A Strategic View of Computational Transportation Science

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IWCTS-09

Seattle, November 3, 2009

As Researchers

- **We focus on long-term and fundamental problems**
- **We want to see our results used widely**
- **We collaborate with Industry, Government, customers, etc.**
- **"Purpose of Computing is Insight, Not Numbers"**
  - **Richard W. Hamming**
- **"You Americans are always trying to find out how something can be used. That's a good way to discover things!"**
  - **Herbert Jehle to Richard Feynman**
    - When Feyman discussed the connection between the Lagrangian and quantum mechanics
  - from Richard Feynman Nobel Lecture December 11, 1965
- **Today: Strategy-Driven Discovery and Data-Driven Strategy Formulation**

Traffic Signals and STOP Signs

- **Discovery**: Major Problems Caused by Traffic Signals and STOP Signs
  - Low Throughput and Time Delay
  - Waste of Fuel – Idling while waiting
  - Emissions into the Atmosphere
  - Some Solutions: Signal synchronization, One Way Streets…
- **My Objective**: **Do NOT Fix but Eliminate the Problem!**
  - Aware of the trend towards autonomous vehicles, Passive versus Active Safety, Occupant Protection to Never-Crash Vehicles, V2V to V2X
- **Strategy**: Eliminate Traffic Signals and STOP Signs
  - AI Connection → Collaborative Autonomous Agents Research
  - Peter Stone's Research at UT Austin – "Intersection Management"

Traffic Signals and STOP Signs

- **Results**:
  - **Peter's Simulation Video**
  - **Indian Traffic Video**
  - Connected Peter with Relevant GM People
  - **Solution Simulates an Overpass!**
- **DARPA Urban Challenge – GM+CMU+..**
  - **"Boss" in Action**
- **Challenge** (long term)
  - Work with US DOT and the IntelliDrive Program to Implement in Stages

Autonomous Intersection Management

Goal: Create a scalable, safe, efficient, multi-agent robotic framework to manage and control vehicles at intersections

Motivation:

Traffic Intersections are:

Dangerous

- 1/3 of all accidents and 1/4 of all fatal accidents

Wasteful

- Most vehicles are just stopped

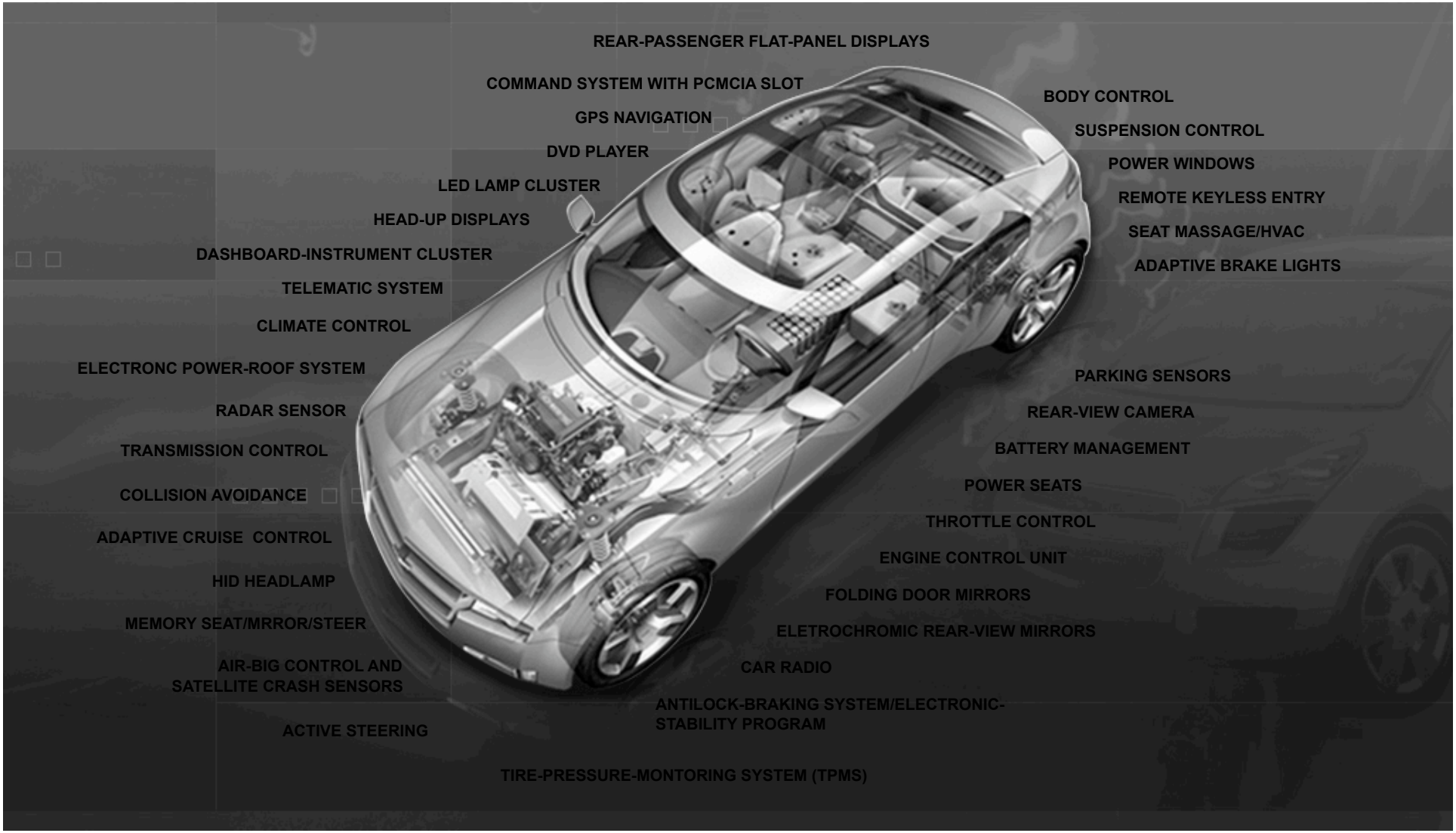
Autonomous Intersection Manager

- Driver agents "call ahead" to reserve a path through the intersection
- Intersection manager approves or denies based on an intersection control policy
- Vehicles may not enter the intersection without a reservation, like red lights today
- Plan to handle special cases: ambulances, fire trucks

Make driving safer and easier

Courtesy: Peter Stone, UT Austin

Vehicle Electronics and Sensors



Courtesy: Steve Holland, GM R&D

Simple User Interface

Focuses on Mainstream Market

- **Designed for the average user NOT the most technically adept**
- **Voice interface for least driver distraction**
- **Simple to explain and understand**
- **Simple to acquire and install**
- **Simple to use**
- **Simple visually/aesthetically**

Courtesy: Sanjay Khunger, OnStar

Monthly Subscriber Interactions

Automatic Crash Response
2,000/Month

Emergency Services *10,000/ Month*

Good Samaritan
7,000/Month

Stolen Vehicle Assistance
500/Month

Remote Door Unlock *62,000/ Month*

Roadside Assistance
26,000/Month

Turn-by-Turn Routes Delivered *
Over 1.2 Million/Month

OnStar Vehicle Diagnostics
Over 3.4 Million Emails Sent

On-Demand Diagnostics
45,000/Month

OnStar Hands-Free Calling
Over 27 Million Minutes Purchased/Month

One Very Hardworking Button
Over 220 Million Cumulative Service Interactions

Courtesy: Sanjay Khunger, OnStar

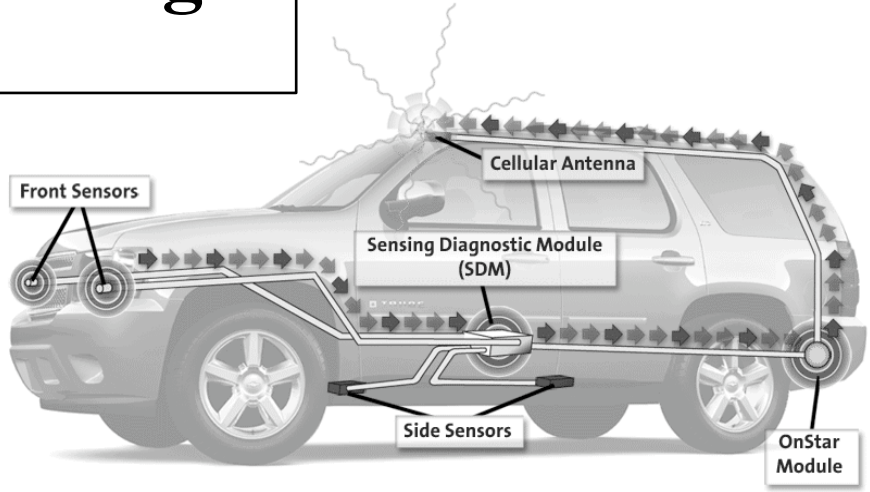
** Includes Advisor and TBT delivered routes*

3 Month Rolling Average (Apr '09 – Jun '09)

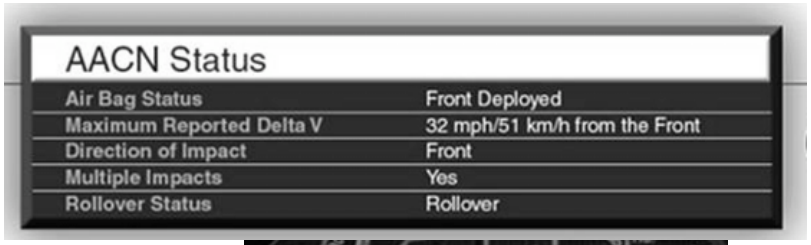
U.S. and Canada

Automatic Crash Response System

OnStar's Next-Generation "Digital Crash Signature" Continues to Define the Category



Sensors create a protective 360^0 circle to capture crash data instantaneously



On a crash, ACR sends crucial information to the OnStar Advisor that is used by the 911 dispatcher to determine the right emergency responder team to dispatch

Courtesy: Sanjay Khunger, OnStar

Crisis Assist

Assistance in wide scale crisis like hurricane, tornado, earthquake…

- **OnStar Command Center monitors events in the U.S. and Canada and alerts Advisors to wide scale emergency situations**
- **During a crisis, OnStar opens its services to all affected subscribers regardless of their service plans**
- **Provides services like:**
  - Routing help out of crisis area
  - Contacting and/or locating loved ones
  - Medical assistance
  - Information regarding permission to re-enter area
  - Routing assistance back home
  - Hotel reservations
  - Location of Hospitals
  - Disaster relief aid

Courtesy: Sanjay Khunger, OnStar

OnStar Turn-by-Turn Navigation (TBT)

Defining a new "Connected Navigation" category

- Complete step-by-step audio directions to the vehicle
- Directions played automatically through the vehicle's radio, triggered by system's GPS capabilities
- Safely allows driver to get to destination while keeping hands on wheel, eyes on the road – without stopping
- In May 2008, launched "eNav" in collaboration with MapQuest to bring web-routing capability
- In Sep 2008, launched Destination Download for downloading directly to screen-based navigation systems

Courtesy: Sanjay Khunger, OnStar

Stolen Vehicle Assistance Services

- Facts
  - Over 1 million stolen vehicles annually in the U.S. leading to 30,000 high speed chases
  - 25% result in injuries, often innocent bystanders
  - 300 deaths
- OnStar Stolen Vehicle Slowdown
  - Launched in Sept 2008
  - Once reported stolen and on the request of law enforcement, OnStar can send a signal to the vehicle to ignore throttle input
- OnStar Remote Ignition Block
  - Launched in July 2009
  - Once reported stolen, OnStar can send a Remote Ignition Block signal to the vehicle to keep it from starting

Courtesy: Sanjay Khunger, OnStar

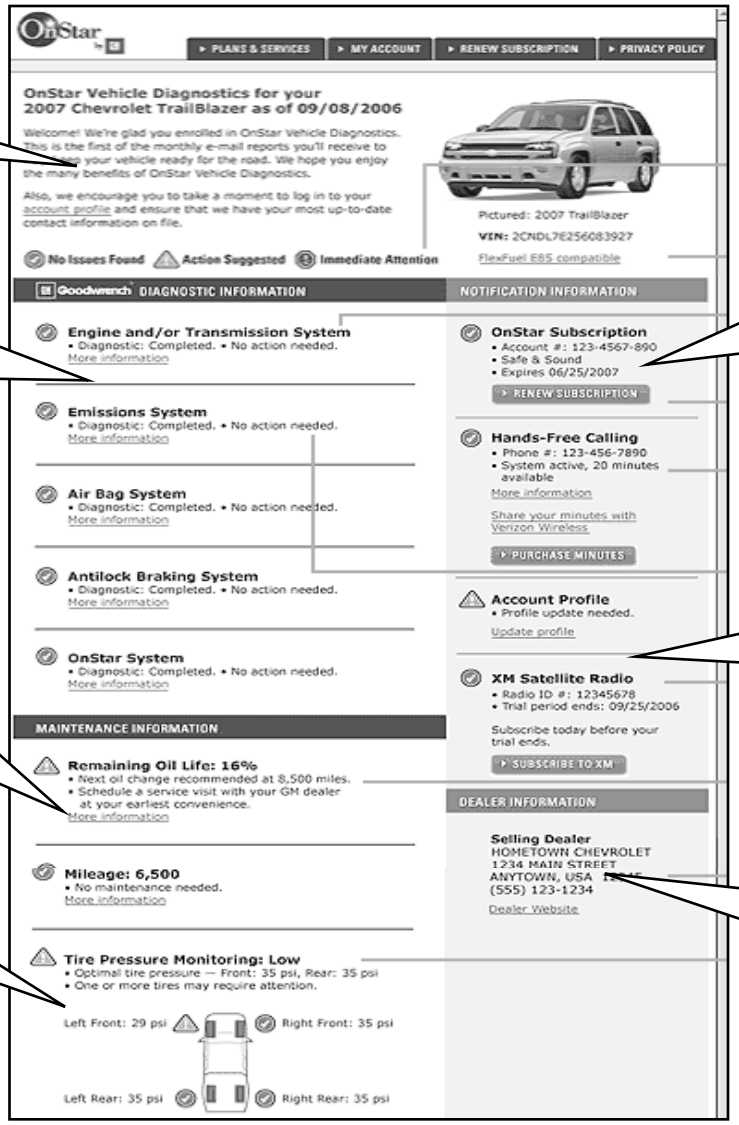
GM OnStar Today Vehicle Diagnostics Email Message

Introductory Message:
Variable msg. Content

Vehicle Diagnostics:
Variable msg. Content based on codes received, codes will not be communicated

Maintenance Alerts:
Required maintenance messages based on mileage and oil life remaining

Tire Pressure Monitoring
Beginning deployment Q4 '06



Account Information:
Name, Acct. No., Vehicle type, VIN, Phone No., Package Type

HFC/XM Information:
Minutes remaining, Expiration date, Variable msg. content

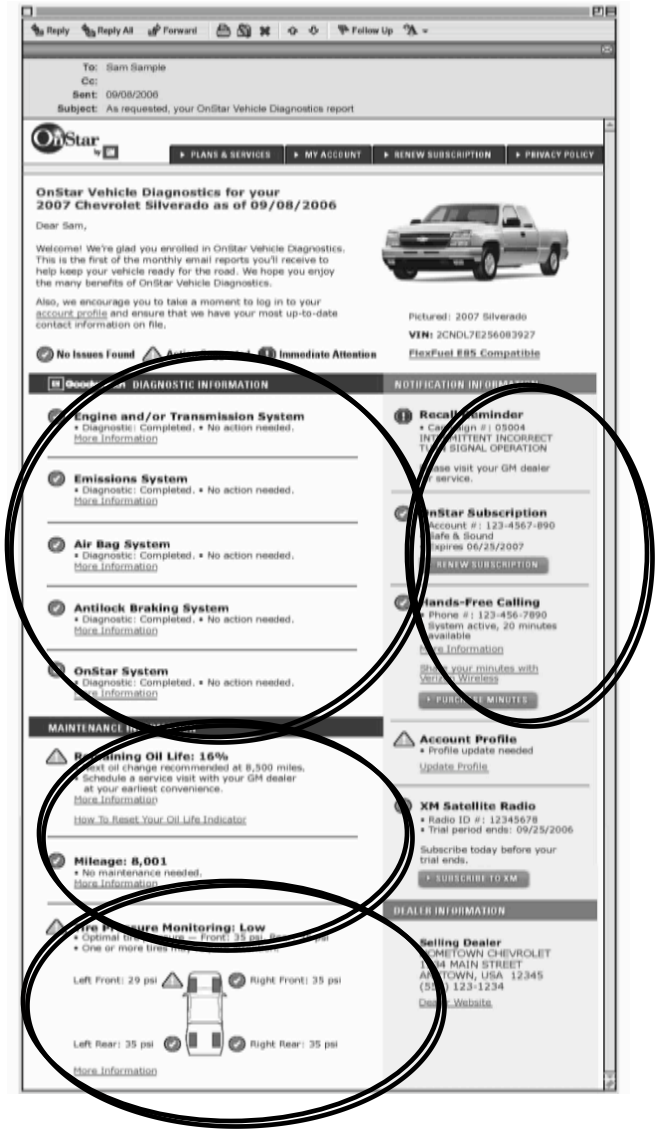
Selling Dealer Information and Link

Courtesy: Steve Holland, GM R&D

OnStar Vehicle Diagnostics (OVD)

- Monthly email from vehicle to its owner
  - Status of engine, air bag, antilock brakes and OnStar systems
  - Current mileage, remaining oil life and scheduled maintenance reminders
  - Status of OnStar subscription
  - Number and expiration of OnStar Hands-Free calling minutes in vehicle
  - Tire pressure information

Over 3 million vehicles enrolled



Courtesy: Sanjay Khunger, OnStar

Transportation Environment

- **My Japan Trip Experience**
  - **How Infrastructure is utilized (data, display, ..)**
  - **Flexibility and multiple uses of Data**
  - **Multimodal Routing**
  - **CAHD and HACD**
  - **Our Different and Innovative Application in USA**
  - **Car Sharing**
- **Bicycle sharing, Zipcar, …**
- **Vehicles, People, Infrastructure, …in Context**

Thinking Outside The Car

First there were seat belts. Then air bags. Then the reengineering of car fronts to help pedestrians bounce up instead of getting knocked down when hit. Now the Dutch Cycling Federation is calling for carmakers to install air bags on vehicle hoods to protect cyclists. The group says external air bags would prevent 60 deaths—and 1,500 serious injuries—yearly in the Netherlands, where many people get around by bike. Scandinavians, who invented air bags, may come through. Although it has yet to find any takers, Sweden's Autoliv, a leading air bag supplier, has developed a hood-mounted model that inflates on impact. It covers most of the hood and some of the windshield. "In Europe, roughly 15% of all traffic fatalities are pedestrians," says Autoliv spokesman Mats Odman. "Most of them hit their head on the hood." –David Kiley

BELLE MELLOR

BusinessWeek-080512

Zipcar - The Best New Idea in Business

Fortune Magazine Cover Story 090914

How Zipcar works

1. Book
Make a reservation at the Zipcar website or with the iPhone application, which launches in September. Your information is transmitted wirelessly to the car's onboard computer system.

2. Unlock
Wave your Zipcard at the car's reader on the windshield or press a button on the iPhone app to unlock the car and enable the starter (keys are inside). The iPhone can also make the horn beep to help locate the car.

3. Fill up
If gas gets low, you can fill up free using the special charge card in the car. As you drive, beware of breaking the rules: Smokers have been ratted on by fellow Zipsters who spied them puffing away.

4. Extend
If you're running late, call or text Zipcar and an automated system recognizes your number and lets you extend the rental. Forget to call and you'll be charged a late fee of $50 per hour plus the regular hourly rate.

5. Clean up
Zipcars are cleaned out and washed weekly, though some members have complained of detecting traces of the previous occupant, such as the hard-to-erase smell of fast food.

Zipcar

COURTESY: APPLE (PHONE); ZIPCAR (SCREEN)

Zipcar's new iPhone app lets users locate, reserve, and unlock nearby cars.

http://money.cnn.com/2009/08/26/news/companies/zipcar_car_rentals.fortune/index.htm

Courtesy: Mike Daily, HRL

WebOnWorld Concept

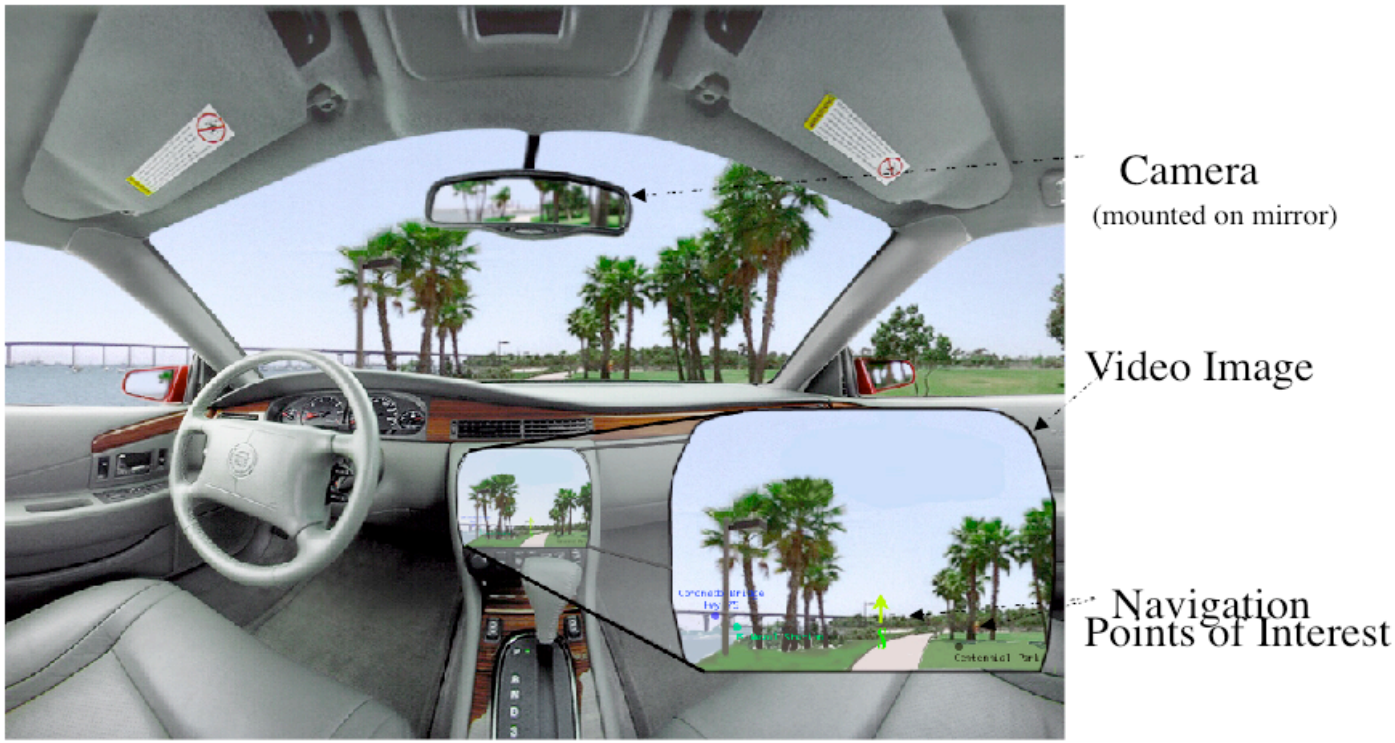
Location Specific Information
Adaptive to Context
Spatially Registered
Consumer Driven

Courtesy: Mike Daily, HRL

WebOnWorld Vehicle Concept

Near Term

Head Down Display with Video Camera

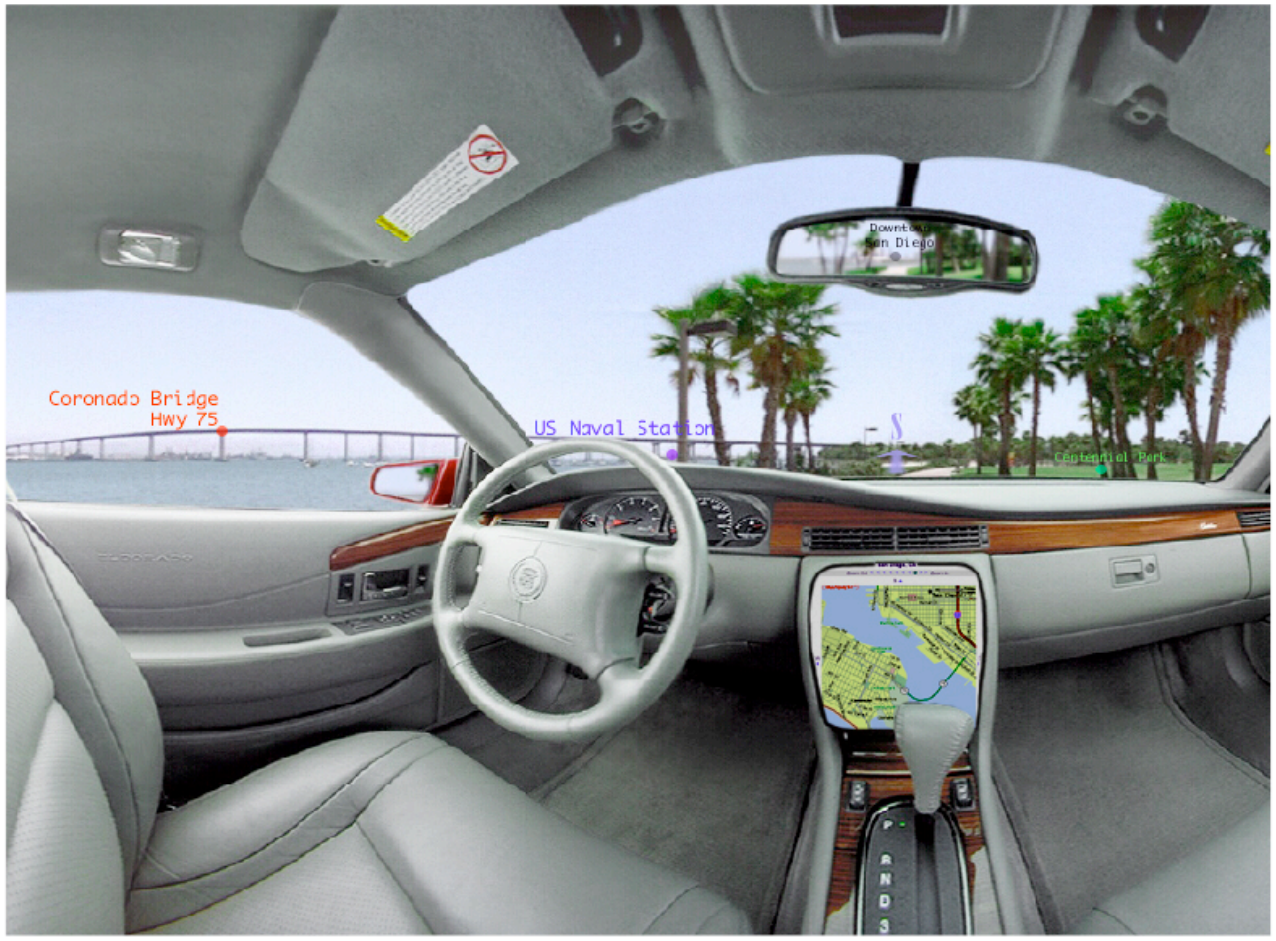


Courtesy: Mike Daily, HRL

WebOnWorld Vehicle Concept

Long Term

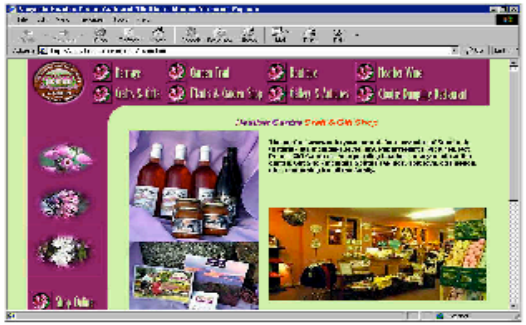
Head Up Display Direct View (worn or on windows)



Courtesy: Mike Daily, HRL

Geo-Coded Visual Information
Three Modes

Driver's View | Display

Geo-coded web pages


Geo-coded navigation photos


Geo-coded virtual billboards and tags

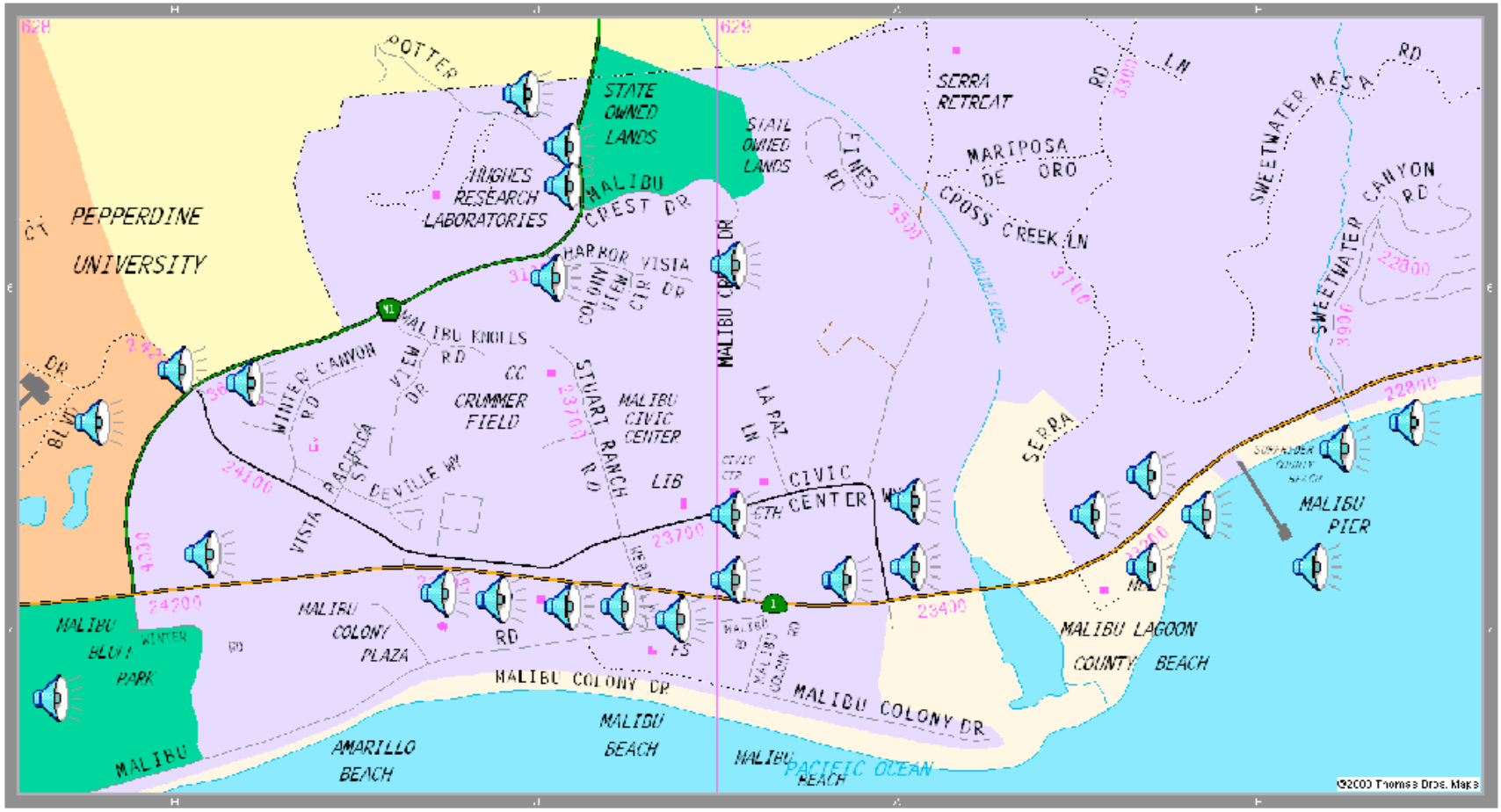
Courtesy: Mike Daily, HRL

Geo-Coded Spatial Audio Concepts

Capability	*Use*
Spatial audio tags	Label points of interest, landmarks, navigation aides, commerce
Audio whiteboard concept	Interactive, asynchronous communication through the environment
Spatial cell phone conversations	Potentially reduce distraction, "live" advisor, virtual passengers
Spatial diagnostic and safety warnings	"door ajar" sound from location of door ajar, Obstacle warnings from location of obstacle
Super Dolby (commercially available)	Carnegie Hall environment within car using multi-channel immersive audio
Spatial inter-car communications	Spatial cues to improve situation awareness
Acoustically transparent vehicle (source localization)	Filter unwanted noise, spatially amplify selective sounds (e.g. sirens, nearby horns).

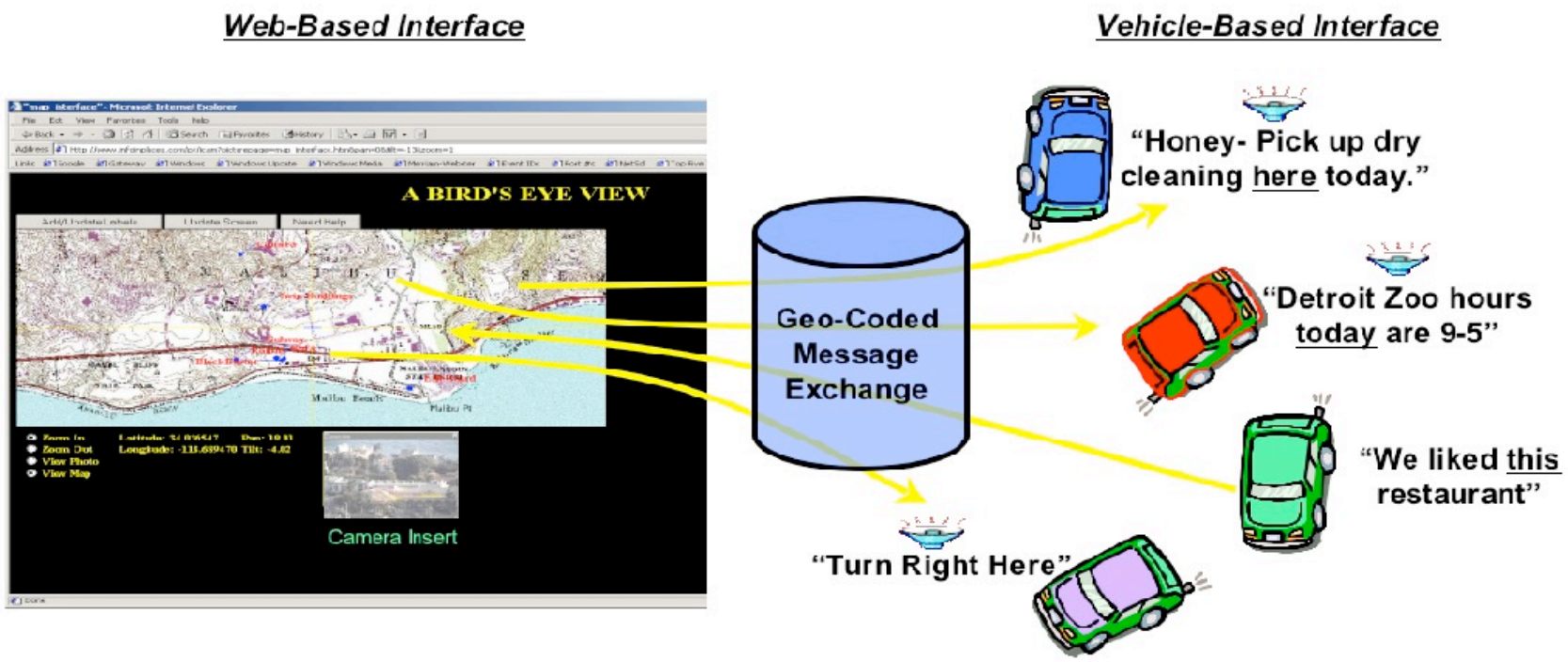
Courtesy: Mike Daily, HRL

Demonstration Scenario
Audio Tags



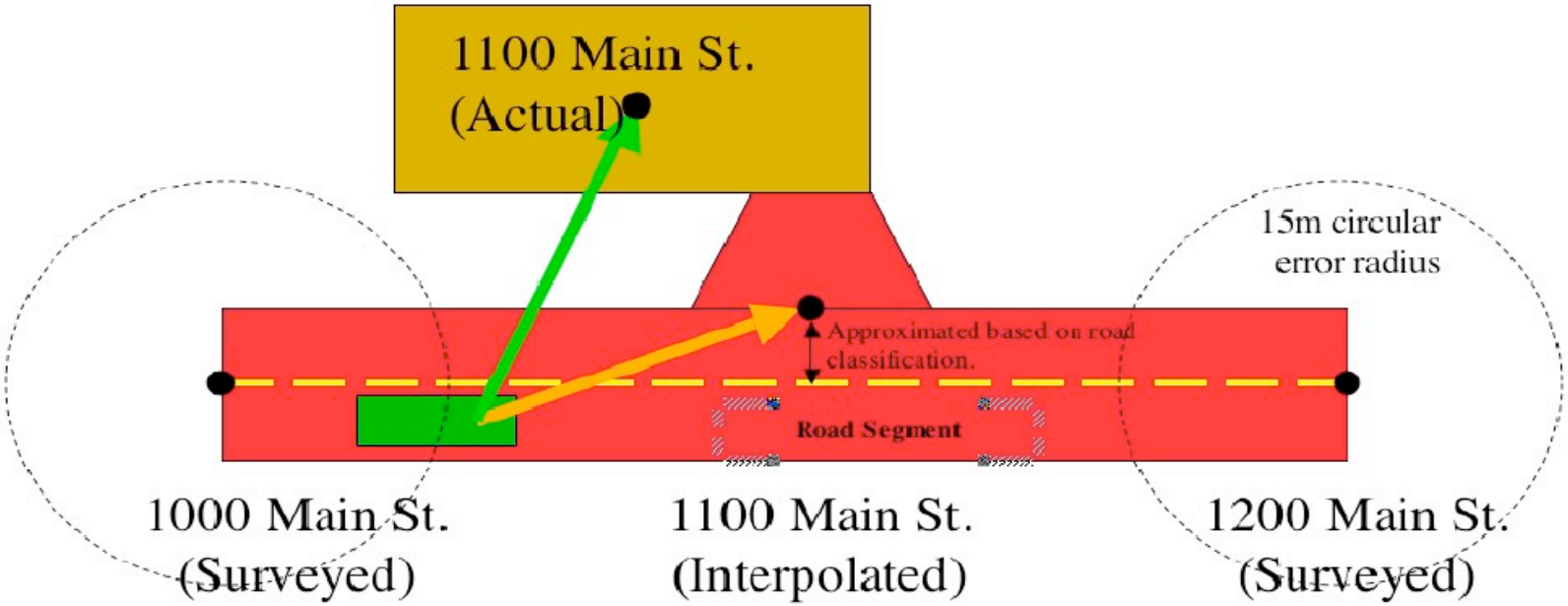
Courtesy: Mike Daily, HRL

WebOnWorld Audio Whiteboard



Courtesy: Mike Daily, HRL

Positional Errors
Locating Points of Interest



Courtesy: Mike Daily, HRL

HRL LABORATORIES

Conclusion

- **WebOnWorld prototype enables several novel methods for communicating with a driver**
  - **Augmented, geospatially registered video**
  - **Geospatial audio**
  - **Audio whiteboard**
- **Many remaining issues**
  - **Visual registration requires tracking 6DOF pose**
  - **How and when to display information to avoid clutter, distraction, occlusion**
  - **Optimizing vehicle environment for spatial audio**
  - **Automatically populating database**

Courtesy: Mike Daily, HRL

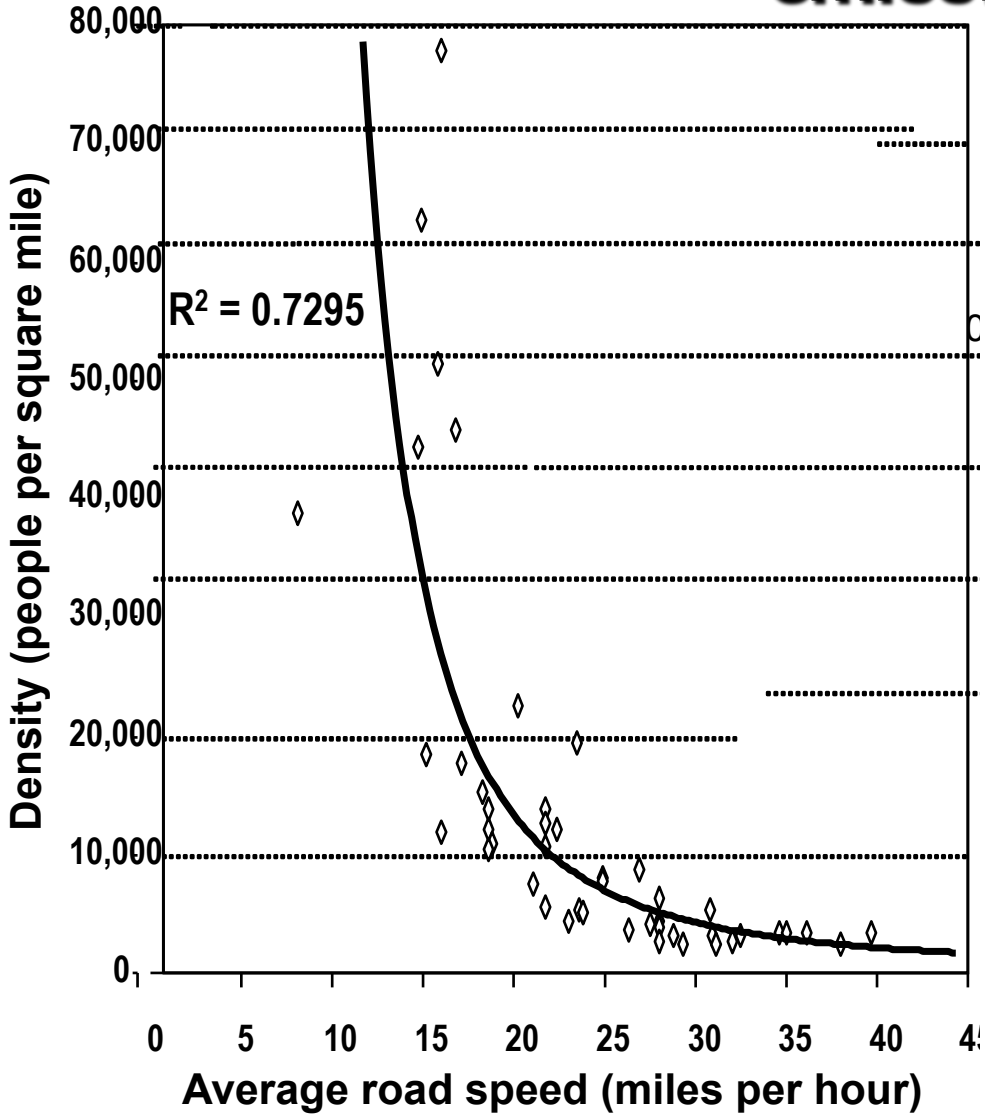
Challenges to Sustainable Auto Industry

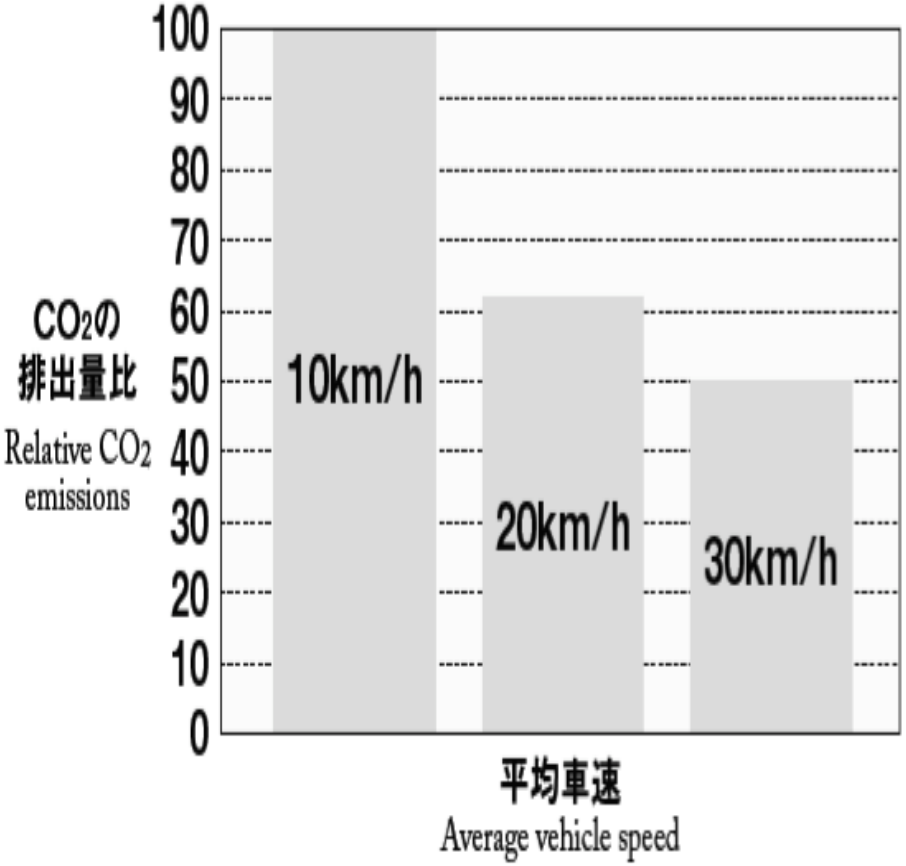
- Energy
- Environment
- Safety
- Affordability
- Congestion
- Parking

Urban Mobility

Courtesy: Dr. Christopher E. Borroni-Bird, General Motors

Population Density and Traffic Speed and CO_2 emissions





10km/hで走行するときを100とした場合のCO2排出比率

Relative CO2 emissions (vehicle speed of 10 km/h = 100)

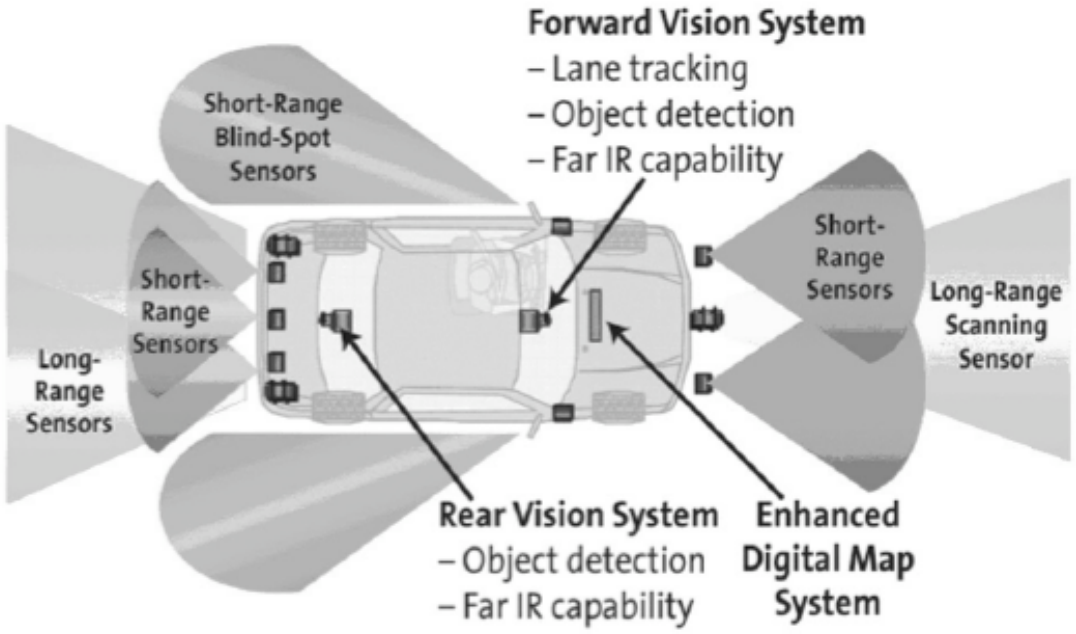
Source: NEDO report (2009)

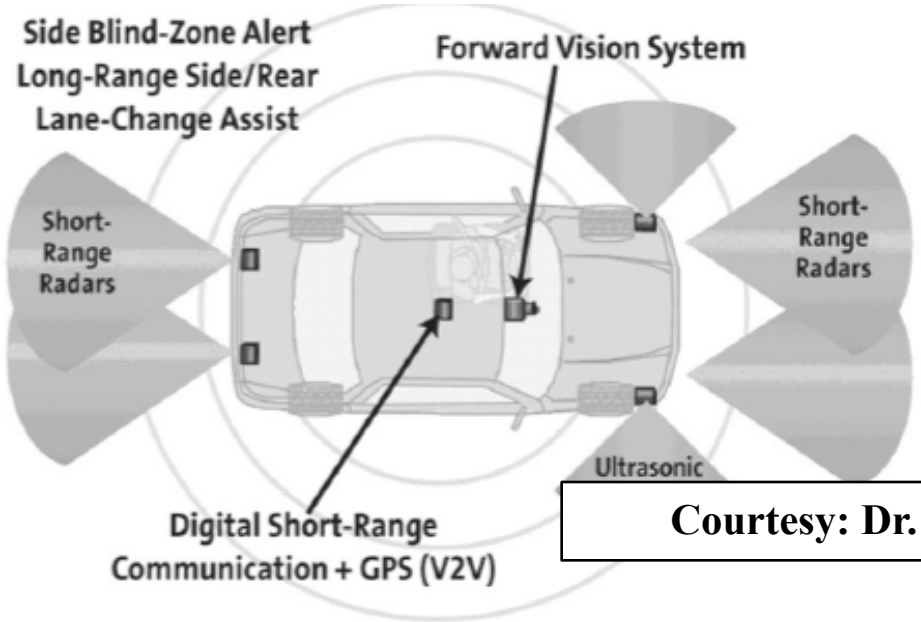
Development of Energy saving ITS Technologies

Courtesy: Dr. Christopher E. Borroni-Bird, General Motors

Source: data from Jeffrey R. Newman, Felix B. Laube (eds) (2002)

Autonomous Driving

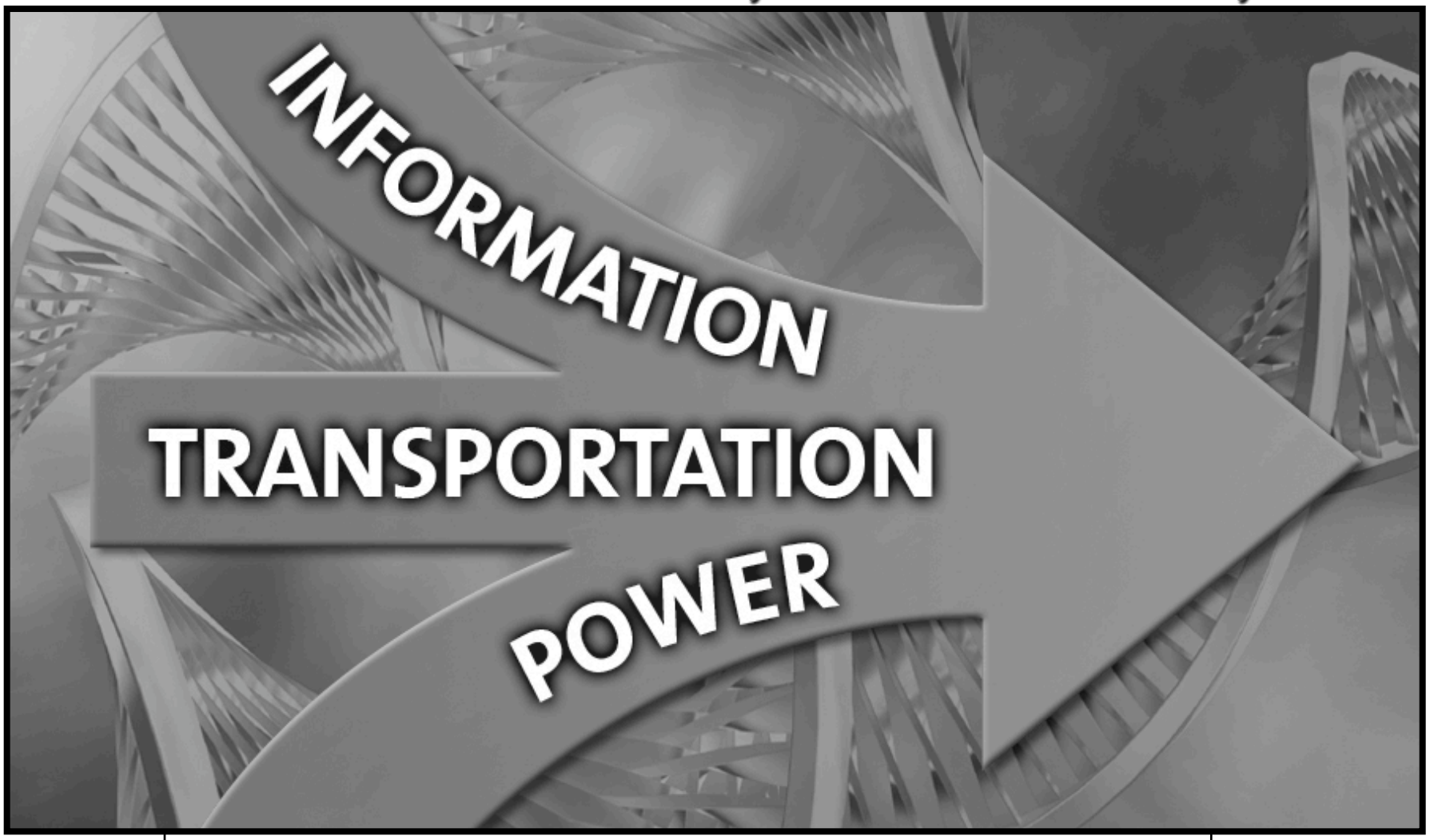




Courtesy: Dr. Christopher E. Borroni-Bird, General Motors

Reinventing the Automobile:

Personal Urban Mobility for the 21st Century



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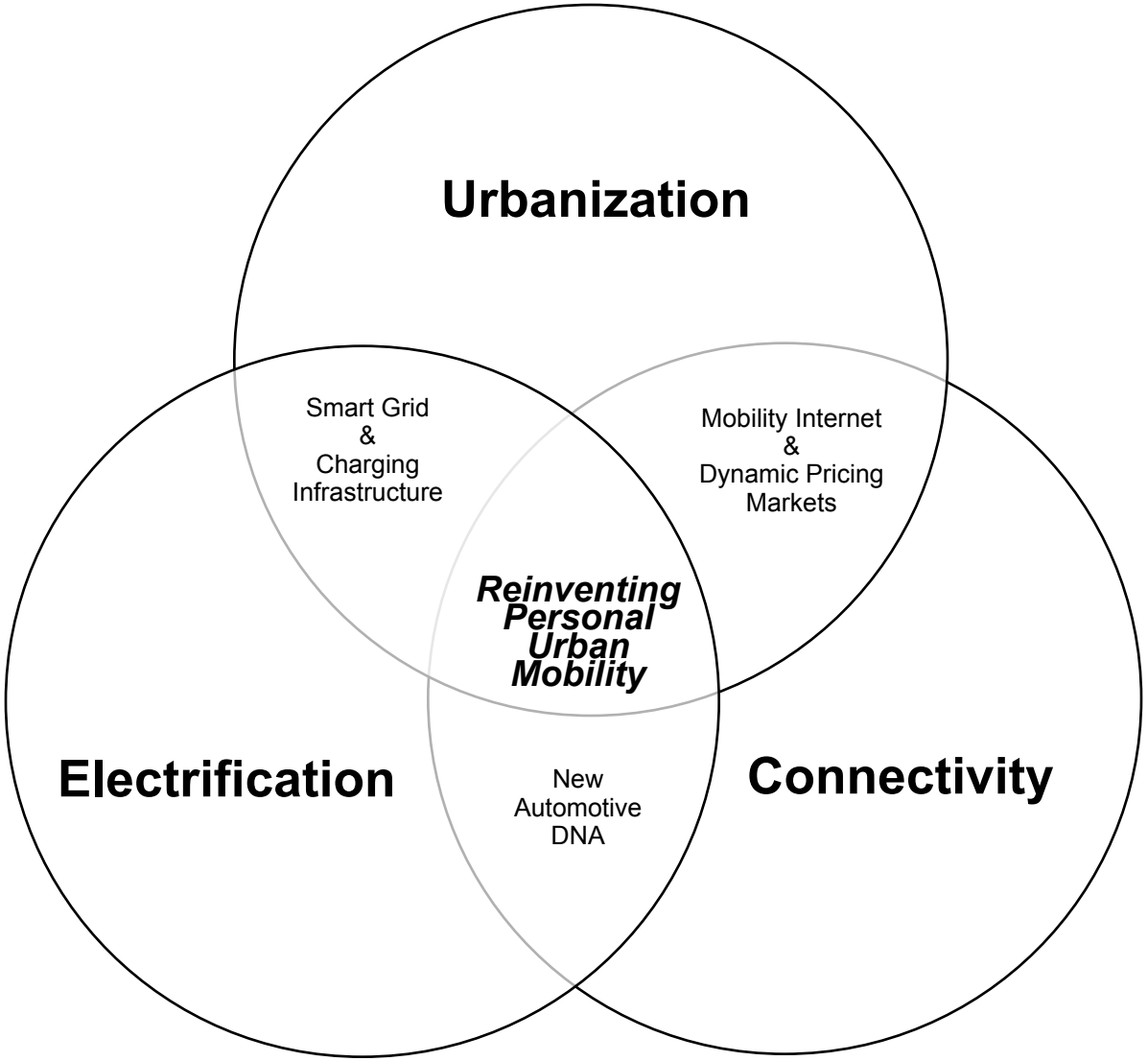

Courtesy C. Borroni-Bird, General Motors

Megatrend: Urbanization

http://www.192021.org/

192021

19 of these cities will be chosen as case studies exploring the impact of this population phenomenon

▲ MENU ◄ PREVIOUS NEXT ►

http://www.192021.org/

http://www.192021.org/

http://www.192021.org/

19|20|21

19.20.21 will provide a roadmap for understanding the world ahead. A five-year study that will encompass all aspects of the phenomenon of supercities, it will be an invaluable, entertaining, comparative and statistical analysis of the world's great cities of today and tomorrow.

Subjects of exploration will include:

- Health
- Education
- Transportation
- Demographics
- Energy consumption and distribution
- Growth patterns
- Water sources, use, and quality
- Waste management
- Economics and the cost of living
- Infrastructure
- Quality of life and standard of living indices
- Crime dynamics
- Calamity risk
- Culture and art

http://www.192021.org/

http://www.192021.org/

Case Study: UPS

- **UPS Data: 100,000 Trucks Delivering 16 Million Packages Daily**
- **Discovery: Fuel and Time Waste Waiting to Turn Left !**
- **Strategy: No Left Turn Policy**
  - **Reduce Cost + Desire to be Green and Let the World Know**
- **Result:**
  - **Reduces idle time on vehicles waiting to make a left turn.**
  - **Conserves Fuel - 5 million gallons of fuel per year**
  - **Reduces Emissions - 30000 Tons of CO2 Emissions**
  - **Improves Safety**
  - **Reduces driver wait time at red lights, Reduces miles travelled**
  - **Great Publicity – Late 2007**
- **3 years of software development and deployment**
  - **How to Load Packages, Dynamic Routing, Real-time Monitoring, ….**
- **Total Reduction of 3.1 Million Tons of CO2 Emissions through all green initiatives in 2007**
- **Challenge (short term)**
  - **Policy for its 1000 aircrafts?**
  - **FedEx, USPS, and others… exploit the idea?**
  - **Similar to CSPAN TV Pool Share Trucks, Planes, ….**
  - **Lack of exploiting the data discovery idea and implementation of proven RoI**

Case Study: Miles Per Gallon

- **Data**: Claims - CSX Railway – 400mpg, BMW – 240mpg, …
- **Observation**: mpg makes no sense going forward due to many types of vehicles
  - Hybrid, Fuel Cell, Compressed Air, Ethanol, Bio-fuels, Electric, …
  - Need to find a way to assess the energy conversion and efficiency of any vehicle, busses, trucks, taxis, trains, airplanes (kerosene to biofuels to ..), ..
  - Mpg for one vehicle is necessarily dependent on other vehicles, etc
- **Strategy**: Develop methodologies to designate efficiency of the new vehicles that is appropriately conveys the meaning, standard, and consistency of mpg designation
- **Result**: NHTSA, EPA, NIST, etc working on them?
- **Challenge** (long term)
  - Globally meaningful designation
  - Avoid testing by Federal Agencies by exploiting V2X (real time, unrestricted number of vehicles driven under all conditions and all drivers, etc)

Summary

- **Computer Science Contributions and Challenges**
- **Sensor-Laden Ecosystem of Vehicles, People, ..**
- **Autonomous Transportation Environment**
- **No Need for Traffic and Navigation!**
- **Augmented Reality – (WoW) not just vehicles but Airlines, Trains, Buses, Taxis, People, …**
- **Computational and Service Challenges – OnStar,**
- **Congestion, Urban Mobility, Personalization, ..**

Challenges

- **Strategic and Systemic Thinking**
- **Strategy-Directed CTS**
- **Incorporating Domain Knowledge**
- **Integration and Interoperability of Large Number of Multimedia Databases**
- **Delivering Value from Data**
- **Exploiting Cloud Computing**
- **Interestingness**

Challenges

- **Soft Computing Idea**
- **Moore's Law's real impact**
- **Of the things you heard which one has the most impact?**
- **Which one interests you the most and feel strongly about?**
- **What technology or expertise will you apply to it?**
- **If you could assemble a dream of experts to address this issue who will they be?**