Topic Paper #5

The Connected Car: Smart Technologies to Reduce Congestion (Intelligent Transport Systems)

On August 1, 2012, The National Petroleum Council (NPC) in approving its report, *Advancing Technology for America's Transportation Future*, also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the study's Task Groups and/or Subgroups. These Topic Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

These Topic Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents, but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency.

The Connected Car: Smart Technologies to Reduce Congestion

Overview:

The NPC Future Transportation Fuels Study addresses specific technology and fuel pathways that can improve the vehicle economy and fuel mix that will be utilized from now through 2050. There are three key categories where fuel economy can be improved and thus reduce greenhouse gases; the vehicle, the driver's habits, and the transportation infrastructure. In addition to technology improvements to the traditional ICE to improve fuel economy and reduce greenhouse gases, there are information and communication technologies that can also be incorporated into the vehicle and the surrounding transportation infrastructure to further improve fuel efficiency and reduce greenhouse gases. The application of "telematics", or the integration of telecommunication and informatics, has generated the possibility for the vehicle to communicate with the road infrastructure, for vehicles to communicate with each other and for vehicles to obtain this information about the traffic environment in which it is operating. The push behind "connected vehicles" is to ensure that cars are driving smoothly and safely and that traffic is moving as efficiently as possible thus reducing congestion. "In megacities like London, New York, Beijing, Singapore and New Delhi, the sheer number of vehicles on the road has become unsustainable," says Chris Borroni-Bird, General Motors director of Advanced Technology Vehicle Concepts"[1]

These integrated information and communication technologies make up what is known as an "Intelligent Transportation System" (ITS). ITS is an application of technologies used to maximize the use and efficiency of vehicles within a transportation infrastructure in order to improve safety and reduce congestion by providing real-time information via vehicles and infrastructure to a coordination network center or the driver. Real-time traffic data can be transmitted from field sensors, RFID readers or cameras and integrated into the traffic management software and traffic control center. This integrated view can allow control centers to facilitate availability of information back to vehicles directly in On Board Units (OBU) or Smart Phones to allow travel choices and can intelligently and adaptively manage traffic flow through traffic signal changes to optimize road networks and reduce congestion.

Although telematics may have been rolled out initially to promote accident avoidance, and has proved successful: according to a U.S. Department of Transportation (DOT) report, connected vehicle systems potentially address about 81 percent of all-vehicle target crashes; 83 percent of all light-vehicle target crashes; and 72 percent of all heavy-truck target crashes annually,[2] the focus of this piece is how telematics can reduce congestion through automated highway systems and self-driving cars.

Congestion is a large problem in America's urban areas causing a waste in time, money and fuel. In 2010, congestion caused urban Americans to travel 4.8 billion hours more (equivalent to the time Americans spend relaxing and thinking in 10 weeks) and to purchase an extra 1.9 billion gallons of fuel

[1] http://media.gm.com/content/media/us/en/news/news_detail.brand_gm.html/content/Pages/news/us/en/2010/Dec/1202_ENV

[2] http://www.its.dot.gov/connected_vehicle/connected_vehicle_research.htm

(equivalent to about 2 months of flow in the Alaska Pipeline) for a congestion cost of $101 billion ($23 billion of the delay cost was the effect of congestion on truck operations.) The cost to the average commuter was $713 in 2010 (compared to an inflation-adjusted $301 in 1982). And the problem is only likely to get worse. The national congestion cost could grow to $175 billion in 2020 (in 2010 USD) and delays could grow to 7.7 billion hours - with the average commuter wasting 41 hours and 19 gallons in 2020.[3]

One of the most significant contributors to fuel use in an urban environment is the stop start behavior of traffic flow, particularly common during congestion periods. Vehicles emit CO_2 while accelerating, decelerating and idling. In general, if vehicles accelerate gradually and if speed fluctuations are reduced, fuel consumption can be reduced. Through the incorporation of telematics, a given vehicle can be made aware of the traffic and infrastructure in which it is operating and adjust the driving condition en route. The goal of the information is to smooth out the drive over some look-ahead time – thus reducing the vehicle's acceleration and deceleration activity.

Necessary Vehicle Technology:

A Connected Vehicles can be equipped with GPS, maps, cameras, radar, lasers and sensors that figure out where the vehicle is, convey information about the surrounding traffic and how to get to its destination. In addition, a more advanced "autonomous" self-driving vehicle may be equipped with additional advanced decision-making software. The information received and conveyed from the multiple "connected" cars on the highway allows for the car to follow traffic speeds and signals, sense other vehicles, make room for merging vehicles, pass other vehicles, adjust a vehicle's velocity and choose alternate routes. In addition, Vehicles/Drivers will need a tool for receiving information such as via SMS, on board display units within the vehicle, radio channels, etc.

The GM EN-V (Electric Networked-Vehicle), a two-seat electric vehicle which has been tested in Shanghai is an example of an enabled car and has powertrain electrification, sensing, automation and telematics built into a vehicle about the third of the size of a traditional vehicle. The vehicle combines vehicle to infrastructure and vehicle to vehicle communications and can benefit from real-time rerouting and autonomous operation. "The sensing technology derived from the winning vehicle in the 2007 DARPA Urban Challenge allows the EN-V to detect other vehicles, obstacles and pedestrians virtually eliminating crashes.[4]"

The DARPA Urban Challenge held in 2007 which required teams to create an autonomous vehicle capable of driving in traffic, performing complex maneuvers such as merging, passing, parking and negotiating intersections while encountering manned and unmanned vehicles in a true traffic environment[5] also sparked Google's entrance into the autonomous vehicle. Google's entrance into the autonomous vehicle shows how traditional automotive business models are changing. Google's

[3] Texas Urban Mobility Report 2011

[4] http://media.gm.com/content/media/us/en/news/news_detail.brand_gm.html/content/Pages/news/us/en/2010/Dec/1202_ENV

[5] http://archive.darpa.mil/grandchallenge/index.asp

autonomous cars have now driven over 200,000 miles (March 2012)[6] and use video cameras, radar sensors and a laser range finder to "see" other traffic, as well as detailed maps (which are collected using manually driven vehicles) to navigate the road ahead. Google's core business, data centers and data analytics synchronizing hardware and software, provide the information and process the information necessary to operate the autonomous test drive[7].

Necessary Infrastructure Technology:

In order to create an Intelligent Transport System real-time, frequent, broadcasted data is necessary. In 1999, the U.S. Federal Communications Commission allocated a portion of the 5.9 GHz band for the use of ITS. The "next generation of 5.9-GHz systems, which are being developed mainly in the United States to address a wider spectrum of intelligent transportation systems (ITS) and connected vehicle applications, will provide longer range communication and multiple channels.

In addition to the communication infrastructure to transmit data; sensors and monitoring devices must be deployed throughout travel routes to gather data from passing vehicles and an integrated transportation center must be created to analyze the data and provide "best options" to drivers. There are several types of monitoring devices and control networks that can be installed:

- Optical beacon (Used in Japan and already linked to Traffic Management Centers in each prefecture): infrared emitting and receiving unit
  - Collect and provide information in narrow area
  - Enable lane by lane information collection and supply
  - Large communication capacity
  - Simple structure
- J-Eyes: traffic monitoring system installed at major signalised traffic junctions. These cameras alert operators at the Intelligent Transport System (ITS) control centre of any congestion or disruption to the traffic flow so that action can be taken quickly
- The Expressway Monitoring and Advisory System (EMAS) – an incident management system monitors and manages traffic along expressways. Provides early detection of traffic problems, quick recovery service for motorists in distress, and also alerts motorists to abnormal or dangerous traffic conditions ahead
- Dynamic route guidance systems for navigation
- Global Positioning Systems (GPS):
  - provides a real-time spatial and time measurement of a location
  - offers a low capital cost and low installation cost
  - offers a low data collection cost
  - high location accuracy

[6] http://googleblog.blogspot.com/2012/03/bringing-self-driving-cars-to-nascar.html#!/2012/03/bringing-self-driving-cars-to-nascar.html

[7] Google Blogspot, What We're Driving At, October 2010, http://googleblog.blogspot.com/2010/10/what-were-driving-at.html#!/2010/10/what-were-driving-at.html

- Electronic Toll Collection Sites (ETC): Installed on highways or bridges, these sensors can alert operators at the Intelligent Transport System of congestion or disruption and can also increase speed of payment minimizing further congestion

Beyond providing information between vehicles and infrastructure to reduce congestion, the Intelligent Transport System could also one day function as an automated highway system to significantly increase highway throughput (vehicles per lane per hour moving along the highway). Platooning, or vehicles operating in tight coordination, is one way to exhibit this. Platooning allows vehicles to operate closer together by "connecting" them electrically (through use of inter-vehicle communication, passive lane position information from ground mounted magnetic sensors) or even mechanically and increases lane capacity by at least double. Other benefits such as reduction in drag are also seen which could reduce fuel consumption and exhaust emissions. "Wind-tunnel tests at the University of Southern California have shown that the drag force can be cut in half when vehicles operate at a separation of about half a vehicle length. Analyses at UC Riverside have shown how that drag reduction translates into improvements of 20 to 25% in fuel economy and emissions reductions."[8]

Case Study:

Yokohama Japan[9]:

There are two modes of fuel consumption: a congestion mode and a smooth flow mode each with an average trip speed. The fuel consumption profile of the congested mode occurs at average trip speed of 0-40km/h and without further information, the driver has little influence. However, for the smooth flow mode (at average trip speed of 40-100km/hr) the driver has more control of driving actions and fuel consumption can be reduced.[10] In order to alter road congestion and move the drive predominantly into the smooth flow mode, real-time information is required.

Nissan has created and tested in Japan an in-car navigation system which collects data from other Nissan car users on the road as well as traffic sensors. The system then directs users on the best route to take avoiding road congestion and enabling more of the trip to function in smooth flow mode.

Solution

- Probe cars complement and expand time and spatial information from traffic sensors
- Prove cars are necessary for Eco route guidance which is fed to connected cars with route and probe link travel time

Results of pilot:

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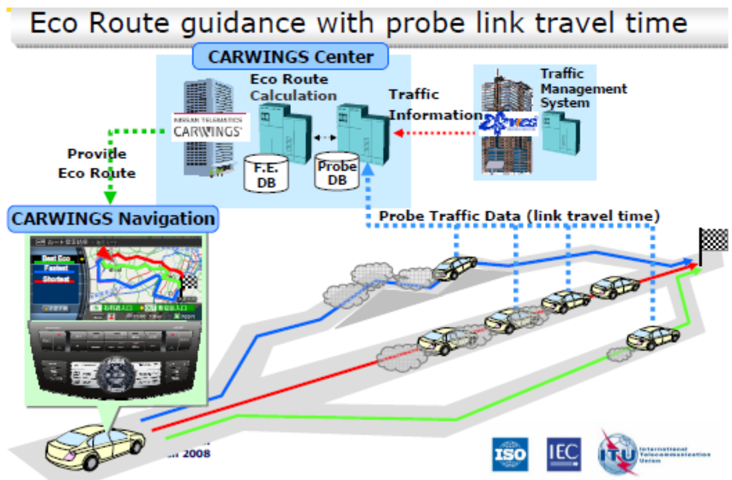
[8] Vehicle Platooning and Automated Highways, California PATH (Partners for Advanced Transit and Highways)
[9] The Fully Networked Car, Takashi Sugano, Nissan Motor Manufacturing UK LTD, Belgian Branch, United Nations International Telecommunication Union (ITU) Conference Geneva 5-7 March 2008
[10] The Fully Networked Car, Takashi Sugano, Nissan Motor Manufacturing UK LTD, Belgian Branch, United Nations International Telecommunication Union (ITU) Conference Geneva 5-7 March 2008

- 60% more traffic information
- Travel time reduced 20% by probe data by providing fastest route guidance
- Average speed increased 26%
- Reduction in CO2 emissions by 17%



Case Study:

New York City: Midtown in Motion[11]

New York City has recently launched *Midtown in Motion,* a new, technology-based traffic management system that allows City traffic engineers to monitor and respond to Midtown Manhattan traffic conditions in real time, improving traffic flow on the city's most congested streets. The system, which will eventually encompass 12,400 traffic signals located throughout the five boroughs currently includes Radio Frequency Identification (RFID) readers, 100 microwave sensors, 32 traffic video cameras and E-ZPass readers at 23 intersections to measure traffic volumes, congestion and record vehicle travel times in the approximately 110-square block area bound by Second to Sixth Avenues and 42nd to 57th streets. Upon completion this system will create the largest traffic signal control system in North America. The program utilizes Advanced Solid State Traffic Controllers – a state-of-the-art piece of equipment installed at signalized intersections that controls the traffic signals at the intersection wirelessly.

The combined data is transmitted wirelessly to the City's Traffic Management Center in Long Island City, allowing engineers to quickly identify congestion choke points as they occur and remotely adjust Midtown traffic signal patterns to clear traffic jams. Depending on the traffic situation, traffic lights can be adjusted to provide a more even distribution of traffic entering Midtown so that already congested areas do not become oversaturated, or priority can be given to clearing isolated backups resulting from

[11] Mayor Bloomberg Announces New, Real-Time Traffic Management System to Reduce Congestion in Midtown Manhattan, New York City Press Release July 18 2011

breakdowns, fender-benders or double-parked vehicles. On the avenues, engineers can switch more easily between a simultaneous signal pattern, where all the signals on the avenue turn green or red at the same time, and a traffic signal progression, which lets vehicles traveling at the speed limit encounter green lights as they drive along a corridor. The system lets engineers use the more effective pattern based on measured traffic conditions

The real-time traffic flow information will be made available to motorists and to app developers for use on PDAs and smart phones. The wireless system is made possible through the use of the New York City Wireless Network (NYCWiN) – a wireless network developed and managed by the Department of Information Technology and Telecommunications. The system employs the National Transportation Communications for ITS Protocol (NTCIP) standards, the Advanced Transportation Controller (ATC) standard, and NEMA TS2 Standards for traffic control.

Challenges:

Although much of the technology is available both to receive and emit data there are still several challenges that must be overcome before the fully Connected Vehicle will become commonplace on the roadways. The main obstacle for the technology to be deployed wide scale is that a significant number of cars on the road must be equipped to emit and receive data for the system to be effective and the communication networks must be common among vehicles.

In order to reach wide scale deployment, several areas need to be further developed in order to overcome these challenges including:

- Close collaboration between public and private sectors
- Standardization of communications, telecom architecture and ITS standards
- Standards on data collection and privacy
- Economic viability / business case – how to provide value to early adopters

However there are agencies that are currently exploring solutions to these challenges. The International Organization for Standardization (ISO) has begun the process on developing the following standard:

- ISO TC204: Standardization of information, communication and control systems in the field of urban and rural surface transportation, including intermodal and multimodal aspects thereof, traveler information, traffic management, public transport, commercial transport, emergency services and commercial services in the intelligent transport systems (ITS) field[12]

In addition, the National Highway Traffic Safety Administration (NHTSA) is currently testing V2V communication technology (with a main focus on safety) and has stated it will make an agency decision for vehicle communication safety systems by 2013 with potential impacts to OEMs to include equipment to support V2V and V2I safety applications in new cars by a future date.[13]

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[12] http://www.iso.org/iso/iso_technical_committee?commid=54706

[13] USDOT Connected Vehicle Research Program, Vehicle-to-Vehicle Safety Application Research Plan, NHTSA, DOT HS 811 373, October 2011

Active Regulations:

Although many current regulations for autonomous vehicles are more focused on safety and emergency call functions such as Ecall EUROPEAN REGULATION, vehicle tracking such as CONTRAN 245 regulation in Brazil and electronic toll payments for trucks such as eToll France; in February 2012, Nevada introduced laws to establish requirements companies must meet to test their vehicles on public roadways. Nevada DMV partnered with Google, automobile manufacturers, testing professionals, insurance companies, universities and law enforcement to establish the new regulations. “Nevada is the first state to embrace what is surely the future of automobiles," Department of Motor Vehicles Director Bruce Breslow said[14]. Lawmakers in California, Hawaii, Oklahoma, Florida and Arizona have also introduced bills to follow Nevada’s lead.

Conclusion:

Although there have only been a few integrated tests to deploy Intelligent Transportation Systems globally, as technology and data become more engrained in consumers’ daily lives the request for data and information around driving and the increased knowledge of driver safety will likely be driving forces to deploy this concept on a wide scale, resulting in decreased congestion and greenhouse gas emissions and increased fuel economy.

[14] Regulations Clear the Road for Self-driving Cars, Nevada DMV Press Release, February 15, 2012, http://www.dmvnv.com/news/12001-regulations-for-self-driving-cars.htm

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USDOT Connected Vehicle Research Program, Vehicle-to-Vehicle Safety Application Research Plan, NHTSA, DOT HS 811 373, October 2011: http://www.nhtsa.gov/DOT/NHTSA/NVS/Crash%20Avoidance/Technical%20Publications/2011/811373.pdf

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