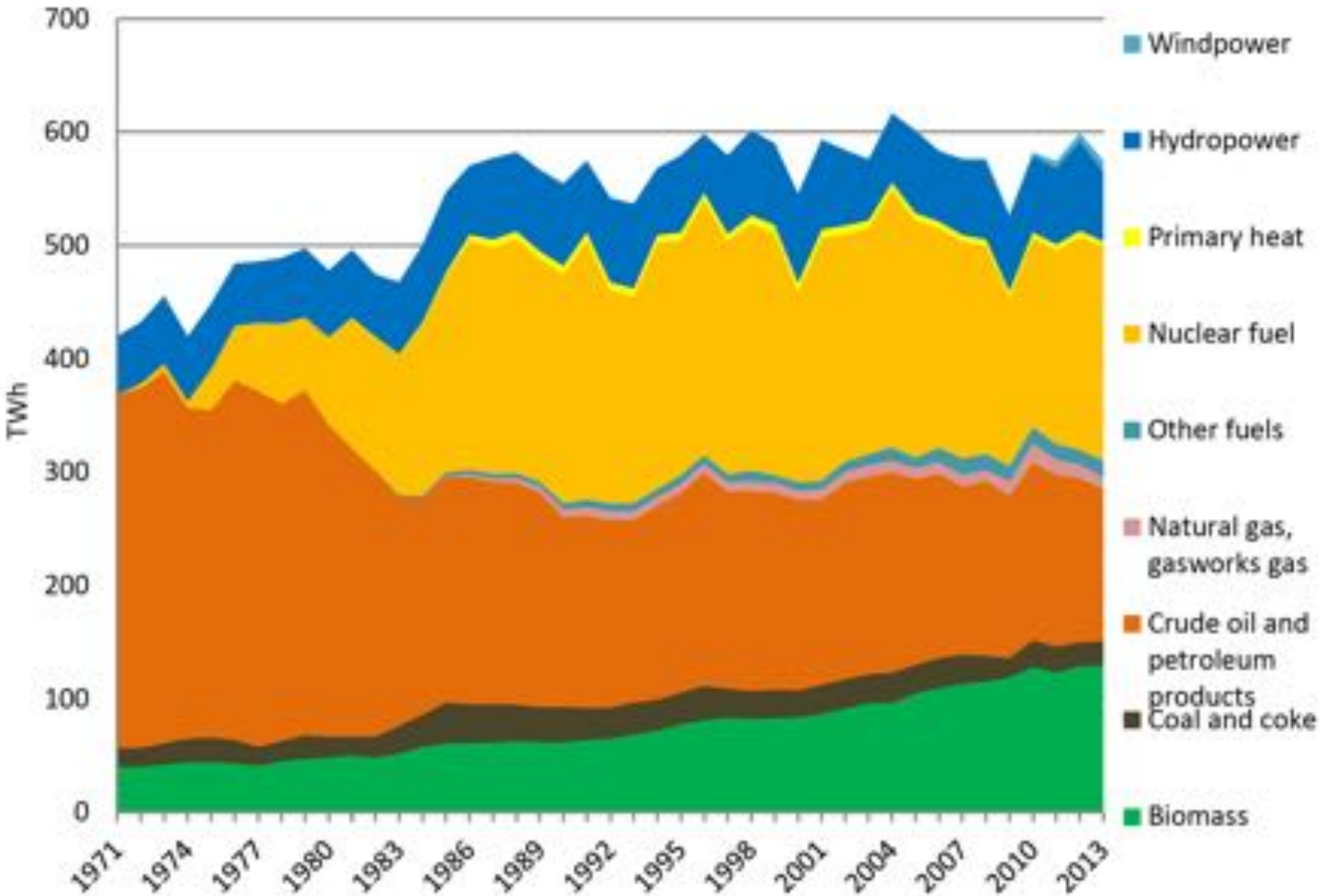
Figure 2 Total energy supply by energy commodity 1971 – 2013, TWh



Swedish Energy Agency, 2015

SOME OBSERVATIONS

1 Quad ~ 300 TWh~ 10^{12} MJ

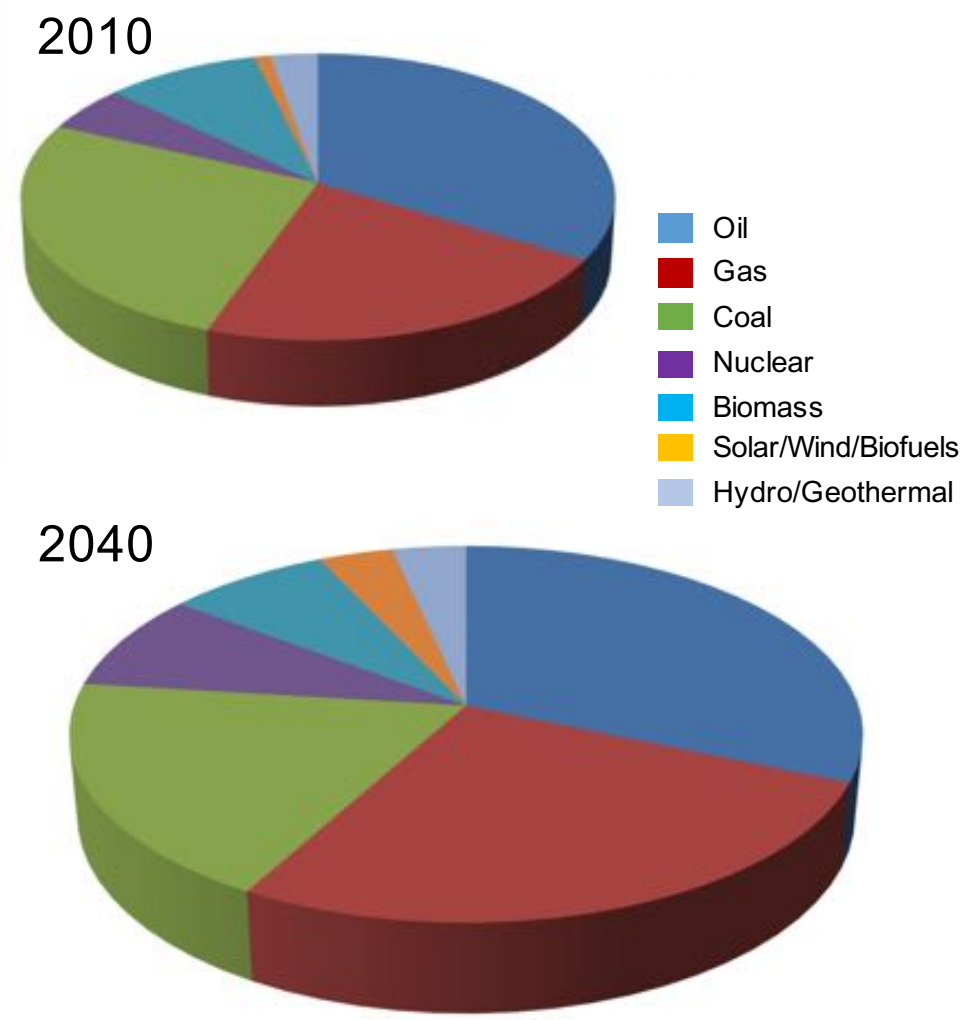
USA~50xSE (energy)

USA~30xSE (people)

What I know about Sweden, I think, offers us some good lessons. Number one, the work you have done on energy I think is something the United States can and will learn from. Because every country in the world right now has to recognize if we are going to continue to grow and improve our standard of living while maintaining a sustainable planet, we are going to have to change our patterns of energy use. And Sweden I think is far ahead of many other countries.

Barack Obama, 2013

GLOBAL ENERGY USE - PROJECTIONS



World Energy Portfolio: 2010 and 2040 projections

- Global Primary Energy grows by 36% (vs. population growth of 25%)
- High annual growth rate of renewables (solar, wind and biofuels) but share remains insignificant (<3% share in 2040)
- Oil, gas and coal continue to dominate (77% share in 2040)
- Increase in oil, gas and nuclear EACH exceeds 2040 share of renewables!!

Exxon Mobil 2013 World Energy Outlook | http://www.slideshare.net/MarcellusDN/exxonmobil-2013-the-outlook-for-energy-a-view-to-2040 | (DOE projections are similar)

PEAK OIL? THINK AGAIN…

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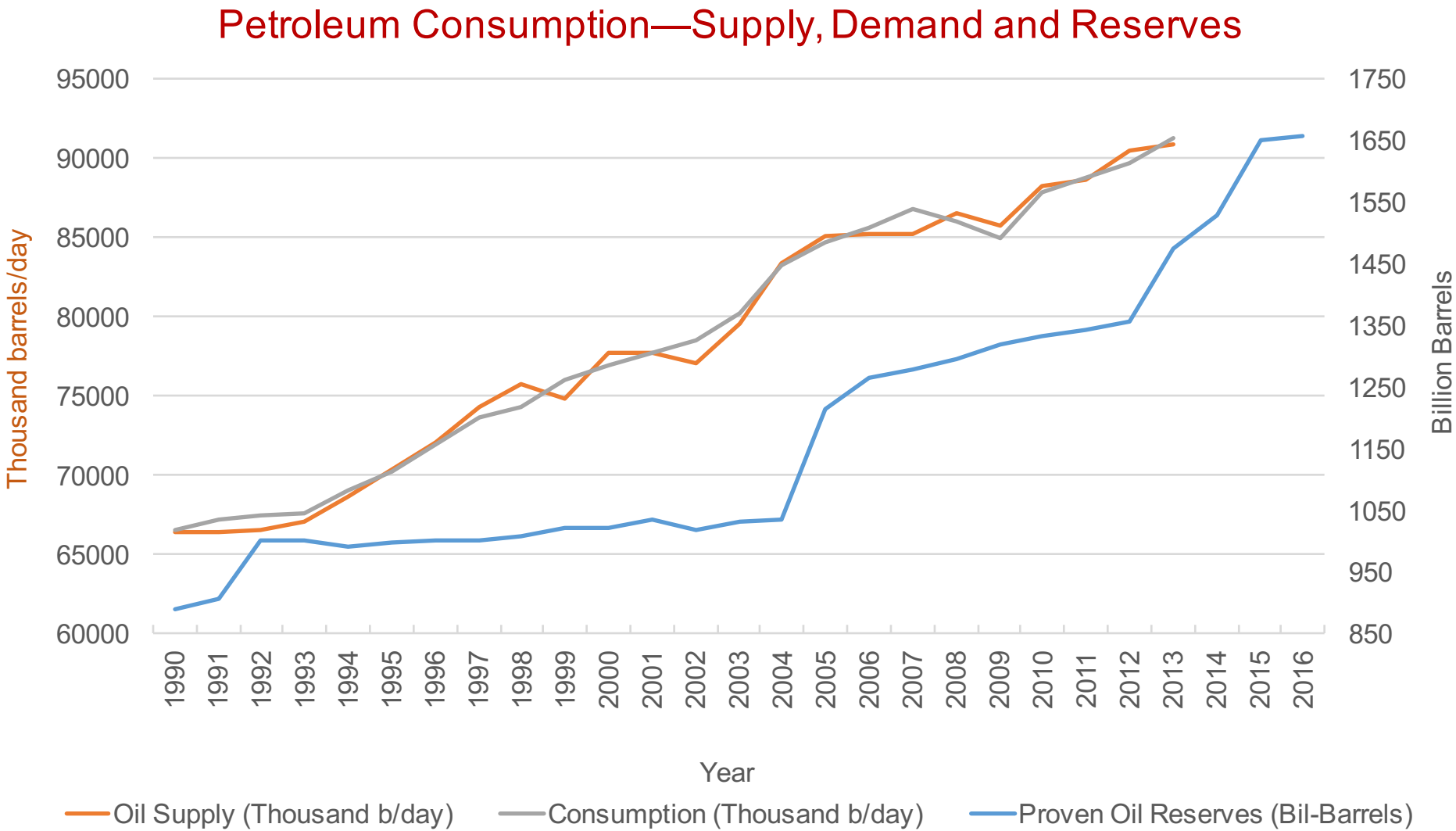
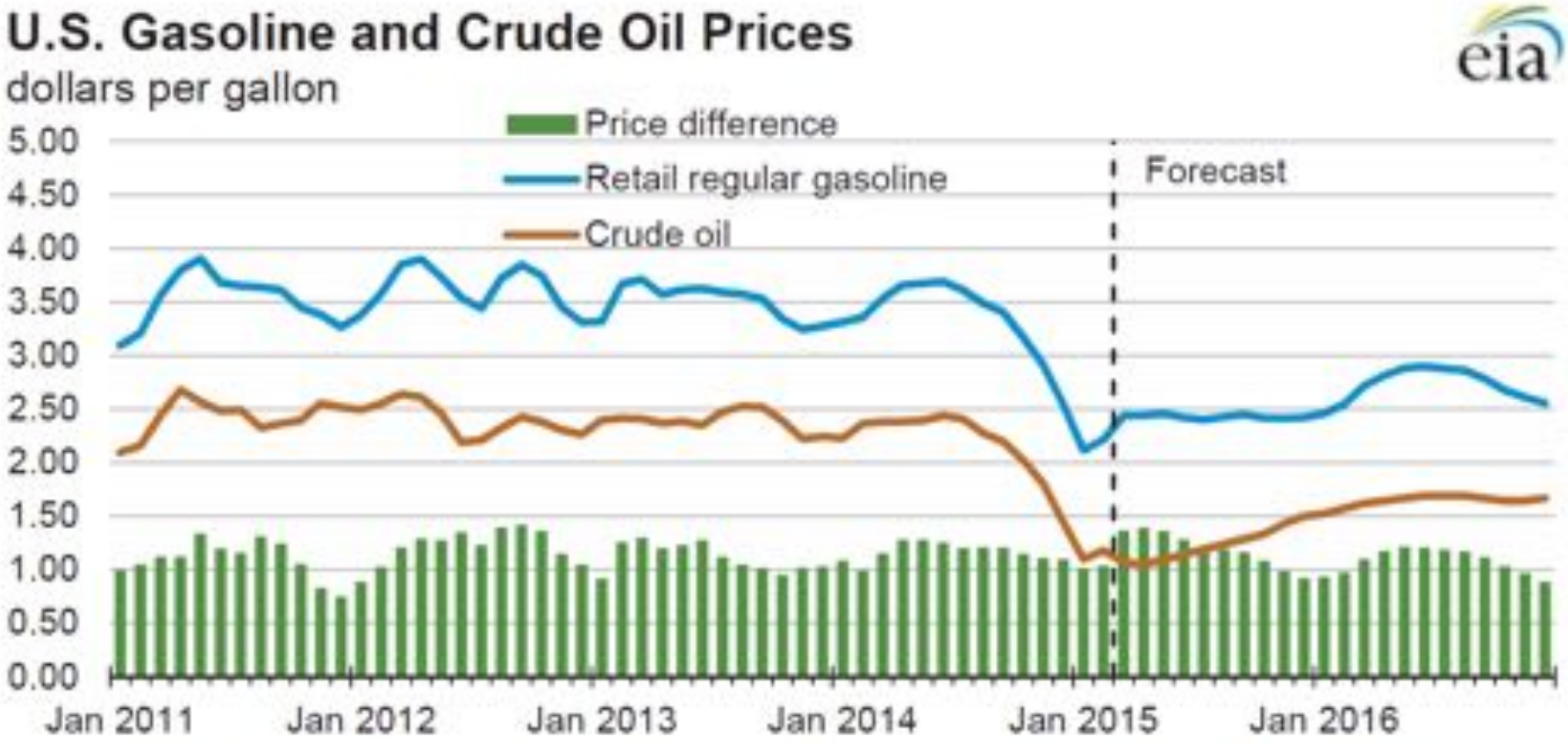


- Transportation is 96% dependent on petroleum
- Proven reserves continue to increase

Source: EIA, 2015

PETROLEUM…IS INEXPENSIVE!

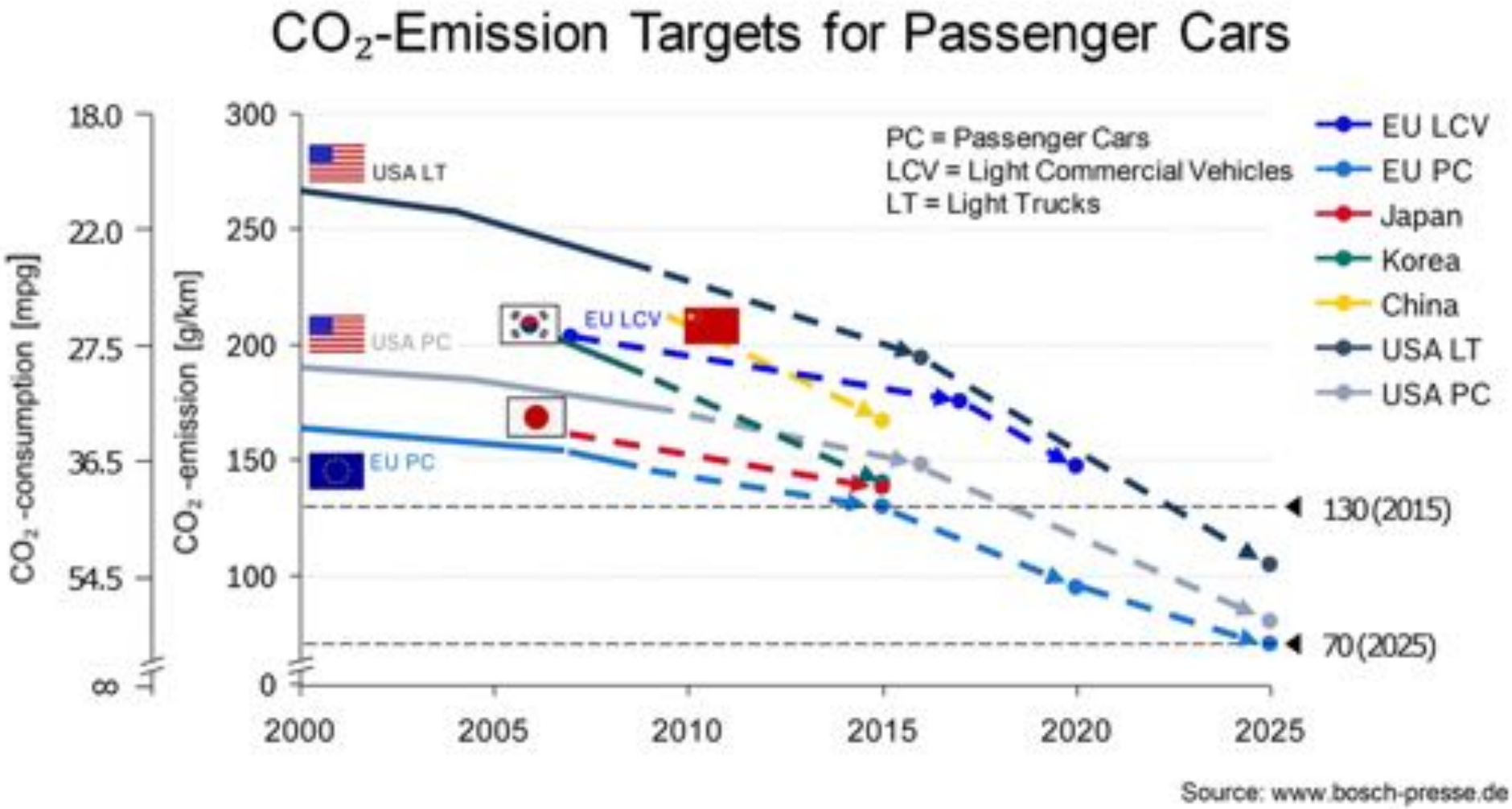


Crude oil price is composite refiner acquisition cost. Retail prices include state and federal taxes.

Source: Short-Term Energy Outlook, March 2015.

PETROLEUM…IS A SIGNIFICANT CONTRIBUTOR TO GREENHOUSE GASES

- Regulations worldwide aim to reduce CO_2 emissions from transportation
- How do we reconcile this with inexpensive petroleum?



US PETROLEUM USE RECENT HISTORY

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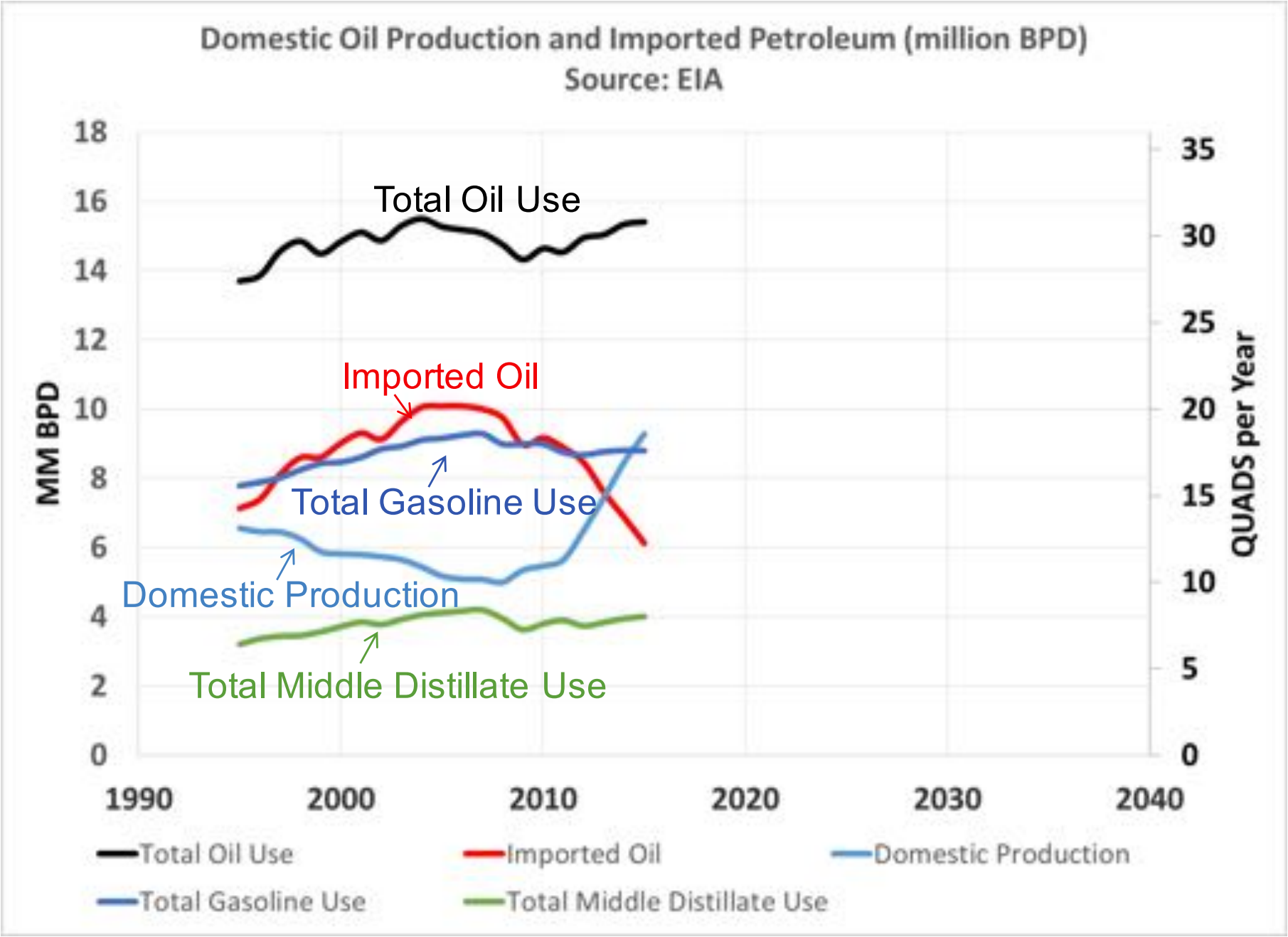
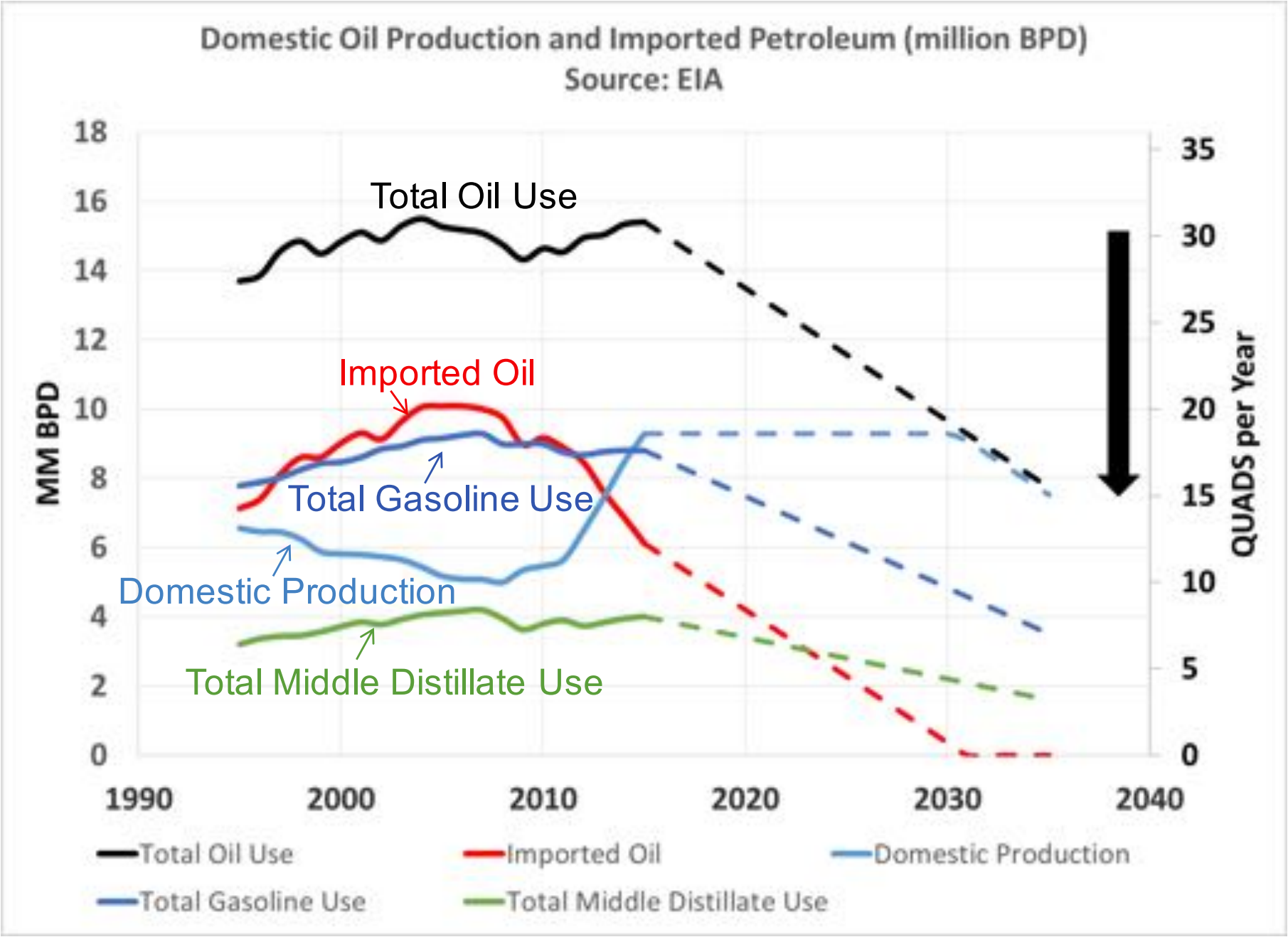


GOAL


Domestic Oil Production and Imported Petroleum (million BPD)
Source: EIA
MM BPD
QUADS per Year
18
16
14
12
10
8
6
4
2
0
35
30
25
20
15
10
5
0
1990
2000
2010
2020
2030
2040
Total Oil Use
Imported Oil
Total Gasoline Use
Domestic Production
Total Middle Distillate Use
Total Oil Use
Imported Oil
Domestic Production
Total Gasoline Use
Total Middle Distillate Use

ARPA-E issues $30M NEXTCAR program funding opportunity; 20% reduction in energy consumption beyond current regulatory requirements

U.S. DEPARTMENT OF ENERGY

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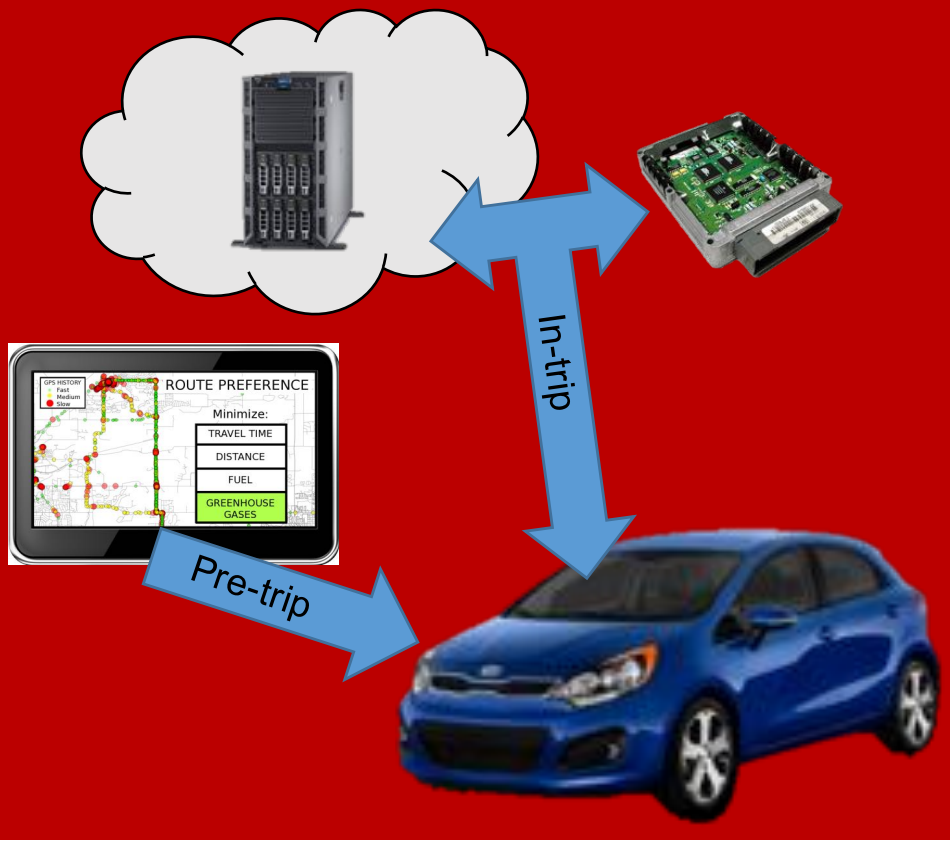
ECO-DRIVING

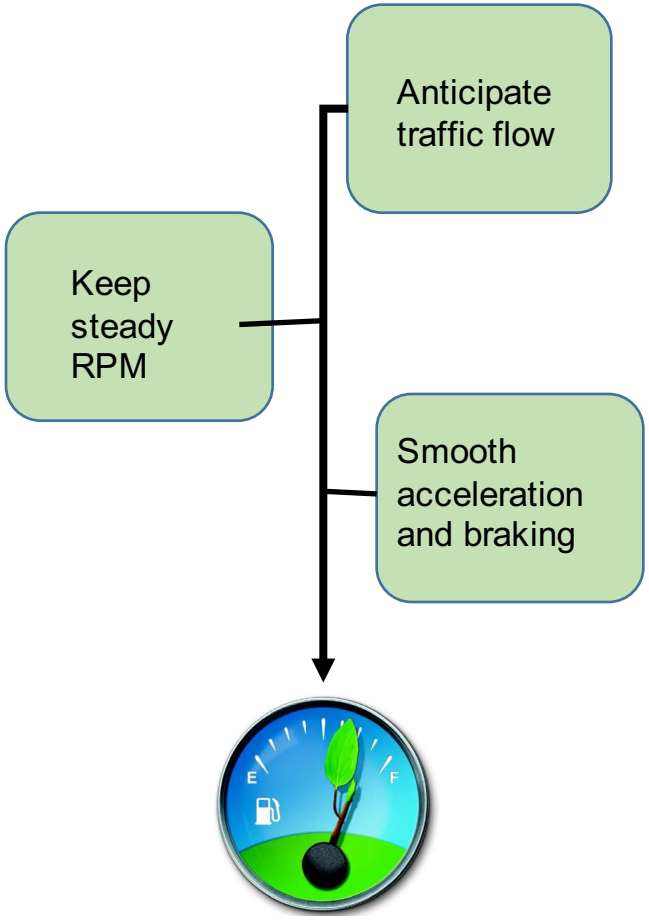


ECO-DRIVING

- Eco-driving is the ability to save fuel and limit emissions based on the driving behavior
  - Ability to apply to any vehicle as it does not require any modification to powertrain

- First developed as lessons to change driver behavior at the wheel to provide greater fuel efficiency
- Main idea is to smooth drive cycle, avoid unnecessary braking or acceleration, anticipate traffic, etc.
- Goal is to try to maximize vehicle fuel efficiency with only driver input
- Fuel economy observed of up to 20% compared to aggressive driving [1]

- However approaches have been made to assist driver to achieve even better fuel economy, biggest improvements have come from cruise control technologies especially in highway scenarios



Gonder et al. Analyzing vehicle fuel saving opportunities through intelligent driver feedback, SAE2012-01-0494 (2012) [1]

ECO-DRIVING

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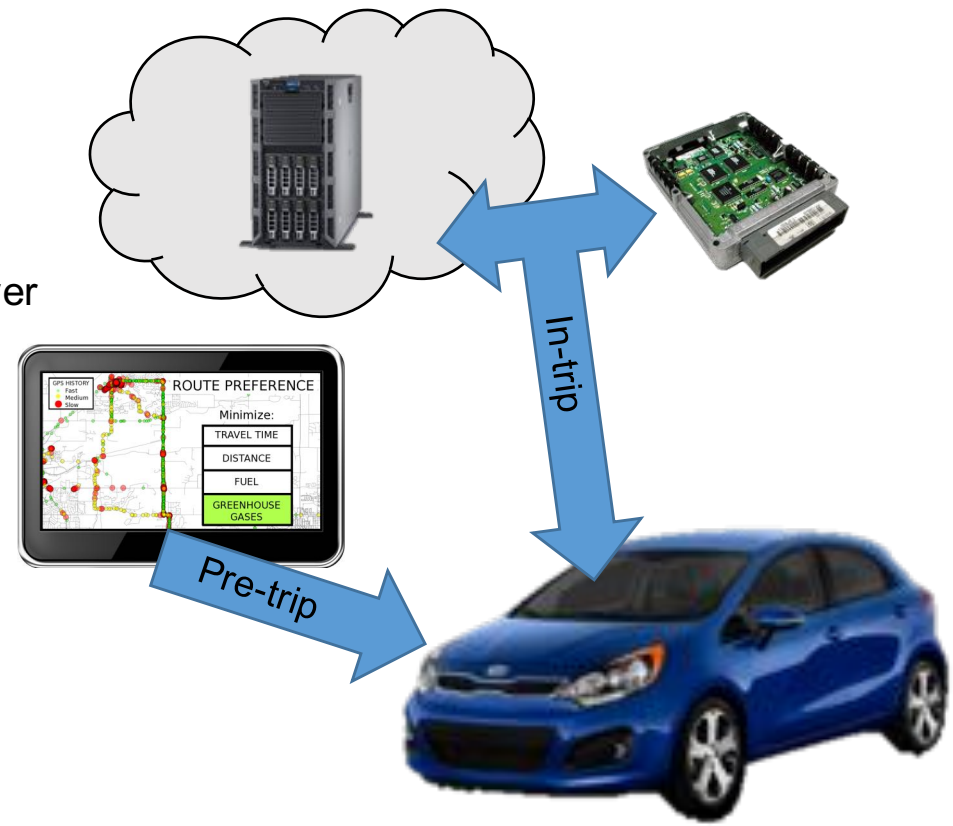
- Advances in software and computation now allow for more systematic approach to eco-driving
- Mainly two types of approach
  - **Pre-trip systems**
    - Makes use of on-board navigation systems and input determined before the drive
  - **In-trip systems**
    - Live feedback provides ability of Advanced Driver Assistance Systems
    - Made possible through the improvement of on-board computation capabilities, as well as connectivity to cloud-based servers

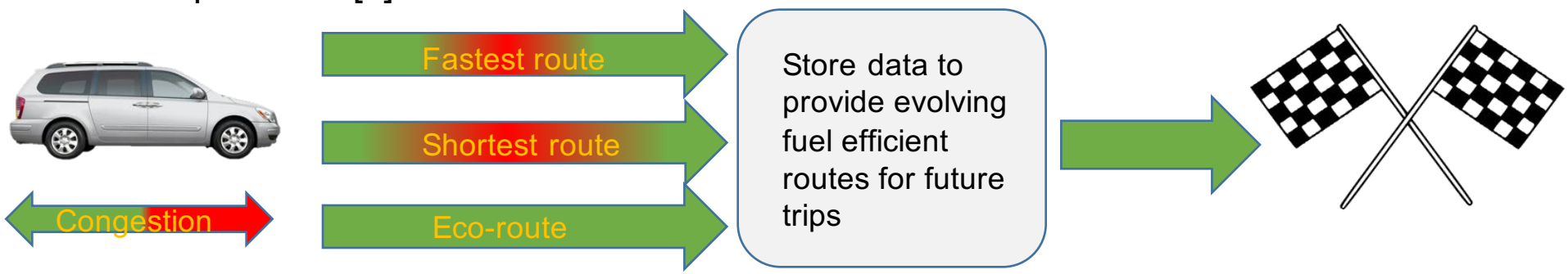


- Advances in eco-driving control strategies
  - Real time computing of optimal velocity profile, paired to parametric optimization of the engine [2]
  - Eco-cruise control using predictive logic [3]
  - Right now very useful for highway and extra-urban setting to provide improve the Adaptive Cruise Control

Sciaretta et al, Optimal Ecodriving Control: Energy-Efficient Driving of Road Vehicles as an Optimal Control Problem (2015) [2]
Rahka, Overview of VTTI's Environmental Connected Vehicle Research Activities [3]

ECO-ROUTING

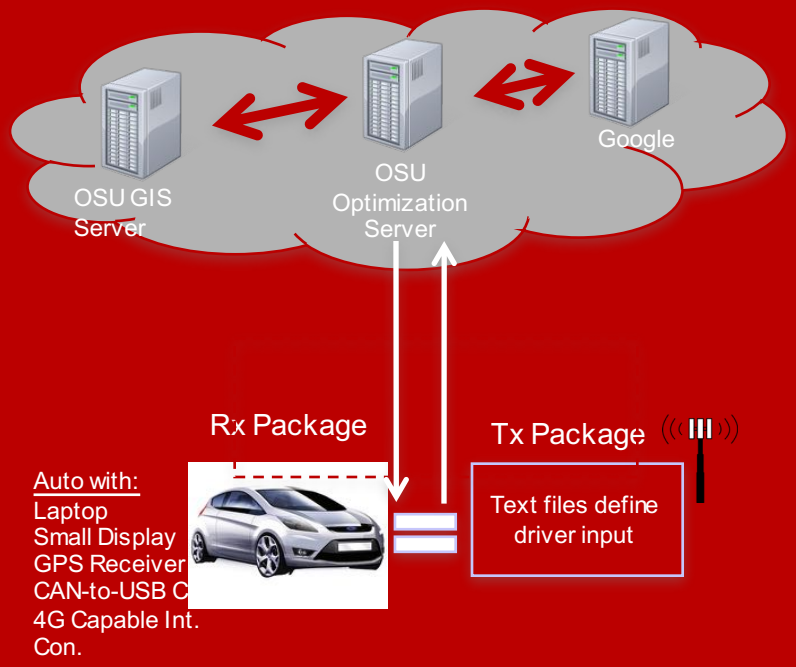
- Eco-routing is the identification of the most fuel efficient route for a vehicle travelling between two points
- Pre-trip systems can determine at the time of travel which route will be the most fuel efficient given current data at the time of calculation.
- However new projects using advanced computation have been able to improve such eco-routing to adapt it to current conditions.
  - By combining recorded data to real time traffic conditions, and algorithms that provide shortest path to most fuel efficient route; it's been observed fuel savings of up to 14% [4]



- Combining optimal route with assisted, and eventually automated, eco control strategies have potential to work well together to increase fuel economy

BORIBOONSOMSIN et al.: ECO-ROUTING NAVIGATION SYSTEM BASED ON MULTISOURCE TRAFFIC INFORMATION (2012) [4]

AN EXAMPLE: CLOUD BASED VELOCITY PROFILE OPTIMIZATION



CLOUD COMPUTING PROBLEM STATEMENT

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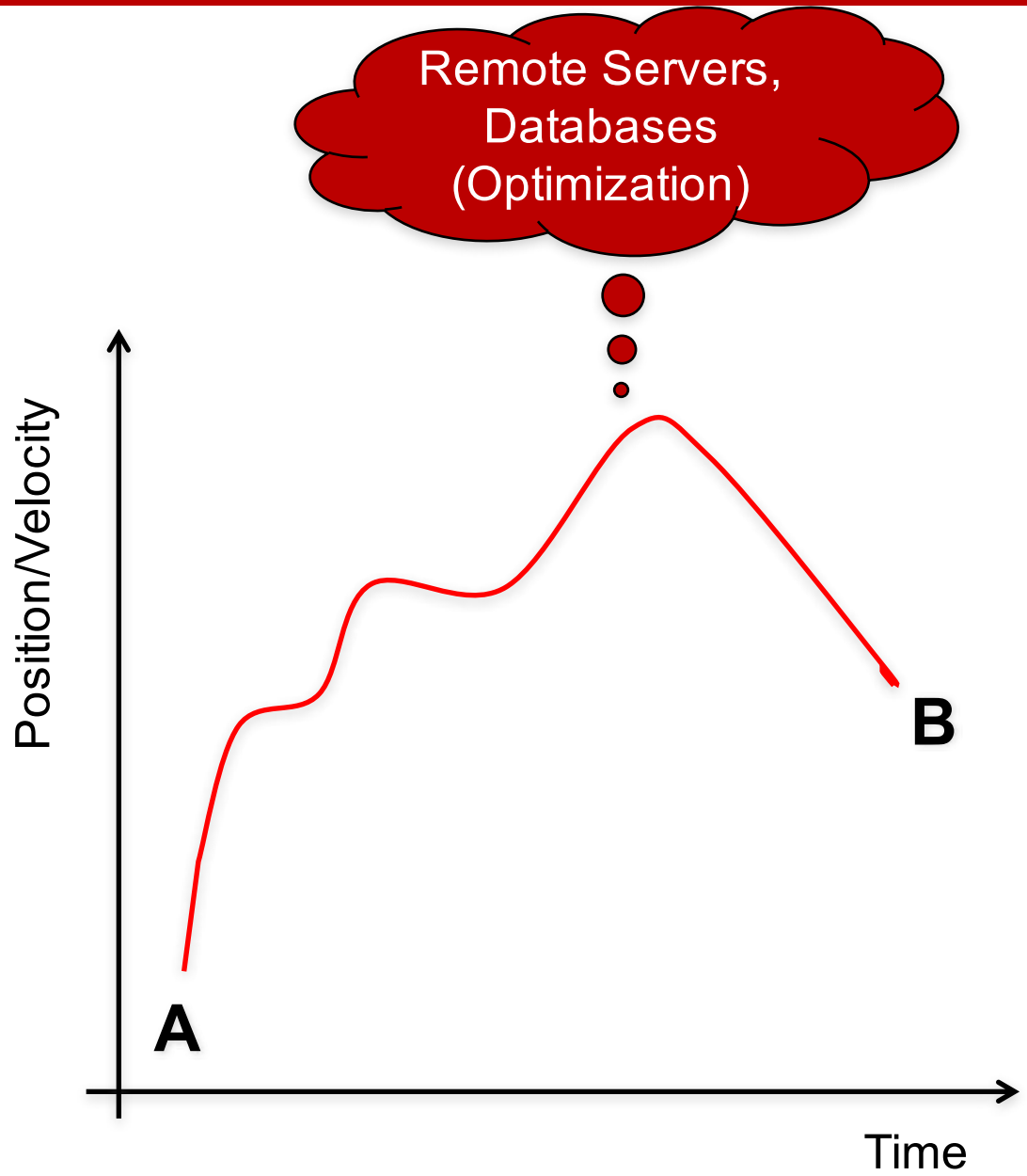

Objective:

Move the vehicle from position A to B minimizing fuel consumption over the trip.

Process:

Build a velocity profile based upon the GIS, online traffic, speed limits, traffic light timings, stop sign information stored in large databases.

To find the optimal solution to move the vehicle from position A to B, a vehicle simulator on the cloud side is used to solve a *dynamic programming* problem which uses all the traffic and GIS information problem

OPTIMIZATION PROBLEM FORMULATION

- State: velocity (v) $\longrightarrow$ $\dot{v} = f(v, F_{trac})$
- Independent variable: distance (D)

- Performance Index : $\min_{u \subset U} \int_0^{D_f} \dot{m}_f (T_{ice}, \omega_{ice})\, dD$

- Control input: Engine torque $\longrightarrow T_{ice} = \begin{matrix} T_{ice\_\min} \\ \vdots \\ T_{ice\_\max} \end{matrix}$

- Constraints:

$v(0) = 0; v(D_f) = 0$ Boundary conditions

$$\left(dv/_{dD}\right)_{min} < \left(dv/_{dD}\right) < \left(dv/_{dD}\right)_{max}$$

$$0 < v < v_{max}(D)$$

Where D_f is the length of the trip (distance from A to B)

Maximum velocity is function of distance, it changes according to the location of intersection, stop sign, traffic flow etc.

CLOUD COMPUTING ENVIRONMENT

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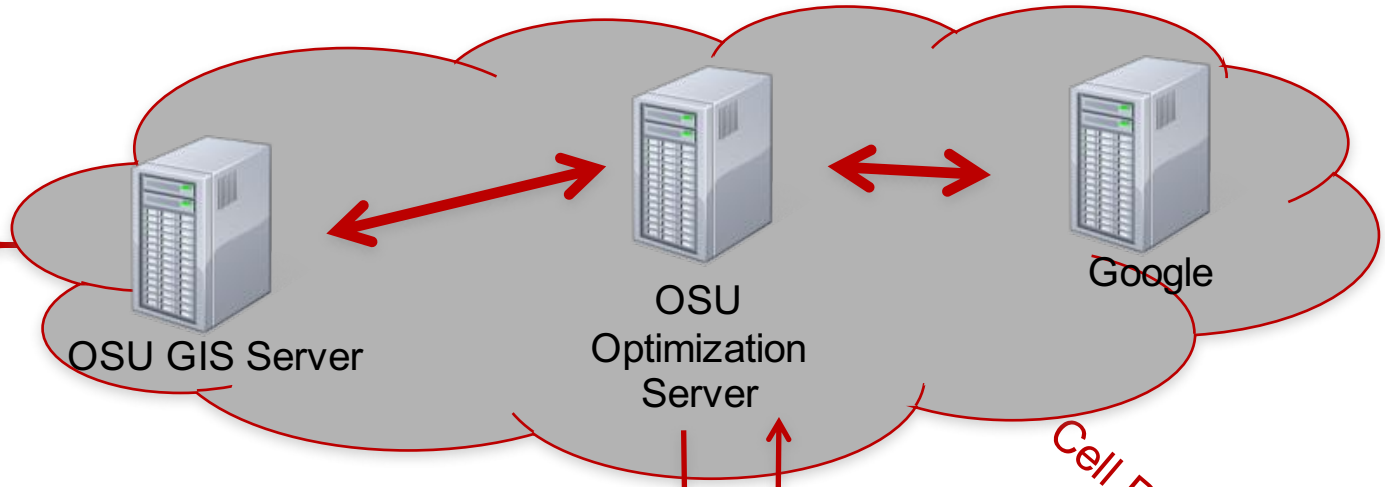
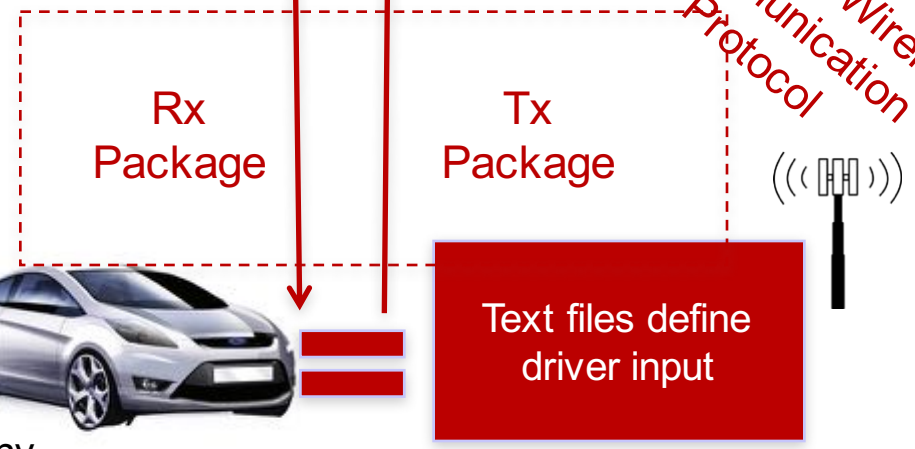
1. Routing Data
2. Road Grade
3. Traffic Information
   - Speed Limits
   - Statistical Average Speed
   - Measured Average Speed
   - Stop Signs
   - Traffic Light Timing



Cell Phone Wireless Communication Protocol



Legend:
ArcGIS Server
Google Maps API
Navteq, Historical Traffic Model, Local Transportation Departments

Auto with:
Laptop
Small Display
GPS Receiver
CAN-to-USB Conv.
4G Capable Int. Con.

TEST VEHICLE

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Fully Equipped Test Vehicle

- Lincoln MKS provided by Ford.
- GPS Receiver
- CAN-to-USB Converter
- 4G Capable USB Modem
- Screen
- Laptop

Continuously Receives Data from ECU and GPS (Data Fusion)

Communication with Server

- Capable of sending information to server
- Receives optimal velocity profile

Continuous Position Synchronization

- Accurately shows advised velocity at correct position.

Ozatay, E., Onori, S., Wollaeger, J., Ozguner, U., Rizzoni, G., Filev, D., Michelini, J., Di Cairano, S. "Cloud-Based Velocity Profile Optimization for Everyday Driving: A Dynamic Programming Based Approach", IEEE Transactions on Intelligent Transportation Systems, Vol. 16, Issue 6, Dec. 2014.

HIGHWAY ROUTE EXAMPLE

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Route Type	Highway
Total Distance	25 miles

	Total Fuel Consumption [gal]	Fuel Economy Improvement [%]
Natural Driving June 8th	1.036	**12.9**
Advisor Following June 8th	0.9024	
Advisor Following July 6th	0.884	**14.7** **(Compared to actual baseline of test June 8th)**
Average Fuel Economy Improvement		**13.8**

TEST RESULT: BASELINE JUNE 8TH

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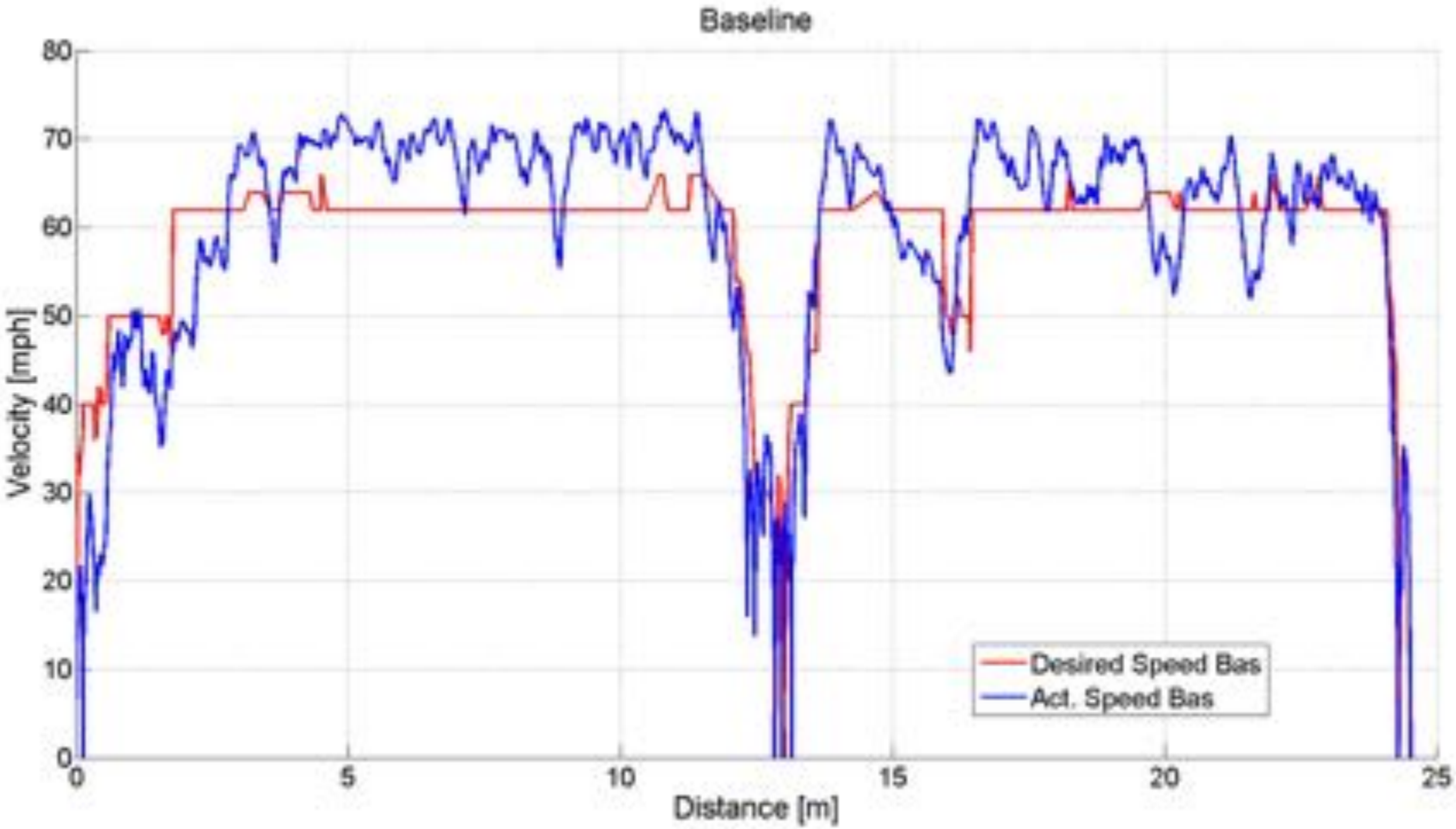
Baseline Velocity Profile (Test of June 8, **Driver:** E. Ozatay, # of Passengers = 2)



TEST RESULT: ADVISORY JUNE 8TH

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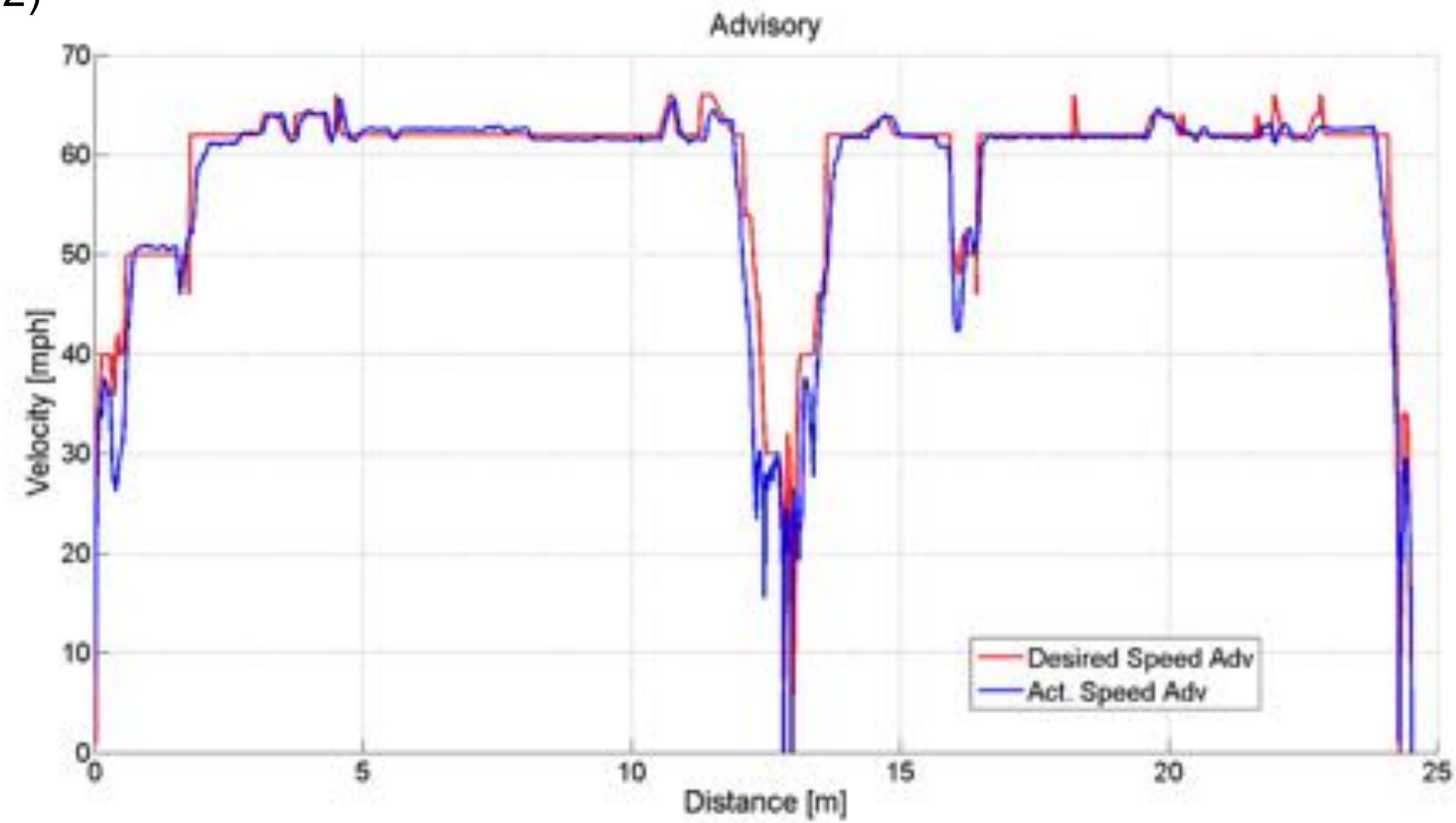
Advisory Velocity Profile (Test of June 8, **Driver:** E. Ozatay, # of Passengers = 2)



TEST RESULT: ADVISORY JULY 6TH

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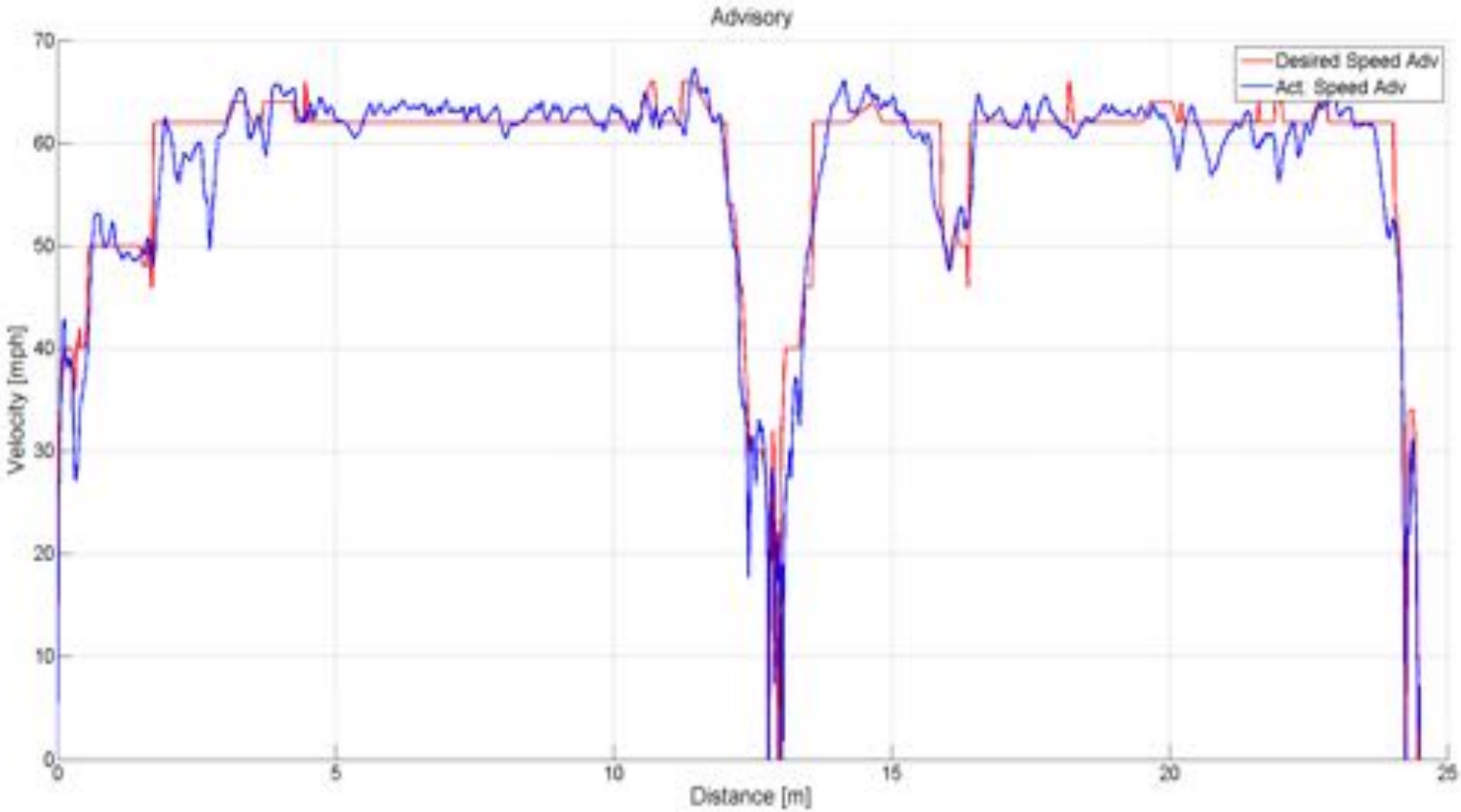
Advisory Velocity Profile (Test of July 6, **Driver:** J. Michelini, # of Passengers = 2):



TEST RESULTS COMPARISON

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	Total Fuel Consumption [gal]	Fuel Economy Improvement [%]
Natural Driving June 8th	1.036	12.9
Advisor Following June 8th	0.9024	
Advisor Following July 6th	0.884	14.7 (Compared to actual baseline of test June 8th)
Average Fuel Economy Improvement		13.8

URBAN ROUTE EXAMPLE

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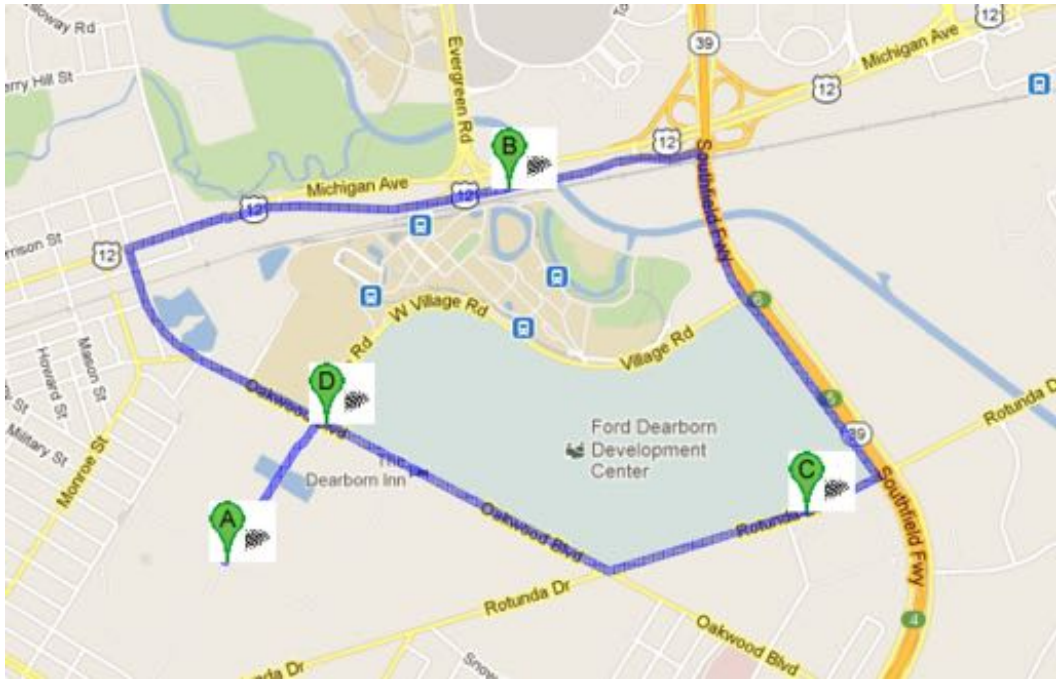
Dearborn short route

- 5.4 miles
- Urban, freeway combined route
- 8 different drivers performed 2 sets of tests
  - Natural driving
  - Advisor following
- Tests performed with 2 passengers



TEST RESULTS

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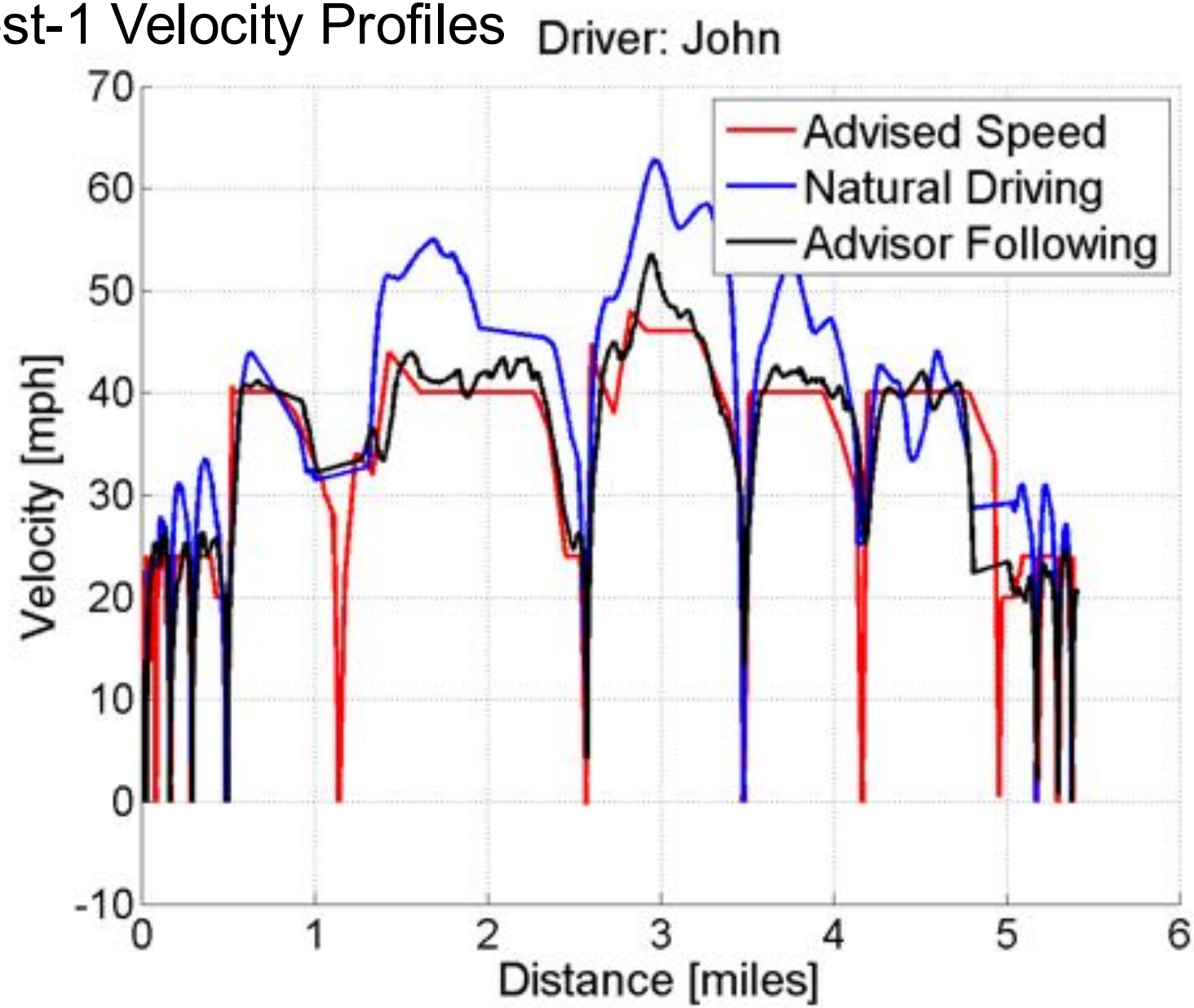
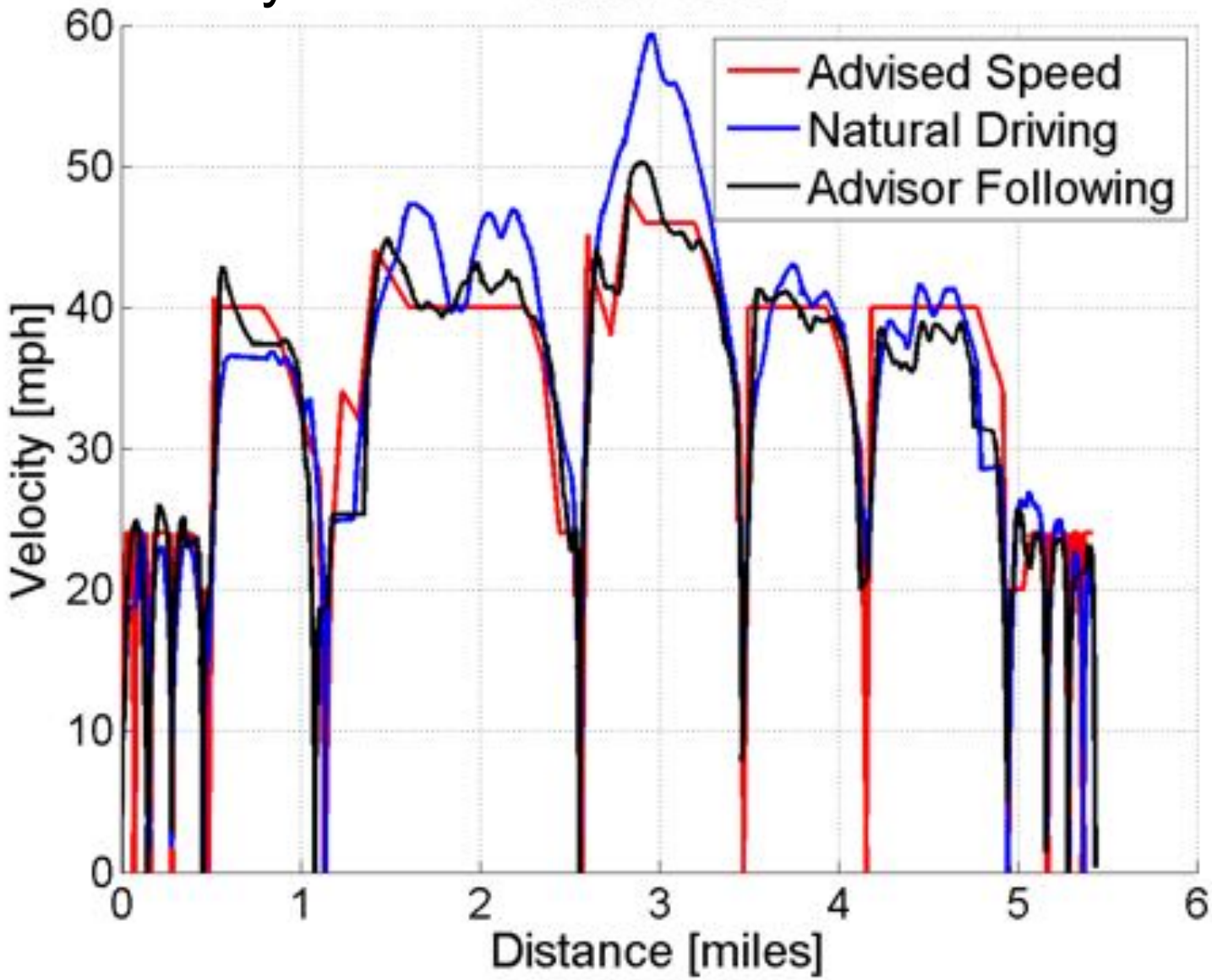
Test-1 Velocity Profiles



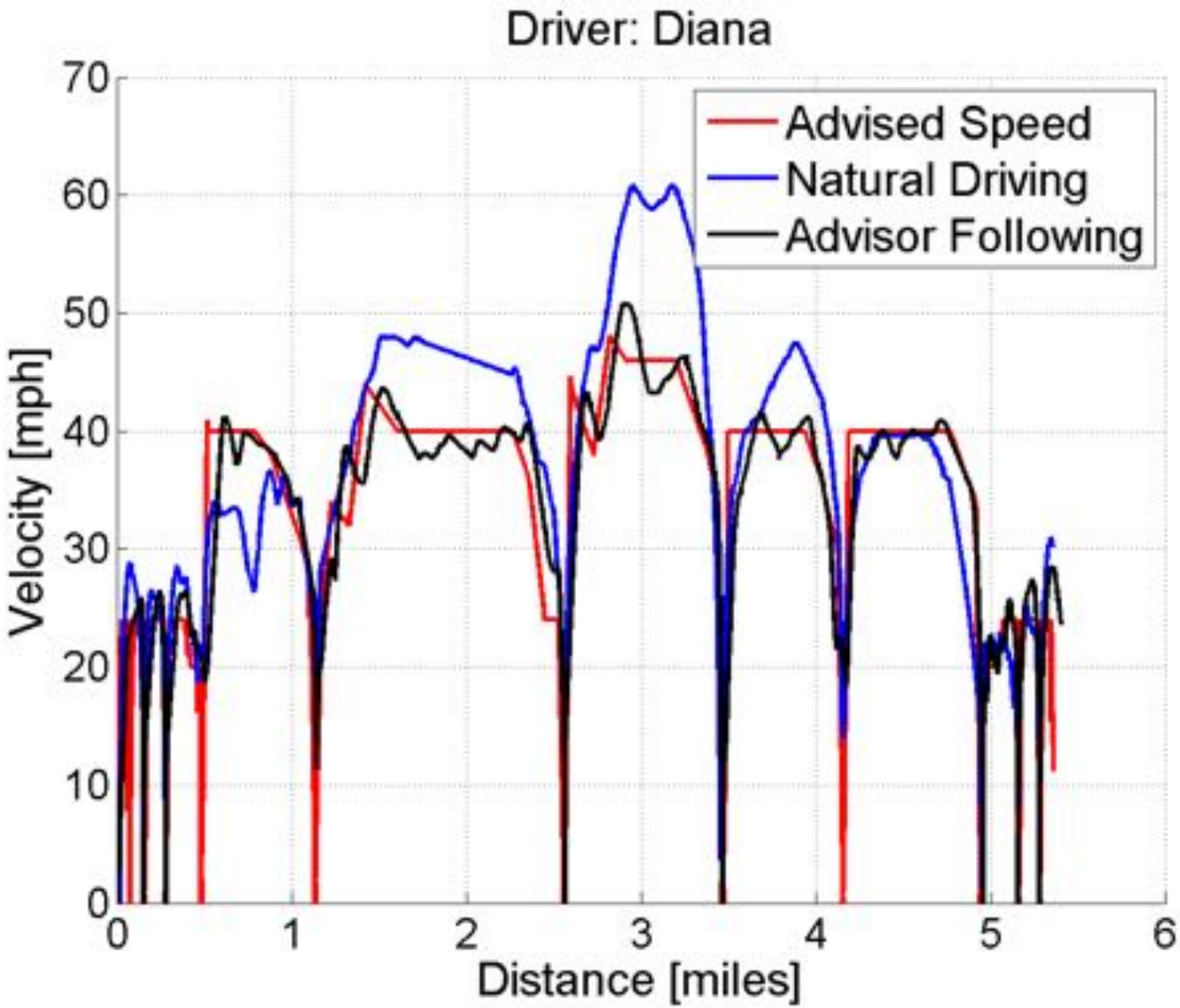
TEST RESULTS

Test-2 Velocity Profiles Driver: Steve

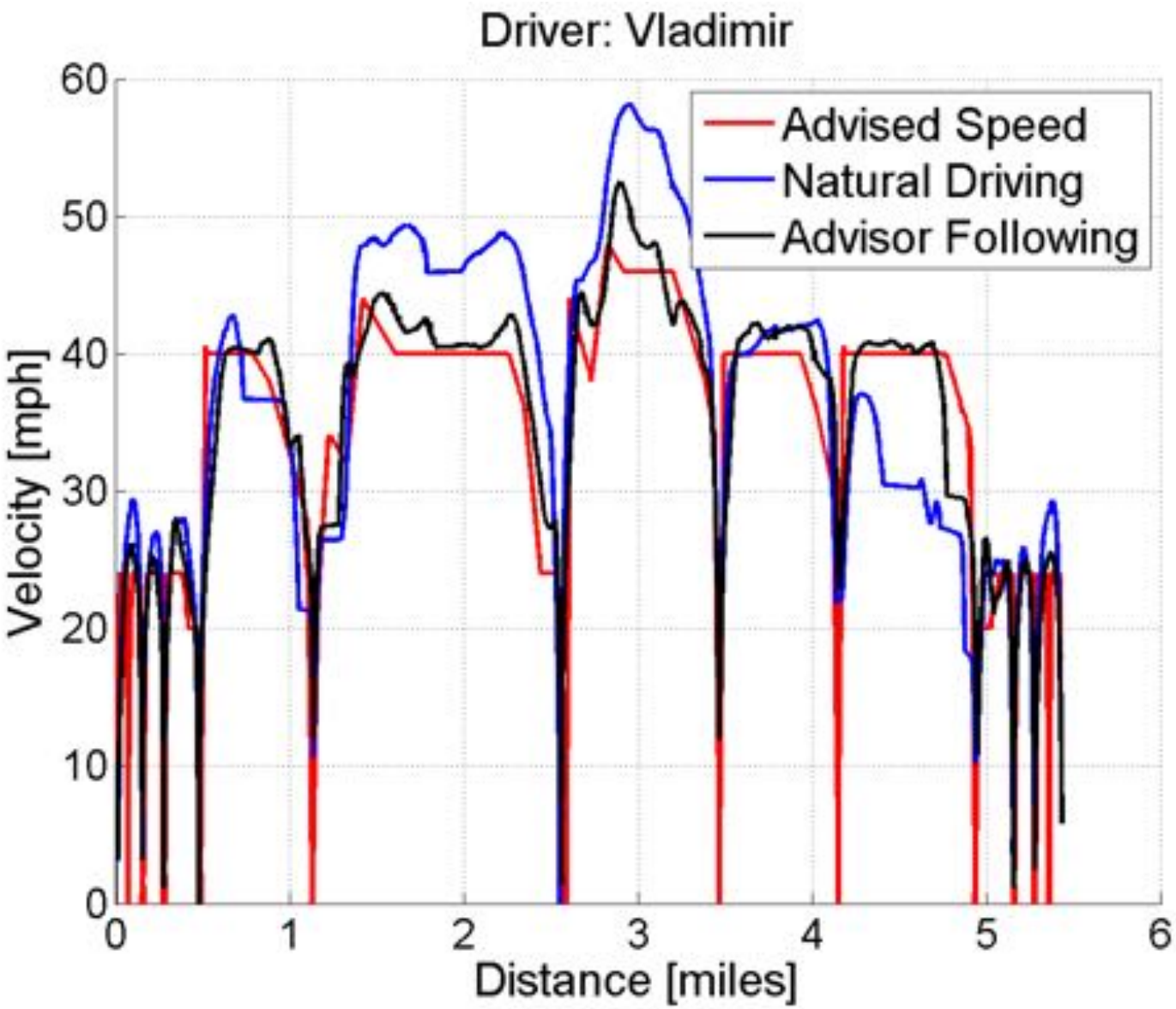


TEST RESULTS

Test-3 Velocity Profiles



Test-4 Velocity Profiles



TEST RESULTS

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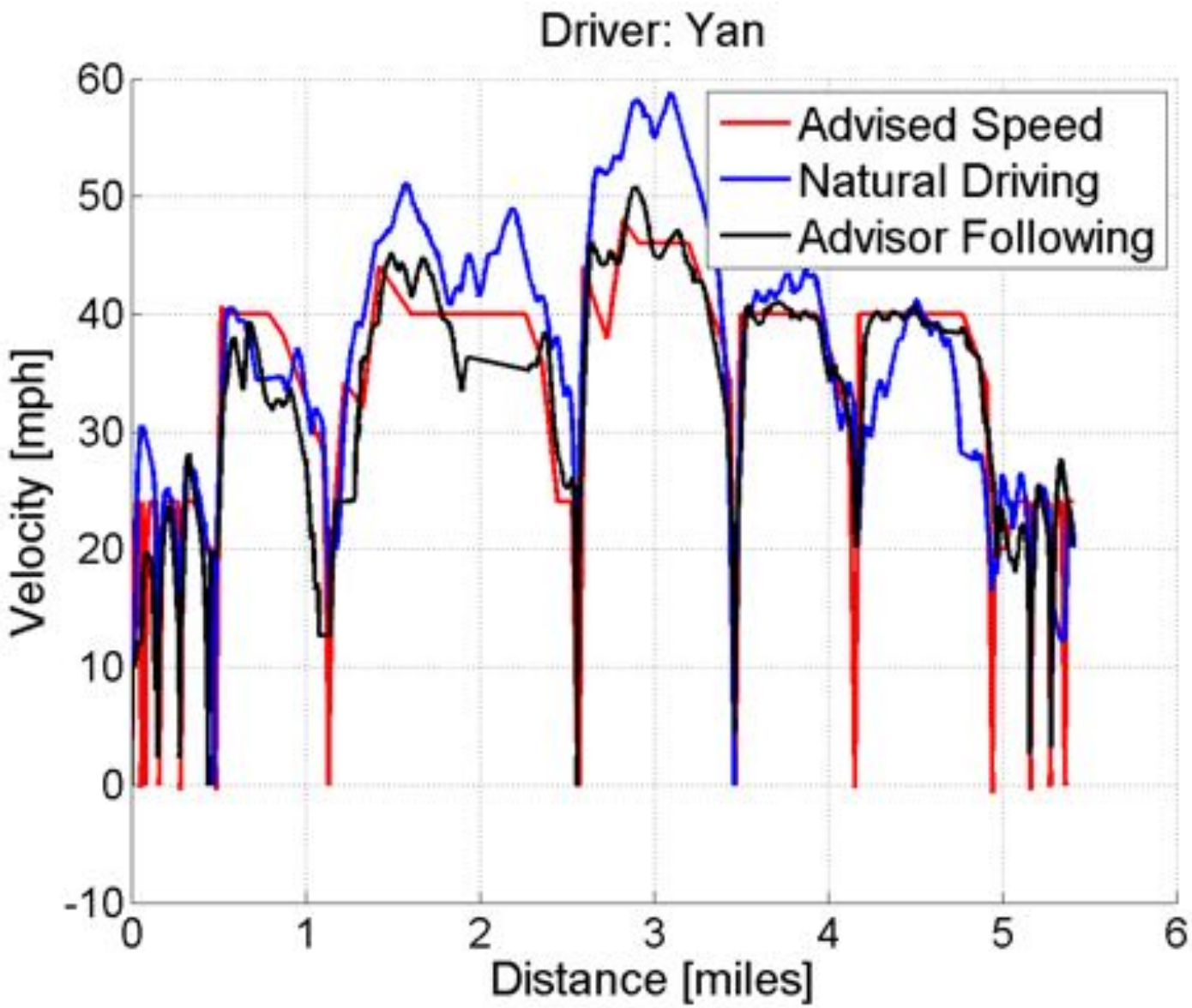
Test-5 Velocity Profiles



TEST RESULTS

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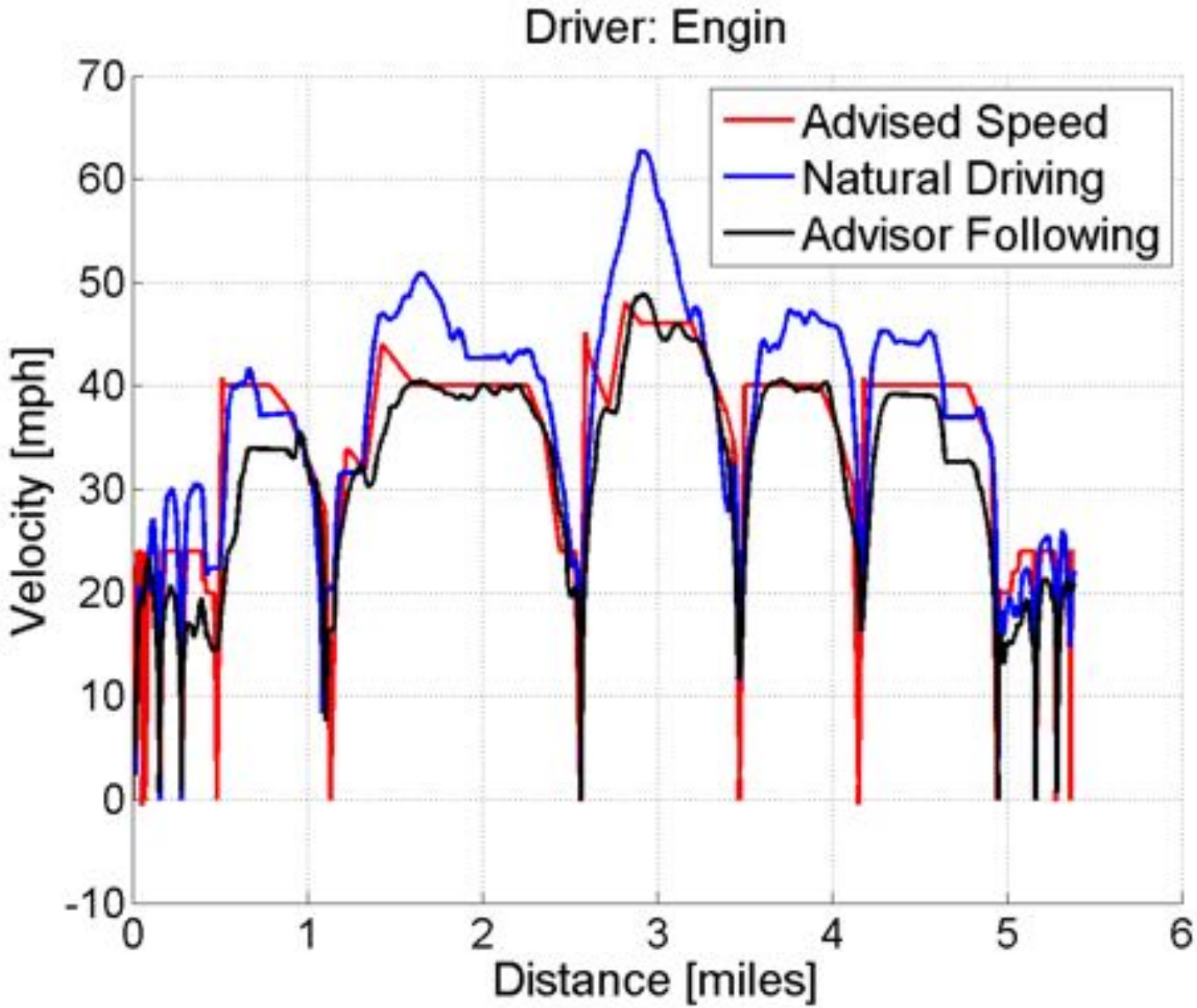
Test-6 Velocity Profiles



TEST RESULTS

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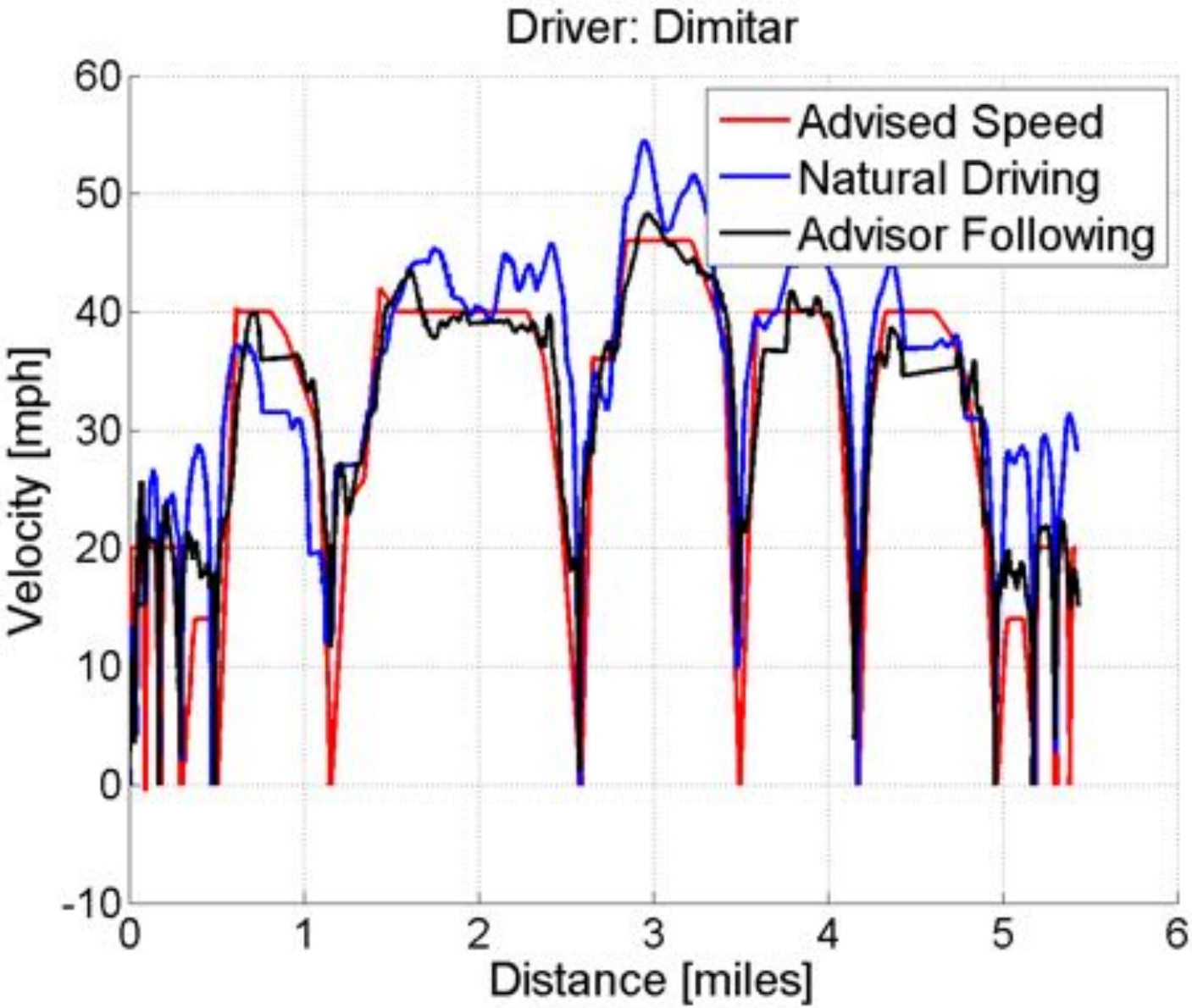
Test-7 Velocity Profiles



TEST RESULTS (URBAN DRIVING)

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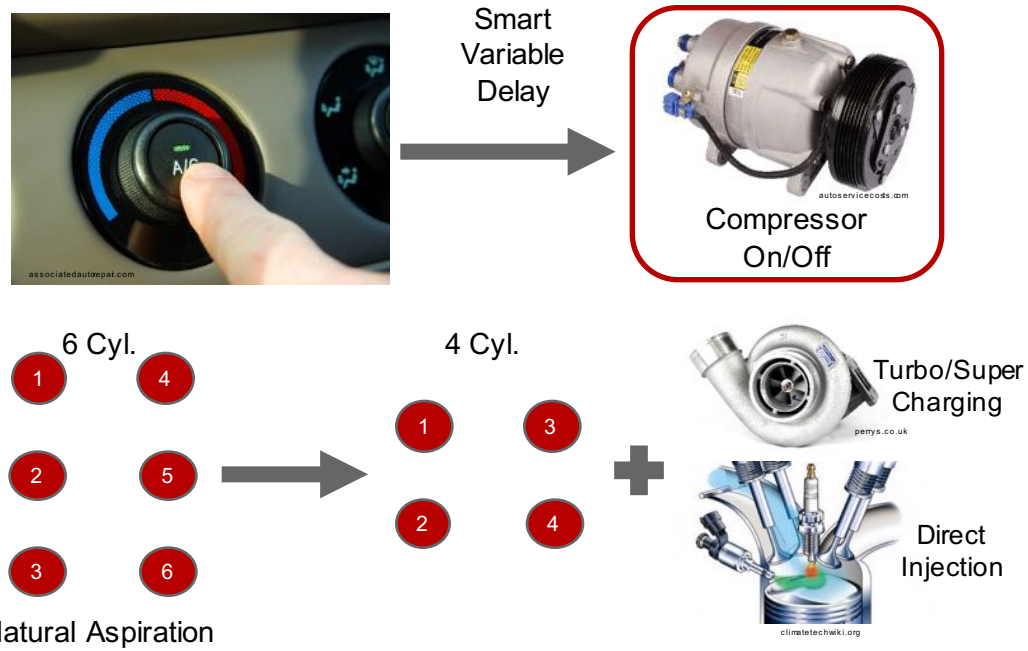
		Test1	Test2	Test3	Test4	Test5	Test6	Test7	Average
Meas. Fuel Econ. [mpg]	Advisor Follow.	20.8	21.0	20.8	21.5	21.5	22.8	19.6	21.1
	Natural Driving	19.4	19.8	19.7	20.2	20.3	20.7	17.8	19.7
IMPROV. [%]		7.2	5.8	6.2	6.3	5.8	10.0	10.2	7.4
Theor. Fuel Econ. [mpg]	Advisor Follow	22.3	21.5	24.3	25.6	23.7	25.9	25.9	24.1
	Natural Driving	20.2	20.1	24.0	23.7	23.3	21.6	21.6	22.0
IMPROV. [%]		10.4	7.2	1.0	7.9	1.5	19.9	19.9	9.7

LET'S GO UNDER THE HOOD…

UNDER THE HOOD (POWERTRAIN AND ACCESSORIES)

Further Development of Existing Technology

- Ultra-**lean operation** from advanced boosting, fueling, and ignition systems
- Control of **auxiliary load timing**
- **Dilution** through air or EGR
- **Variable compression** ratio engines
- Very **high compression** with knock mitigation
- **Low temperature combustion**,dual fuel or reactivity controlled combustion

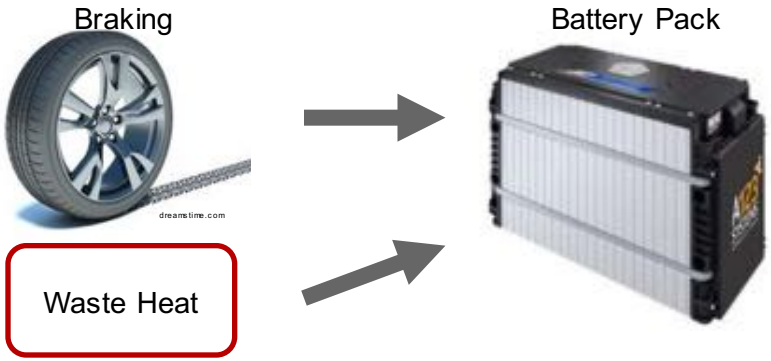


http://arpa-e.energy.gov/sites/default/files/02_Atkinson_Powertrain_Innovations.pdf

UNDER THE HOOD (POWERTRAIN AND ACCESSORIES)

Further Development of Existing Technology, cont.

- Friction, pumping loss, and auxiliary **load reduction**
- **Thermal loss reductions** (reduced surface area available for heat transfer)
- Automatic engine **stop/start**
- Waste heat and direct **energy recovery** systems
- **Hybridization** (eAssist, start/stop, regenerative braking, engine transient management, …)



http://arpa-e.energy.gov/sites/default/files/02_Atkinson_Powertrain_Innovations.pdf

UNDER THE HOOD (POWERTRAIN AND ACCESSORIES)

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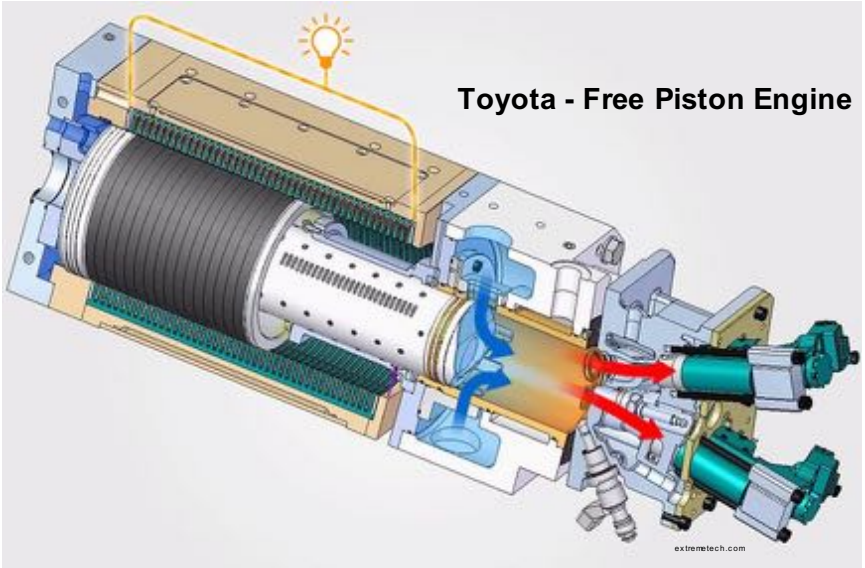
New engine architectures

- **Free piston** engines
- **Split-cycle** engines
- Entirely **new** thermodynamic and combustion **cycles**

New engines and powertrain operating systems

- **Variable displacement** engines
- **Intermittent operation** engines
- **Integration** with electric machines or other **hybrid systems**



http://arpa-e.energy.gov/sites/default/files/02_Atkinson_Powertrain_Innovations.pdf

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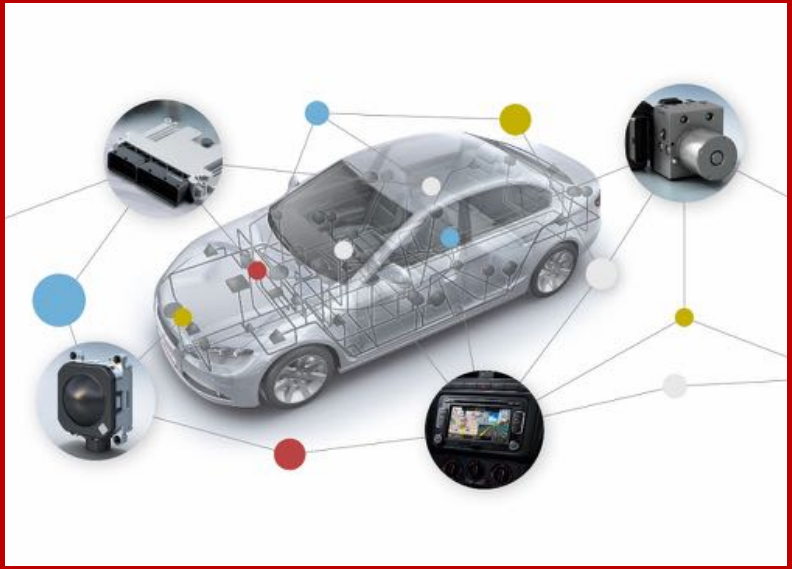
HOW CAN ADVANCES IN CONNECTED AND AUTOMATED VEHICLE TECHNOLOGY BE LEVERAGED?



GOAL – FUEL ECONOMY IMPROVEMENT

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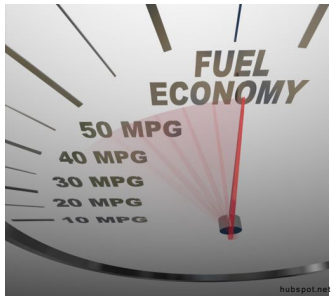
- Advances in CAV technology **enable information** on destination, terrain, traffic signals, weather, other vehicles, etc. to be **readily available** at the **individual car level**
- How can advancements in CAV technology be leveraged for **powertrain control** to **improve fuel economy**?



LEVELS OF CONNECTIVITY

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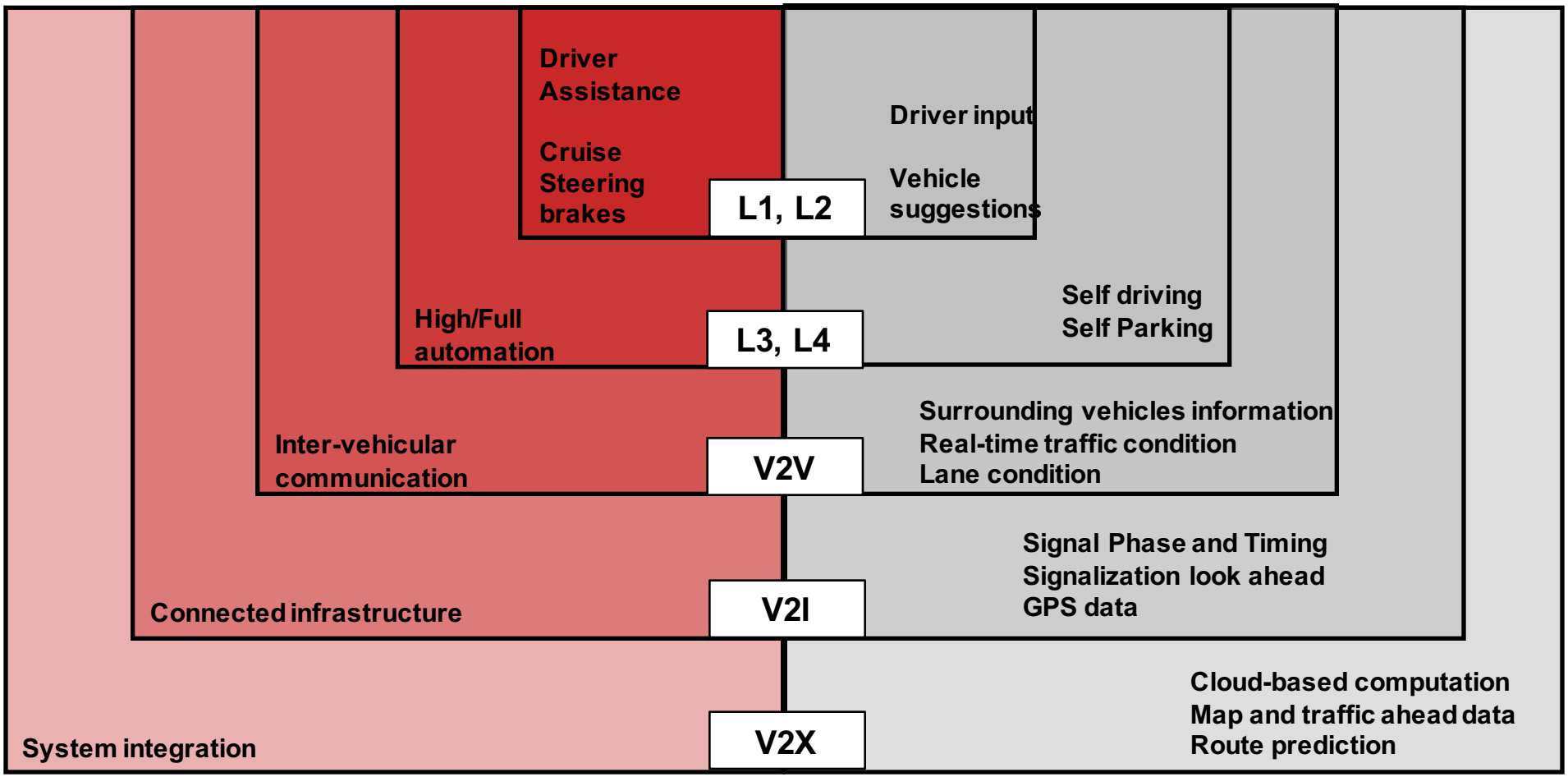

RECENT ADVANCES LEVERAGING CAV TO ENHANCE FUEL ECONOMY

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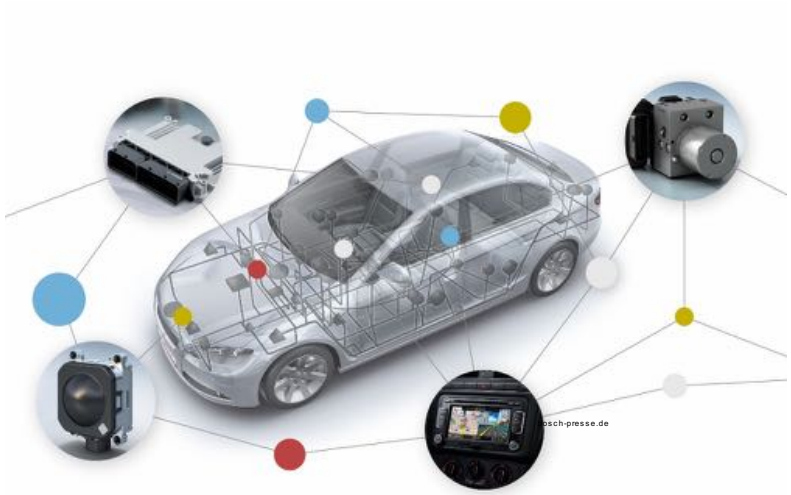
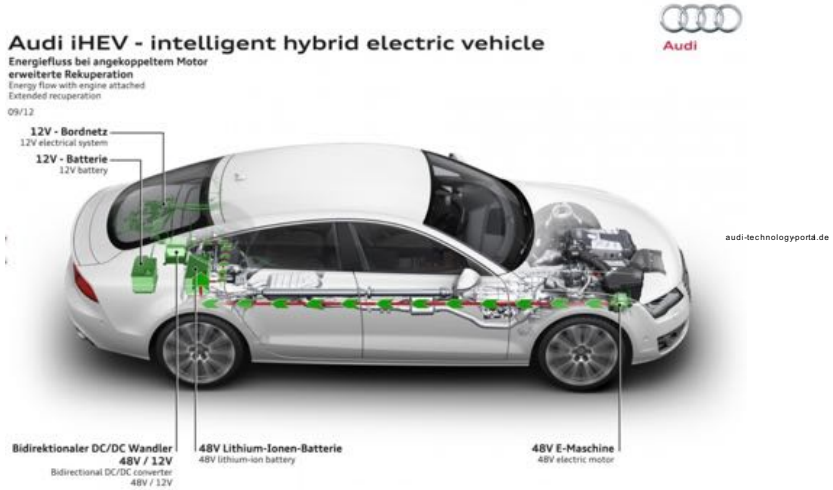
Commercially Available Technology

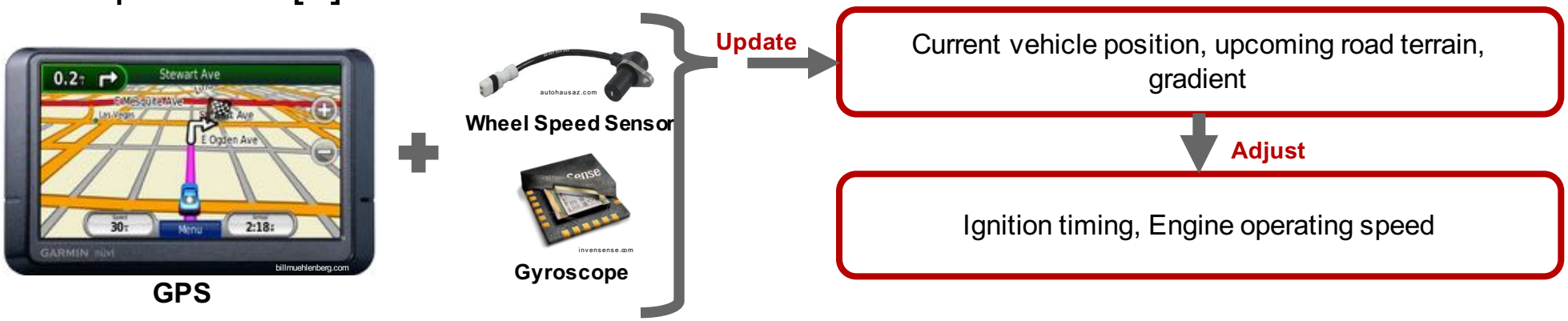
- Bosch Electronic Horizon: Predicts required drive energy and controls the engine
- Audi Predictive Efficiency Assistant: Look-ahead GPS control of hybrid (energy management)
- AVL Connected Powertrain: Simulation tools for OEM implementation





RECENT ADVANCES LEVERAGING CAV TO ENHANCE FUEL ECONOMY

- GPS to update and replace road information, adjusting engine control parameters
  - Neuro-Fuzzy derived relief map of test route [6]
- Vehicle position estimation
  - Road slope aid through sensor fusion of GPS and onboard sensors [7]
- Energy management strategy through slope preview
  - Model predictive control with numerical computation for high efficiency operation [8]



6. Lee et al, Intelligent GPS-based predictive engine control for a motor vehicle, International Journal of Hybrid Intelligent systems (2010)
7. Kichun at al, Road slope aided vehicle position estimation system based on sensor fusion of GPS and automotive onboard sensors, IEEE Transactions on Intelligent Transportation Systems (2016)
8. Yu et al, Model predictive control of a power-split hybrid electric vehicle system with slope preview, Artificial Life and Robotics (2015)

RECENT ADVANCES LEVERAGING CAV TO ENHANCE FUEL ECONOMY

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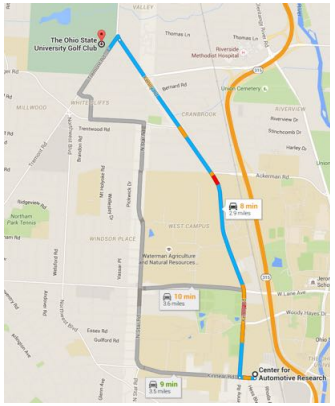
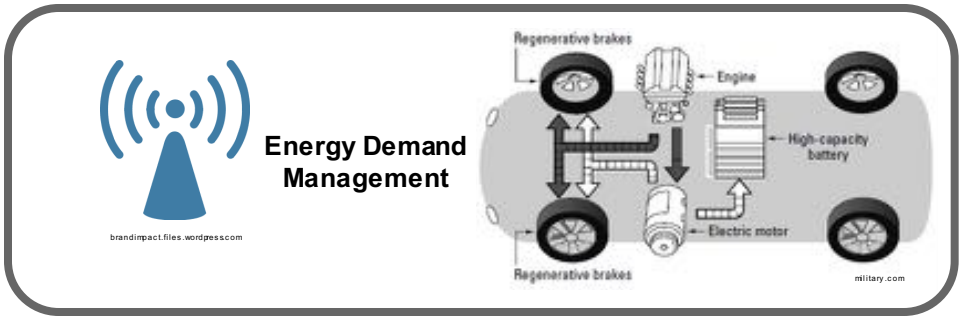
- Trip based power demand distribution in hybrids
  - Driving pattern-based dynamic programming with feedback control for application [9]
  - Deterministic dynamic programming with penalties for fuel consumption [10]
- Traffic data to improve hybrid energy management
  - Neural network model and adaptive equivalent consumption minimization strategy [11]
  - Data-enabled predictive energy management framework [12]



Trip Data

Historical Traffic Data



Individual Vehicle

9. Yu et all, Trip-oriented energy management control strategy for plug-in hybrid electric vehicles, IEEE Transactions on Control Systems Technology (2014)
10. Patil et al, Comparison of supervisory control strategies for series plug-in hybrid electric vehicle powertrains through dynamic programming, IEEE Transactions on Control Systems Technology (2014)
11. Tianheng et al, A supervisory control strategy for plug-in hybrid electric vehicles based on energy demand prediction and route preview, IEEE Transactions on Vehicular Technology (2015)
12. Sun et al, Dynamic traffic feedback data enabled energy management in plug-in hybrid electric vehicles, IEEE Transactions on Control Systems Technology (2015)

RECENT ADVANCES LEVERAGING CAV TO ENHANCE FUEL ECONOMY

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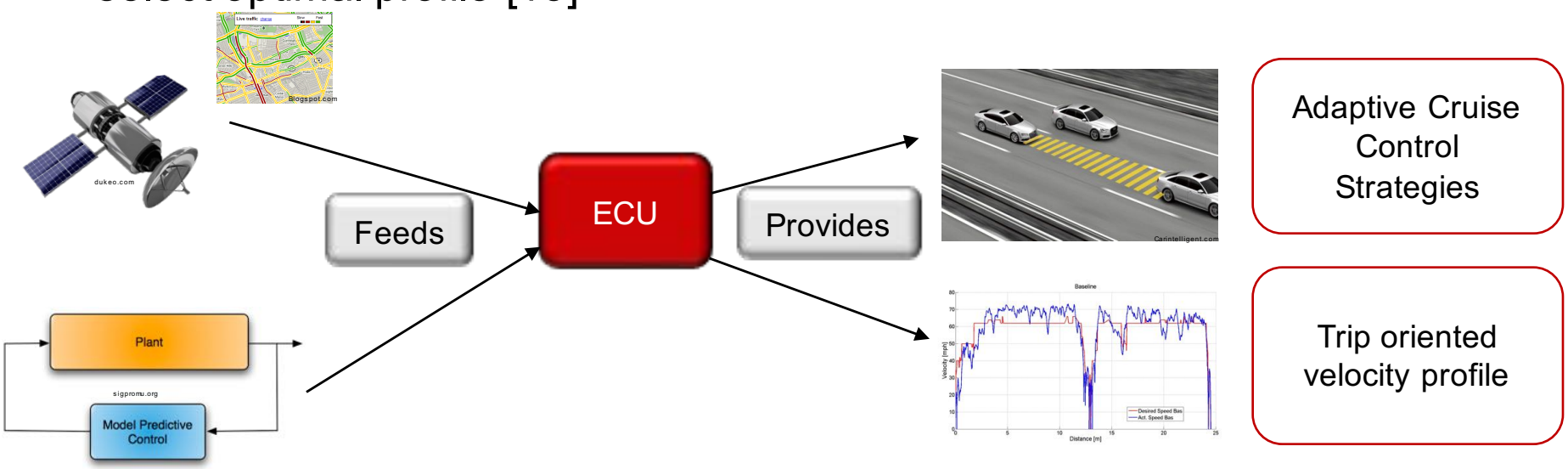
Advances in Literature, cont.

- Adaptive cruise control
  - Nonlinear model predictive control [13]
  - Intelligent: traffic, fuel economy, ride comfort [14]
- Velocity trajectory optimization through look-ahead
  - Satellite navigation, vehicle mass, and road load parameters to estimate and select optimal profile [15]



13. Vajedi et al, Ecological adaptive cruise controller for plug-in hybrid electric vehicles using nonlinear model predictive control, IEEE Transactions on Intelligent Transportation Systems (2016)
14. Luo et al, Intelligent hybrid electric vehicle ACC with coordinated control of tracking ability, fuel economy, and ride comfort, IEEE Transactions on Intelligent Transportation Systems (2015)
15. Keulen at al, Velocity trajectory optimization in hybrid electric trucks, American Control Conference (2010)

POTENTIAL APPLICATIONS FOR POWERTRAIN CONTROL

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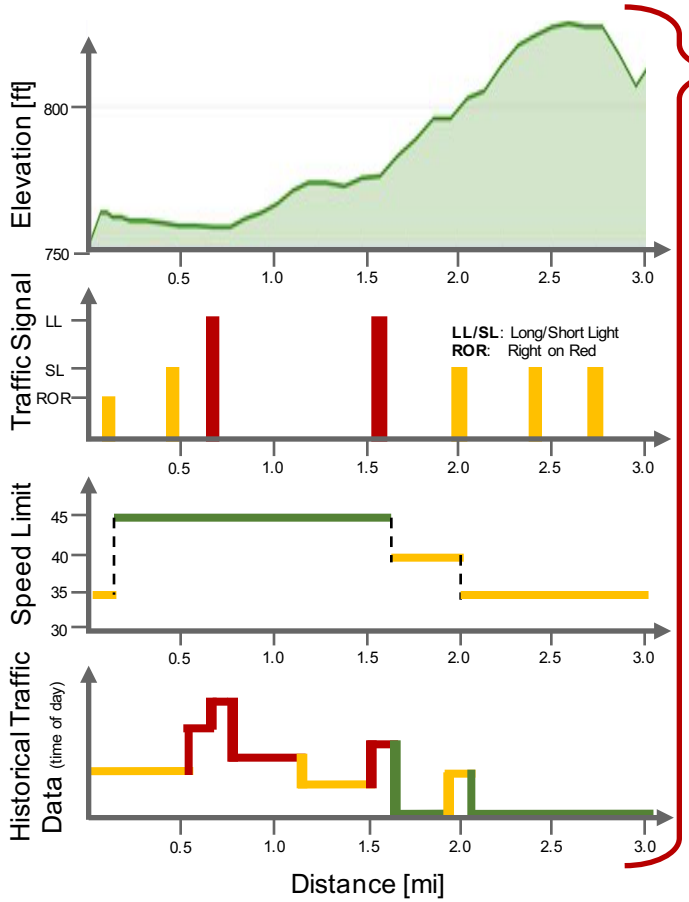
Further **shape the driving cycle** – end goal of removing the driver from the loop completely

Trip Data from GPS



V2I

- **Current and future terrain**
- **Real-time and historical traffic information**
- **Traffic signal phase and timing**
- **Critical crash scenarios**
- **Priority assignment for emergency vehicles**
- **Commercial vehicle enforcement**
- **Intersection safety**

V2V

- **Position**
- **Velocity**
- **Steering-wheel position**
- **Brake status**
- **Notice of action**
- **Right-of-way**

POTENTIAL APPLICATIONS FOR POWERTRAIN CONTROL

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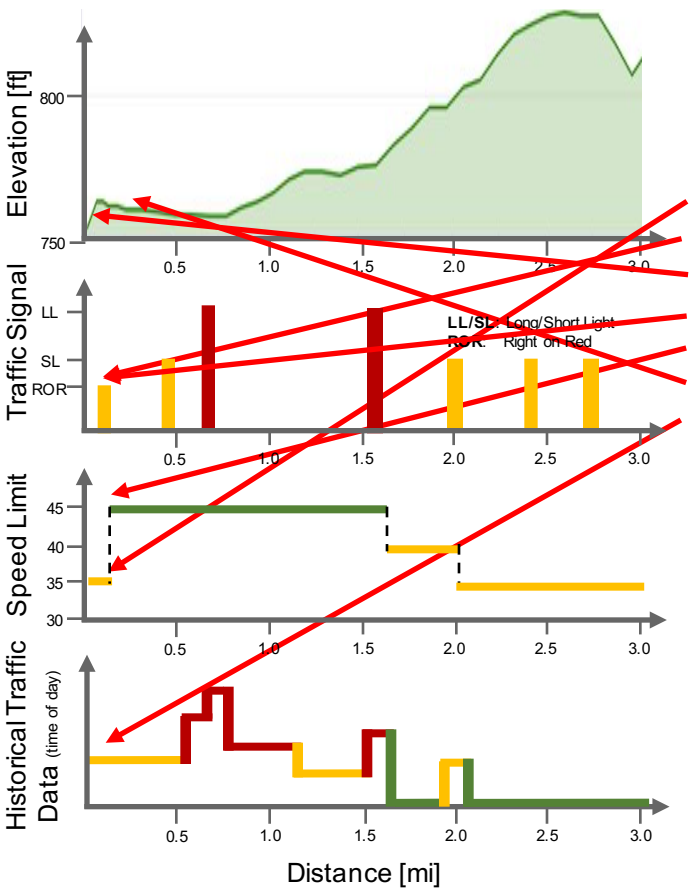
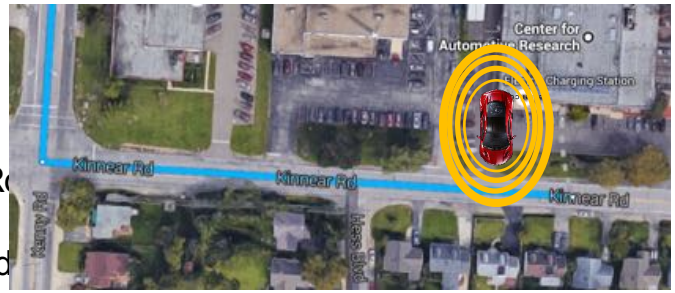
Further **shape the driving cycle** – end goal of removing the driver from the loop completely





Interface Information

- Right turn into traffic (onto Kinnear R
- Speed limit 30 MPH
- Traffic signal 555 ft ahead (Kenny Rd
- Elevation gain of 14 ft
- Able to turn right at traffic signal (pending traffic)
- Speed limit will be 45 after turn
- Elevation will decrease (<1%) after turn
- Traffic typically moderate on Kinnear Rd. (2 PM on Friday)

Real-Time Information

- Traffic currently moderate on Kinnear Rd. (train recently stopped traffic), may be difficult for initial right turn onto Kinnear Rd.
- Traffic signal currently red, will turn green in 7 seconds
- Traffic waiting for light at Kenny (not able to turn right as lead car is continuing on Kinnear)
- Weather: Temp. 77 F, Humidity 57%, Skies Cloudy, Wind 15-20 MPH SSW, Road Status - dry
- Emergency vehicle 2.3 mi SE on Olentangy River Rd. – will need Kinnear Rd. open (87% chance traffic signal and traffic will allow your clearance)
- Train 15 mi S, heading N, will cause delays on Kinnear in ~4 min 25 sec
- Gap of 50 ft between 2nd and 3rd vehicle traveling W on Kinnear – 3rd vehicle slowing down and enabling your entrance onto road

POTENTIAL APPLICATIONS FOR POWERTRAIN CONTROL

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From V2V and V2I information, both real time and historical, how should the powertrain be controlled for optimal fuel economy?

Interface Information

- Right turn into traffic (onto Kinnear Rd.)
- Speed limit 30 MPH
- Traffic signal 555 ft ahead (Kenny Rd.)
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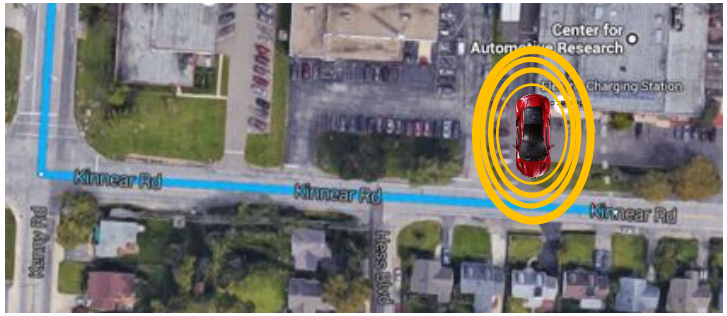
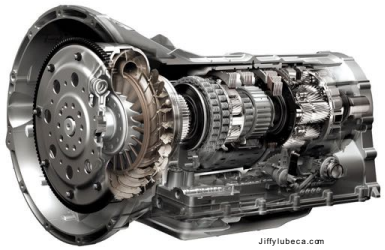
- Train 15 mi S, heading N, will cause delays on Kinnear in ~4 min 25 sec
- Gap of 50 ft between 2nd and 3rd vehicle traveling W on Kinnear – 3rd vehicle slowing down and enabling your entrance onto road

- Engine off until gap between 2nd and 3rd vehicle
- Use battery to smooth acceleration torque request on start (battery at full capacity)
- Minimal regenerative braking possible with traffic signal distance, traffic, speed
- Cylinder deactivation enabled due to small duration with expected wait for signal
- Transmission remain in low gear due to traffic, only 555 ft until signal, elevation
- If gap closes or delayed entrance onto Kinnear Rd., remain stationary for emergency vehicle to pass
- With dry roads, moderate weather, and new tires traction should be sufficient for first gear and maximum of 88% torque request (vehicle in front, however, has a flat left rear tire – may cause slow acceleration)
- AC compressor should remain off, if possible, until after speed achieved on Kenny Rd. (elevation decrease), regenerative braking leading to signal at Woody Hayes Dr.



POTENTIAL APPLICATIONS FOR POWERTRAIN CONTROL

- Optimal transmission operation
  - Look-ahead to plan optimal gear selection depending on type of road, road gradient, speed limit,…
- Smart control of auxiliary loads
  - Reduce accessory load in moments of heavy road loads (e.g. steep road)
- Cloud-based computation capabilities
  - Cellular capabilities connect vehicle to cloud-based servers that can perform more advanced calculations
  - Limits the need for on-board computers and allows for virtually unlimited computation



SMART CITY

THE CITY OF COLUMBUS

ANDREW J. GINTHER, MAYOR

COLUMBUS, OHIO

WHAT IS THE SMART CITIES CHALLENGE?

THE OHIO STATE UNIVERSITY
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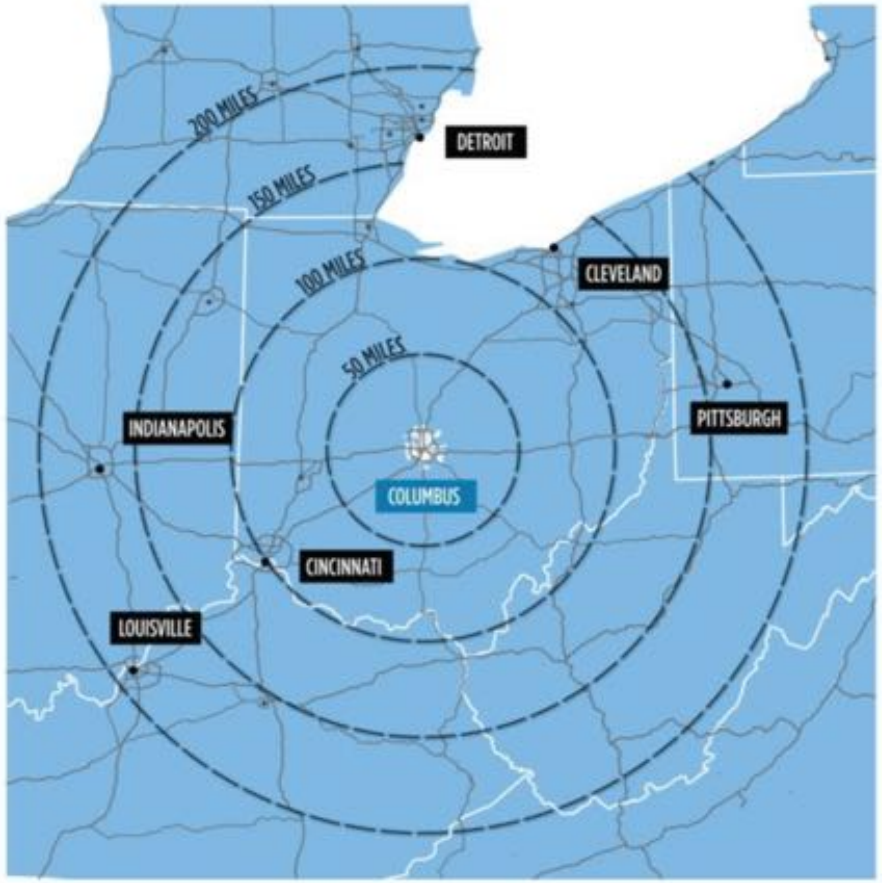
- The U.S. Department of Transportation (USDOT) will make an award of $40 Million to one mid-sized city (between 200,000 and 850,000) that can demonstrate the best vision for how advanced data, applications, and intelligent transportation systems (ITS) technologies can be used.
- Vulcan Inc. will contribute an additional $10 million to incorporate electric vehicle infrastructure.
- Mobileye will install driver assistance safety technology on every bus in the winning city.

Figure 4 Columbus in Context



COLUMBUS' VISION

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COLUMBUS APPLICATION

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Develop smart corridors to demonstrate the capability of intelligent infrastructure to improve transit service and efficiently

Enhance the timeliness and quality of the traffic condition data, complemented by a routing app for trucks to improve the reliability of our highway system for the movement and delivery of freight

Push real time information to users on traffic and parking conditions and transit options to minimize the impacts of concentrated travel demands associated with major events or incidents

Develop and deploy communication technology solutions to address the obstacles that low-income "unbanked"/cash-economy based residents and those who lack smartphone data services face in accessing and using shared and real-time transportation options and app-based services

Expand the usage of electric and smart vehicles through changes to policy and practice and the expansion of our Smart Grid in order to serve our energy and climate change objectives

THE PROCESS

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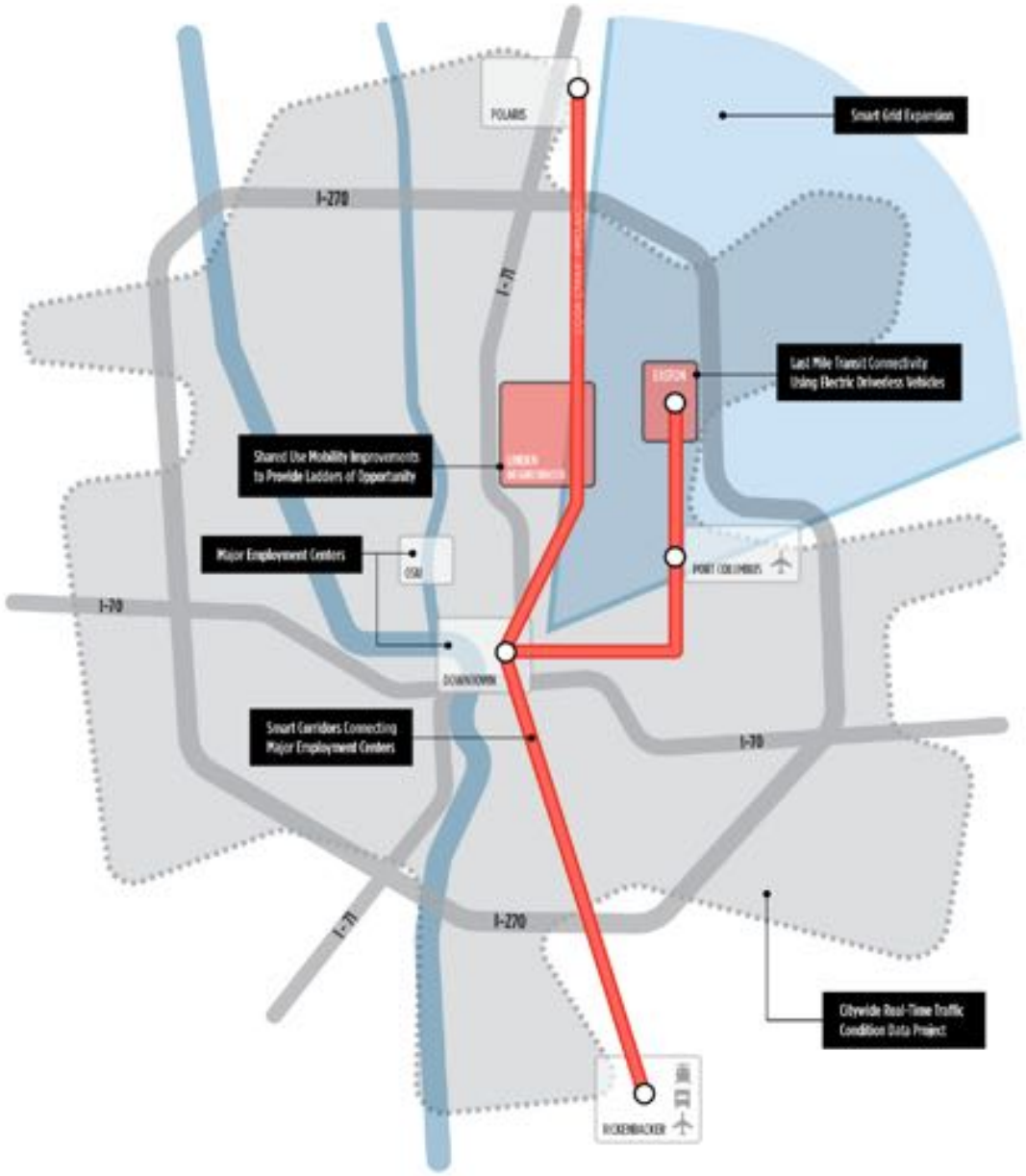

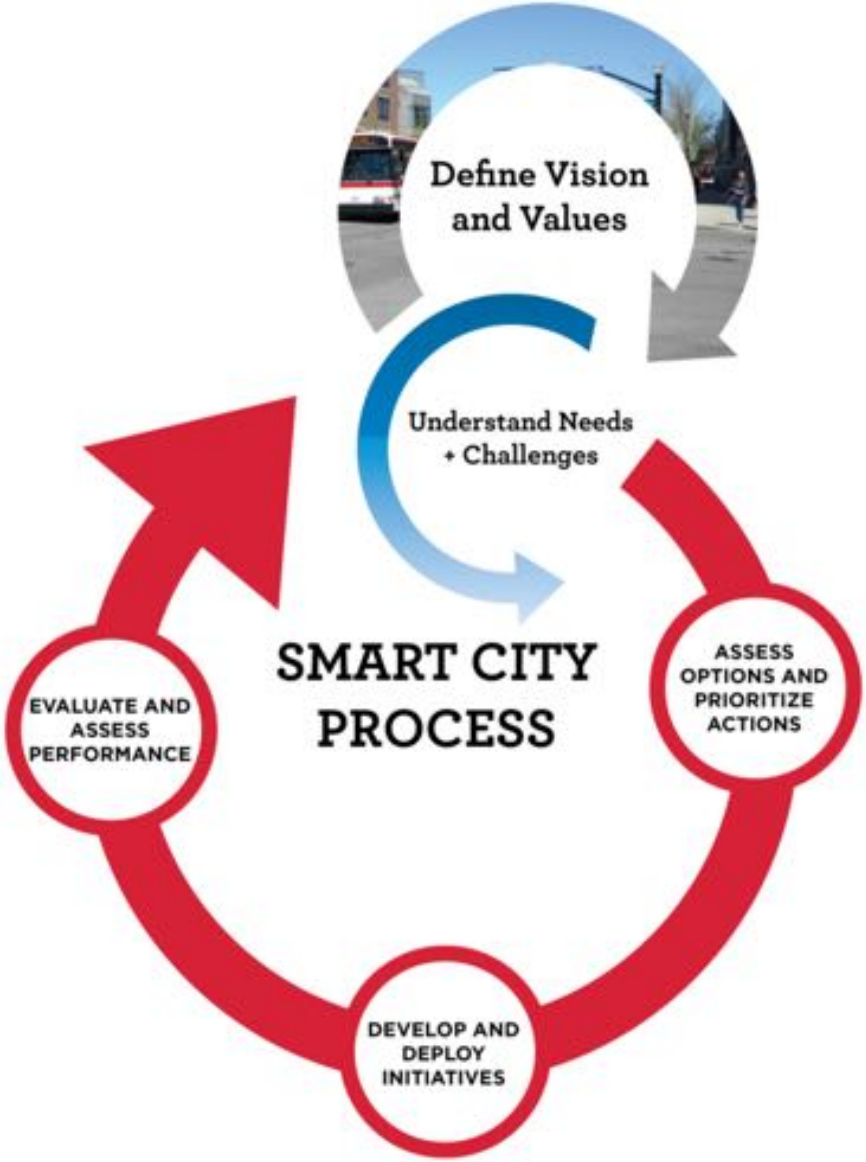

THE MISSION: REINVENTING THE AUTOMOBILE

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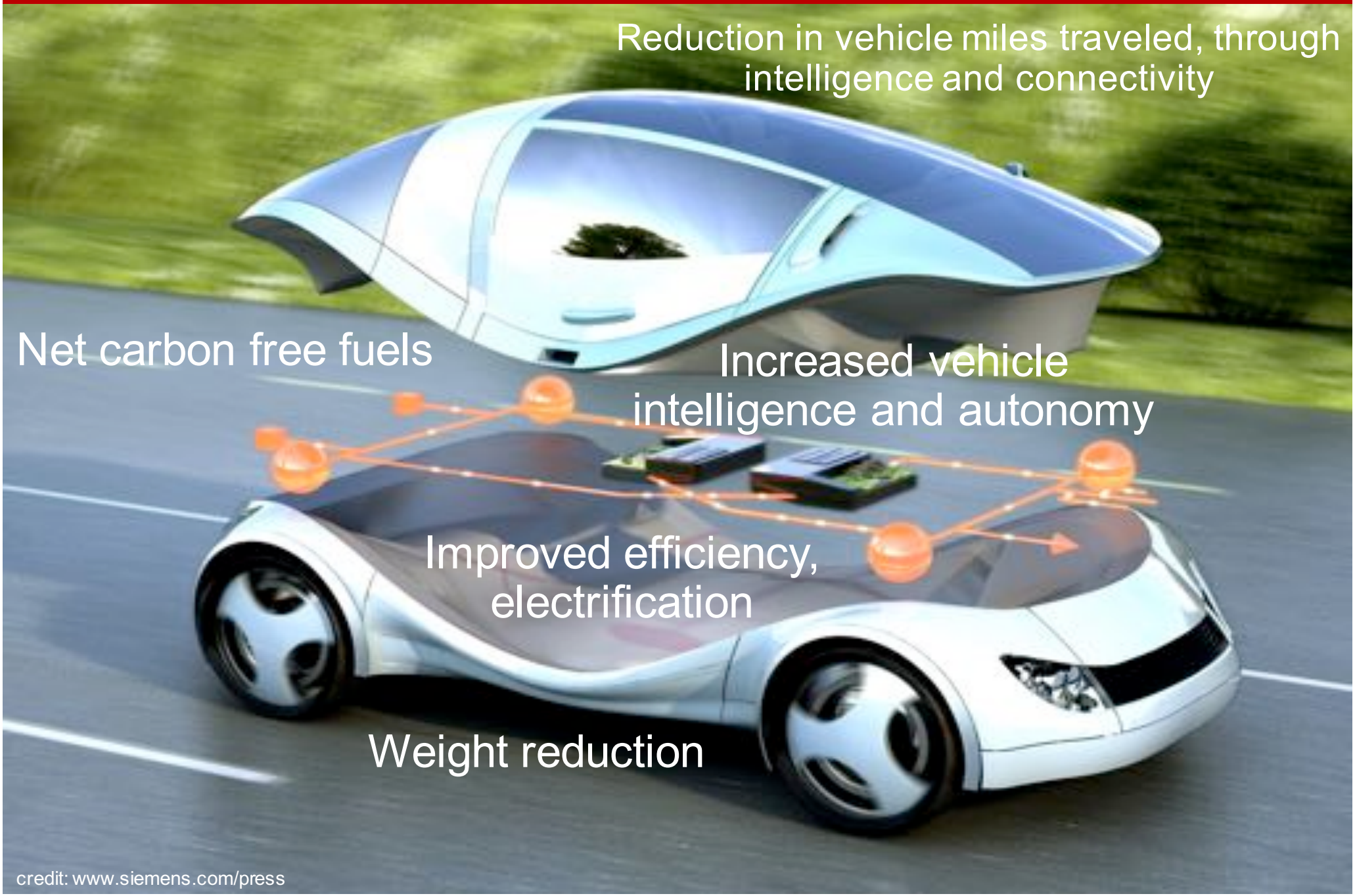

credit: www.siemens.com/press

AND IF WE FAIL,
BACK TO HORSE AND CARRIAGE?

THE OHIO STATE UNIVERSITY
CENTER FOR AUTOMOTIVE RESEARCH

The Ohio State University Archives, 1892

Tack för er uppmärksamhet
Thank you for your kind attention!
谢谢您的关注与支持!
Vielen Dank für Ihre Aufmerksamkeit!
Grazie della cortese attenzione!